September 30, 2011

Mr. Rob Burkhart
DEQ Northwest Regional Office
2020 SW Fourth Ave Suite 400
Portland, Oregon 97202

Subject: Stormwater Source Control Measure Final Design Report
Arkema Portland Facility

Dear Mr. Burkhart:

Legacy Site Services LLC (LSS), agent for Arkema, is submitting this Final Design Report Stormwater Source Control Measures for your review. This Final Design Report is being submitted in accordance with the Mutual Agreement and Order (MAO) No. WQ/I-NWR-10-175, effective August 4, 2010 and subsequent DEQ and LSS agreements.

Please contact me at (610) 594-4430 if you have any questions regarding this submittal.

Sincerely,

Legacy Site Services LLC

for

J. Todd Slater
Manager, Environmental Technologies
And Remedial Procurement

cc:

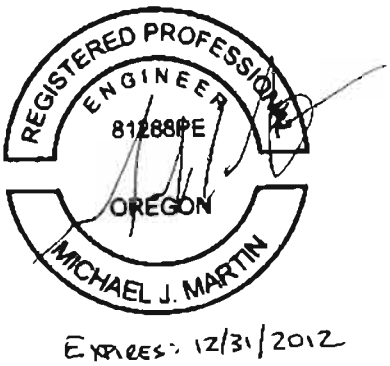
Matt McClincy, DEQ
David Livermore, Integral
Mike Martin, Integral
Kevin Deeny, KC Environmental

Legacy Site Services LLC
468 Thomas Jones Way
Exton, PA 19341-2528
Tel: 610 594-4421

FINAL DESIGN REPORT
STORMWATER SOURCE CONTROL MEASURES

Former Arkema Inc. Facility
Portland, Oregon

Prepared for
Legacy Site Services LLC
468 Thomas Jones Way
Exton, PA 19341-2528



Prepared by

integral consulting inc.

319 SW Washington Street
Suite 1150
Portland, OR 97204

September 30, 2011

CONTENTS

LIST OF FIGURES ..... **v**

LIST OF TABLES ..... **vii**

ACRONYMS AND ABBREVIATIONS ..... **ix**

1 INTRODUCTION **1-1**

1.1 DESIGN REPORT OBJECTIVES 1-2
1.2 SELECTED SOURCE CONTROL MEASURES 1-2
1.3 REPORT ORGANIZATION 1-3

2 BACKGROUND **2-1**

2.1 SITE DESCRIPTION 2-2
2.1.1 Location and Area Land Use 2-2
2.1.2 Physical Characteristics 2-2
2.1.3 DDx in Soil 2-3
2.1.4 DDx in Stormwater and Previous Interim Remedial Measures 2-3
2.1.5 Recontamination Assessment 2-5
2.1.6 Stormwater Drainage 2-6

3 BASIS OF DESIGN **3-1**

3.1 DESIGN PARAMETERS AND CONSTRAINTS 3-2
3.2 VARIABLES AND UNCERTAINTIES 3-3
3.3 DESIGN ASSUMPTIONS 3-4
3.4 RATIONALE FOR SYSTEM ELEMENT DESIGN 3-4
3.4.1 Decommissioning of the Existing System 3-4
3.4.2 Temporary Capping 3-5
3.4.3 Detention Basin 3-5
3.4.4 Sand Filter 3-7
3.5 ANTICIPATED DESIGN ELEMENT PERFORMANCE 3-9
3.5.1 Temporary Capping 3-9
3.5.2 Decommissioning of Existing Stormwater Collection System 3-10
3.5.3 Stormwater Conveyance and Treatment 3-11
3.5.3.1 Stormwater Conveyance Channels 3-11
3.5.3.2 Detention Basin 3-12
3.5.3.3 Sand Filter 3-12
3.5.4 Estimates of Summary Design Effectiveness 3-13

4 TEMPORARY CAPPING 4-1
4.1 EXISTING CONDITIONS 4-1
4.1.1 Area to Be Capped 4-1
4.1.2 Site Surface Features 4-1
4.2 DESIGN OBJECTIVES 4-2
4.3 DESIGN ELEMENTS 4-2
4.3.1 Potentially Erodible Soil 4-3
4.3.2 Asphalt Paving 4-4
4.3.3 Abandoned Railroad Tracks 4-4
4.3.4 Former DDT Manufacturing Building Foundation 4-4
4.3.5 Former DDT Storage Warehouse No. 2 Building Foundation 4-5
4.3.6 Former DDT Storage Area 4-5
4.3.7 Timing of Cap Placement 4-5
5 DECOMMISSIONING OF EXISTING STORMWATER COLLECTION SYSTEM 5-1
5.1 EXISTING CONDITIONS 5-1
5.2 DESIGN OBJECTIVES 5-1
5.3 DESIGN ELEMENTS 5-2
6 STORMWATER CONVEYANCE AND TREATMENT 6-1
6.1 EXISTING CONDITIONS 6-1
6.1.1 Surface Topography 6-1
6.1.2 Existing Stormwater System 6-1
6.2 DESIGN OBJECTIVES 6-1
6.3 HYDROLOGIC ANALYSIS 6-2
6.3.1 Drainage Analysis 6-2
6.3.2 WinTR-55 Runoff Calculations 6-4
6.3.3 Hydraulic Modeling 6-5
6.4 DESIGN ELEMENTS 6-6
6.4.1 Stormwater Channels 6-6
6.4.2 Detention Basin 6-8
6.4.3 Sand Filter 6-10
6.4.4 Discharge 6-11
6.4.5 Berms and Fill Areas 6-12
7 PERMITTING 7-1
7.1 LOCAL 7-1
7.2 STATE 7-2

7.3 FEDERAL....7-2

8 PERFORMANCE MONITORING....8-1

9 SCHEDULE....9-1

10 REFERENCES....10-1

Appendix A. Construction Quality Assurance Plan

Attachment A. Erosion, Sediment, and Pollution Control Plan

Attachment B. Emergency Response and Spill Contingency Plan

Attachment C. Dust Control Plan

Appendix B. Contaminated Material Management Plan

Appendix C. Site Management Plan

Appendix D. Air Monitoring Plan

Appendix E. Operation and Maintenance Plan

Appendix F. Performance Monitoring Plan

Appendix G. Quality Assurance Project Plan

Appendix H. Health and Safety Plan

Appendix I. WinTR-55 Modeling Reports

Appendix J. HydroCAD Modeling Reports

Appendix K. Standard Step Backwater Analysis

Appendix L. SEDCAM Recontamination Modeling Report

Appendix M. Basin Stability Analysis

Appendix N. Draft Design Report Comment and Response Summary

LIST OF FIGURES

Figure 2-1. Site Location

Figure 2-2. Aerial Photograph and Adjacent Properties

Figure 2-3. Site Features

Figure 2-4. DDx Concentrations in Surface Soil (0 ft – Approximately 1 ft bgs)

Figure 2-5. DDx Concentrations in Subsurface Soil (1 ft – Approximately 10 ft bgs)

Figure 2-6. DDx Mass in the Willamette River for Three Stormwater Source Control Measure Options

Figure 2-7. Predicted DDT Surficial Sediment Concentrations, "Best Estimate" Sedimentation Rate

Figure 2-8. Predicted DDE Surficial Sediment Concentrations, "Best Estimate" Sedimentation Rate

Figure 2-9. Predicted DDD Surficial Sediment Concentrations, "Best Estimate" Sedimentation Rate

Figure 2-10. Current Stormwater System

Figure 3-1. Potential Particle Size Distribution Ranges

Figure 4-1. Temporary Capping – Area of Former Acid Plant and Drainage Subbasin for Outfall 002

Figure 4-2. Temporary Capping – Site Surface Features

Figure 4-3. Temporary Capping – Site Construction Plan

Figure 5-1. Decommissioning of Existing Stormwater Collection System – Existing Conditions

Figure 5-2. Decommissioning of Existing Stormwater Collection System

Figure 6-1. Depression Analysis

Figure 6-2. Drainage Catchments

Figure 6-3. Outlet Hydrographs from WinTR-55 Modeling

Figure 6-4. Stormwater Conveyance and Treatment General Layout

Figure 6-5. Detention Basin Outlet Structure

Figure 6-6. 2-Year Detention Basin Outlet Hydrograph

Figure 6-7. 5-Year Detention Basin Outlet Hydrograph

Figure 6-8. 10-Year Detention Basin Outlet Hydrograph
Figure 6-9. 25-Year Detention Basin Outlet Hydrograph
Figure 6-10. 100-Year Detention Basin Outlet Hydrograph
Figure 6-11. Sand Filter Cross Sections
Figure 6-12. 2-Year Sand Filter Outlet Hydrograph
Figure 6-13. 5-Year Sand Filter Outlet Hydrograph
Figure 6-14. 10-Year Sand Filter Outlet Hydrograph
Figure 6-15. 25-Year Sand Filter Outlet Hydrograph
Figure 6-16. 100-Year Sand Filter Outlet Hydrograph
Figure 6-17. 100 Year Flooding Estimate
Figure 6-18. Soil Staging Areas
Figure 9-1. Project Schedule

LIST OF TABLES

Table 1-1. Stormwater Treatment System Effluent Goals

Table 2-1. Comparison of Model-Predicted Fully Mixed Surficial Sediment Concentrations with Portland Harbor Sediment PRGs and RALs

Table 3-1. Estimated Size of Particle Removed by Settling in the Detention Basin

Table 3-2. Sand Filter Sizing, Stormwater Source Control Measures

Table 3-3. Filtration Removal Mechanism, Stormwater Source Control Measures

Table 3-4. Areas of Outfall Drainage Basin and Temporary Capping

Table 3-5. Summary of DDx Concentrations in Suspended Sediment in Stormwater Discharge

Table 3-6. Summary of DDx Concentrations in Sediments Collected from Catch Basin Filter Socks

Table 3-7. Summary of Stormwater Sediment DDx Concentrations Entering and Exiting the Existing Stormwater Conveyance System

Table 3-8. Summary of Detention Pond TSS Removal Performance from BMP Database

Table 3-9. Summary of Media Filter Design Information from BMP Database

Table 3-10. Estimated Required Percent Reduction in Stormwater Concentrations to Meet Effluent Level Goals

Table 3-11. Summary Table of Estimated Design Effectiveness

Table 6-1. Subcatchment Characteristics

Table 6-2. 24-Hour Rainfall Depths at Portland Airport

Table 6-3. Conveyance System Outlet Flow Characteristics from WinTR-55 Model

Table 6-4. Hydraulic Modeling Results

Table 6-5. Design of Surface Channels and Lining

Table 6-6. Design of Channel, Side Slope Analysis

Table 6-7. Specific Detention Basin Design Criteria

Table 6-8. Specific Sand Filter Design Criteria

Table 6-9. Relevant River Stages

Table 8-1. Stormwater Monitoring Requirements

Table 8-2. Performance Monitoring Decision Tree

Table 8-3. Corrective Action Decision Tree

ACRONYMS AND ABBREVIATIONS

bgs	below ground surface
BMP	best management practice
cfs	cubic feet per second
CN	curve number
Consent Order	Order on Consent DEQ No. LOVC-NWR-08-04
COPC	constituent of potential concern
DEA	David Evans and Associates
DEM	digital elevation model
DEQ	Oregon Department of Environmental Quality
ECSI	Environmental Cleanup Site Information
EE/CA	engineering evaluation and cost analysis
EMC	event mean concentration
EPA	U.S. Environmental Protection Agency
FFS	focused feasibility study
FRP	fiberglass reinforced pipe
FS	feasibility study
GIS	geographic information systems
GLISP	Guild's Lake Industrial Sanctuary Plan
JSCS	Joint Source Control Strategy
IRM	interim remedial measure
LF	linear foot
LiDAR	Light Detection and Ranging
LLDPE	linear low-density polyethylene
LSS	Legacy Site Services LLC
MAO	Mutual Agreement and Order No. WQ/I-NWR-10-175
NAVD88	North American Vertical Datum 1988
NGVD	National Geodetic Vertical Datum
NPDES	National Pollution Discharge Elimination System

NRCS	Natural Resources Conservation Service
PRG	preliminary remediation goal
PVC	polyvinyl chloride
RM	river mile
SCM	source control measure
SLV	screening level value
SWC&T	stormwater conveyance and treatment
TSS	total suspended solids

1 INTRODUCTION

On behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc., Integral Consulting Inc. has prepared this *Final Design Report, Stormwater Source Control Measures* (Final Design Report) for the former Arkema Portland Plant (the site) located at 6400 NW Front Avenue, Portland, Oregon. This Final Design Report is prepared pursuant to the Order on Consent requiring source control measures (SCMs) issued by the Oregon Department of Environmental Quality (DEQ) and signed October 31, 2008 (DEQ No. LQVC-NWR-08-04) (Consent Order), and the Mutual Agreement and Order No. WQ/I-NWR-10-175, executed by DEQ and LSS on August 4, 2010 (MAO). The Final Design Report has been completed in accordance with DEQ and other agency comments on the Draft Design Report and subsequent meetings and agreements between LSS and DEQ as documented in the comment and response summary (Appendix N).

The goal of the stormwater SCMs is to eliminate the potential for migration of constituents of potential concern (COPCs) in stormwater to the Willamette River at concentrations greater than values presented in Table 1-1. These values will be used to measure the progress toward these goals, and to identify the need to modify or optimize the system. However, these goals are not stormwater system effluent benchmarks for the purposes of National Pollution Discharge Elimination System (NPDES) permit compliance. These goals also may ultimately not be achievable and, therefore, deemed technically impracticable. Under the latter conditions, LSS will work with DEQ to identify performance requirements that are technically practicable for NPDES permit compliance.

The stormwater SCMs consist of collecting site stormwater, conveying it to a stormwater detention basin, equalizing the storm volume, providing primary solids removal through sedimentation in the basin, and providing second stage treatment through a sand and/or a sand amended with carbon filtration system. Other elements of the stormwater SCMs include temporary capping of selected areas of the site that contain COPCs in exposed surficial soil and decommissioning of a majority of the existing stormwater conveyance piping. These stormwater SCMs are being implemented to control COPCs from site stormwater, to the extent practicable, prior to implementation of the non-time-critical removal action or other Portland Harbor sediment remedial actions. The stormwater SCMs are considered an interim action that are being applied in advance of the sitewide feasibility study and selection of a final site remedy that addresses COPCs in soil, groundwater, and stormwater in the upland portions of the site. Thus, all SCMs implemented as part of this design are considered temporary in nature. The final upland site remedy is anticipated within approximately the next five years.

This report provides the design of the stormwater SCMs. This Final Design Report, which has been prepared in accordance with the MAO, is based on the following documents: *Stormwater Interim Remedial Measures, Focused Feasibility Study Report* (FFS; Integral 2008b), and associated comments received from DEQ and the U.S. Environmental Protection Agency (EPA; McClincy

2008, pers. comm.); a letter dated March 18, 2009, from Todd Slater, LSS, to Matt McClincy, DEQ, regarding the Stormwater FFS, Arkema Portland (Slater 2009, pers. comm.), the *Draft Stormwater Source Control Measure Design & Implementation Plan* (Design Work Plan; Integral 2009); and the *Draft Design Report, Stormwater Source Control Measures* (Draft Design Report; Integral 2010) and subsequent comments and agreements between DEQ and LSS (McClincy 2011, pers. comm.; McClincy and Burkhart 2011, pers. comm.; Slater 2011a,b,c, pers. comm.).

1.1 DESIGN REPORT OBJECTIVES

The objectives of this Final Design Report are as follows:

- Present background information, including a summary of the site physical setting, land use, and existing stormwater drainage system information, that provides a general understanding of the site setting
- Provide the basis for the design of the stormwater SCMs, and provide the design for the three major components of the stormwater SCMs, including 1) the design for temporary caps that will be placed in selected portions of the site; 2) the design for the decommissioning of the existing stormwater collection system; and 3) the design for the new stormwater conveyance and treatment (SWC&T) system
- Provide a summary of the permit requirements for the stormwater SCMs
- Provide a summary of the performance monitoring requirements and criteria for the stormwater SCMs
- Provide a schedule for agency review of the stormwater SCMs design, construction, and operation and maintenance
- Provide a summary of comments and responses on the Draft Design Report and documentation of the final agreements and resolution of comments with respect to agency comments on the Draft Design Report.

1.2 SELECTED SOURCE CONTROL MEASURES

Per the August 4, 2010, MAO, the selected SCMs include the following elements:

1. Erosion control measures of capping portions of the drainage basins that discharge to Outfalls 001 and 002, which historically have had the highest surface soil concentrations of COPCs, to prevent the potential migration of COPCs in this soil to the river via the stormwater drainage system.

2. Eliminating the potential for migration of COPCs in the existing stormwater collection system by decommissioning this system.

3. Rerouting stormwater via a new surface conveyance system and treating stormwater runoff from the site using detention and filtration. Discharge of the treated stormwater through an existing outfall equipped with a diffuser (Outfall 004).

The stormwater SCMs described in this report are being administered and implemented in accordance with the MAO. The goal of the stormwater SCMs for this site is to eliminate the potential for migration of COPCs in stormwater to the Willamette River at concentrations greater than values presented in Table 1-1 by implementing best management practices (BMPs), including erosion control and decommissioning the existing stormwater collection system, and structural treatment BMPs, including detention basin and filtration. Because this stormwater treatment system is being implemented in accordance with the MAO, and in conjunction with the facility's existing NPDES permit, new or revised numerical discharge limits are not part of the design basis for these SCMs; however, LSS has agreed to conduct performance monitoring of the SCMs and use an adaptive management approach to optimize performance of the stormwater treatment, based on comparisons of effluent levels to values presented in Table 1-1.

1.3 REPORT ORGANIZATION

The remainder of this Final Design Report is organized as follows:

- Section 2 provides background information on the stormwater SCMs, the site physical setting and land use, DDx concentrations in surface and subsurface soil, and the existing stormwater drainage system
- Section 3 provides a basis of the design of the stormwater SCMs
- Section 4 provides details of the design for temporary capping in the vicinity of the former DDT manufacturing and process area
- Section 5 provides details of the design for the decommissioning of the existing sewer collection system
- Section 6 provides details of the design for the SWC&T system
- Section 7 presents a summary of permitting requirements
- Section 8 presents a summary of the performance monitoring plan and requirements
- Section 9 presents a schedule for implementation of the stormwater SCMs
- Section 10 lists references cited in this Final Design Report.
- Appendices A through H provide the construction plans for the implementation of the stormwater SCMs, including:
  - Construction Quality Assurance Plan (Appendix A)

- Contaminated Material Management Plan (Appendix B)
- Site Management Plan (Appendix C)
- Air Monitoring Plan (Appendix D)
- Operation and Maintenance Plan (Appendix E)
- Performance Monitoring Plan (Appendix F)
- Quality Assurance Project Plan (Appendix G)
- Health and Safety Plan (Appendix H)

Appendices I, J, and K provide results of WinTR-55 modeling, HydroCAD modeling, and step back water calculations, respectively. Appendix L presents the results of the SEDCAM recontamination modeling, and Appendix M presents the results of an engineering analysis of basin stability. Appendix N provides a summary of comments and responses on the Draft Design Report and documents the final agreements and resolution of comments with respect to agency comments on the Draft Design Report.

2 BACKGROUND

The Joint Source Control Strategy (JSCS)[1] was developed by DEQ and EPA to identify, evaluate, and control sources of contamination to the Willamette River in a manner that is consistent with the objectives and schedule for the Portland Harbor Superfund cleanup. The goal of the JSCS is to achieve timely upland source control to prevent the risk of significant recontamination after the Portland Harbor cleanup is completed. The JSCS recommends that upland source control be substantially completed to the greatest extent practicable before or during any early removal actions, as well as non-time critical removal actions, in order to reduce the potential for recontamination of river sediment.

Between September 2000 and November 2006, several stormwater interim remedial measures (IRMs), including soil removal, temporary capping, and BMPs, were implemented at the Arkema site to address chemicals in stormwater (Integral 2007). Despite success of those IRMs at reducing concentrations of COPCs in stormwater, DEQ determined that these IRMs were not capable of meeting JSCS source control objectives. DEQ's and EPA's JSCS guidance states that the JSCS values are not to be used as cleanup levels; therefore, LSS did not and does not agree with DEQ's determination that the stormwater IRMs were not achieving the objectives. However, because the planned groundwater SCMs were going to require a substantial modification and rerouting of the existing stormwater system, LSS has agreed to further enhance the stormwater BMPs as outlined in this Final Design Report. LSS subsequently commenced with the preparation of an FFS to evaluate additional stormwater IRMs. The FFS was submitted to DEQ on July 3, 2008 (Integral 2008b), and comments on the FFS were received from DEQ on December 18, 2008 (McClincy 2008, pers. comm.). A response to comments was provided by LSS in a letter dated March 18, 2009 (Slater 2009, pers. comm.). LSS then commenced with preparation of the Design Work Plan, which was submitted to DEQ on October 7, 2009 (Integral 2009). Draft comments were received from DEQ by LSS on December 15, 2009. Subsequent to this submittal, DEQ and LSS entered into the MAO. The MAO was executed on August 4, 2010. The Draft Design Report was submitted to DEQ on December 2, 2010 (Integral 2010). Agency comments were submitted to LSS on February 15, 2011 (McClincy 2011), and a response to the comments was submitted to DEQ and EPA on March 17, 2011 (Slater 2011a). DEQ and LSS representatives participated in a meeting on May 10, 2011 to discuss LSS's response to comments on the Draft Design Report. A final set of agency comments was submitted to LSS on June 16, 2011 (McClincy and Burkhart 2011). LSS and DEQ finalized agreements on the resolution of the comments during two telephone calls between Matt McClincy (DEQ) and Todd Slater (LSS) on June 30 and July 1, 2011 (Slater 2011b and c). This Final Design Report addresses agency comments and is consistent with the agreements between LSS and DEQ.

---

[1] *Portland Harbor Joint Source Control Strategy* prepared by the Oregon Department of Environmental Quality and the United States Environmental Protection Agency (December 2005) (a framework for making upland source control decisions at the Portland Harbor Superfund Site).

2.1 SITE DESCRIPTION

This section of the Final Design Report provides a brief description of the site location and physical characteristics pertinent to the stormwater SCMs design. For additional information on the site, see the FFS (Integral 2008b).

2.1.1 Location and Area Land Use

The site is located along the southwest bank of the Willamette River between approximately River Mile (RM) 6.9 and 7.6 at 6400 NW Front Avenue in Portland, Oregon (Figures 2-1 and 2-2). The property lies within the Guild Lake Industrial Sanctuary Plan (GLISP) (formerly the Northwest Portland Industrial Sanctuary; Integral 2008a). The site is zoned and designated "IH" for heavy industrial use (Portland Development Commission 2004).

The purpose of the GLISP is to maintain and protect this land as a dedicated area for heavy and general industrial uses. Therefore, while future use of the facility is unknown, it will remain zoned as heavy industrial.

The site is bordered to the east by the Willamette River and to the south by CertainTeed Roof Product Manufacturing (GS Roofing Products; DEQ's Environmental Cleanup Site Information [ECSI] database 117; Figure 2-2). The Willbridge Bulk Fuel Storage Terminal (ECSI 1549) and Kinder Morgan (ECSI 2104) sites are located immediately to the south of CertainTeed. Front Avenue borders the site to the north and west. Five cleanup sites are located to the west of Front Avenue, upgradient of the site. The sites include Starlink (Rhône-Poulenc; ECSI 155), Gould Industries (ECSI 49; a National Priorities List "Superfund" site), Doane Lake (ECSI 36), ESCO (ECSI 397), and Kinder Morgan (ECSI 2104; southwest of the site). The Siltronics Inc. site (ECSI 183) is located immediately north of Front Avenue. Additional details on the adjacent properties can be found in DEQ's ECSI database.[2]

Heavy industrial land use surrounds the site, isolating it from parks and residential areas. The nearest residential structures are located approximately 0.3 mile west of the facility. Forest Park, a large forested public park, is located 0.5 mile to the west of the facility (ERM 2005).

2.1.2 Physical Characteristics

The site occupies approximately 54 acres with surface elevations between 20 and 42 ft (North American Vertical Datum [NAVD] 1988; Figure 2-3). An approximately 20-ft bluff borders the eastern side of the property, forming the west bank of the Willamette River (Tract "A"). Above the bank, site surface elevations are generally flat and range between 34 and 42 ft NAVD 88. The portion of the site above the bank (uplands) is composed of four lots (Figure 2-3). Lots 3 and 4 comprise approximately 40 acres and are the part of the site where chemical

[2] http://www.deq.state.or.us/lq/ecsi/ecsiquery.asp

manufacturing and processing occurred (refer to Section 2.2 of *Upland Level II Screening Ecological Risk Assessment* [Integral 2008a] for details regarding site operational and ownership history). Buildings have been demolished in Lots 3 and 4 and the ground cover is a mixture of pavement, building foundations, crushed rock, and bare soil. Lots 1 and 2, at the northeast end of the site, are undeveloped. Lots 1 and 2 are covered by a mixture of grasses, bare soil, and scrub-shrub vegetation.

2.1.3 DDx in Soil

DDx is the primary COPC for site stormwater. Figures 2-4 and 2-5 show the DDx concentrations in both surficial soil (approximately 0–1 ft bgs) and subsurface soil (approximately 1–10 ft bgs) from the site remedial investigation and subsequent investigations. Most of the DDx soil investigations have focused on the area of the former DDT manufacturing operations in the Acid Plant area. Additional soil samples have been collected from around the perimeter of the Acid Plant area and in other parts of the site, including Lots 1 and 2, and the riverbank. Note that these figures do not include any of the extensive sampling and DDx analysis of Willamette River sediments for the in-water engineering evaluation and cost analysis (EE/CA) investigation as these data do not relate to or affect stormwater quality.

As expected, most of the DDx concentrations in soil are found in the area between the former DDT manufacturing building and the former warehouse where DDT was packaged for shipment (former Warehouse No. 2). The focus of interim remedial measures conducted in 2000 and 2001 was removal of soil in some of these DDx areas (Figures 2-4 and 2-5). Some areas of DDx impacted soil are still present in the Acid Plant area; however, most of this soil is under existing pavement, concrete foundations, or temporary caps. Areas where surficial soil is not presently covered or contained will be the focus of temporary capping measures as described later in the Final Design Report.

2.1.4 DDx in Stormwater and Previous Interim Remedial Measures

Stormwater sampling for DDx for the remedial investigation and subsequent stormwater interim remedial measures was initiated in 1999. Between 1999 and 2005, 55 stormwater samples were collected from 2 manholes and 4 outfalls to evaluate stormwater quality across the site (Integral 2008b). During this period, 2 phases of soil IRMs were conducted within the Acid Plant area (i.e., where former DDT manufacturing was conducted), including the removal of more than 4,700 tons of soil and the temporary capping of selected unpaved soil. After soil IRMs were completed, DDx concentrations were substantially reduced, from 2 to 35 times lower than pre-IRM stormwater concentrations (ERM 2005). In the temporary cap placement area, DDx stormwater concentrations were reduced by more than 90 percent.

In 2005, stormwater sampling was expanded to include 3 to 5 upstream manhole samples in each outfall sewer drain system. DDx was detected in all of the manhole stormwater samples;

however, some of the stormwater samples were visibly turbid. The range of total DDx concentrations within each sewer system was (Arkema 2005):

- No. 1 sewer system (0.051 to 1.6 μg/L)
- No. 2 sewer system (0.47 to 4.9 μg/L)
- No. 3 sewer system (0.089 to 0.25 μg/L)
- No. 4 sewer system (0.063 to 1.9 μg/L).

From 2006 to 2007, LSS completed additional improvements to existing BMPs, including catch basin inspection and cleaning, and filter sock and biobag installation. LSS conducted additional stormwater sampling to monitor BMP improvements. Post-BMP DDx stormwater concentrations did not achieve reductions below those that had been obtained previously through soil IRMs and BMPs. Stormwater sample results showed that total DDx concentrations were approximately an order of magnitude higher than dissolved concentrations, indicating that DDx is primarily transported in the particulate phase associated with fine-grained sediment within the stormwater conveyance system (Integral 2008b).

For the FFS, LSS calculated the stormwater load of DDx from Outfalls 001 through 004 versus the load of DDx that is transported in the Willamette River from legacy upstream DDT sources, including agricultural, forest, and upstream urban sources. Based on these calculations, approximately 0.0572 lb (less than 1 oz) of DDx discharges to the river in a year from the site stormwater system, with most of the DDx mass from Outfall 001 because of the larger volume of stormwater discharge from this outfall subbasin. DDx loading from the Willamette River upstream of the site was based on DDx concentration and river discharge data from eight Willamette River water sampling events conducted by the Lower Willamette Group at river mile 11 (approximately four miles upstream of the site) (Integral 2008b). Even after excluding the highest river flow (169,000 cubic feet per second [cfs]), which would have increased the estimated Willamette River DDx load substantially, the average annual Willamette River DDx base load is at least 13.4 lb/year. Consequently, the annual DDx flux in stormwater from the site is minimal in comparison (approximately 1 oz on average versus at least 13.4 lb on average) of the annual base load of DDx in the Willamette River immediately upstream of the site. Given the comparatively low mass contribution of DDT from the site, even if substantial DDT removal is obtained from the implementation of the stormwater SCMs described in this Final Design Report, the lower Willamette River would still be carrying a large DDT load, and would be water quality limited, as a result of the majority of upstream sources that are still not controlled (Figure 2-6). Any additional or follow on SCM enhancements must take this fact into consideration. Current Willamette River sediment DDx transport conditions and recontamination potential are discussed in Section 2.1.5.

2.1.5 Recontamination Assessment

A screening level analysis was performed to evaluate the potential for recontamination of the nearshore sediments by site stormwater discharges following the implementation of the new stormwater SCMs. The stormwater SCMs design reduces COPC concentrations prior to discharge and routes discharge to the downstream edge of the proposed early action area. The stormwater SCMs are expected to minimize sediment recontamination to levels that meet or are below Portland Harbor remedial action levels (RALs) or preliminary remediation goals (PRGs). The screening level analysis was performed to support this premise.

Note that the use of draft Portland Harbor PRGs and RALs as comparison values in this recontamination analysis does not denote LSS' endorsement of these values. LSS use of these values is only intended for perspective, to relate this recontamination analysis to the harbor-wide remedial actions that are being evaluated as part of the Portland Harbor Feasibility Study.

A mathematical mass balance model, SEDCAM (Jacobs et al. 1988), was applied to evaluate potential recontamination. SEDCAM predicts surficial sediment contaminant concentrations over time. The model assumes that the source inputs of sediments are fully mixed within the surficial layer over the area of potential recontamination. Model inputs include sediment concentrations of incoming (upstream) sediments, sediment load and concentration in the stormwater discharge from the site, initial surficial sediment concentration over the area of potential recontamination, and sedimentation rate. Model input parameters were developed from available site data. Where parameters were uncertain, a range of values were evaluated to provide a bounding estimate of potential sediment concentrations. Details of the model assumptions and input parameters are provided in Appendix L.

The model was designed to evaluate DDD, DDE, and DDT, the primary COPCs in the stormwater discharging from the site. The stormwater SCM will discharge treated stormwater, with target concentrations as described below in Section 3. The recontamination analysis evaluated both the target concentrations as well as the existing previously measured stormwater concentrations at Outfalls 001 through 004. The latter analysis provides a prediction of potential recontamination, assuming no treatment of the discharged stormwater, to provide a "no-action" baseline scenario.

Model predicted surficial sediment concentrations within the estimated depositional area were calculated for DDT (Figure 2-7), DDE (Figure 2-8), and DDD (Figure 2-9). Predictions are presented as a function of time, where the initial surficial sediment concentration in the depositional area is assumed to be zero at time=0. For each isomer, model predicted concentrations were calculated for the existing and the goal stormwater ("SW") concentrations and for the estimated high, low, and "best estimate" net sedimentation rates. The diffuser on Outfall 004 will also diffuse the solids. Therefore, even these estimated high, low, and "best estimate" net sedimentation rates are unrealistically biased high. The conservative high and

low net sedimentation rates provide bounds on the expected results, and the "best estimate" rate, which falls in between these values, is presented in Figures 2-7 through 2-9. Also included on the figures are the predicted surficial sediment concentrations in the depositional area without the contribution of the site stormwater load ("no SW"). These values represent the predicted recontamination due to the upstream loads only. The predicted surficial sediment concentrations in the depositional area without the contribution of the Willamette upriver load ("Target SW Concentration, Zero Upstream Concentration") are also shown on the figures. The latter values represent the predicted recontamination due to the stormwater load only.

Model predictions were compared to the Portland Harbor sediment RALs and PRGs currently being used for feasibility study evaluations. The RALs and PRGs and the fully mixed predicted surficial sediment concentrations are summarized in Table 2-1. All of the predicted surficial sediment concentrations, with the exception of DDE at the existing stormwater concentrations and the draft "Alternative F" RAL, meet or are below the draft LWG RALs and all are below the draft PRGs. The screening level analysis provides predictions of sediment recontamination resulting from stormwater discharge from the site. The model predictions indicate that the stormwater load (both existing and treated) contributes to potential recontamination of fully remediated surficial sediments. However, the predicted sediment concentrations meet or are below the draft LWG RALs, with the exception of one scenario, DDE in existing stormwater. The model predictions show that stormwater load under current conditions already meets Portland Harbor PRGs. It is also important to note that the recontamination analysis show that the greatest potential for recontamination is due to deposition from upstream. These results suggest that any recontamination of sediments that may result from site stormwater discharge will not cause any additional remediation activities or result in unacceptable risk. This screening level analysis incorporated many conservative assumptions that likely result in higher predicted recontamination from site stormwater discharge than will actually be observed.

2.1.6 Stormwater Drainage

The layout of the existing stormwater sewer system is shown in Figure 2-10. Much of the existing stormwater sewer system on the site has been in place since the mid-1950s and was primarily designed to carry very large volumes (35.54 cfs[3]) of industrial noncontact cooling water and secondarily to handle stormwater drainage. The stormwater sewer system was also designed to drain building basements and process sumps and, therefore, is up to 12 ft below ground surface (bgs) in certain locations (Integral 2008a). Stormwater at the site is currently discharged under a NPDES permit (#100752).

The stormwater collection system for Lots 3 and 4 previously had been divided into four smaller drainage subbasins based on site topography before building demolition (Figure 2-10).

[3] Pennwalt Corporation Design Drawings as received from LSS.

Figure 2-10 presents an evaluation of existing stormwater drainage at the site. The existing stormwater collection in each of the four previously defined drainage subbasins is connected to a separate large concrete Parshall flume and discharge pipe (identified as Outfalls 001 through 004) located on the riverbank (ERM 2005). As shown in Figure 2-10, the Parshall flumes for Outfalls 001 and 002 are located between the southernmost dock (Salt Dock) and the northernmost dock (No. 2 Dock). Outfall 003 is located immediately north of No. 2 Dock, and Outfall 004 is located approximately 400 ft north of the No. 2 Dock. Discharge pipes and diffusers extend out into the river from each Parshall flume (ERM 2005). Parshall flumes were historically used to measure process water discharge flow rates. However, because the existing stormwater discharge is a small fraction of the historic cooling and process[4] water discharge, the Parshall flumes are currently oversized and cannot be used to adequately measure stormwater flow.

Stormwater from Lots 3 and 4 that does not infiltrate, enters the site stormwater system and is discharged through the four outfalls under NPDES permit No. 100752. No cooling or process water has been discharged from the site since the plant closed in 2001. Stormwater drainage from portions of the site outside of the drainage basins for Outfalls 001, 002, 003, and 004 either ponds or infiltrates on site (i.e., large portions of Lots 1 and 2), flows overland from Lots 1 and 2 to Outfall 004, or during some heavy rainfall events flows overland and discharges as a non-point source to the Willamette River.

[4] The majority of the water historically discharged through the existing system was cooling water with a small amount of process water.

3 BASIS OF DESIGN

As stated in Section 1, the goal of the stormwater SCMs is to eliminate the potential for migration of COPCs in stormwater to the Willamette River at concentrations greater than the goals presented in Table 1-1. Because of a variety of site-specific factors, it is difficult to accurately predict stormwater quality from one storm event to another and the degree to which the proposed treatment system will be able to achieve these low effluent concentration goals. Furthermore, extensive literature reviews of available technologies for treating stormwater at similar sites have not identified any proven, effective, implementable technology that will ensure the removal rates over the range of stormwater flow conditions to achieve Table 1-1 effluent concentration goals. To address these uncertainties to the extent technically practicable, an adaptive management approach to the stormwater system will be implemented. This approach consists of immediate implementation of a full-scale system as defined within the MAO, monitoring the performance of the system, and adapting the system, as necessary, to achieve the goals of the SCMs to the extent technically practicable.

The SCMs design includes two source control elements: 1) temporary capping to isolate potentially erodible soil with DDx concentrations from stormwater runoff and 2) decommissioning of the existing stormwater collection system to remove potentially accumulated sediment discharges from stormwater. Stormwater runoff from uncapped areas of the site will be treated via settling and filtration prior to discharge to remove suspended particulates and associated DDx and other COPCs. The ability to achieve the effluent treatment goals will depend, in large part, on the effectiveness of SCMs to eliminate sources of COPCs to the stormwater runoff. These SCMs will, in turn, affect the nature (both chemical nature and physical nature) of the stormwater quality that will be treated by the planned treatment measures (equalization, settling, and filtration) and, therefore, the effectiveness of these treatment measures are difficult to predict at this time. However, the best estimated removal effectiveness of the overall SCMs as designed exceeds the estimated 95th percentile removal efficiency required to achieve the treatment effluent goals based on existing stormwater discharge concentrations (Section 3.5.4).

The remainder of this section of the Design Report discusses the basis of the design for the full-scale system. The following subsections discuss the initial design parameters and also the variables and uncertainties associated with the design of the SCMs. Assumptions made to complete the SCMs design are also presented. Finally, the rationale for the sizing of each system component is presented followed by an initial estimate of the performance of each SCMs design element.

3.1 DESIGN PARAMETERS AND CONSTRAINTS

During the development of the MAO, and preceding documents from which the MAO was based, several design parameters were discussed and agreed to by LSS and DEQ. Some of these design parameters were subsequently modified as a result of comments, discussion, and agreements made after submittal of the Draft Design Report (McClincy 2011, pers. comm.; McClincy and Burkhart 2011, pers. comm.; Slater 2011a,b,c, pers. comm.). The currently agreed upon parameters include the following:

- The treatment design storm for the conveyance and treatment system will be the 25-year, 24-hour storm (3.9 in. of water over a 24-hour period). The stormwater system will convey and treat storms of this magnitude or smaller.
- Hydraulically, the system should back up larger storm events onto the site and allow site infiltration as long as two criteria are met:
  - Infiltration caused by backing up water in excess of the design capacity is limited to the extent practicable to areas behind the proposed groundwater barrier wall and extraction system such that it is contained and treated on site.
  - No runoff to adjacent property occurs.
- The conveyance and treatment system will limit, to the extent practicable, any attractive nuisance to wildlife at the site. This includes limiting any new vegetative areas (i.e., conveyance channels to be rock-lined instead of grassy swales) and limiting any permanent standing water, to the extent practicable.
- The stormwater SCMs will consist of the following components:
  - Capping portions of the drainage basins that have concentrations of COPCs in potentially erodible surface soil as an erosion control measure.
  - Decommissioning the existing stormwater collection system to eliminate the potential for migration of COPCs.
  - Rerouting stormwater via a new surface conveyance system and treating stormwater runoff from the site using detention and filtration.

Physical features of the site present several constraints to the design. These include the following:

- The site provides very limited relief to allow for gravity conveyance of stormwater. Decommissioning of pipelines to Outfalls 001, 002, and 003 require gravity drainage to Outfall 004.

- Willamette River flood levels can rise to within a few feet of the site surface, further limiting the ability to convey stormwater via gravity flow.
- The area available for siting stormwater conveyance and treatment components at the site is limited because of existing concrete caps that were left during demolition.

3.2 VARIABLES AND UNCERTAINTIES

Storm intensity, magnitude, duration, and frequency are significant factors affecting the variability of stormwater quality. Stormwater runoff velocities, as influenced by storm intensity and magnitude, will affect the amount and size of particulates entrained in stormwater runoff. Antecedent dry conditions (i.e., duration since last storm event) can also affect both the amount and the size of particulates entrained within stormwater runoff. The variability of COPC concentrations can be further influenced, showing even greater variability, as individual COPCs may be preferentially associated with a specific particle size range entrained within the runoff.

In addition to the storm- and site-related variables that will effect COPC concentrations, as described above, several improvements will be completed at the site prior to and during the implementation of the stormwater SCMs. These improvements should substantially improve stormwater quality at the site compared to existing conditions. Site improvements include the following:

- Temporary capping will change both the chemical composition of the runoff from the capped areas (i.e., reduce COPCs in stormwater) and the nature of suspended sediment in stormwater (i.e., particle size distribution).
- Regrading of several areas of the site will facilitate stormwater flow, including areas around the former salt pads, immediately adjacent to new treatment facilities, and near the installation of the stormwater conveyance channels and berms around the site, and will affect stormwater runoff flow rates and suspended sediment. There are several areas that will be capped after filling activities, thus reducing the potential for COPC loading to stormwater.
- Decommissioning of the existing stormwater collection system will eliminate the transport of historic sediment containing COPCs that has potentially accumulated in stormwater pipelines that are significantly oversized for conveying stormwater because they were primarily designed to carry large volumes of non-contact cooling water that no longer exists.
- Other site improvements (e.g., the installation of the groundwater SCMs, a groundwater barrier wall, and groundwater extraction and treatment system) will temporarily disturb some areas of the site, but will ultimately provide additional regrading and capping of those areas of the site.

The performance of these SCMs is expected to substantially improve stormwater quality conditions. The degree to which each of the improvements will contribute to achieving the Table 1-1 goals is uncertain and, therefore, will require monitoring as addressed in Section 7.

3.3 DESIGN ASSUMPTIONS

Several assumptions about the nature of the stormwater quality were made to develop the SCMs design. General stormwater influent particle size distribution was assumed to be similar to that of typical urban stormwater runoff. Site-specific assumptions that were made to facilitate the design include:

- SCMs will focus upon reductions of the primary site COPCs, DDT, DDD, and DDE (DDx). It is anticipated that SCMs for DDx will also address the other COPCs as they are, in general, insoluble and will be removed as suspended solids are removed. COPCs will be monitored and addressed during performance monitoring and adaptive management, as needed.

- Reductions in suspended solid loading were used as a surrogate for reductions in DDx concentrations for design of the stormwater treatment system. This methodology is consistent with the assumptions used by DEQ for addressing DDx in stormwater discharges at other locations within the Willamette River basin (e.g., Johnson Creek TMDL Study). During the adaptive management process, total and dissolved phase COPC concentrations will be measured, if necessary, to assess the nature of the COPC concentrations in stormwater, and to implement appropriate adaptive management measures.

3.4 RATIONALE FOR SYSTEM ELEMENT DESIGN

Standard sizing techniques were used as the basis for the stormwater treatment system design. Additional information on the specific design basis for the sizing of each element of the SCMs is presented in the following sections.

3.4.1 Decommissioning of the Existing System

Decommissioning of the existing stormwater collection system is required for installation of groundwater source control measures to be completed. With one exception, stormwater flow through the existing stormwater conveyance system will be eliminated. The component of the existing system that is connected to Outfall 004 (i.e., the piping and first manhole hydraulically upgradient of the Parshall flume connected to Outfall 004) will be maintained and used as a combined outfall for stormwater discharges from the new SCMs and for treated groundwater.

Section 5 has a complete discussion of the decommissioning of the existing stormwater collection system.

3.4.2 Temporary Capping

Surficial soil concentrations of DDx have been found in the Acid Plant area, where DDT manufacturing occurred historically (Figure 2-4). The DDx soil concentrations in this area have likely led to observed concentrations of DDx in catch basin sediments and stormwater discharges. The Acid Plant area is located within the drainage basin for Outfall 002, where the highest DDx concentrations have been measured in the stormwater discharge (Integral 2008b). Because DDT manufacturing occurred in this area, erodible soil in this area is a potential source of DDx to the stormwater conveyance system on Lots 3 and 4**.** This soil is transported by overland flow and to a lesser degree by wind to the catch basin capture zones. Erodible soil in the former Acid Plant area would be expected to have the highest potential of DDx relative to other outfall subbasins. This erodible soil is considered to be the primary potential source of DDx to stormwater (Integral 2008b). Therefore, the former Acid Plant area will be the focus of the installation of temporary capping for the design of the stormwater SCMs, which is expected to eliminate stormwater contact with this potential source.

3.4.3 Detention Basin

The main focus of the detention basin design is to equalize stormwater flow to control flow rates to the sand filter. The basis of the detention basin design is to maintain flow to the surface of the sand filter between 1 cfs for the 2-year design storm and 3 cfs for the 25-year design storm. Controlling flow at the surface of the sand filter between these rates provides for a minimal size of sand filter while also controlling the approach velocity to the sand filter during the 2-yr storm and not exceeding the maximum storage head requirements above the sand filter for the 25-yr storm (see Section 3.4.4). In addition, providing adequate storage to maintain sand filter flow rates to less than 3 cfs allows for other reasonable active treatment processes to be implemented, if determined necessary, during the adaptive management phase of the project.

Concurrent with controlling flow rates to the sand filter, the detention basin also provides for enhanced settling. Suspensions of solids in stormwater typically have three overlapping components based on particle size: coarse materials that settle out quickly (>50 μm) by discrete settling, intermediate size silt that tends to naturally flocculate while undergoing discrete settling (5 to 50 μm), and very small clay particles (<5 μm) that neither settle easily nor flocculate quickly as they are colloidal, negatively charged, and resist coagulation (Minton 2005).

Because of the highly variable nature of particulates in stormwater discharges due to the range of storms that will be treated, as well as the positive effect that site improvements will have on stormwater quality (see Section 3.2), the effectiveness of the detention basin could not be

estimated using settling theory (see Section 3.5). However, preliminary effectiveness of the detention basin for discrete settling (not considering potential enhancements due to flocculating particles) can be calculated using Stoke's Law:

$$\text{Stoke's Law: } V_s = gd^2(\rho_s - \rho_l)/18\mu$$

Where:

V_s = particle settling velocity
g = acceleration due to gravity (32 ft/sec^2)
d = diameter or particle (assumed spherical)
ρ_s = density of solid, 165 lb/ft^3
ρ_l = density of liquid, 62.47 lb/ft^3
μ = viscosity of liquid, 8.8 x 10-4 lb/ft-sec for water at 50°F.

Estimated particle size removal using settling velocities for the 2-year, 5-year, 10-year, and 25-year design storms are provided in Table 3-1. Discharge rates from the detention basin were determined by hydraulic modeling using HydroCAD® v. 9.1 (Section 6.3.3) and the size of the basin (150 ft x 300 ft at the bottom of the basin) was determined from the iterative approach to detention basin and sand filter sizing described in Section 3.4.4.

An anticipated range of particle-size distributions can be estimated from 1) evaluating data from other urban sites, 2) evaluating data from the site for sediments collected in catch basin filter socks and within the bottom of the catch basins collected during 2006-2007 sampling (Integral 2007), and 3) evaluating February and April 2010 particle-size distribution data for stormwater discharges from the existing collection system. As expected, particle-size distribution from typical urban sites fall between the current stormwater discharge particle-size distribution and particle-size distributions analyzed from the catch basin and filter sock solids (Figure 3-1). It is anticipated that stormwater particle size distribution in detention basin influent will vary substantially from the particle size distribution of stormwater currently discharging from the site because of changes to the physical setting after SCM implementation (see Section 3.2). It is further expected that loading (or flux) of COPCs to the influent of the detention base will decrease due to site improvements.

Comparing particle sizes anticipated to be removed by the detention basin (Table 3-1) with a particle-size distribution from a typical urban site (Figure 3-1) results in between a 50 to 60 percent removal expectation by the detention basin. This removal rate will be enhanced by flocculation of particles between 5 and 50 μm as well as the longer detention times of the frequent storms that are smaller than the 2-year storm. Given this enhanced settling and that stormwater particle sizes will most likely vary significantly by storm event, anticipated performance of the detention basin was estimated using empirical data from other sites (see Section 3.5).

3.4.4 Sand Filter

The basis of the sand filter design was the use of standard stormwater sizing techniques (City of Austin 1988; King County 2005; Claytor and Schueler 1996). Sizing of sand filters was initially based upon filtration of the 2-year, 24-hour storm (the 2-year, 24-hour storm event is 2.4 in. over 24 hours and a Natural Resources Conservation Service [NRCS] Type 1A rainfall distribution) and was determined based on the principles of Darcy's law, which is commonly used in sand filter design (City of Austin 1988; King County 2005; Claytor and Schueler 1996):

$$\text{Darcy's Law: } Q = KiA_f, \text{ or } A_f = Q/Ki$$

Where:

A_f = surface area of the sand filter (ft^2)
Q = flow through the sand filter
K = hydraulic conductivity of filter media
i = hydraulic gradient in ft/ft, = $(h_f + d_f)/d_f$, where:
h_f = head above the sand filter
d_f = depth of sand filter

City of Portland (2008) criteria for minimum sand filter bed depth (18 in.), L:W ratio (2:1), and filter media gradation were originally used in sizing of the sand filter. The filter media gradation required by the City of Portland is:

Sieve Size	Percent Passing
3/8"	100
#4	95–100
#8	80–100
#16	45–85
#30	15–60
#50	3–15
#100	<4

While initial hydraulic conductivities of this sand will be large (>10 ft/day), a hydraulic conductivity of a "conditioned" sand filter with adequate settling of 3.5 ft/day was used for initial sizing determinations (Claytor and Schueler 1996). Conditioning of sand occurs during the filtration process as smaller particles will settle on the surface and within the sand filter (see discussion below). This process will effectively reduce the hydraulic conductivity of the sand media.

The maximum head above the sand filter was set to 1.5 ft for initial 2-year design storm calculations. While the City of Portland does not specify a maximum head above the sand filter, other municipalities (King County 2005) set a maximum head above the sand filter of 6 ft. This maximum head will determine velocities through the sand filter, and setting a maximum depth assures velocities will stay within a range that will effectively filter stormwater. Setting the maximum head at 1.5 ft for the 2-year storm allows for additional head above the sand filter to pass the flow from larger storm events through the filter without significantly affecting treatment. The maximum head for the 25-year storm was set at the design criteria of 6 ft.

Initial flow rates to the filter for the 2-year and 25-year storms were determined using an iterative approach. Combinations of detention basin and the sand filter sizes were modeled (Section 6.3.3) to determine the most effective size of both the treatment components to minimize the size of the sand filter and also so that one basin would not be over-sized in comparison to the other. This approach resulted in a 1.0 cfs flow rate to the surface of the sand filter for the 2-year storm, a 3.0 cfs flow rate for the 25-year storm, and approximately 2:1 ratio for the size of the detention basin as compared to the sand filter. This methodology resulted in a sand filter of 80 ft x 160 ft to effectively filter stormwater runoff from up to the 25-year, 24-hour storm event. The low surface loading rate will enhance settling of smaller particles at the surface of the filter as discussed below. Table 3-2 presents the results of the sand filter sizing.

Particulates will be removed from stormwater by several mechanisms during the filtration process. The significance of each mechanism is related to the size of the particulates within the stormwater (Table 3-3). Straining is the process by which a particle is removed by lodging within a space smaller than the particle. For clean sand media, particles larger than approximately 50 μm are removed by this mechanism. Particulates with settling velocities greater than the approach velocity of the water to the surface of the sand filter will settle on the surface of the sand filter. This process will be a dominant removal mechanism during the smaller and more frequent storms (i.e., <2 year, 24 hour storm) where particles as small as 5 μm may settle on top of the media. As space between media filtration solids is reduced due to the accumulation material on the surface of the sand filter (i.e., conditioning of the sand filter), smaller particles are mechanically strained.

Particulates in the range of 1 μm to 5 μm are the most difficult to remove by filtration. Straining and sedimentation are less effective due to the small size of the particles but they are too large for electrochemical mechanisms (i.e., removal by electrostatic forces) to be effective. For particles less than a few microns, the removal efficiency increases as particles size decreases. As the particle size decreases the electrostatic/chemical forces become stronger because of the large surface area relative to particle diameter.

Because of the unknown effects site improvements will have on stormwater quality, the effectiveness of the sand filter could not be estimated using settling theory (see Section 3.5).

However, sand filter performance is typically modeled using the standard model for slow sand filtration (Iwasaki 1937):

$$C/C_o = e^{-\lambda L}$$

Where:

C = suspended solids in the filter effluent
C_o = suspended solids in the filter influent
λ = filter coefficient (1/feet)
L = filter media thickness

Several researchers have developed equations for calculating the filter coefficient based on several factors, including: amount of solids accumulated at the surface of the sand filter, media particle size, suspended solid particle size, and filtration rate (Boyd and Ghosh 1974; Fitzpatrick and Spielman 1973; Ives and Sholji 1965). However, all of these equations rely on empirically determined coefficients for calculation of the filtration coefficient. Therefore, modeling of the sand filter performance was not attempted. Design element performance of the sand filter was estimated from empirical data obtained from similar sites (see Section 3.5).

3.5 Anticipated Design Element Performance

Current loads of DDx in stormwater runoff are derived from contact of stormwater runoff with site surface soil and from the mobilization of impacted sediment potentially entrained within the existing stormwater conveyance system. The SCMs design includes two source control elements: 1) temporary capping to isolate soil with elevated DDx concentrations from rainfall/stormwater runoff and 2) decommissioning of the existing stormwater collection system. Stormwater runoff from uncapped areas of the site will be treated via settling and filtration prior to discharge to remove suspended particulate and associated DDx. This section presents an estimate of the treatment performance of these various design elements.

3.5.1 Temporary Capping

Capping will reduce the load of DDx in stormwater by isolating concentration in soil from stormwater runoff. The SCMs includes the placement of a temporary soil cap in the Acid Plant area where DDx concentrations in soil are known to be the highest. This temporary soil cap will cover approximately 3.76 acres of the 32.12-acre area that is presently uncapped at the Site. The temporary cap will provide 100% coverage of the remaining portions of the drainage basin for Outfall 002 which are not currently capped, 9% of the drainage basin for Outfall 003, and 7% of the drainage basin for Outfall 001 (Section 4.0, Table 3-4). In addition, 21% of the surface soil in

the drainage basin for Outfall 004 will be covered by the detention basin and sand filter, preventing contact of runoff with soil in these areas.

The cap is expected to eliminate the current DDx loading to runoff associated with the drainage basin of Outfall 002, the majority of which is already covered with asphalt or concrete. If it is assumed that soil DDx concentrations are evenly distributed across the drainage basins to Outfalls 001, 003, and 004, capping is expected to result in a reduction in the load of DDx to runoff that is directly proportional to the area of the cap (7%, 9%, and 21%, respectively). This assumption is conservative for drainage basins 001 and 003, as the cap will isolate the Acid Plant soil in these areas where DDx concentrations (and thus DDx loads to surface water) are expected to be highest. The sitewide reduction in DDx loading to stormwater runoff by capping can be estimated by weighting the relative areas to be capped in each drainage basin by the percentage of the total site drainage area that the individual drainage area represents. These calculations indicate that capping will result in a reduction in DDx loads to stormwater of approximately 15% (Table 3-4).

3.5.2 Decommissioning of Existing Stormwater Collection System

Available monitoring data indicate that mobilization of sediments entrained in the existing stormwater collection system by storm flows represents a potential source of DDx to stormwater discharge. As a result, decommissioning of the stormwater collection system is expected to substantially reduce DDx discharges from the site. Assuming there is no net change in stormwater flow rates entering and exiting the stormwater collection system, the DDx load from the system to stormwater can be estimated based on the difference in DDx concentration in suspended solids entering and exiting the system. Sediment concentrations in the discharge from the stormwater collection system were estimated from the concentrations of DDx and total suspended solids (TSS) measured at each outfall (Table 3-5). As no direct measurements of DDx and TSS concentrations in the stormwater entering the collection system are available, sediment concentrations in stormwater influent to the system were estimated from DDx concentrations measured in sediments collected from the catch basin filter socks. Particle size analyses show, as expected, that the filter sock sediments have a greater coarse-sized fraction than the suspended sediments in the stormwater discharge. To account for this, the DDx concentrations in the catch basin filter sock sediments were normalized to fines content to provide a better approximation to the sediment class that would be observed in a TSS sample, such as those collected at the outfalls. Fines-normalized sediment concentrations were calculated as:

$$DDx_{Fines-normalized} = \frac{DDx_{dry\ weight}}{\frac{(clays + silts)}{100}}$$

where DDx concentrations are in units of μg/kg, and clays and silts are in units of percent. Table 3-6 provides a summary of the measured fines-normalized DDx concentrations in catch basin filter sock sediments. It is likely that this calculation does not fully represent the concentration of DDx entering the collection system because the coarser fraction of sediment particles that is more prominent in the filter sock sediments would tend to have lower DDx concentrations per unit mass than the fine fraction sediments.

Comparison of the estimated DDx concentrations entering the conveyance system to the DDx concentration exiting the system suggests that loading from the conveyance system has the potential to be the primary source of DDx in the current stormwater discharge (Table 3-7). Calculations suggest that DDx loads from the stormwater conveyance have the potential to represent up to 97 percent of the total DDx in the outfall discharge—suggesting that decommissioning of the stormwater conveyance system is likely to result in a substantive reduction in DDx concentrations in site stormwater discharge. As noted above, this estimate is likely an overestimate of the actual contribution of the DDx load from the existing stormwater conveyance system. For the purposes of estimating the reduction in DDx loading by this SCM, it was assumed that the decommissioning would result in a 50% reduction in DDx loads, and an assumed minimum and maximum load reduction of 25% and 90%, respectively.

3.5.3 Stormwater Conveyance and Treatment

The SCM conveyance and treatment includes three primary elements: 1) stormwater conveyance channels, 2) a stormwater detention/settling basin, and 3) a sand treatment filter. Each of these elements will retain suspended solids in stormwater derived from the site and thereby reduce the concentrations of suspended solids and associated DDx in site stormwater discharge.

As discussed in Section 3.2, the concentration of COPCs in stormwater that will enter the conveyance and treatment system is currently unknown, but the loading is expected to be significantly lower than present conditions. Therefore, it is not possible to confidently predict the SCMs treatment performance based on theoretical calculations (e.g., settling velocities, filtration theory). As such, the estimates of treatment performance are based on a review of performance data for similar systems provided in the International Stormwater Best Management Practices Database (http://www.bmpdatabase.org/). The BMP database is a compilation of performance data for over 400 studies of stormwater management practices.

3.5.3.1 Stormwater Conveyance Channels

Stormwater conveyance channels will provide the mechanism by which stormwater from across the site will be delivered to the detention and settling basin. These are low-gradient channels lined with 4 in. of crushed stone (2-in. diameter). The primary purpose of the channels is to

convey stormwater to the primary treatment facilities and minimize erosion caused by the flows. These channels have the potential to reduce DDx concentrations in stormwater by the trapping of sediment and the infiltration of stormwater through the permeable channel base. In addition, the SCM is designed to pond stormwater within these channels and in adjacent onsite areas during large runoff events until such time that the ponded stormwater is passed through the detention basin and sand filter (Section 3.1). Under these conditions, a portion of the suspended sediment (and associated DDx) will settle out of the ponded stormwater. Because of the ancillary nature of, and the uncertainty in, estimating the magnitude of any load reduction due to the conveyance channels, it was conservatively assumed that no reduction in DDx concentrations will occur within the stormwater conveyance system.

3.5.3.2 Detention Basin

The detention basin will serve two purposes within the stormwater treatment system. The first will be the modulation or equalization of flow rates to the sand filter. The second will be to provide a region of low flow velocity to allow sediments to settle out of suspension. The effectiveness of detention basins for the treatment of stormwater was estimated by reviewing the performance data available in the BMP database.

Because no measured effectiveness for the treatment of DDx compounds is included in the BMP database, TSS was selected as a proxy analyte to estimate DDx treatment. TSS has been used as a surrogate for DDx at other sites (e.g., Johnson Creek TMDL study), which is consistent with the low-solubility, nonpolar characteristics of the DDx compounds.

The calculation of TSS removal utilized reported TSS values in basin influent and effluent from the BMP database. For each individual study in the BMP database, a single TSS removal percentage was calculated from the difference between the median concentrations of the influent and effluent. These single study removal percentages were then grouped to estimate the range (minimum and maximum) and central tendency (median and mean) of treatment effectiveness for the stormwater treatment method. The analysis of the BMP database found a total of 32 studies of detention basins; of these 28 were grass-lined basins, 3 were concrete-lined basins, and 1 was an underground vault. A summary of TSS treatment effectiveness is presented in Table 3-8. Twenty-one of the studies reported influent and effluent TSS concentrations, of these 18 studies reported effluent TSS concentrations to be lower than influent concentrations. The range of TSS removal for the subset of 18 was from 21% to 95%, with a median value of 67% (mean 62%). The median value (67%) was used as a "best estimate" for calculating overall treatment system performance (Section 3.5.4).

3.5.3.3 Sand Filter

The performance of the sand filter was estimated from applicable studies in the BMP database. As discussed in the previous section, TSS was used as a proxy for the treatment of DDx

compounds. A total of 27 sand filter studies were reported in the BMP database; a summary of design information and TSS treatment effectiveness is presented in Table 3-9. Sand filters with no filter media adjuncts (such as peat or activated carbon) with a maximum bed depth of 18 in. were identified as the most comparable to the sand filter designed for the site. Eleven studies were found to be comparable; of these, ten reported influent and effluent TSS concentrations, and nine studies found TSS concentrations lower in the effluent than in the influent. Of these eight studies the range of removal efficiencies was 70% to 94%, with a median of 86% (mean 83%). The median value (86%) was used as a "best estimate" for calculating overall treatment system performance (Section 3.5.4).

3.5.4 Estimates of Summary Design Effectiveness

The goal of the stormwater treatment system and SCMs is to reduce stormwater concentrations of DDD, DDE, and DDT and other COPCs to meet the stormwater effluent goal for each compound (the practical quantification limit, 0.05 μg/L for DDx compounds). Measured stormwater concentrations of these compounds in Outfalls 001 to 004 range from non-detect to 2.48 μg/L (Table 3-10). 4,4'-DDT requires the greatest level of reduction to meet the effluent goal. Sampling to date indicates that, on average, the combined SCMs performance must achieve 73% removal to meet the effluent goal for 4,4'-DDT, with a 95th percentile removal performance of 96% for 4,4'-DDT. 95th percentile removal performance is typically selected as a design point to address an anticipated monthly maximum influent concentration.

Table 3-11 summarizes the estimated removal efficiencies for each of the SCMs design elements, as discussed above. SCMs are estimated to result in a net reduction in DDx of 58% (capping and storm sewer decommissioning estimated range = 36 to 92%). The wide range in this estimate is related to the uncertainty in DDx loading associated with the existing stormwater conveyance system and the conservatively low reduction in DDx loading applied to the calculations of the minimum performance efficiency. Treatment of stormwater by the detention basin and sand filtration system is estimated to result in 95% removal of TSS (range = 76% to 99.7%), not accounting for any removal that may be realized in the stormwater conveyances. Collectively, the SCMs source control and treatment design elements are estimated to achieve a 98% reduction (best estimate) in DDx concentrations in site stormwater discharge (range = 85% to 99.97%). The best estimate removal effectiveness far exceeds the estimated removal required on average (73%) to achieve the SCM design goals and exceeds the 95th percentile (96%) of the estimated removal efficiency required based on stormwater discharge monitoring.

The conservative analysis presented herein indicates that the source control and treatment SCMs will have a high likelihood of achieving the stormwater discharge goals. However, it is recognized that there is a large degree of uncertainty in the estimates of SCMs performance. Such uncertainty is inherent to stormwater source control and treatment measures. In recognition of this uncertainty, an adaptive management approach will be taken in which the

performance of each SCM design element will be routinely evaluated to ensure that the system is performing as expected. This approach allows for early identification of any elements of the system that may be underperforming, such that they can be optimized and adapted, as necessary, to ensure that performance goals are met as technically practicable.

4 TEMPORARY CAPPING

This section details the design of the temporary capping component of the stormwater SCMs.

4.1 EXISTING CONDITIONS

This section describes the area to be capped and surface conditions within this area. Figure 4-1 presents locations of historic operations and current site features within the area to be capped.

4.1.1 Area to Be Capped

Surficial soil concentrations of DDx have been found in the Acid Plant area, where DDT manufacturing occurred historically (Figure 2-4). The DDx soil concentrations in this area have likely led to observed concentrations of DDx in catch basin sediments and stormwater discharges. The Acid Plant area is located within the drainage basin for Outfall 002, where DDx has been measured in the stormwater discharge (Integral 2008b). Because DDT manufacturing occurred in this area, erodible soil in this area is a potential source of DDx to the stormwater conveyance system on Lots 3 and 4. This soil is transported by overland flow and to a lesser degree by wind to the catch basin capture zones. Erodible soil in the former Acid Plant area would be expected to have the highest potential of DDx relative to other outfall subbasins. This erodible soil is considered to be the primary potential source of DDx to stormwater (Integral 2008b). Thus, areas of remaining exposed soil within the former DDT process area will be capped as part of the stormwater SCMs (Figure 4-1).

4.1.2 Site Surface Features

Presently, the majority of DDx-impacted soil within Acid Plant area is contained beneath asphalt paving or concrete building foundations. However, portions of the Acid Plant area remain unpaved and some of the paved surfaces are in poor condition. In addition, certain remaining concrete surfaces have the potential to contain DDx residues that may pose ongoing risk of contamination to stormwater. These site features are illustrated in Figure 4-2, and described briefly below:

- **Potentially Erodible Soil.** Potentially erodible (exposed) soil exists mainly near and around the building foundations. This soil is believed to be a potential source of COPCs to stormwater.
- **Asphalt Paving.** The majority of the area is covered with asphalt paving. The paving provides physical isolation of stormwater from contaminated surface soil; however, in some areas minor deterioration (i.e., cracking) of the asphalt pavement has occurred.

- **Abandoned Railroad Tracks.** Abandoned railway tracks are located near the southwest boundary of the Acid Plant area. Potentially erodible soil in and around these tracks is a potential source of COPCs to stormwater.
- **Former DDT Manufacturing Building Foundation.** The building where DDT was manufactured has been demolished; however, the foundation of this building remains. Weathered concrete from this foundation is a potential source of COPCs to stormwater as it erodes.
- **Former DDT Warehouse No. 2 Building Foundation.** The building where DDT was stored has been demolished; however, the foundation of the building remains. While this building has been sealed with a concrete sealer, weathered concrete from this foundation is a potential source of COPCs to stormwater as it erodes.
- **Former DDT Storage Area.** Exposed soil surrounding the two tank bases is a potential source of COPCs to stormwater.

4.2 DESIGN OBJECTIVES

Section 3 describes the design basis of the temporary cap. Described below are the design objectives and design criteria.

Design Objectives:

- Reduce erosion potential of exposed soil within the Acid Plant area and the drainage basin for Outfall 002
- Reduce exposure of potentially contaminated concrete surfaces to stormwater runoff
- Reduce exposure potential of soil beneath asphalt paving within the Acid Plant area and the drainage basin for Outfall 002.

Design Criteria:

- Cap must be relatively impermeable
- Cap must have design life of 5 years
- Cap surface must be sufficiently competent to support equipment that will place capping materials.

4.3 DESIGN ELEMENTS

Exposed soil, deteriorating asphalt pavement, and potentially contaminated concrete surfaces in the former Acid Plant area will be stabilized by a temporary cap. The temporary cap will

physically isolate potentially contaminated surface soil from stormwater drainage, thus reducing the potential for contaminated soil to be entrained in stormwater discharges. The area where a temporary cover will be placed is shown in yellow and purple on Figure 4-3.

A geotextile-gravel cap and asphalt patching was chosen for this area to isolate surface soil from stormwater. Details on these cap systems are described in the following sections. Construction of the temporary cap will be coordinated with the installation of the groundwater cut-off wall that is being incorporated with the groundwater SCMs at the site.

4.3.1 Potentially Erodible Soil

Unpaved areas will be stabilized using a geotextile-plastic sheeting-gravel cover system. These areas include the former tank pads and exposed soil within the process area (Figure 4-3). The cap design and construction methodology for these areas will be the same as those used during the Phase I Soil IRM (ERM 2001):

- The area will be cleared of all vegetation. All surface debris and sharp stones will also be removed.
- A layer of geotextile filter fabric will be installed over the entire area, with edges overlapping a minimum of 1 ft.
- A layer of black, 10-mil plastic sheeting will be installed over the geotextile with edges overlapping a minimum of 1 ft.
- A second layer of geotextile filter fabric will be installed.
- A minimum of 2 in. of 3/4-in.-minus baserock will be spread over the geotextile fabric, anchoring the fabric/plastic layers to the ground, armoring the layers against adverse weather, and providing primary protection against physical hazards.

The cover will be placed such that it overlaps a minimum of 1 ft with any adjacent impervious surfaces (e.g., asphalt paving and/or other cap material). When adjacent to a building foundation or other abrupt increase in elevation, the area to be capped will be filled with a clean borrow material to provide a gradual (i.e., 2 horizontal:1 vertical) slope up to the adjacent elevation. If adjacent to an abrupt decrease in elevation, the reverse (i.e., fill in the adjacent area to provide a gradual slope) will be conducted to provide for the 1-ft overlap.

This low permeability cover system will limit contact of surface soil containing DDT with stormwater, reducing erosion of potentially DDT-impacted surface soil. This temporary cover is expected to have a design life of approximately 5 years (ERM 2001).

4.3.2 Asphalt Paving

A site visit was conducted in September 2010 to verify the conditions in the Acid Plant area. The visit revealed that most of the asphalt surface is in good condition, with the exception of visible cracks in some isolated areas. Asphalt cracks that are substantial enough to expose surficial soil to stormwater flows will be sealed to prevent the movement of potentially contaminated surface soil in stormwater. Asphalt maintenance areas are shown in Figure 4-3 and the process for crack repair is described below:

- Area for repair will be dry, clean, and free of all loose and foreign material.
- The ambient and pavement temperatures shall be at least 45°F, or per manufacturer's recommendations, at the time of application of the sealant, whichever is higher.
- Cracks will be filled with hot poured joint filler. Cracks will be sealed from the bottom up, so that upon completion of the work, the surface of the sealant material is flush to 3/16 in. below the adjacent pavement surface.

4.3.3 Abandoned Railroad Tracks

The areas around the former railroad tracks will be filled to provide a level surface for the placement of the cap materials. Any pits, trenches, depressions, etc. will be filled with clean borrow material to the top of the rails. All cap granular materials must be virgin pit run or manufacture soil free of contamination. Fill will be compacted to a dense state using a plate compactor, roller, or similar equipment.

Fill material will be placed such that it provides a gradual transition to adjacent areas. When the adjacent area requires an increase in elevation, the area to be capped will be filled to provide a gradual (i.e., 2 horizontal:1 vertical) slope up to the adjacent elevation.

The temporary cover on the abandoned railroad tracks will consist of a geotextile-plastic sheeting-gravel cap cover as described in Section 4.3.1. Figure 4-3 shows the areas where this type of cover will be placed.

4.3.4 Former DDT Manufacturing Building Foundation

The former DDT manufacturing building foundation contains small aboveground structures (e.g., former equipment pads) and pits or cracks. These structures will be demolished to the extent practicable and filled to grade to provide a level working surface for the placement of the cover material. Any pits, cracks, etc. will be filled with clean borrow material to the proper grade. All cap granular materials must be virgin pit run or manufacture soil, free of contamination. Fill will be compacted to a dense state using a plate compactor, roller or similar equipment.

Fill material will be placed such that it provides a gradual transition to adjacent areas. Outside the foundation, the area will be filled to provide a gradual (i.e., 2 horizontal:1 vertical) slope down to the adjacent elevation to provide for a 1-ft overlap of cover material with the adjacent area.

The temporary cap on the concrete foundation will consist of a geotextile-plastic sheeting-gravel cap as described in Section 4.3.1. The cover will be placed to prevent ponding and promote runoff from the foundations. Figure 4-3 shows the areas where this type of cap will be placed.

4.3.5 Former DDT Storage Warehouse No. 2 Building Foundation

During demolition activities, this foundation was sealed with a concrete sealer. The foundation will be inspected and re-sealed as necessary as per the Operation and Maintenance Plan (Appendix E). If re-sealed, an epoxy-type concrete sealer will be used with a minimum life of 10 years as determined by the manufacturer. Figure 4-3 shows the area of foundation inspection and possible re-sealing.

4.3.6 Former DDT Storage Area

The areas around the former DDT storage area will be filled to the level of the tank bases to provide a level surface for the placement of the cover materials. Any pits, trenches, depressions, etc. will be filled with clean borrow material to the top of the tank bases. All cap granular materials must be virgin pit run or manufacture soil, free of contamination. Fill will be compacted to a dense state using a plate compactor, roller, or similar equipment.

Fill material will be placed such that it provides a gradual transition to adjacent areas. At the edges of the storage area, next to pavement, the area will be filled to provide a gradual (i.e., 2 horizontal:1 vertical) slope down to the adjacent elevation to provide for a 1-ft overlap of cover material with the adjacent area.

The temporary cap on the DDT storage area will consist of a geotextile-plastic sheeting-gravel cap as described in Section 4.3.1. The cap will be placed to prevent ponding and promote runoff from the foundations. Figure 4-3 shows the areas where this type of cap will be placed.

4.3.7 Timing of Cap Placement

The placement of temporary cap material will be closely coordinated with the installation of the groundwater barrier wall and groundwater extraction and treatment system being installed as part of the groundwater SCMs. Construction of the stormwater and groundwater SCMs are anticipated to occur during the summer and fall of 2012. Construction of temporary caps will not be initiated until required construction activities related to the groundwater barrier wall or extraction and treatment system are completed in these areas.

5 DECOMMISSIONING OF EXISTING STORMWATER COLLECTION SYSTEM

This section details the design of the decommissioning of the existing stormwater collection system component of the stormwater SCMs.

5.1 EXISTING CONDITIONS

Figure 5-1 presents the approximate locations of the stormwater collection system components, including catch basins, manholes, and buried pipes based on Arkema plant drawings, the 2007 David Evans and Associates (DEA) survey, and information from Arkema site personnel with the best knowledge of existing conditions. However, some manholes, sewers, and/or catch basins were plugged or may have been destroyed during plant demolition activities. Note that the compiled information on the existing stormwater collection system is, at best, considered incomplete because of unknowns related to the original site construction, historic decommissioning of stormwater system components, the potential impact of past site demolition activities on the stormwater system, and discrepancies between the Arkema plant drawings and the DEA survey.

An inventory of the pipe network was compiled from the now obsolete Arkema plant drawings to tentatively identify the size, length, and type of each pipe associated with the stormwater system as it was once configured at the site. Based on these historical drawings, the system consisted at one time of the following:

- Approximately 2,100 linear feet (LF) of pipes 30 in. in diameter or greater
- Approximately 2,200 LF of pipes 15 to 24 in. in diameter
- Approximately 1,500 LF of pipes 10 to 12 in. in diameter
- Approximately 6,400 LF of pipes 4 to 8 in. in diameter.

In addition, the collection system consisted of approximately 70 manholes, 38 active catch basins, and several sumps. Note that some manholes, sewers, and/or catch basins were plugged or may have been destroyed during plant demolition activities.

5.2 DESIGN OBJECTIVES

Section 3 describes the design basis for the decommissioning of the existing stormwater collection system. Described below are the design objectives and design criteria.

Design Objectives:

- Eliminate all stormwater flow through the stormwater collection system connected to Outfalls 001, 002, and 003 in the vicinity of the groundwater barrier wall
- Eliminate stormwater discharge to Outfalls 001, 002, 003, and 004 from the existing stormwater collection system.

Design Criteria:

- Eliminate all stormwater flow into existing catch basins
- Maintain structural integrity of all manholes
- Maintain structural integrity of pipes 24 in. in diameter and larger requiring decommissioning as per the design objectives
- Eliminate flow in all pipes at catch basins and manholes.

5.3 DESIGN ELEMENTS

Based on the historical information and uncertainties previously identified, the stormwater collection system piping, that may still be potentially active, connected to Outfalls 001, 002, and 003 is within approximately 250 LF to the west of the groundwater barrier wall and will be decommissioned in place (Figure 5-2). To the east of the groundwater barrier wall, the stormwater collection system piping connected to Outfalls 001, 002, and 003 will be decommissioned in place to within approximately 25 ft of the Parshall flumes. The downstream portion of the Parshall flumes and diffusers for Outfalls 001, 002, and 003 will be maintained for possible future use after final site remediation. The stormwater collection system piping connected to Outfall 004 will be decommissioned in place 250 LF to the west of the connection point to the stormwater conveyance and treatment system (Section 6). All manholes and catch basins that may still be potentially active will be decommissioned in place. These stormwater system components will be decommissioned in place per the following:

- Pipelines greater than 24 in. in diameter that can be located and are potentially still active will be decommissioned in place by filling with a controlled low strength material with a compressive strength of 100–200 psi. Pipelines will be plugged with a grout seal at manholes.
- Pipelines less than 24 in. in diameter that can be located and are potentially still active will be plugged with a grout seal at the manholes and catch basins and left in place. [All manholes and catch basins that can be located and are potentially still active will be decommissioned by filling with 3/8-in.-minus pea gravel and compacted up to 2 ft bgs. The pea gravel would then be covered with a non-woven geotextile filter fabric. Finally,

the remainder of the manhole will be filled with a controlled low strength material and capped with asphalt.

Additional work required to decommission the remainder of the existing stormwater collection system will be incorporated into the final site remedy, as necessary.

6 STORMWATER CONVEYANCE AND TREATMENT

This section details the design of the SWC&T component of the stormwater SCMs.

6.1 EXISTING CONDITIONS

This section summarizes the key existing surface and stormwater system conditions applicable to the SWC&T system design.

6.1.1 Surface Topography

The site surface topography is generally described in Section 2.1.2. On the upland portion of the site, ground surface elevations range between 34 and 42 ft NAVD 88 (Figure 2-3). Lots 3 and 4, the former plant area, are generally flat, ranging in elevation between 34 and 38 ft NAVD88. Lots 3 and 4 slope slightly from east to west. Lots 1 and 2 have not been previously developed and range in elevation between 34 and 42 ft NAVD88 with a high point in the northwestern corner of Lot 1. Figure 2-10 shows existing drainage patterns at the site.

6.1.2 Existing Stormwater System

The stormwater collection system is described in Section 2.1.3 and is presented on Figure 2-10. The majority of the collection system will be decommissioned, as described in Section 5. The discharge system for Outfall 004, including the Parshall flume and discharge diffuser, will be maintained for connection to, and discharge by, the proposed SWC&T system. The pipeline to the discharge diffusers consists of 280 LF of 36-in. diameter fiberglass reinforced pipe (FRP) from the Parshall flume stilling basin to the tip of the diffuser. The 36-in. FRP is anchored by 40 ft on-center concrete anchors, and is kept in place by three guide piles. The diffuser sits at the bottom of the river bed (-17.0 ft USGS datum), and consists of three, 3-in. FRP diffuser ports.

6.2 DESIGN OBJECTIVES

Section 3 describes the design basis for the stormwater conveyance and treatment system. Described below are the design objectives and design criteria as discussed with DEQ (see Section 1 for a listing of correspondence).

Design Objectives:

- Meet the requirements of the MAO to design, install, monitor the performance of, and potentially optimize a stormwater conveyance and treatment system at the site.

- Through treatment, reduce concentrations of site COPCs, and specifically DDx, in site stormwater prior to discharge to the Willamette River. The eventual goal of the combined SCMs is to reduce stormwater effluent concentrations to those goals presented in Table 1-1, if technically achievable.

Design Criteria:

- All basins must be impermeable (i.e., non-infiltrating) basins.
- All stormwater treatment facility components must not be vegetated so that they do not pose an attractive nuisance to wildlife.
- Stormwater shall not discharge to Front Avenue and/or other adjacent properties.
- Convey and treat the 25-year design storm of 3.9 in. over a 24-hour period.
- Prevent permanent ponding of stormwater, which could attract nuisance wildlife.

The existing diffuser system, which previously conveyed millions of gallons per day of non-contact cooling water discharge, will mitigate any potential impacts of in-stream erosion in the Willamette River due to discharge of stormwater from the site. Therefore, flow control requirements were not considered necessary nor evaluated as a part of this design, and the pre-development drainage conditions and flow rates were not evaluated.

6.3 HYDROLOGIC ANALYSIS

A hydrologic analysis was conducted to evaluate stormwater runoff from the site that must be captured and treated to satisfy the design criteria (Section 6.2) The NRCS Technical Release 55 (TR-55, NRCS 1986) within the WinTR-55 software package[5] was used to develop runoff hydrographs for a range of storm events (see below). The input parameters for the TR-55 method are provided for each scenario modeled, and are discussed in more detail below.

6.3.1 Drainage Analysis

Half-foot surface terrain contours derived from a 2007 survey by DEA are the primary data input for the hydrologic drainage analysis. Due to recent grading activities on the site, the 2007 contours for Lot 1 and a portion of Lot 2 did not reflect current conditions. Half-foot contours derived from Light Detection and Ranging (LiDAR) data collected in 2009 provided by the U.S. Army Corps of Engineers were substituted for DEA contours within these areas. The resulting surface terrain of the combined half-foot contours was further modified using Autodesk Civil 3D software to include proposed stormwater SCMs elements of channels, berms, and fill areas

[5] The WinTR-55 modeling program is available at http://www.wsi.nrcs.usda.gov/products/w2q/h&h/tools_models/wintr55.html.

on the site (see Section 6.4) to conduct the post-construction drainage analysis. The modified terrain contours were imported into ArcGIS geographic information system (GIS) software and interpolated to produce a digital elevation model (DEM). The DEM was generated at 1-ft pixel resolution to perform the hydrologic drainage analysis.

The ArcHydro extension in the ArcGIS software package was used to conduct the hydrologic drainage analysis of the modified site terrain. A depression analysis was performed on the DEM to identify areas on the site where there is no flow outlet and ponding is likely to occur. These areas within the DEM were then filled to define drainage flow paths across the site. Depression areas were defined by subtracting the input DEM from the filled DEM. Depressions identified on the site are shown on Figure 6-1. The depression areas that represent the proposed stormwater channels, detention basin, and sand filter, as well as a small depression area along the berm on the northwest corner of the site, were not filled to preserve the design of these features for the drainage analysis. All other depression areas were filled to the depths displayed on Figure 6-1 in order to establish the overall drainage patterns on the site.

The filled DEM grid is used as input to produce a flow direction grid. The flow direction grid is defined by slopes calculated using an eight-direction pour point model. The flow direction grid is used as input to produce a flow accumulation grid, which records the number of cells that drain to a specific cell in the grid. Drainage line and catchment areas are defined from a stream definition grid with the use of a threshold drainage area value. The catchment and longest flow path draining to the channels (Figure 6-2) are subsets of the drainage lines and catchment polygons output by ArcHydro. The resulting longest flow paths and catchments identify dominant drainage catchment areas to the proposed stormwater conveyances and are inputs for the TR-55 software package.

Nine different catchments (Basins 1 through 9, Figure 6-2) were defined as draining to the stormwater treatment system by the hydrologic drainage analysis by defining outlet points within the proposed stormwater channel system. Table 6-1 presents the results of the hydrologic drainage analysis as inputs to the TR-55 software package.

The proposed stormwater conveyance system will capture the majority of stormwater runoff from the Lots 2, 3, 4, and a portion of Lot 1. Stormwater from the majority of Lot 1 will continue to infiltrate or flow overland to the Willamette River as it has in the past. A small portion of Lot 1 will continue to flow to a low point that is heavily vegetated with large trees in the northwest corner where stormwater has historically infiltrated. The installation of a berm in the northwest corner of the property will decrease the amount of stormwater that will drain and infiltrate at this low point.

6.3.2 WinTR-55 Runoff Calculations

WinTR-55 is a single-event rainfall-runoff, small watershed hydrology model. The model uses the WinTR-20 computational routine for generating, routing, and adding hydrographs. Data required for WinTR-55 include the following:

- Dimensionless unit hydrograph
- Storm data source
- Rainfall distribution type
- Catchment data:
  - Name
  - Receiving reach/outlet
  - Area
  - Land use (soil type, vegetation, pervious/impervious surface, etc.)
  - Drainage characteristics (manning's coefficient, slope)
- Reach data:
  - Length (longest flow path)
  - Drainage characteristics (channel geometry, Manning's coefficient, friction slope).

WinTR-55 was used to model the 2-, 5-, 10-, 25-, and 100-year storm based on rainfall data from the Portland Airport (Table 6-2), as reported in the City of Portland's Stormwater Management Manual (City of Portland 2008). The NRCS Type 1A 24-hour storm distribution, which is representative of Pacific maritime climates, was used in the hydrologic analysis.

WinTR-55 was used to predict the volume of stormwater runoff based on catchment basin-specific conditions. In stormwater runoff calculations, the WinTR-55 model assumes that rainfall occurs uniformly across the entire watershed over a specified duration (24 hours). The amount of runoff is calculated based on the NRCS runoff curve number (CN) method (NCRS 1986). Runoff flow (Q) is estimated by this method according to the following equation:

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$

Where:

Q = runoff (cm)
P = rainfall (cm)
S = potential maximum retention after runoff begins (cm).

The potential maximum retention, S, is related to the soil and cover conditions of the watershed/segment, and is estimated from the curve number according to the following equation:

$$S = \frac{1000}{CN} - 10 \cdot$$

Weighted CNs were derived for each basin in accordance with the protocols detailed in NRCS (1986) based on the hydrological soil type, as defined in the City of Portland Bureau of Development Services web site (http://www.portlandonline.com/bds/POindex.cfm), and the land use based on review of aerial photographs and site knowledge. Table 6-1 summarizes the characteristics of each catchment and associated weighted CNs. A total of five reaches were defined to represent the stormwater conveyance system connecting the catchments to the stormwater treatment system (Figure 6-2). As described in Section 6.4.1, the stormwater conveyance system design characteristics were input into the WinTR-55 model to predict flow through the conveyance to the treatment system. Additional detail regarding the catchment basin and reach characteristics used in the WinTR-55 modeling are provided in Appendix I.

The model-predicted peak flow rate and total volume discharged are presented in Table 6-3 for the five storm events modeled. Hydrographs for each storm event are presented in Figure 6-3. These hydrographs represent the flow rate and total volume of water entering the detention basin. Complete model outputs are provided in Appendix I.

6.3.3 Hydraulic Modeling

Stormwater hydraulics through the treatment system (i.e., detention basin and sand filter)were modeled utilizing HydroCAD Version 9.1.[6] Inflow hydrographs were imported from the WinTR-55 software package for each of the modeled storms and passed through each of the treatment facilities (i.e., first the detention basin and then the sand filter) to evaluate system design and determine maximum discharge flow rates and water elevations. Appendix J provides a description and the results of the hydraulic modeling.

Backwater effects on surface water profiles from the detention basin and into the stormwater conveyance channels were modeled using standard step backwater surface profile calculations (TxDOT 2009). The step backwater method, or standard step method, uses the energy equation to "step" the stream water surface along a profile (in an upstream direction because the channel exhibits subcritical flow). Eight cross sections were chosen to complete the standard step method, a cross section at the end of each reach, as defined by the TR-55 hydrology model, and one at approximately the mid-point of each reach. Water surface profiles were started at the

[6] HydroCAD 9.10 (Build 21). Copyright ® 2010 HydroCAD Software Solutions LLC. www.hydrocad.net.

water surface elevation modeled at the sediment forebay by the HydroCAD model (see above). Appendix K provides a description and results of the standard step calculations.

Results of the hydraulic and standard step calculations are provided in Table 6-4. The hydraulic modeling indicates that the detention basin and sand filter should provide effective hydraulic capture and conveyance of up to the 25-year, 24-hour storm with no impacts from Willamette River flood stages. The site will contain up to the 100-year, 24-hour storm with no site runoff. The conveyance channels will back up and cause limited site flooding for any storms greater than the precipitation of 1-inch over 24-hours storm. This flooding is limited to a small area that is a "low point" at the site, near the former BPA substation. The system, as-design will convey, without backing up, significantly greater than 90% of the annual average runoff from the site and will not result in flood impacts of onsite structures.

6.4 DESIGN ELEMENTS

The stormwater conveyance and treatment system is designed to convey, and provide primary (solids removed by settling) and secondary (solids removed by filtration) treatment and discharge of the 25-year, 24-hour storm as described previously. The system will consist of stormwater channels to convey stormwater to a two-stage treatment system. The first stage of treatment will consist of an impermeable detention basin and will provide flow equalization and primary treatment through settling of stormwater solids from stormwater. The second stage of the treatment system is a sand filter to provide polishing removal of solids. Following treatment, stormwater will be discharged to the Willamette River via the existing diffuser system located at Outfall 004. Soil excavated during the construction of the conveyance and treatment system will be managed onsite as per the Contaminated Materials Management Plan (Appendix B). The layout of the stormwater conveyance and treatment system are presented in Figure 6-4.

6.4.1 Stormwater Channels

The channels are required to convey the 25-year storm with minimal ponding throughout the site. Because this is an interim measure (pending final site remedy), the entire site will not be re-contoured to drain. Thus, limited ponding will occur in depressions across the site. New proposed stormwater channels were located to minimize this ponding and mitigate any potential flood impact. A post-construction depression analysis was conducted as described in Section 6.3.1. While the channels have been sized to convey the 25-year storm under uniform flow conditions, the design of the stormwater treatment system (Section 6.4.2 and Section 6.4.3) to maximize treatment to up to the 25-year, 24-hour storm will cause "backwater effects" within the stormwater channels. The level of water within the detention basin will cause water to back up within the channels and overflow these channels for storms greater than the 1-inch, 24-hour

storm (Section 6.3.3). While this will cause limited site flooding, it will also maximize infiltration.

Channel design was based the U.S Department of Transportation Federal Highway Association Hydraulic Engineering Circular No. 15 (USDOT 2005). Table 6-5 presents the design procedure for the channel size and bottom stone lining (2-in. media size crushed stone). Manning's Coefficient, η, was determined based on an estimate of the flow depth using the following equation (Equation 6.1, USDOT 2005):

$$\eta = \alpha d_i 1/6/(2.25 + 5.23\log(d_i/D_{b,50}))$$

Where:

η= Manning's Coefficient of roughness
α = unit conversion, 0.319 metric, 0.262 US standard
d_i = estimated flow depth
$D_{b,50}$ = median size of the bottom stone

Manning's Equation (see below) was then applied to determine a discharge rate for each reach.

$$\text{Manning's Equation: } Q = (\alpha/\eta)AR^{2/3}S_f^{1/2}$$

Where:

Q = Discharge flowrate (cfs)
α= unit conversion, 1.0 metric, 1.49 US standard
A = cross-section area (ft)
R = hydraulic radius (ft)
S_f = friction gradient, for uniform flow, bed gradient S_o (ft/ft)

These calculated discharge rates were compared to the maximum discharge rates for each reach during the 25-year storm obtained from the hydrologic analysis. The estimated flow depth was then adjusted until the modeled and calculated maximum discharge rates agreed (+/- 5%).

Side slopes were then analyzed to determine side slope lining in Table 6-6, using the following equation (Equation 6.15, USDOT 2005):

$$D_{s,50} = [K_1/K_2] \times D_{b,50}$$

Where:

$D_{s,50}$= D_{50} required for a stable side slope
$D_{b,50}$= D_{50} required for a stable channel bottom
K_1 = ratio of channel side to bottom shear stress
= 0.77 for side slope ≤ 1.5
= 0.066 x side slope for 1.5 < side slope < 5

= 1.0 for 5.0 ≤ side slope

K_2 = tractive for ratio

$= (1-(\sin\Theta/\sin\Phi)^2)^{1/2}$

Where:

Θ = angle of side slope

Φ = angle of repose (for 2-in. crushed rock, Figure 6.1, USDOT 2005).

The stormwater channel design is summarized below:

- Sloped 0.001 ft/ft to drain to the stormwater treatment system.
- Trapezoidal in shape, with a 2-ft bottom, and side slopes of 2.5H:1V; where the two channels come together, the channel bottom increases to 4 ft.
- Flow depths, assuming uniform flow conditions and no backwater effects, are estimated to range from 1.04 ft to 2.49 ft in the east channel (nearest the river), 0.89 ft to 1.56 ft in the west channel (nearest NW Front Avenue), and up to 3.06 ft in the combined channels during the 25-year, 24-hour storm (Table 6-5). Backwater effects within stormwater channels are discussed in Appendix K.
- Channel bottom and side slopes are lined with 2-in. (median diameter) crushed rock, 4-in. thick.

6.4.2 Detention Basin

The design of the detention basin was based on two criteria. First, to minimize the maximum discharge rate from the basin to the extent practicable, and second, to provide sufficient hydraulic retention to allow for a silt-size particle to settle from the top of the basin water column to the bottom of the basin, when filled. Specific design criteria for the detention basin are provided in Table 6-7.

For the first criterion, channel erosion from stormwater discharge to the Willamette River was considered. In general, discharge flow rates to the Willamette are not a concern to promote channel erosion because of the existing outfall diffuser system (see Section 6.2), which was designed to discharge a maximum of 5 million gallons per day or approximately 7.74 cfs (Patterson 2010, pers. comm.). The maximum discharge rate from the system was set below this design rate. Further, the maximum discharge rate affects the sizing of the sand filter (see Section 6.4.3). To control discharge rates from the detention basin, several iterations of detention basin and sand filter sizing were evaluated in HydroCAD version 9.1. (Refer to Section 3.4.3 on specifics discussing the sizing of the detention basin.) This resulted in a detention basin size of 150 ft wide by 300 ft long at the bottom. The detention basin will be constructed as two cells: a sediment forebay and a main detention cell. The sediment forebay will consist of approximately 20% of the basin bottom length and will extend across the width

of the basin. Baffles will be incorporated within the main detention cell to provide a length to width ratio of 3:1 for the entire detention basin. These baffles will extend across 80% of the bottom width of the basin to minimize short circuiting within the main detention cell. Multiple perforated pipe risers with large-storm overflow were also selected to provide outlet flow control. The perforated pipe section was designed to control the flowrate for the majority of the storms (i.e., the 2-year, 24-hour event and smaller). The outlet flow control consists of multiple 8–in. polyvinyl chloride (PVC) perforated riser pipes, with 4 rows of 2, 1-in.-diameter, orifices spaced at 6-in. centers. These pipes will be placed on 10-ft centers, for a total of 5 riser pipes, across the outlet of the basin to provide an even flow across the basin flow path. These pipes will also be open at the top to control flows and mitigate flooding of the site for events larger than the 2-year, 24-hour event. Figure 6-5 depicts a cross section of the outlet structure.

Stormwater hydraulics through the detention basin and sand filter were modeled utilizing HydroCAD Version 9.1. Inflow hydrographs were imported from the WinTR-55 software package for each of the modeled storms and passed through each of the treatment facilities (i.e., the detention basin and the sand filter) to determine maximum discharge flow rates and water elevations. Appendix J presents the inputs as well as the results of the HydroCAD modeling. Figures 6-6 through 6-10 present the detention basin outflow hydrographs for each of the modeled storm events, as well as elevation levels within the detention basin during the modeled storm events.

Hydraulic calculations indicate that levels within the detention basin will back up water levels within the western stormwater channel during the 2-year, 24-hour storm event and larger events. This will cause short-term ponding of stormwater near the western boundary during these events. Ponding will cause a limited increase of infiltration along selected channel areas. Ponding will be limited in duration and to a relatively small area near the former BPA substation (see depression area [green outline]; Figure 6-1). The stormwater will be contained onsite by the berms surrounding the site (Section 6.4.5).

The detention basin design is summarized below:

- 150 ft wide by 300 ft long at the bottom of the basin.
- Side slopes 4H:1V.
- Finished grade bottom elevation 30.0 ft NAVD88.
- 1.5 ft of dead space at the bottom of the basin for sediment accumulation.
- Impermeable geomembrane liner consisting of an impermeable, linear low-density polyethylene (LLDPE) liner covered by a geotextile, 12 in. of sand, and an addition of 6 in. crushed rock cover.

- Sediment forebay separated by the main detention cell with a block wall with overflow weir of 5 ft long by 2.5 ft wide set at elevation of 31.75 ft for passing water from the sediment forebay to the main detention cell.
- Outlet structure consisting of five 8-in. diameter PVC perforated riser pipes (each with 2 columns of 1-in.-diameter orifices at 6-in. centers from 31.50 ft to 33.00 ft NAVD88) which will be spaced on 10-ft centers across the back of the basin to spread flow across the entire basin. Each riser will have a 12-in. PVC outer pipe to serve as a baffle and prevent trash from plugging the orifices. Each riser will also be open at the top to allow for flood stage flow through the outlet system set an elevation of 33.75 ft. The orifices were sized to control the flow rate of water to the sand filter and minimize significant backup of stormwater on the site.
- 310 ft of 24-in. PVC pipe connected to the PVC risers outlet structure for drainage to the sand filter. The pipe will have a starting invert elevation of 31.0.5 ft NAVD88 and an outlet invert elevation of 29.50 ft NAVD 88.

6.4.3 Sand Filter

The sand filter was sized to provide polishing treatment after primary treatment from the detention basin, including all storms up to the 25-year, 24-hour event (3.9 in. over 24 hours and a NRCS Type 1A rainfall distribution). A description of the sizing of the sand filter system is presented in Section 3.4.4. The sand filter bottom is 80 ft wide by 160 ft long. Table 6-8 presents specific criteria used for the design of the sand filter. Small clear wells (influent, 9 ft wide by 80 ft long; effluent, 14 ft wide by 80 ft long) will exist on each side of the Concrete Block Weirs (2.5 ft wide; Figure 6-11) to allow even flow across the width of the sand filter on the influent side of the filter, and to capture flow from both the underdrain system and overflow weir on the effluent side of the filter. The underdrain system will consist of 4-in. perforated PVC pipe on 10-ft centers (Figure 6-11).

As discussed in Section 6.3.3 and Appendix J, stormwater hydraulics through the detention basin and sand filter were modeled with HydroCAD Version 9.1. Inflow hydrographs were generated from the detention basin for the modeled storms and passed through the sand filter. The small storage from the influent clear well was not modeled, and the sand filter was modeled as only storage above the filter, exfiltration was modeling to the underdrain system (consisting of a multi-orifice pipe followed by a culvert), and included a 206 minute lag to allow flow through the filter. Appendix J presents the inputs as well as the results of the HydroCAD modeling. Figures 6-12 through 6-16 present the outflow hydrographs for each of the modeled storm events, as well as peak elevation and storage within the detention basin. These hydrographs are for the entire system including discharge (see below).

The sand filter design is summarized below:

- 80 ft wide and 188 ft long at the bottom of the basin. The length includes an 80-ft by 160-ft filter; 9-ft by 80-ft influent clear well (not including 2.5-ft-wide influent weir); and 14-ft by 75-ft effluent clear well (not including 2.5-ft-wide effluent weir).
- Side slopes 4H:1V.
- Impermeable geomembrane liner consisting of an impermeable LLDPE liner covered by a geotextile, 12 in. of sand cover, and an addition of 6 in. crushed rock cover.
- Underdrain system consisting of a 4-in. PVC perforated pipe on 10-ft centers.
- Approximately 165 ft of 24-in. PVC pipe sloped at 0.005 ft/ft connected to the effluent clear well for drainage to the sand filter. The pipe will have an inlet invert elevation of 28.0 ft NAVD88 to collect drainage from the underdrain system and an outlet invert elevation of 27.26 ft NAVD88. The outlet pipe will lie upon the soil layer with a sump constructed around the outlet pipe such that stormwater flow from the underdrain system can freely flow to the outlet culvert.

6.4.4 Discharge

The facility will discharge to an existing manhole to the Outfall 004 collection system.[7] A manhole with sump will be located between the sand filter and the Outfall 004 manhole for flow monitoring and possible adaptive management purposes. Flood stages of the Willamette River were evaluated to assess the potential impacts on the hydraulics of the SWT&C system. Flood Stages for the Willamette River are presented in Table 6-9. As indicated by the river stage, the system has a potential to back up (i.e., river stage is greater than the invert elevation of the discharge pipe) during the 50-year and 100-year storm events. The system will be allowed to back up during these events that are greater than the design of the system to provide protection from buoyancy effects from groundwater underneath the basin liner. There is a very low probability that the 100-year event for the Willamette River basin upstream of the site (approximate drainage area 11,200 square miles; USGS 2010) will occur simultaneously with a 100-year event at the site (approximate drainage area of 0.08 square miles) as indicated in the Oregon Department of Transportation's Hydraulic Manual (ODOT 2005). The 100-year, 24-hour storm was evaluated to determine the potential for flooding. If discharge could not occur[8], it was assumed that the entire 100-year, 24-hour would need to be detained (516,017 ft^3 of water). Under these conditions site stormwater would back up to an elevation of 35.32ft NAVD88. Figure 6-17 presents the extent of the potential flooding. This evaluation determined that while water elevations were elevated within the stormwater conveyance and treatment

[7] A manhole has been identified on the facility drawings on the river bank just above the Parshall Flume; however, this manhole was not located during the DEA surveys. This manhole will be field located prior to construction. If it cannot be located, a new manhole connecting the existing and the new stormwater treatment systems will be installed above the river bank.

[8] Some discharge would still occur even during the 100-year flood; therefore, this evaluation presents a conservative approach.

system, stormwater would be controlled on site by setting property, detention basin and sand filter perimeter berm elevations (see Section 6.4.5.1) to a minimum elevation of 37.0 ft NAVD88, resulting in 1.0 ft of freeboard within the basins. Under these circumstances, flooding would not have the potential to harm any site structures (e.g., the site office or the proposed groundwater treatment system).

6.4.5 Berms and Fill Areas

6.4.5.1 Berms

Potential discharge of stormwater due to the reconfiguration of the stormwater system to adjacent properties (e.g., CertainTeed Roof Product Manufacturing and NW Front Ave) will be prevented by the installation of a berming system at the property boundary. Further, the area just east of the former Acid Plant area will also be bermed to prevent overland flow of stormwater from this area to the Willamette River. Figure 6-4 shows the locations of the berms. The majority of the berm system will be 1 ft tall, sufficient to keep stormwater runoff onsite. A portion of the berm will need to be 2 to 3 ft tall to maintain a minimum berm elevation of 37.0 ft NAVD88 to manage stormwater (Section 6.4.4). This area includes the section of the berm from approximately the front gate to the Lot 1/Lot 2 boundary along NW Front Ave. In addition, berms will be built up around the sand filter and detention basin to a minimum height of 37.0 ft NAVD88.

The berm design is summarized below:

- The area will be cleared of all vegetation. All surface debris and sharp stones will also be removed.
- Berms will be 2 ft wide at the top, with a 2H:1V side slope.
- The berm will be constructed of a compacted, clean borrow material.
- A layer of geotextile filter fabric will be installed over the berm, with edges overlapping a minimum of 1 ft.
- A minimum of 2 in. of 3/4-in.-minus baserock will be spread over the geotextile fabric, anchoring the fabric/plastic layers to the ground, armoring the layers against adverse weather, and providing primary protection against physical hazards.

6.4.5.2 Fill Areas

As stated previously, materials excavated for the construction of the channels, detention basin, sand filter, as well as any piping will be managed on site as per the Contaminated Materials Management Plan (Appendix B). Low lying areas, including the former salt pads and areas of the former asbestos and brine ponds, will be filled with excavated material to promote site drainage (Figure 6-4). While soil staging will be minimized, some staging may be required to

facilitate construction schedules. Potential soil stockpiling areas are indicated on Figure 6-18. After placement, all stockpiled soil will be compacted, sloped to drain (minimum slope of 0.001 ft/ft), and capped with a temporary cap. The temporary cap will be identical to capping described in Section 4.

7 PERMITTING

The stormwater SCMs project is being conducted under a Consent Order and MAO with DEQ. DEQ, through the administration of ORS 465.315, has "permit waiver" authority for cleanup projects implemented under the state cleanup program. The permit waiver provisions require that the substantive permit requirements be met, even though a permit is not required. To meet the permit waiver requirements, the appropriate permitting authority must also be notified, and applicable fees, if any, must be paid. The listing of the applicable permits herein establishes a record of notice to the applicable permitting authorities.

The following permits have been identified for potential applicability to the stormwater SCMs project.

7.1 LOCAL

City of Portland or other local permits that are applicable for the stormwater SCMs construction include:

- Grading permit, including an approved erosion, sediment, and pollution control plan
- Plumbing permit.

Additional City of Portland permit requirements may also be applicable; however, the City has an exempt process that is being utilized for the groundwater SCMs. The City has established the exempt process so that the City can provide input on DEQ-managed cleanup projects. Under this process, City development of permit approvals is not required; however, the substantive requirements of the permits must be met.

The exempt process consists of a 1-month review by the City of Portland Bureau of Development Services and Bureau of Environmental Services for compliance with applicable City codes and regulations, including greenway overlay zoning requirements. This review will be performed for a fixed fee, and does not include a public comment period. A letter of determination will be issued by the City which may contain additional requirements. Additional requirements may be negotiated with City review personnel; however, there is no formal appeal process.

The stormwater and groundwater SCMs design and implementation are on parallel implementation schedules and potential impacts from these SCMs, regarding items such as the greenway overlay zoning requirements, are related. Therefore, a single package consisting of the groundwater and stormwater SCMs documents will be provided to the City of Portland Bureau of Development Services and Bureau of Environmental Services for review.

7.2 STATE

State of Oregon permits that may be applicable for the stormwater SCMs construction include:

- Construction Stormwater General Permit (1200-C). The 1200-C permit is required for projects that have an anticipated disturbed area greater than one acre. Projects with a disturbed area greater than five acres require public review of the permit application. The area anticipated to be disturbed during the implementation of the stormwater SCMs is approximately 4.2 acres.
- NPDES Industrial Stormwater Permit for discharging treated stormwater to the Willamette River. The existing NPDES industrial stormwater permit is currently under a renewal process and the stormwater SCMs, which are being issued under a DEQ water quality MAO, are being implemented in compliance with the MAO requirements. There are no additional NPDES permit requirements.
- Oregon State Dam Act Permit. The Oregon State Dam Act permit is required for any impoundment. Nonstatutory dams (i.e., those dams that are less than 10 ft in height or that impound less than 9.2 acre-ft) do not require design approval and construction oversight by the Water Resources Department.

7.3 FEDERAL

Based on discussions between DEQ and federal agencies, no federal permits will be required for this project. The draft and final design package will be provided to the EPA and other federal agencies as determined by DEQ. In addition, the final draft of the stormwater SCMs design will be available for public notice and review under DEQ's authority.

8 PERFORMANCE MONITORING

Performance monitoring will be conducted to evaluate the presence of COPCs in treated stormwater and to evaluate the performance of the stormwater SCMs. Performance monitoring will be initiated upon completion of all work related to all SCMs being implemented at the site. This includes all the stormwater SCMs as presented in this Final Design Report, as well as groundwater source control measures, including the installation of the groundwater barrier wall and the groundwater extraction and treatment system. As described in Attachment A to Appendix A (Erosion and Sediment Pollution Control Plan) of this Final Design Report and in accordance with agreements reached with DEQ, LSS intends to utilize components of the stormwater SCMs, including the detention basin and sand filter, to control and provide additional treatment to site stormwater during implementation of the stormwater and groundwater SCMs. LSS will monitor the system during this period and implement BMPs as conditions warrant; however, the results of this monitoring will not be indicative of final site conditions. Therefore, performance monitoring per the MAO requirements will not be initiated until all site construction has been completed and the treatment system components have been inspected and, if necessary, cleaned of all excess debris and sediment accumulated during the construction process.

COPC concentrations during the first few months may show an increase over previously observed levels due to the disturbance of soil during the construction process. Also, stormwater COPC concentrations in stormwater effluent will decrease as the sand filter conditions (i.e., builds up a filter cake as smaller particles settle at the surface of the sand filter; refer to Section 3.4.4 for a discussion of sand filter conditioning).

Stormwater samples will be collected using automated samplers at two sample locations: one representative of stormwater treatment system influent, and one representative of stormwater treatment system effluent. The influent sampling location will be collected in the stormwater SCMs drainage channel system, hydraulically upgradient of the inlet to the stormwater detention basin. The effluent sampling location will be at a manhole hydraulically downgradient from the stormwater treatment sand filter and upgradient of the Outfall 004 discharge point. Flow meters will be used to determine the flow rates at the stormwater treatment system influent and effluent locations, and allow for the calculation of the flow-weighted average for each sampled storm (EMC).

As practicable, monthly composite samples will be collected during the first year of operation for the performance monitoring program. Monthly composite samples will consist of at least four discrete samples taken over a discharge event within the first three hours of stormwater discharge. To collect 12 sampling events distributed over the first year following the implementation of the stormwater and groundwater SCMs, the following numbers of samples will be targeted for each month:

- November, December, January, February, and March—Target 16 composite samples (8 influent and 8 effluent) over this period.
- April and May—Target 2 composite samples (1 influent and 1 effluent) over this period
- June, July, and August—Target 2 composite samples (1 influent and 1 effluent) over this period.
- September and October—Target 4 composite samples (2 influent and 2 effluent) over this period.

The ability to collect stormwater samples will be dependent on rainfall and associated runoff during the period of collection. Sampling events will be scheduled when it is predicted that the following storm event criteria will be met:

- Storm event is preceded by a dry period (less than 0.1 in. rainfall) of at least 24 hours
- Storm event is predicted to produce more than 0.2 in. rainfall
- Storm event is predicted to occur over a minimum of 3 hours.

The storm event criteria listed above are considered goals. Each storm event sampled will be evaluated relative to these goals, although circumstances may arise where not all of these criteria can be met (e.g., a storm event of less than 0.2 in. during drier periods). In the latter case, professional judgment will be used to evaluate whether sampling or storm conditions that substantially do not meet the target storm conditions should be considered prior to analyzing stormwater samples collected under these conditions. If, by the last week of a given month and/or the last month of a given period, the minimum number of samples has not been collected, one or more of the aforementioned storm event criteria may be ignored in order to obtain a sample(s).

For at least one of the 12 targeted sampling events, an attempt will be made to sample a storm event greater than the 2-year, 24-hour storm (i.e., storm event predicted to be greater than 2.4 in. over a 24-hour period) to assess the effects of larger storm events on COPC loading in stormwater discharges to the Willamette River.

Stormwater samples will be analyzed for the constituents and frequency listed in Table 8-1, in accordance with Attachment A of the MAO. Unless otherwise specified in Table 8-1, samples will be analyzed for total constituent concentrations. Additional information regarding analytical methods is provided in the QAPP (Appendix G).

Following receipt of laboratory analytical and data validation reports, stormwater sample data will be provided to DEQ in monthly discharge monitoring reports. At the end of the first year of monitoring following implementation of the stormwater SCMs, a performance monitoring

data summary report will also be provided to DEQ[9] that includes analytical results from stormwater samples collected from the previous year. The performance monitoring report will compare influent and effluent stormwater results to calculate the treatment efficiency. Performance monitoring results will also be compared to monitoring results from historical stormwater sample data to determine if COPC concentrations have changed over time.

In addition to the evaluation of the stormwater SCMs effectiveness and stormwater concentration trends, the performance monitoring report will assess the need for modification and/or optimization of the stormwater treatment system (i.e., adaptive management). Table 8-2 provides a list of certain performance issues that could arise during system performance monitoring that may require action. Table 8-2 is a decision tree that will be followed in evaluating the performance issue. In some cases, the performance issue can be addressed during the normal course of operation and maintenance of the stormwater treatment system as discussed further in the Operation and Maintenance Plan (Appendix E). In other cases, the performance issue may indicate that a further evaluation of the treatment system design is required and that design modifications may need to be implemented. In these latter cases, the performance monitoring decision tree directs the analysis to several outcomes that could be considered as listed in Table 8-3, the corrective action decision tree. Through ongoing evaluation of the system through the performance monitoring decision tree and evaluation and application of corrective actions through the corrective action decision tree, the stormwater SCMs can be adaptively managed to provide maximum feasible performance for the design life of the system.

In addition to potential modifications, performance monitoring may indicate that some COPCs are not present in stormwater discharges. LSS proposes that if one or more COPCs are not detected in both influent and effluent samples for four (4) consecutive sampling events, analysis for the specific COPC be discontinued. Further, if one or more COPCs are not detected in effluent samples for the first year of monitoring, analysis of the COPC would be discontinued. Discontinuing of analysis of any COPC will be made with the agreement of DEQ.

Potential future modifications to the treatment system have been considered in the development of the current treatment system design. The following presents potential modifications, data needed to assess the feasibility of implementing these measures, and the current system compatibility with these modifications:

- Additional source control measures could be implemented. This modification could be constructed by installing temporary capping, as specified in this document, in identified areas of surface soil that are potentially contributing COPCs to site stormwater. The

[9] Note that the MAO identifies a report due on June 1; however, this date is based on an outdated schedule and would not allow for collection of a full year of monitoring data and assessment of stormwater conditions during different seasons. The performance monitoring data summary report will be submitted within 3 months following the last monthly discharge sampling at the completion of the first year of monitoring.

only data required to determine whether this modification could be effective is the identification of source areas potentially contributing COPCs to stormwater.

- The sand filter media could potentially be modified to either include a layer of filter media with a smaller diameter or with the addition of a carbon phase (e.g., granular activated carbon) to enhance adsorption of COPCs that exceed effluent criteria. This modification could be implemented by accessing the sand filter by the maintenance access road, removing a portion (e.g., top 6 to 12 in.) of the sand filter media, and either mixing the media with amendments or adding a new media layer. Data required to determine whether this modification could be effective includes determination of whether the COPC is associated with the particulate phase or the aqueous phase (total and dissolved concentrations); particle-size distribution if associated with particulate phase; distribution of the COPC by particle size; and, potentially, general water quality parameters, if metals are the COPC that exceeds criteria.

- Coagulant or flocculant addition could be proposed to destabilize smaller particles, allowing them to flocculate and settle or filter more effectively. This modification could be implemented by one of three or more methods: 1) extracting water from the sediment forebay of the detention basin, addition of coagulant or flocculant, and discharge to the main cell of the detention basin; 2) extracting water from the end of the main cell of the detention basin (within intake below current orifice configuration), addition of coagulant or flocculant, and discharge to the influent flow spreading area of the sand filter; and, 3) extracting water after filtration by installation of a weir around the discharge pipe, addition of coagulant or flocculant, additional above ground filtration (one or both sand and carbon) and discharge to the existing manhole where stormwater discharge occurs. Data required to determine whether this modification could be effective includes determination of whether the COPC is associated with the particulate phase or the aqueous phase (total and dissolved concentrations); particle-size distribution if associated with particulate phase; distribution of the COPC by particle size; jar testing with site stormwater from the location of interest (before detention basin, between the basins, or after sand filtration) to determine coagulant or flocculant type and dosage to maximize effectiveness; and, potentially, general water quality parameters, if metals are the COPC that exceeds criteria.

- Additional passive, but more rigorous, pre-manufactured cartridge type filters (e.g., StormFilter®) could be added to address smaller storm events if these smaller events are associated with COPC exceedances. The designed system could be modified by splitting flow at the manhole between the detention basin and sand filter. A second discharge pipe could be added to route stormwater from the detention basin to the new system, while a weir would be added to assure only larger storm events are routed to the sand filter. This system would discharge to the existing stormwater discharge manhole as a second discharge. Data required to determine whether this modification could be

effective includes determination of whether the COPC is associated with the particulate phase or the aqueous phase (total and dissolved concentrations); particle-size distribution if associated with particulate phase; distribution of the COPC by particle size; and, potentially, general water quality parameters, if metals are the COPC that exceeds criteria.

In addition to potential modifications, performance monitoring may indicate that some COPCs are not present in stormwater discharges. LSS proposes that if one or more COPCs are not detected in both influent and effluent samples for four (4) consecutive sampling events, analysis for the specific COPC be discontinued. Further, if one or more COPCs are not detected in effluent samples for the first year of monitoring, analysis of the COPC would be discontinued. Discontinuing of analysis of any COPC will be made with the agreement of DEQ.

Additional details of the performance monitoring program are provided in the Performance Monitoring Plan, Appendix F to this Final Design Report.

9 SCHEDULE

A schedule that includes document submittals, agency reviews, and other key project milestones, is summarized in Figure 9-1. This schedule is based on the MAO and subsequent agreements with DEQ (see Appendix N). This schedule makes assumptions about turnaround times for agency review of documents submitted by LSS for approval. If actions or events occur that are beyond LSS' reasonable control and that causes or may cause a delay or deviation in performance of the requirements of the MAO or Consent Order, LSS will promptly notify DEQ's project manager verbally of the cause of the delay or deviation, its anticipated duration, the measures that have been or will be taken to prevent or minimize the delay or deviation, and the timetable by which LSS proposes to carry out such measures. LSS will confirm this information in writing within five working days of the verbal notification.

10 REFERENCES

Arkema. 2005. Stormwater Characterization Report, Portland Plant. Arkema Inc., 6400 NW Front Ave., Portland, OR.

Boyd, R.H., and M.M. Ghosh. 1974. An investigation of the influences of some physiochemical variables on porous-media filtration. *J. Amer. Water Works Assn.* 66(2):94-98.

City of Austin. 1988. Design Guidelines for Water Quality Control Basins. City of Austin, Texas. 1988.

City of Portland. 2008. Stormwater Management Manual. City of Portland, Oregon. Bureau of Environmental Services. August 1, 2008.

Claytor, R.A., and T.R. Schueler. 1996. Design of Stormwater Filtering Systems. Prepared for Chesapeake Research Consortium, Solomons, MD. Prepared by Richard A. Claytor and Thomas R. Schueler, The Center for Watershed Protection, Ellicott City, MD. December 1996.

DEQ and USEPA. 2005. Portland Harbor Join Source Control Strategy, Final. Available at: http://www.deq.state.or.us/nwr/PortlandHarbor/jscs.htm. Oregon Department of Environmental Quality, Portland, OR, and U.S. Environmental Protection Agency, Portland, OR. December 2005.

ERM. 2001. Interim Remedial Measures Implementation Report, ATOFINA Facility, Portland, Oregon. Prepared for ATOFINA Inc., Portland, OR. ERM-West, Inc., Portland, OR.

ERM. 2005. Upland Remedial Investigation Report Lots 3 & 4 and Tract A - Revision 1. Prepared for Arkema Inc., Portland, OR. ERM-West, Portland, OR.

Fitzpatrick, J. A., and L.A. Spielman. 1973. Filtration of aqueous latex suspensions through beds of glass spheres. *J. Colloid It. Sci.* 43(2):350–369.

Integral. 2007. Stormwater Interim Remedial Measures Field Sampling and Data Report, Arkema Portland Facility. Prepared for Legacy Site Services LLC, Exton, PA. Integral Consulting Inc., Portland, OR. November 2, 2007.

Integral. 2008a. Draft Arkema Upland Level II Screening Ecological Risk Assessment. Prepared for Legacy Site Services LLC. Integral Consulting Inc., Portland, OR.

Integral. 2008b. Stormwater Interim Remedial Measures Focused Feasibility Study Report: Arkema Portland Facility. Prepared for Legacy Site Services LLC. Integral Consulting Inc., Portland, OR.

Integral. 2009. Draft Stormwater Source Control Measure Design & Implementation Work Plan: Former Arkema Portland Facility. Prepared for Legacy Site Services LLC. Integral Consulting Inc., Broomfield, CO.

Integral. 2010. Draft Design Report, Stormwater Source Control Measures. Prepared for Legacy Site Services LLC. Integral Consulting Inc., Portland, OR. December 2, 2010.

Ives, K.J., and I. Sholji. 1965. Research on variables affecting filtration. J. San. Engr. 91:1–18.

Iwasaki, T. 1937. Some notes on sand filtration. *J. Amer. Water Works Assn.* 29:1591.

Jacobs, L., R. Barrick, and T. Ginn. 1988. Application of a mathematical model (SEDCAM) to evaluate the effects of source control on sediment contamination in Commencement Day. pp. 677-684. In: Proc. First Annual Meeting on Puget Sound Research, Puget Sound Water Quality Authority, Seattle, WA.

King County. 2005. King County, Washington, Surface Water Design Manual. King County, Department of Natural Resources, Seattle, WA. January 24, 2005.

McClincy, M. 2008. Personal communication (letter to T. Slater, Legacy Site Services LLC, dated December 18, 2008, regarding Draft Stormwater Interim Remedial Measures Focused Feasibility Study Report, Arkema Portland Plant, ECSI No. 398). Oregon Department of Environmental Quality, Portland, OR.

McClincy, M. 2011. Personal communication (letter to T. Slater, Legacy Site Services LLC, dated February 15, 2011, regarding Draft Design Report Stormwater Source Control Measures Former Arkema Inc. Facility Portland Oregon ECSI #398). Oregon Department of Environmental Quality, Portland, OR.

McClincy, M., and R. Burkhart. 2011. Personal communication (letter to T. Slater, Legacy Site Services LLC, dated June 16, 2011, regarding Responses to Review Comments Draft Design Report Stormwater Source Control Measures, Former Arkema Inc. Facility Portland, Oregon Arkema, Portland ECSI #398). Oregon Department of Environmental Quality, Portland, OR.

Minton, G.R. 2005. Stormwater treatment: Biological, chemical and engineering principles. Second Edition. Resource Planning Associates, Seattle, WA.

NRCS. 1986. Urban Hydrology for Small Watersheds, TR-55. Technical Release 55. Natural Resources Conservation Service, Conservation Engineering Division, Washington, DC. June 1986.

ODOT. 2005. Hydraulics Manual. Oregon Department of Transportation, Highway Division. Prepared by the Engineering and Asset Management Unit, Geo-Environmental Section, Salem, OR.

Orozco, S. 2006. Evaluation of the effectiveness of short circuiting criterion for stormwater quality basins design using ideal flow modeling. Thesis. University of Houston, Houston, TX.

Patterson, L. 2010. Personal communication (conversation with M. Martin, Integral Consulting, Inc., Portland, OR, on November 30, 2010, regarding design of existing outfall diffuser system). ERM-West, Portland, OR.

Portland Development Commission. 2004. Willamette industrial urban renewal report. Portland Development Commission, Portland, OR. 18 pp. October 27, 2004

Slater, T. 2009. Personal communication (letter to M. McClincy, Oregon Department of Environmental Quality, dated March 18, 2009, regarding Stormwater Focused Feasibility Study, Arkema, Portland). Legacy Site Services LLC, Exton, PA.

Slater, T. 2011a. Personal communication (letter to R. Burkhart, Oregon Department of Environmental Quality, dated March 17, 2011, regarding Response to DEQ's February 15, 2011 Review Comments on the Draft Design Report Stormwater Source Control Measures, Former Arkema Inc. Facility, Portland, Oregon. ECSI #398). Legacy Site Services LLC, Exton, PA.

Slater, T. 2011b. Personal communication (telephone conversation with M. McClincy, Oregon Department of Environmental Quality, on June 20, 2011, regarding final agreements on Arkema stormwater system design). Legacy Site Services LLC, Exton, PA.

Slater, T. 2011c. Personal communication (telephone conversation with M. McClincy, Oregon Department of Environmental Quality, on July 1, 2011, regarding final agreements on Arkema stormwater system design). Legacy Site Services LLC, Exton, PA.

TxDOT. 2009. Hydraulic Design Manual. Available at: http://onlinemanuals.txdot.gov/txdotmanuals/hyd/hyd.pdf. Texas Department of Transportation, Austin, TX. March 2009.

USDOT. 2005. Hydraulic Engineering Circular No. 15, Third Edition, Design of Roadside Channels with Flexible Linings. Publication No. FHWA-NHI-05-114. U.S Department of Transportation. Federal Highway Administration. September 2005.

USGS. 2010. National Water Information Service: Web Interface. USGS 14211720 Willamette River at Portland Oregon. Stream Gage Description. http://waterdata.usgs.gov/or/nwis/nwisman/?site=14211720&agency_cd=USGS. Accessed on November 13, 2010. U.S. Geological Survey.

FIGURES

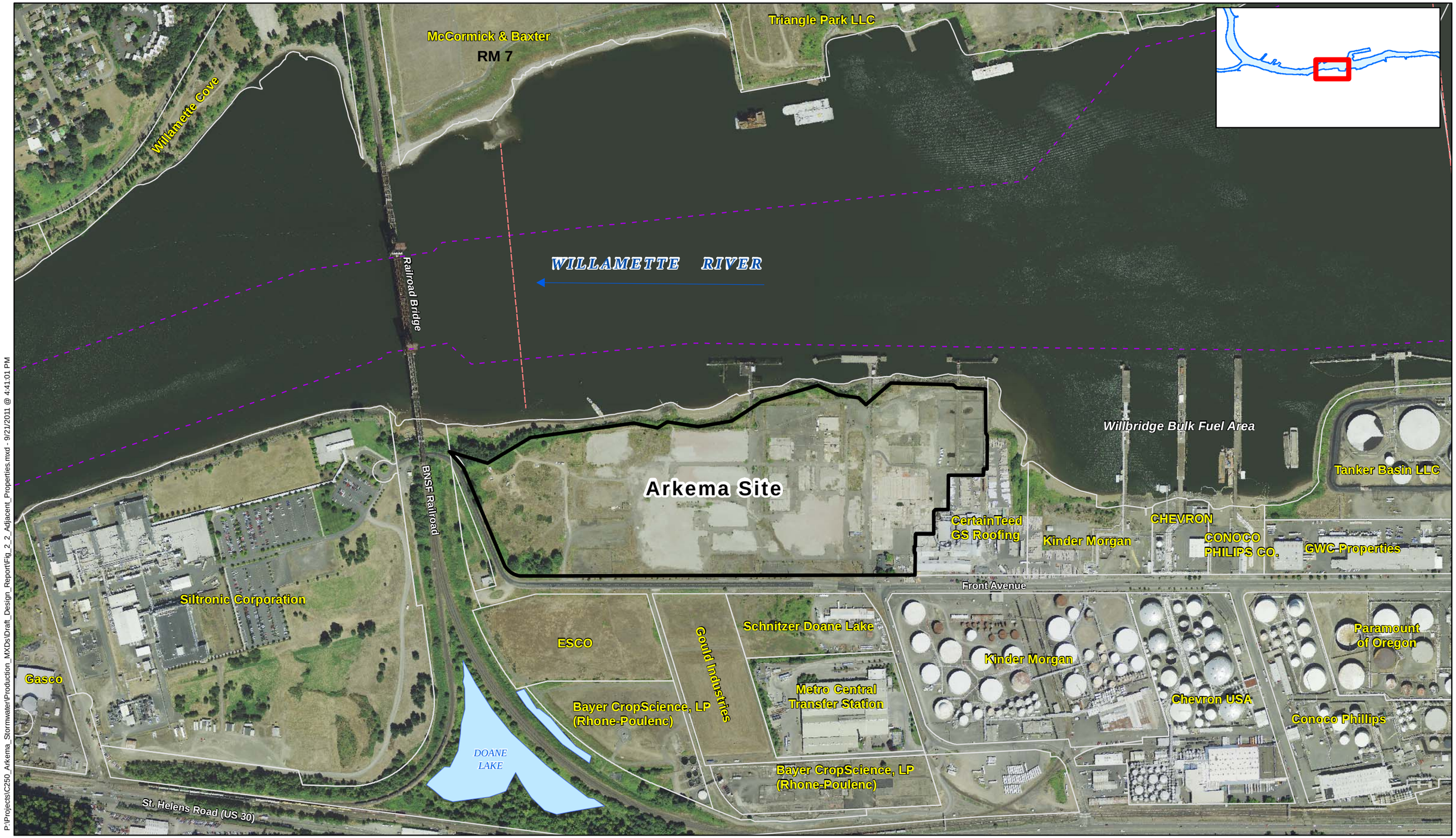
integral consulting inc.

N

FEATURE SOURCES:
Property Boundaries and Transportation Features: Metro RLIS, 2010

0 0.75 1.5 3 Miles

Figure 2-1
Site Location
Final Design Report
Stormwater Source Control Measures



P:\Projects\C250_Arkema_Stormwater\Production_MXDs\Draft_Design_Report\Fig_2_2_Adjacent_Properties.mxd - 9/21/2011 @ 4:41:01 PM

integral consulting inc.

N

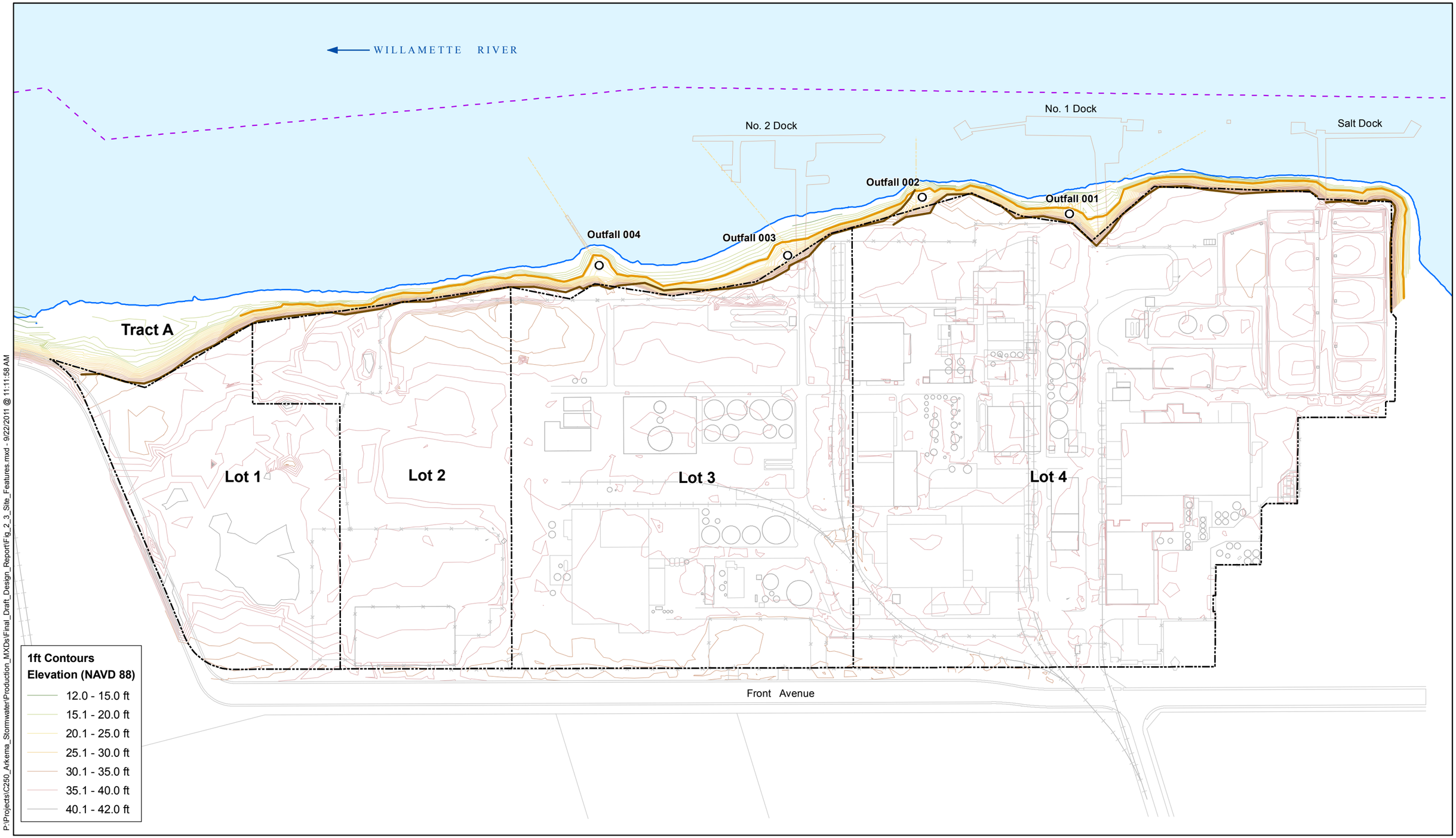
FEATURE SOURCES:
Aerial: Metro, 2007
Property Boundaries: Metro RLIS

0 125 250 500 Feet

Map Features

- River Miles
- Navigation Channel
- Waterfront Taxlots
- Current Doane Lake

Figure 2-2
Aerial Photograph and Adjacent Properties
Final Design Report
Stormwater Source Control Measures



P:\Projects\C250_Arkema_Stormwater\Production_MXDs\Final_Draft_Design_Report\Fig_2_3_Site_Features.mxd - 9/22/2011 @ 11:11:58 AM

integral consulting inc.

N

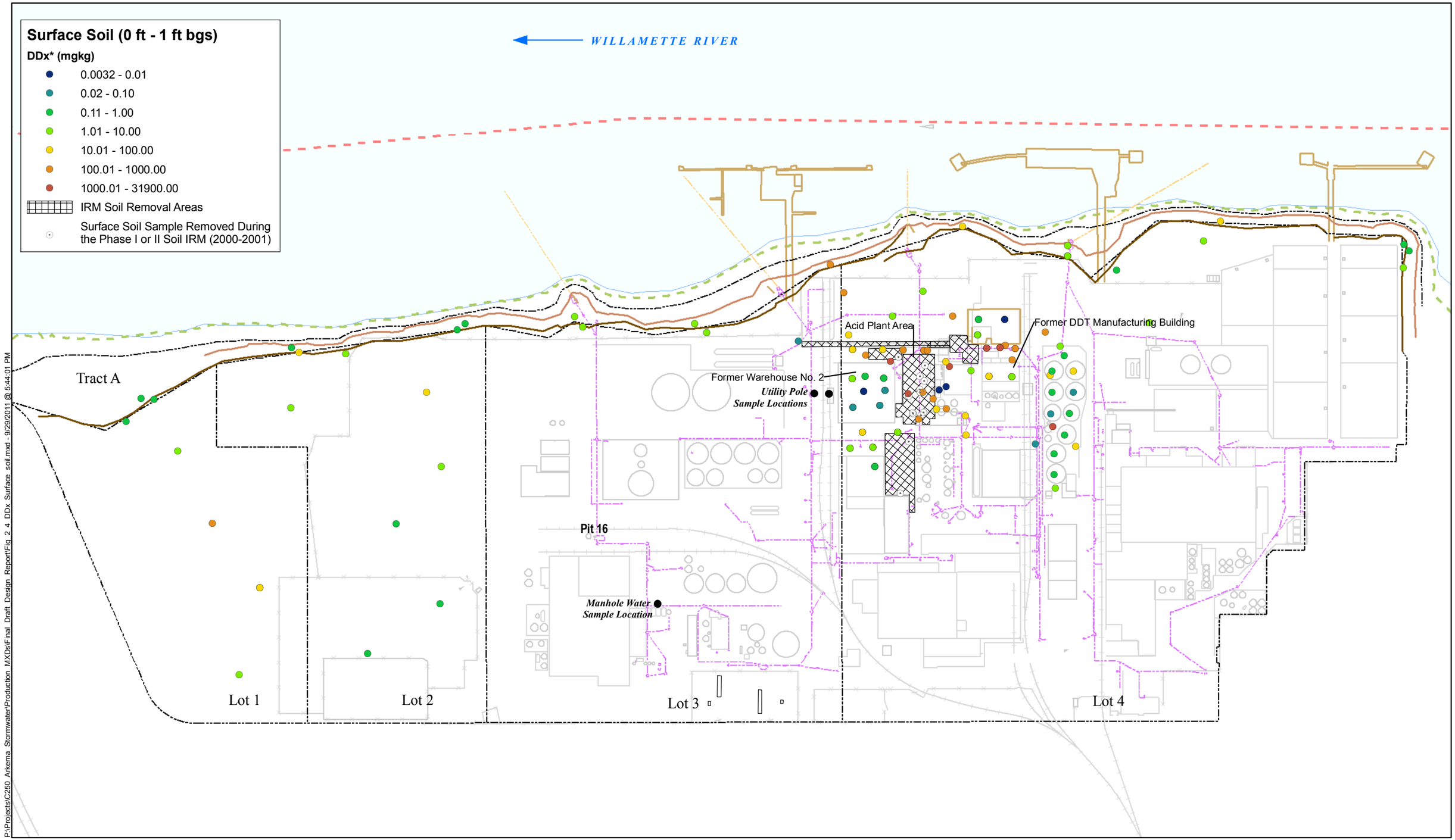
FEATURE SOURCES:
Property Boundaries, OHW, TOB, and Contours (1 ft): DEA Survey
Navigation Channel: US Army Corps of Engineers

0 100 200 400 Feet

Map Features

- Property and Lot Boundary
- Docks and Structures
- Navigation Channel
- River Edge +13 ft NAVD
- Storm Drain
- Ordinary High Water
- Top of Bank

Figure 2-3
Site Features
Final Design Report
Stormwater Source Control Measures



integral consulting inc.

FEATURE SOURCES:
Property Boundaries, OHW, TOB: DEA Survey
Channel: US Army Corps of Engineers.
NOTE:

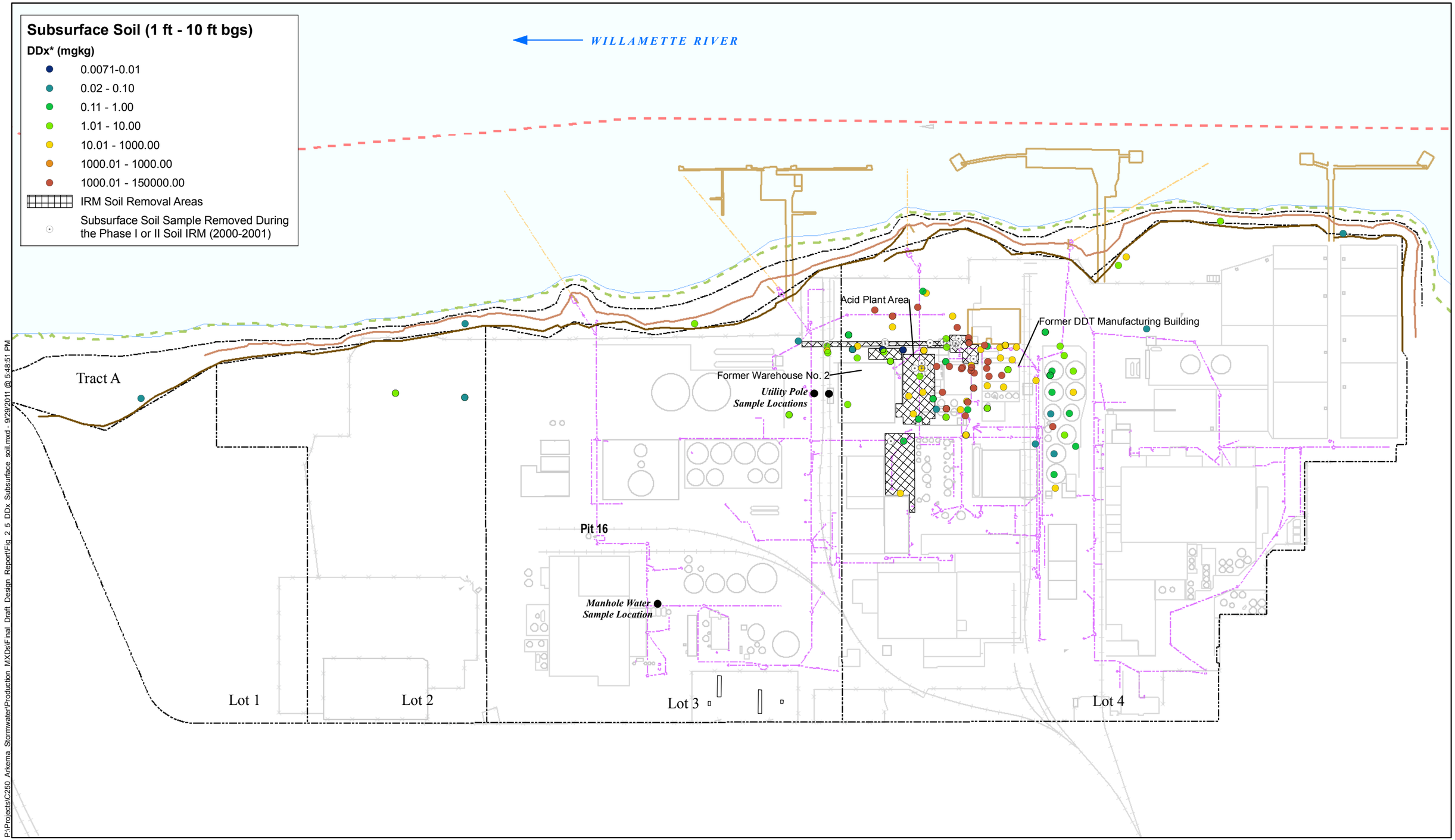
0 50 100 200 Feet

Map Features

- E-Sewer-L
- Storm Drain
- 12 ft Contour
- Navigation Channel
- River
- Ordinary High Water
- Top of Bank
- Property and Lot Boundaries

*DDx = Total of 2,4' and 4,4'-DDD, -DDE, -DDT

Figure 2-4
DDx Concentrations in Surface Soil
(0 ft - Approximately 1 ft bgs)
Final Design Report
Stormwater Source Control Measures



P:\Projects\C250_Arkema_Stormwater\Production_MXDs\Final_Draft_Design_Report\Fig_2_5_DDx_Subsurface_soil.mxd - 9/29/2011 @ 5:48:51 PM

integral consulting inc.

FEATURE SOURCES:
Property Boundaries, OHW, TOB: DEA Survey
Channel: US Army Corps of Engineers.
NOTE:

0 50 100 200 Feet

Map Features

- E-Sewer-L
- Storm Drain
- 12 ft Contour
- Navigation Channel
- River
- Ordinary High Water
- Top of Bank
- Property and Lot Boundaries

*DDx = Total of 2,4' and 4,4'-DDD, -DDE, -DDT

Figure 2-5
DDx Concentrations in Subsurface Soil
(1 ft - Approximately 10 ft bgs)
Final Design Report
Stormwater Source Control Measures

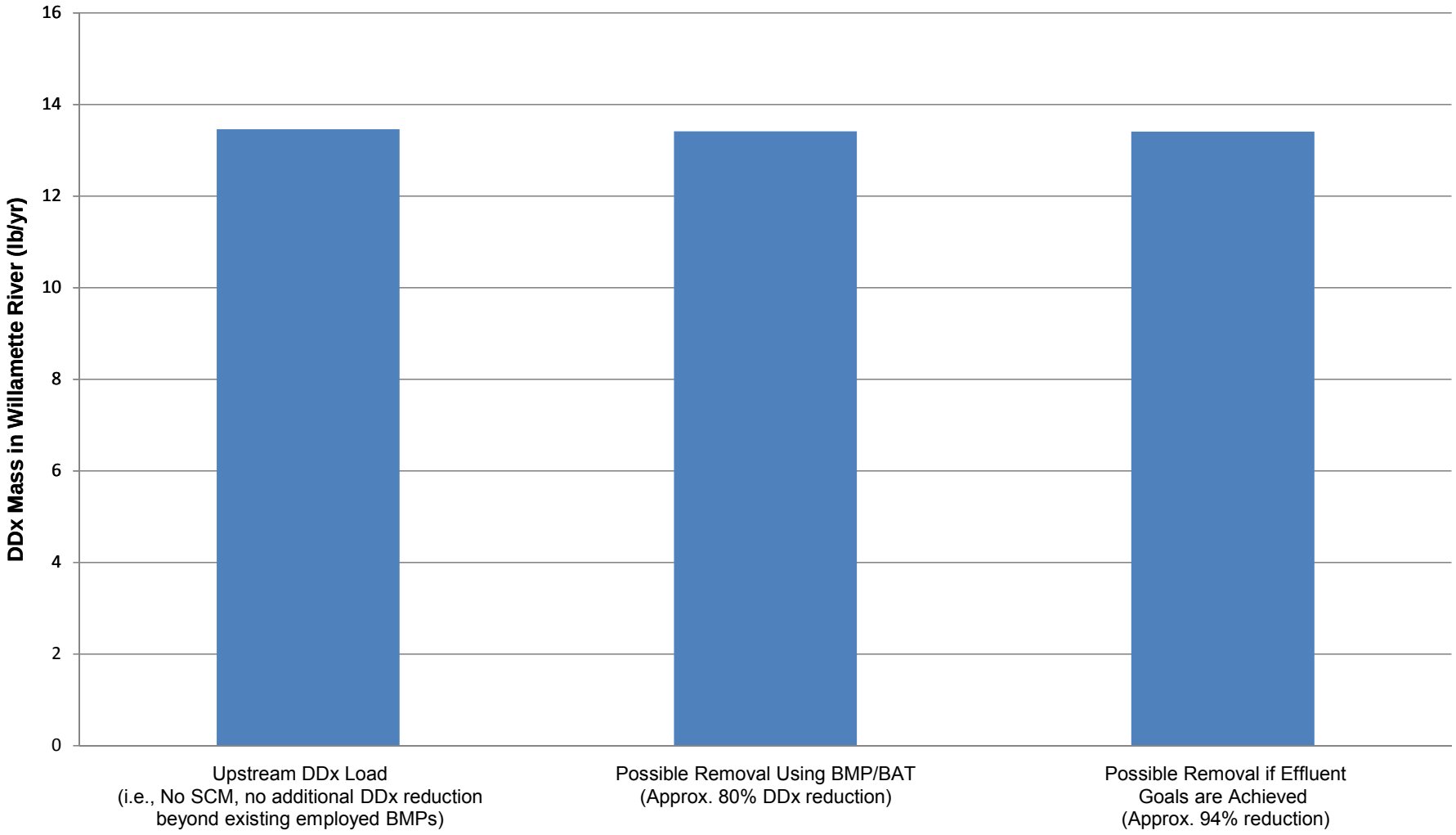


Figure 2-6
DDx Mass in the Willamette River for Three
Stormwater Source Control Measure Options
Final Design Report
Stormwater Source Control Measures

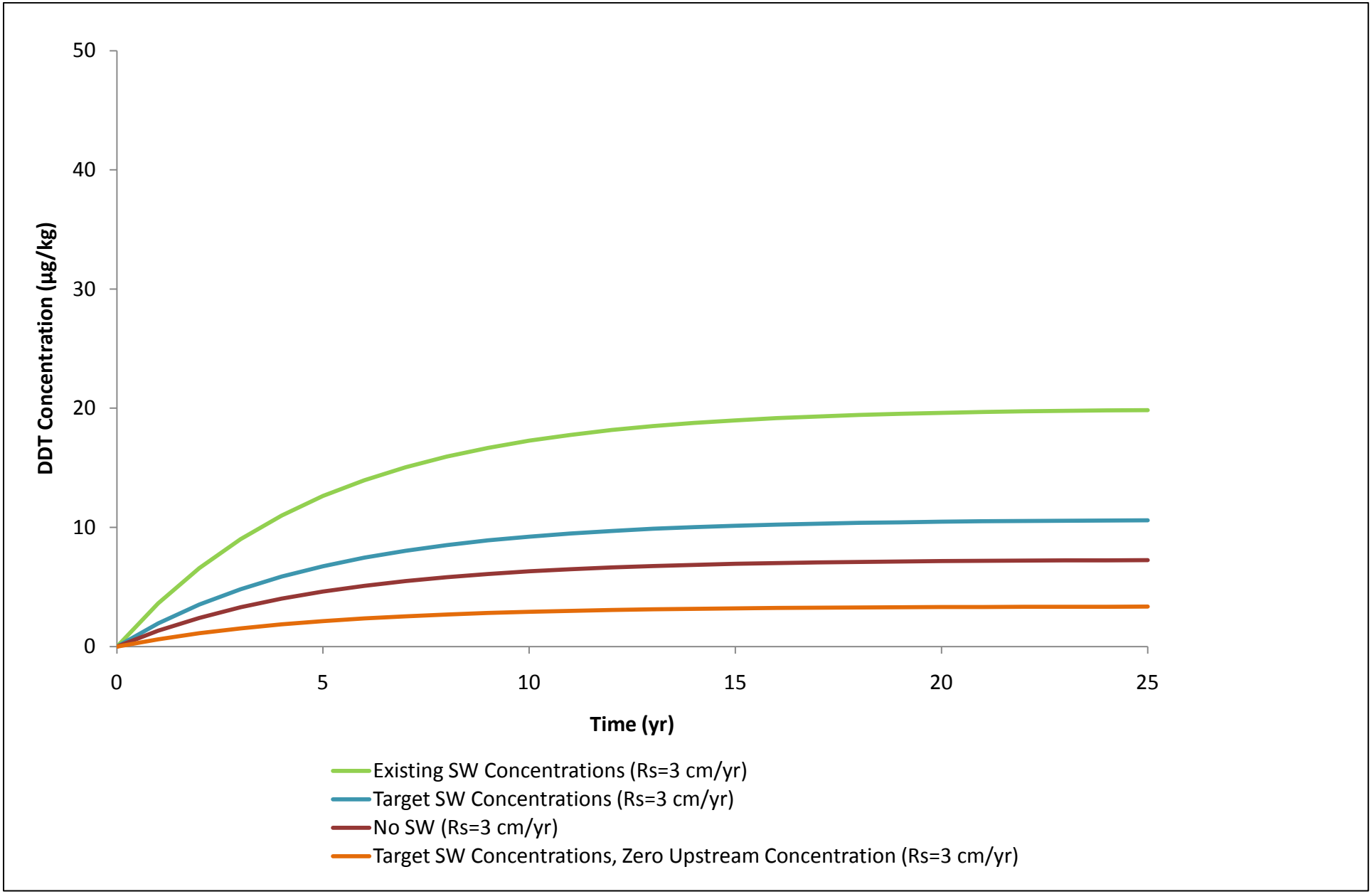


Figure 2-7
Predicted DDT Surficial Sediment Concentrations
"Best Estimate" Sedimentation Rate
Final Design Report
Stormwater Source Control Measures

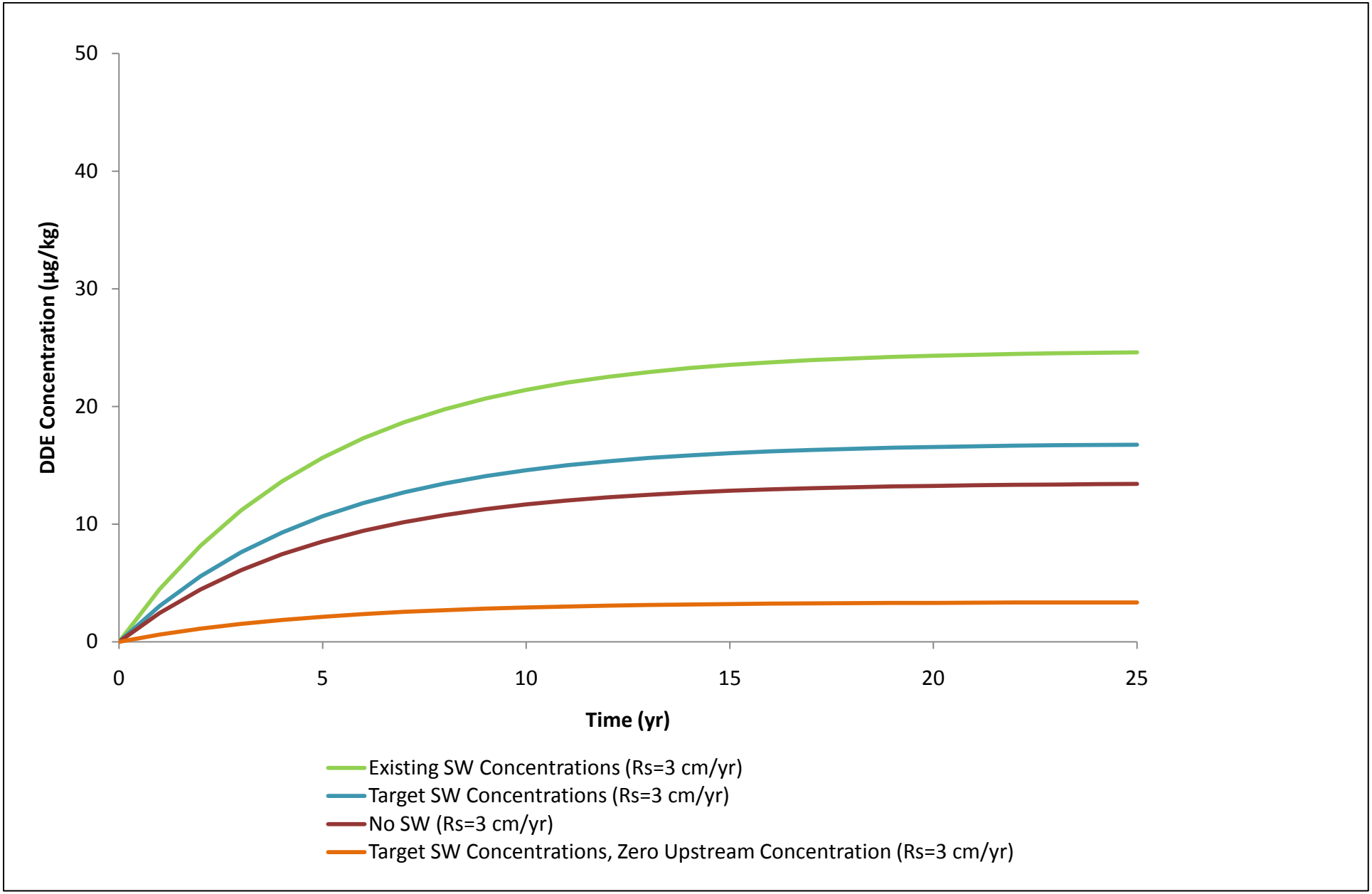
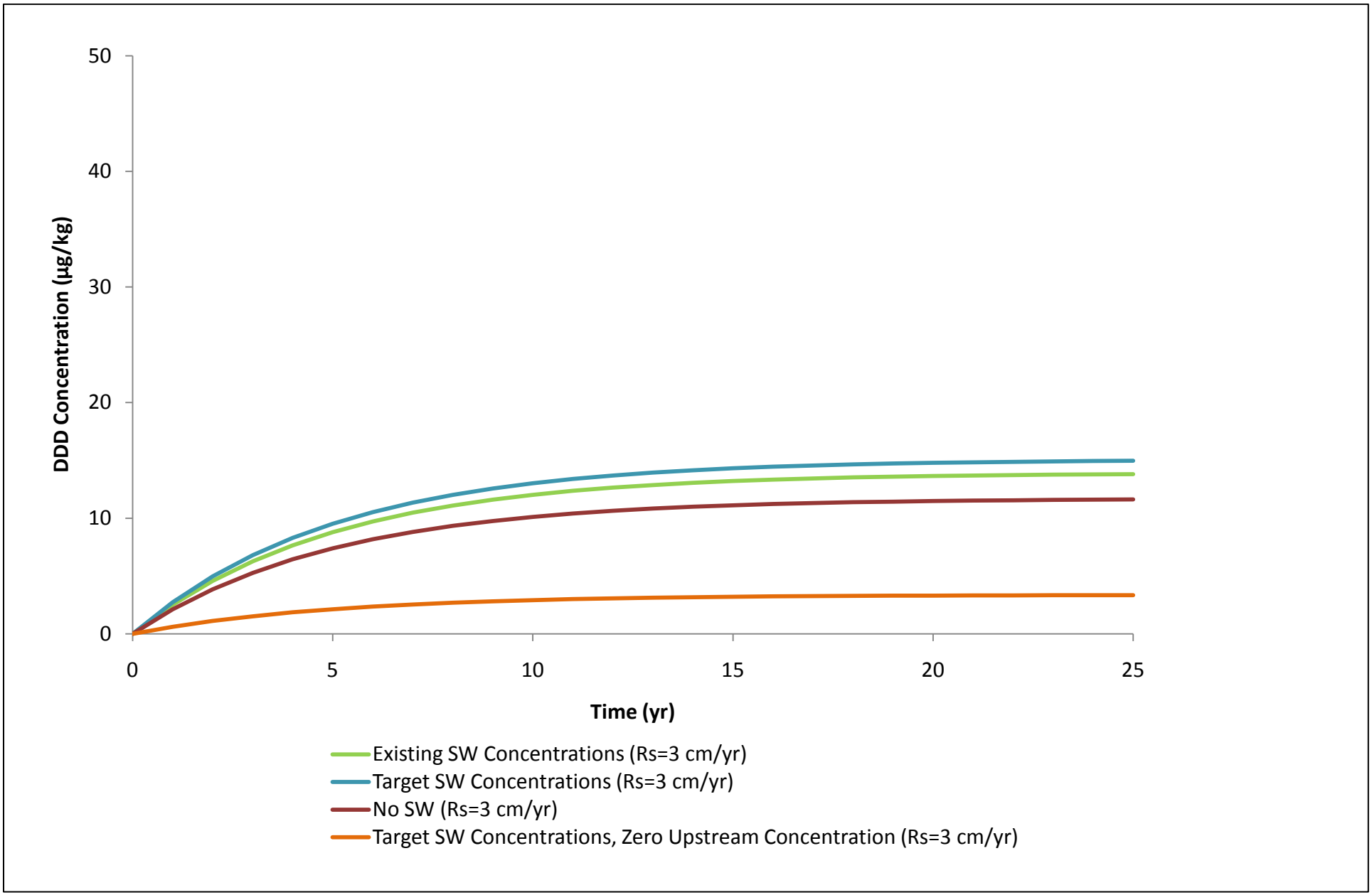
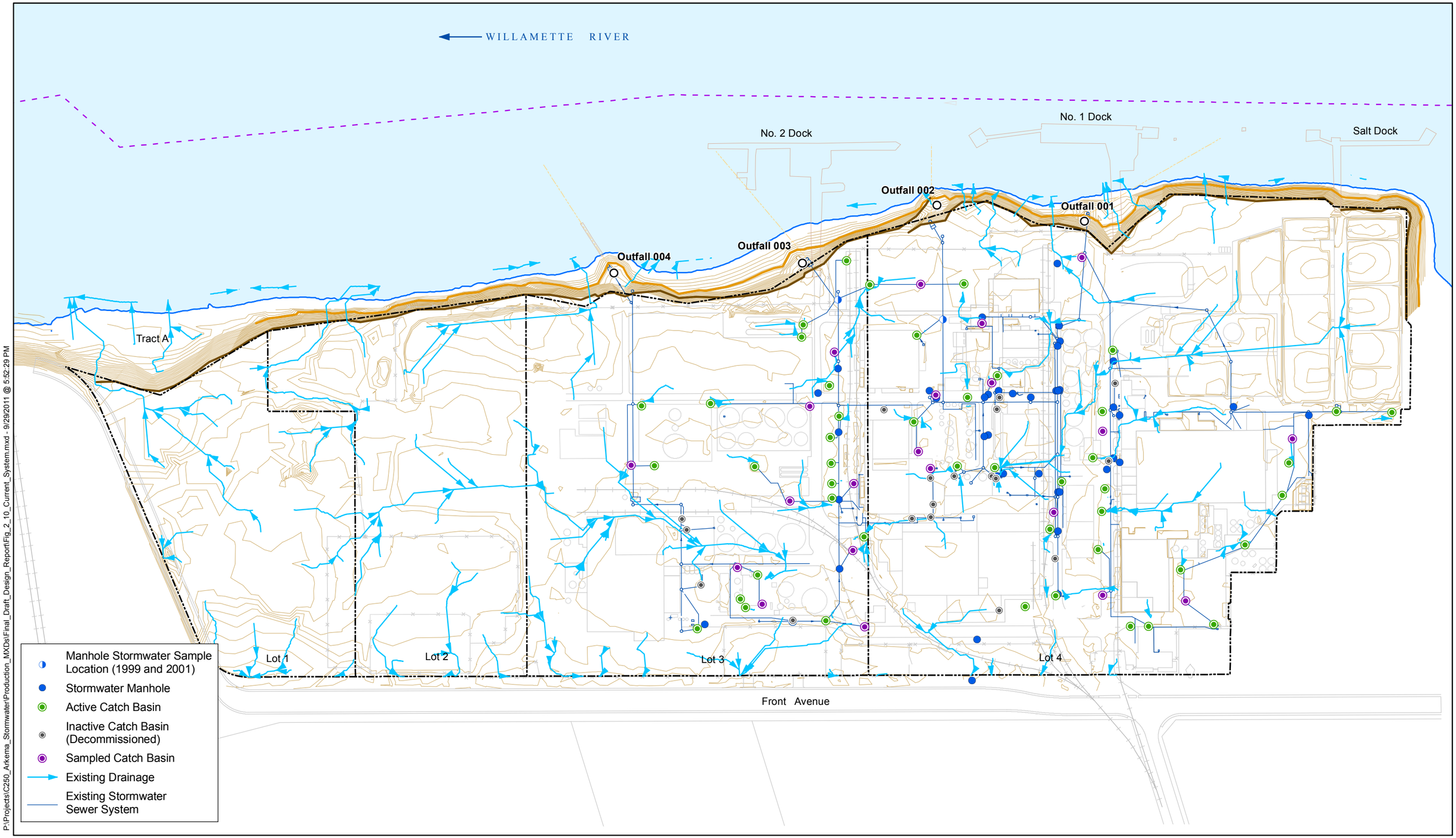


Figure 2-8
Predicted DDE Surficial Sediment Concentrations
"Best Estimate" Sedimentation Rate
Final Design Report
Stormwater Source Control Measures



integral consulting inc

Figure 2-9
Predicted DDD Surficial Sediment Concentrations
"Best Estimate" Sedimentation Rate
Final Design Report
Stormwater Source Control Measures



P:\Projects\C250_Arkema_Stormwater\Production_MXDs\Final_Draft_Design_Report\Fig_2_10_Current_System.mxd - 9/29/2011 @ 5:52:29 PM

integral consulting inc.

N

FEATURE SOURCES:
Property Boundaries, OHW, TOB, and Contours (1 ft): DEA Survey
Navigation Channel: US Army Corps of Engineers

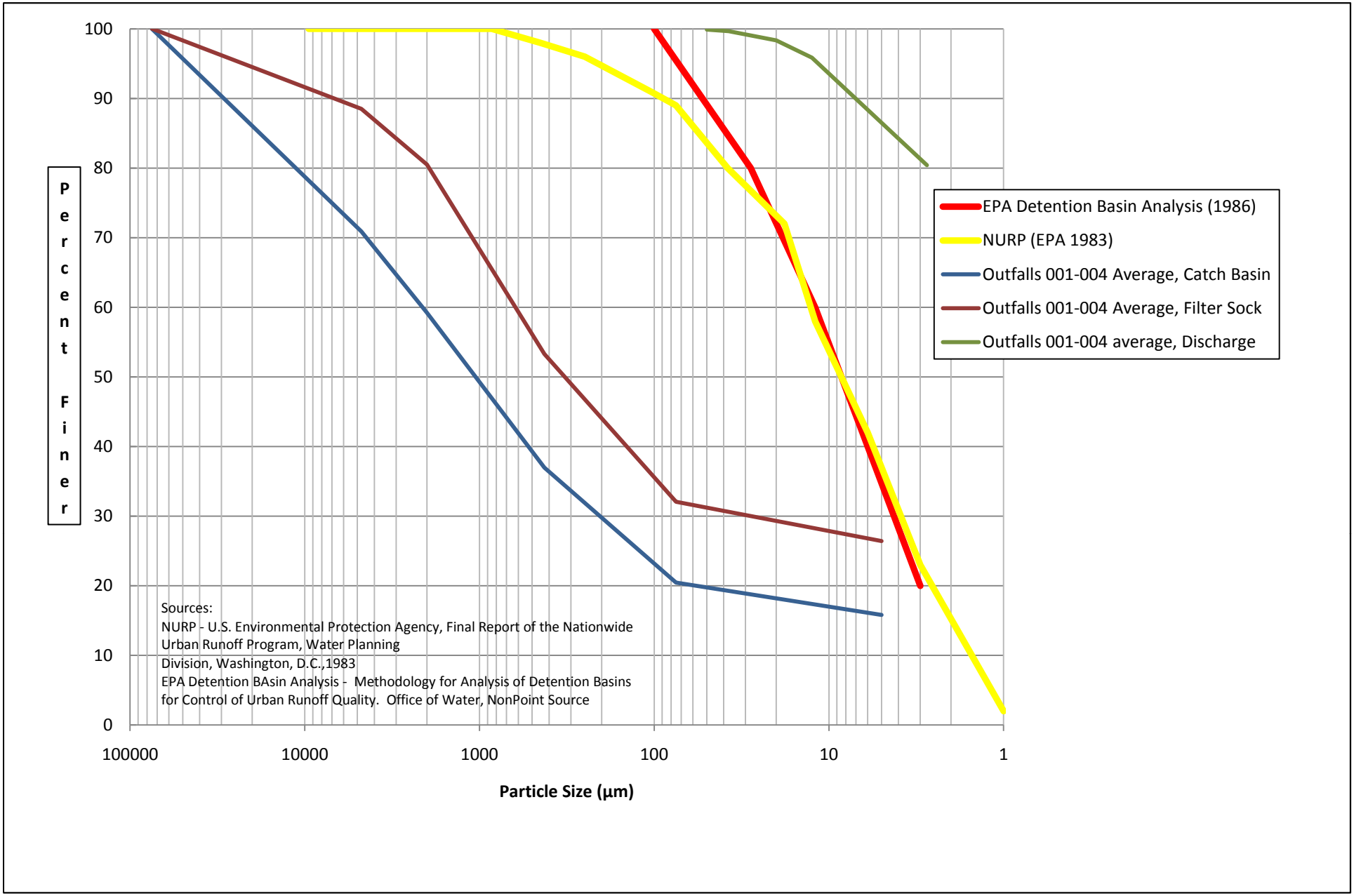
0 100 200 400 Feet

Map Features

- Property and Lot Boundary
- Docks and Structures
- Navigation Channel
- River Edge +13 ft NAVD
- Storm Drain
- Ordinary High Water
- Top of Bank

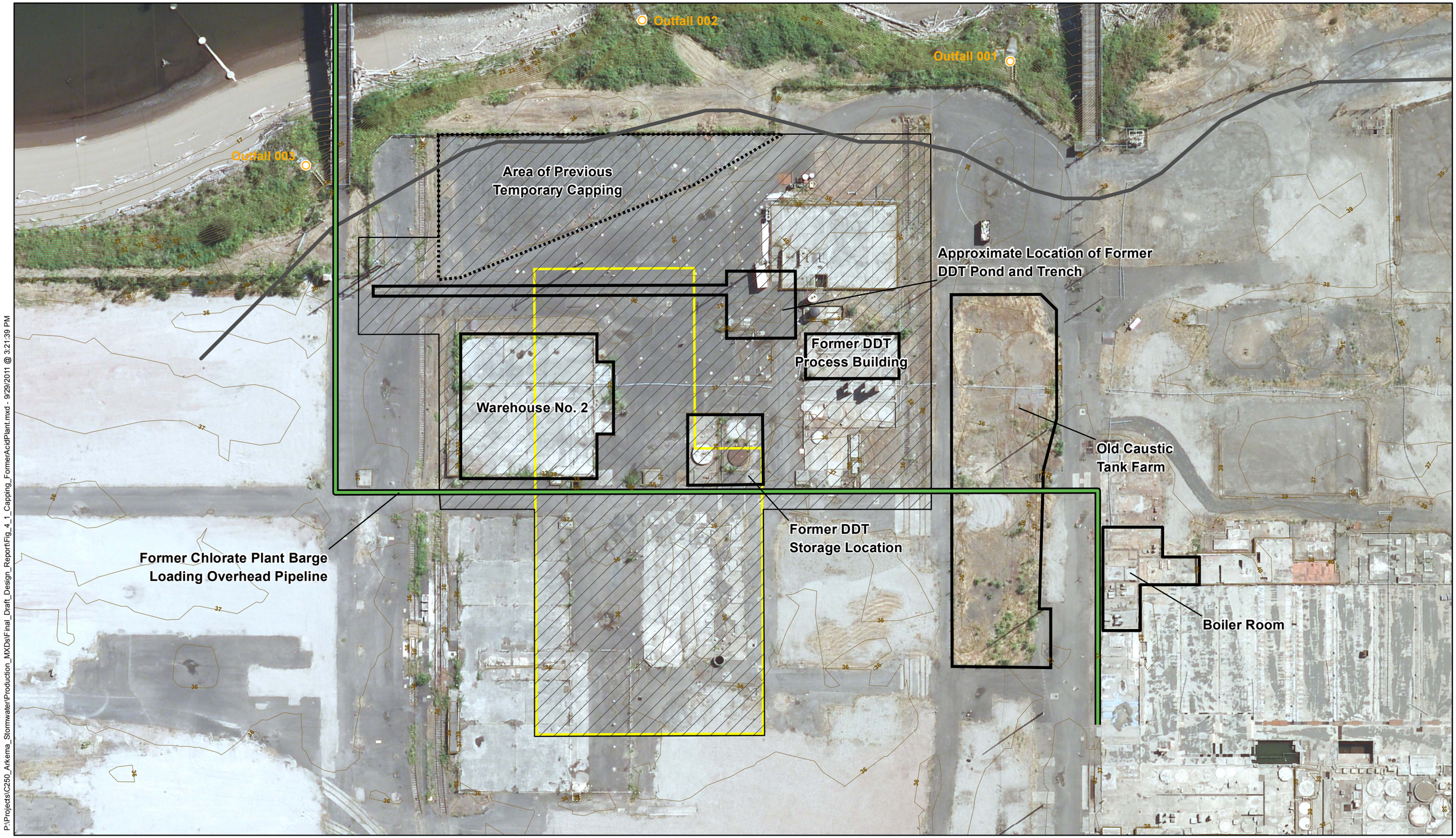
Note: Some manholes, sewers, and/or catch basins were plugged or may have been destroyed during plant demolition activities.

Figure 2-10
Current Stormwater System
Final Design Report
Stormwater Source Control Measures



integral consulting inc.

Figure 3-1
Potential Particle Size Distribution Ranges
FInal Design Report
Stormwater Source Control Measures



P:\Projects\C250_Arkema_Stormwater\Production_MXDs\Final_Draft_Design_Report\Fig_4_1_Capping_FormerAcidPlant.mxd - 9/29/2011 @ 3:21:39 PM

integral consulting inc.

N

FEATURE SOURCES:
Aerial: Metro, June-July 2009
Contours (1 ft): DEA Survey

0 40 80 160 Feet

Map Features

- Acid Plant Area and Vicinity
- Historic Operational Areas
- Groundwater Barrier Wall
- Parshall Flume Outfall
- Previously Delineated Drainage Basin to Outfall 002

Figure 4-1
Temporary Capping - Area of Former Acid Plant
and Drainage Subbasin for Outfall 002
Final Design Report
Stormwater Source Control Measures

P:\Projects\C250_Arkema_Stormwater\Production_MXDs\Final_Draft_Design_Report\Fig_4_2_Capping_SiteSurface.mxd - 9/22/2011 @ 9:50:43 AM

integral consulting inc.

N

FEATURE SOURCES:
Aerial: Metro, June-July 2009
Contours (1 ft): DEA Survey

0 40 80 160 Feet

Map Features

- Previously Delineated Drainage Basin to Outfall 002
- Erodible (Exposed) Soil
- Paved Areas
- Building Foundation

DRAFT
DO NOT QUOTE OR CITE

Figure 4-2
Temporary Capping - Site Surface Features
Final Design Report
Stormwater Source Control Measures

P:\Projects\C250_Arkema_Stormwater\Production_MXDs\Final_Draft_Design_Report\Fig_4_3_Capping_SiteConst.mxd - 9/22/2011 @ 10:06:57 AM

integral consulting inc.

N

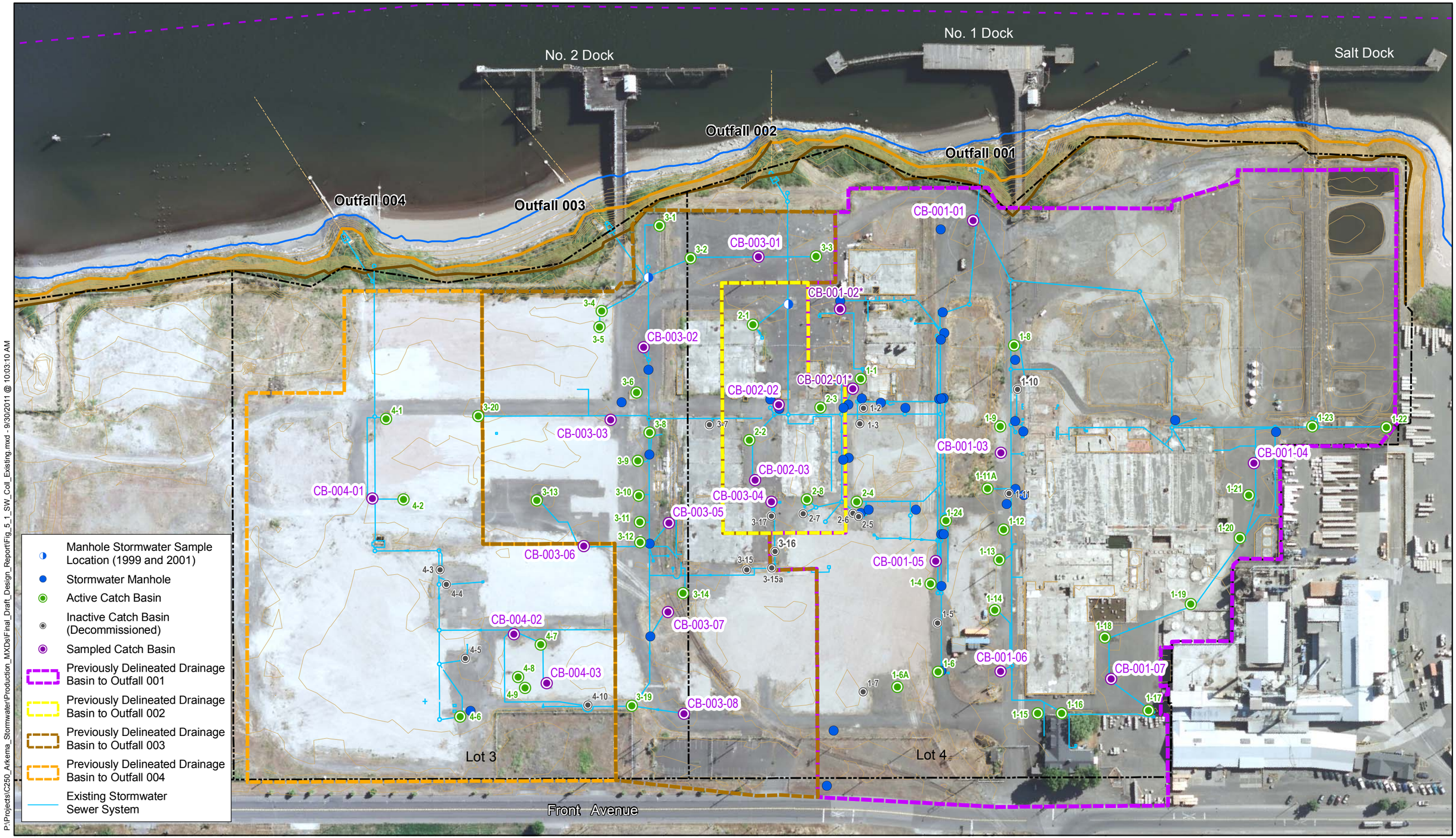
FEATURE SOURCES:
Aerial: Metro, June-July 2009
Contours (1 ft): DEA Survey

0 30 60 120 Feet

Map Features

- Foundation/Railroad - Fill to Level Grade and Cap
- Erodible (Exposed) Soil - Cap
- Paved Areas - Repair As Needed
- Foundation - Reseal with Concrete Sealer

Figure 4-3
Temporary Capping - Site Construction Plan
Final Design Report
Stormwater Source Control Measures



P:\Projects\C250_Arkema_Stormwater\Production_MXDs\Final_Draft_Design_Report\Fig_5_1_SW_Coll_Existing.mxd - 9/30/2011 @ 10:03:10 AM

integral consulting inc.

FEATURE SOURCES:
Property Boundaries, OHW, TOB, and Contours (1 ft) : DEA Survey
Navigation Channel: US Army Corps of Engineers

0 75 150 300 Feet

Map Features

- Property and Lot Boundary
- River Edge +13 ft NAVD
- Navigation Channel
- Storm Drain
- Ordinary High Water
- Top of Bank

Note: Some manholes, sewers, and/or catch basins were plugged or may have been destroyed during plant demolition activities.

Figure 5-1
Decommissioning of Existing Stormwater Collection System – Existing Conditions
Final Design Report
Stormwater Source Control Measures

P:\Projects\C250_Arkema_Stormwater\Production_MXDs\Final_Draft_Design_Report\Fig_5_2_Decommissioning.mxd - 9/30/2011 @ 10:12:13 AM

integral consulting inc.

N

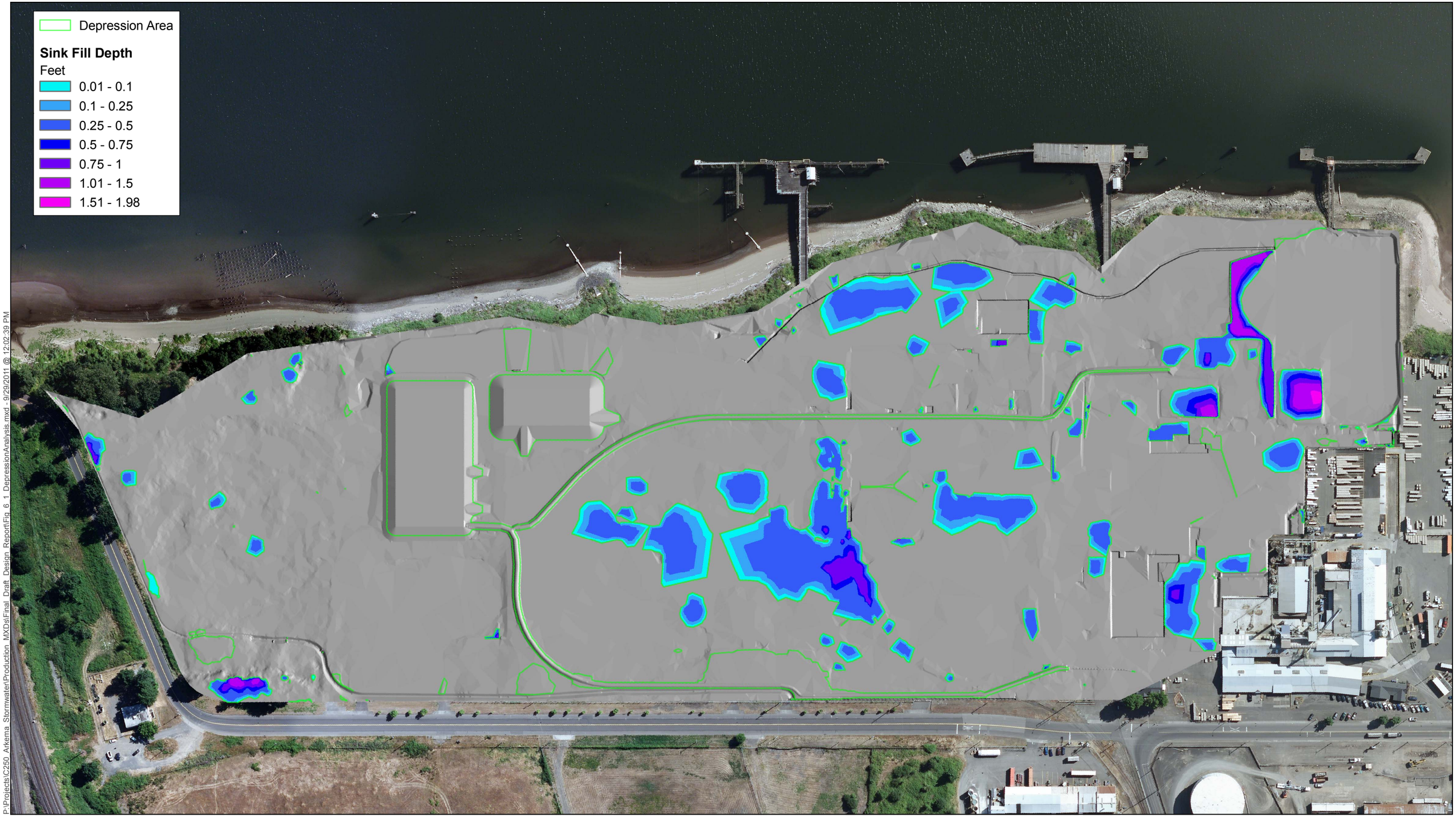
FEATURE SOURCES:
Aerial: Metro, June-July 2009
Property Boundaries and Stormwater Collection Features: DEA Survey

0 50 100 200 Feet

Map Features

- Manhole Stormwater Sample Location (1999 and 2001)
- Stormwater Manhole
- Active Catch Basin
- Inactive Catch Basin (Decommissioned)
- Sampled Catch Basin
- Existing Stormwater Sewer System
- Stormwater Line to be Decomissioned
- Channel Extents
- Groundwater Barrier Wall and Cap
- Detention Basin/Sand Filter Feature
- Property and Lot Boundary

Figure 5-2
Decommissioning of Existing Stormwater Collection System
Final Design Report
Stormwater Source Control Measures



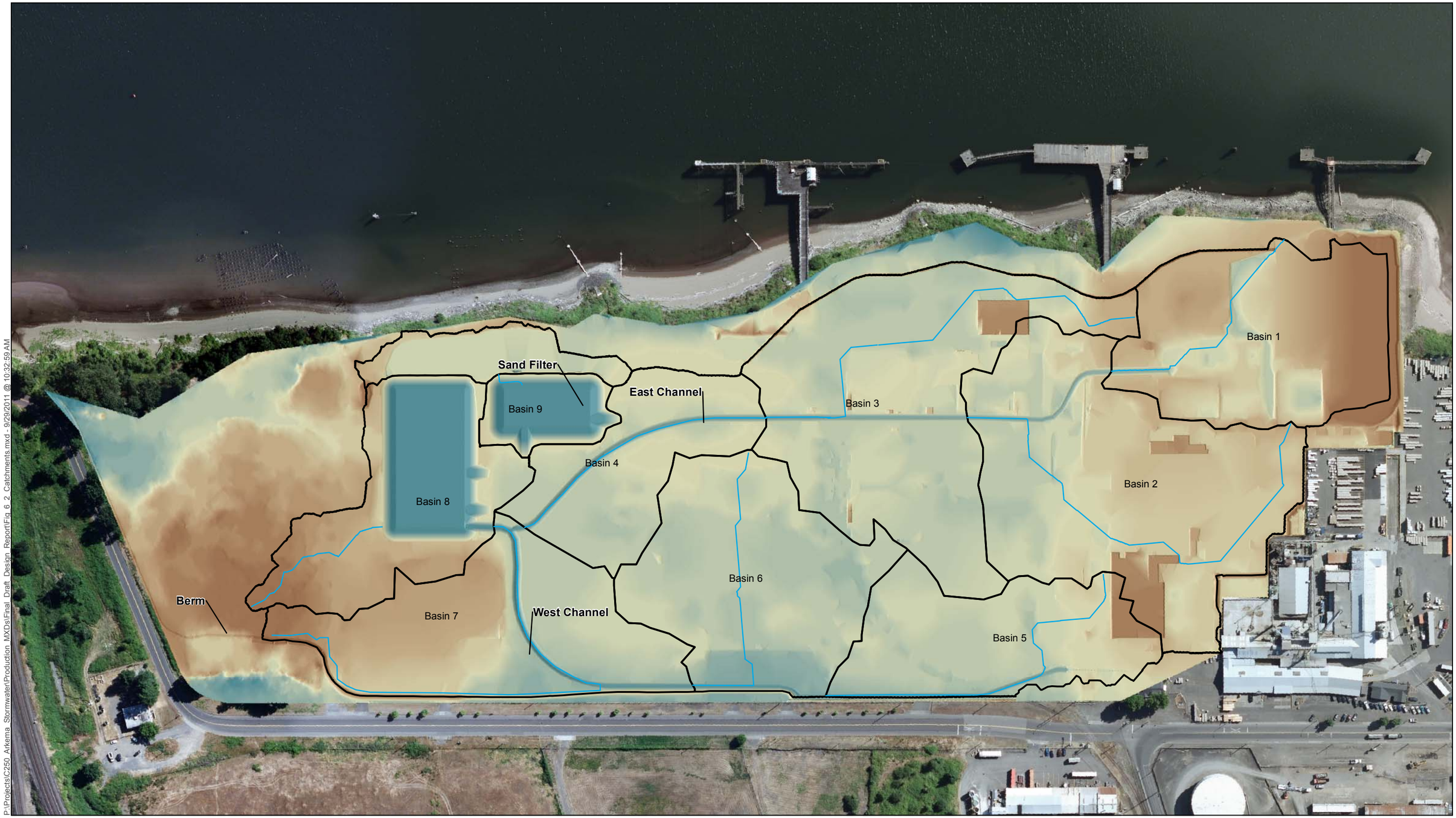
P:\Projects\C250 Arkema Stormwater\Production MXDs\Final Draft Design Report\Fig 6 1 DepressionAnalysis.mxd - 9/29/2011 @ 12:02:39 PM

integral consulting inc.

N

0 100 200
Feet

Figure 6-1
Depression Analysis
Final Design Report
Stormwater Source Control Measures



P:\Projects\C250 Arkema Stormwater\Production MXDs\Final Draft Design Report\Fig 6_2 Catchments.mxd - 9/29/2011 @ 10:32:59 AM

integral consulting inc.

0 100 200
Feet

Catchment Longest Flow Path
Catchments

DEM (1ft Resolution)

Value

High : 44.5

Low : 14.4882

Figure 6-2
Drainage Catchments
Final Design Report
Stormwater Source Control Measures

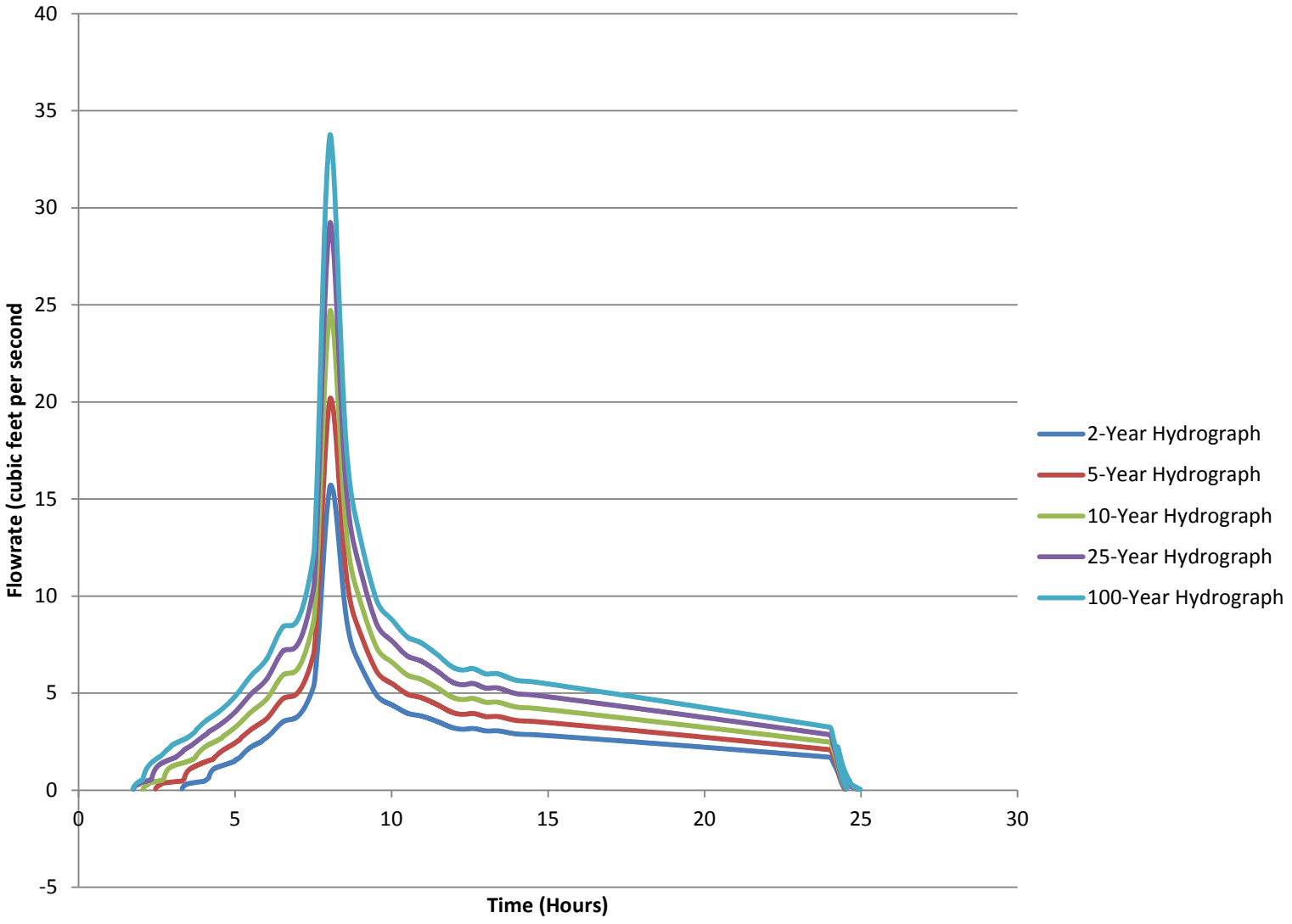
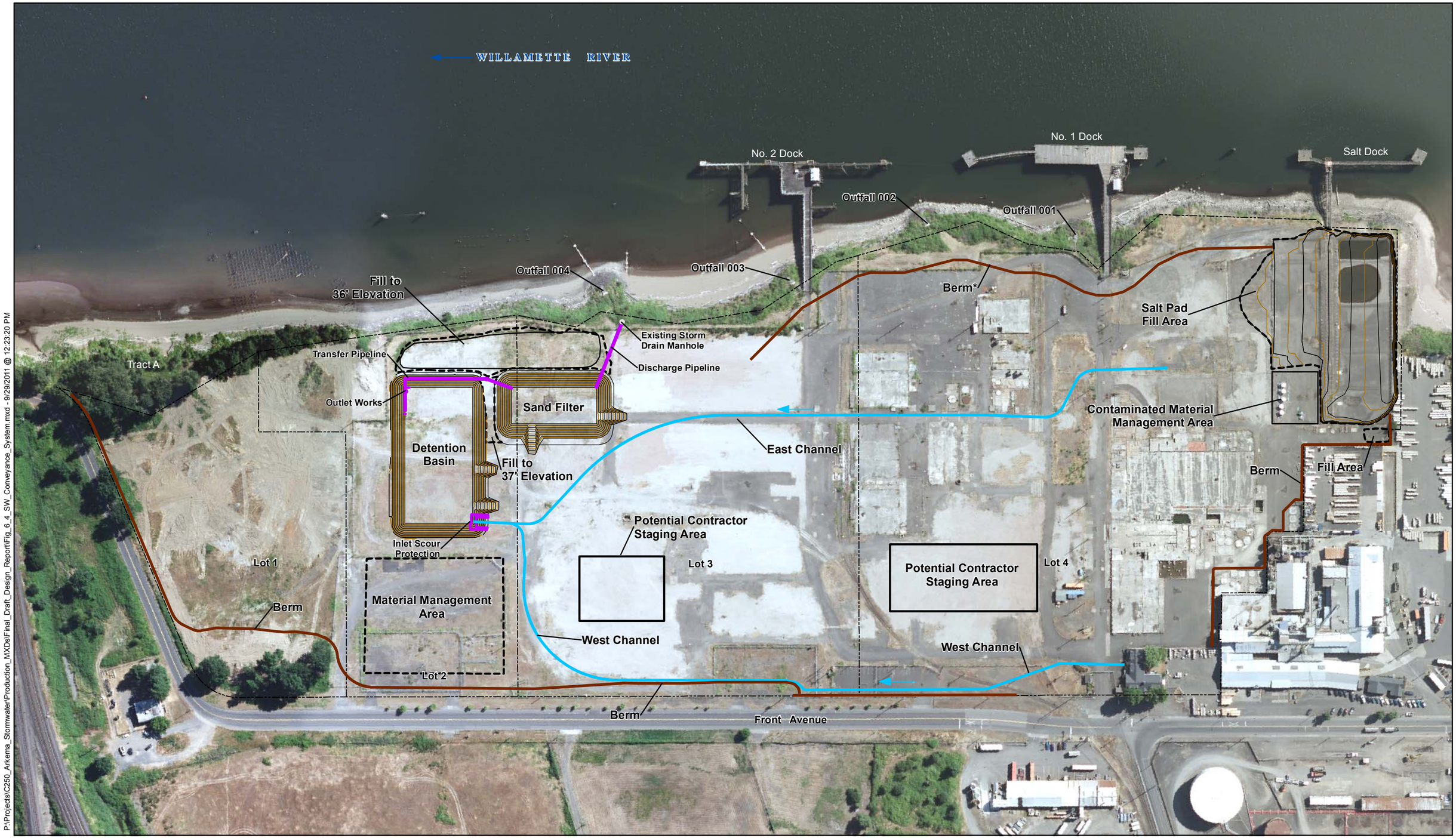


Figure 6-3
Outlet Hydrographs from WinTR-55 Modeling
Final Design Report
Stormwater Source Control Measures



P:\Projects\C250_Arkema_Stormwater\Production_MXDs\Final_Draft_Design_Report\Fig_6_4_SW_Conveyance_System.mxd - 9/29/2011 @ 12:23:20 PM

integral consulting inc.

FEATURE SOURCES:
Aerial: Metro, June-July 2009
Property Boundaries: DEA Survey

N

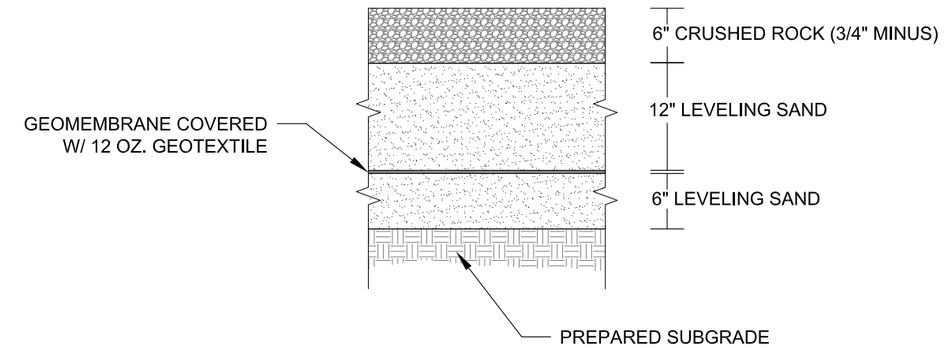
0 100 200 400 Feet

Map Features

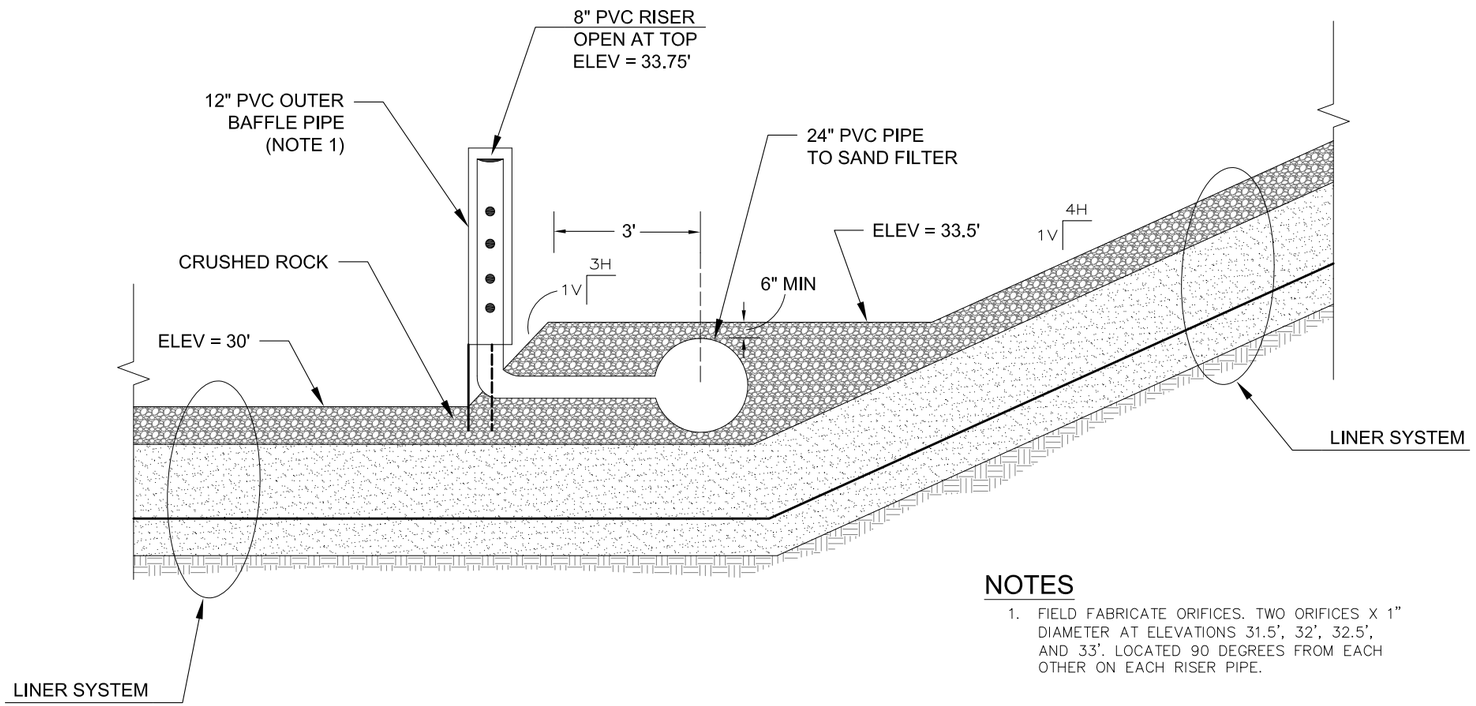
- Channel
- Berm
- Detention Basin/Sand Filter Feature
- Areas to be Filled
- Property and Lot Boundary

*Berm follows alignment of proposed groundwater barrier wall and cap.

Figure 6-4
Stormwater Conveyance and Treatment General Layout
Final Design Report
Stormwater Source Control Measures



LINER SYSTEM DETAIL
N.T.S.



NOTES

1. FIELD FABRICATE ORIFICES. TWO ORIFICES X 1" DIAMETER AT ELEVATIONS 31.5', 32', 32.5', AND 33'. LOCATED 90 DEGREES FROM EACH OTHER ON EACH RISER PIPE.

OUTLET STRUCTURE DETAIL
N.T.S.

integral consulting inc.

Figure 6-5
Detention Basin Outlet Structure
Final Design Report
Stormwater Source Control Measures

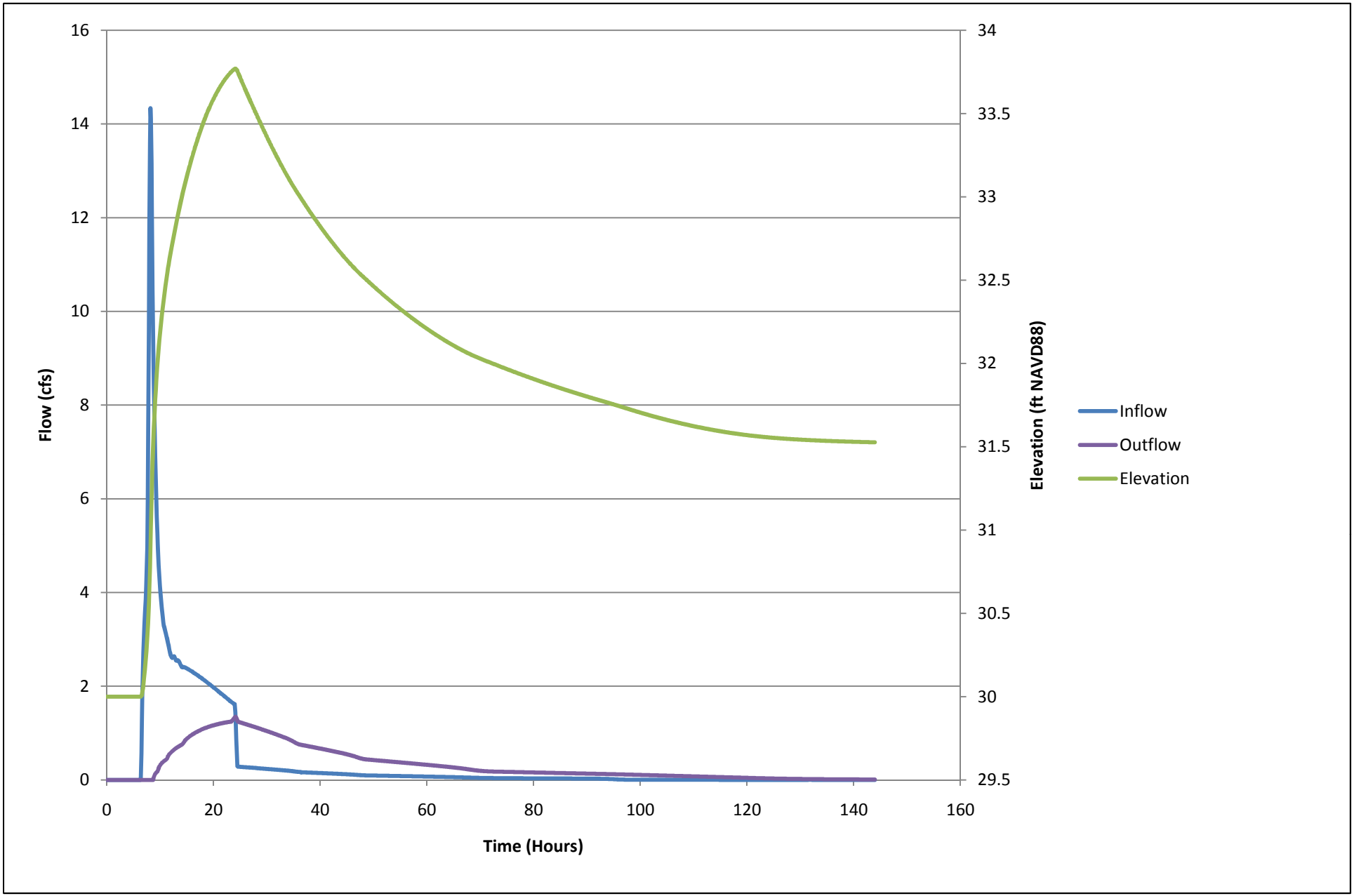


Figure 6-6
2-Year Detention Basin Outlet Hydrograph
Final Design Report
Stormwater Source Control Measures

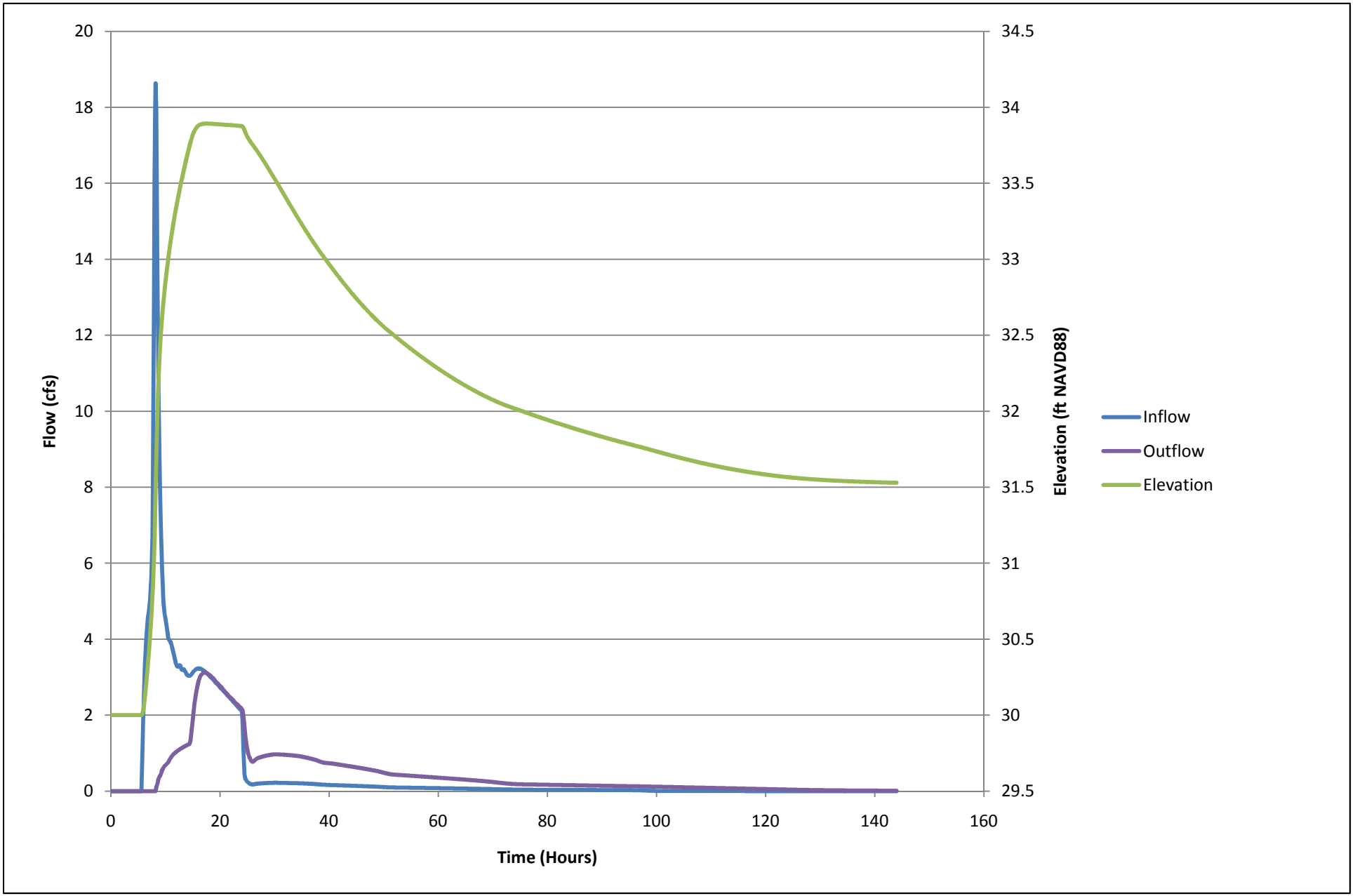


Figure 6-7
5-Year Detention Basin Outlet Hydrograph
Final Design Report
Stormwater Source Control Measures

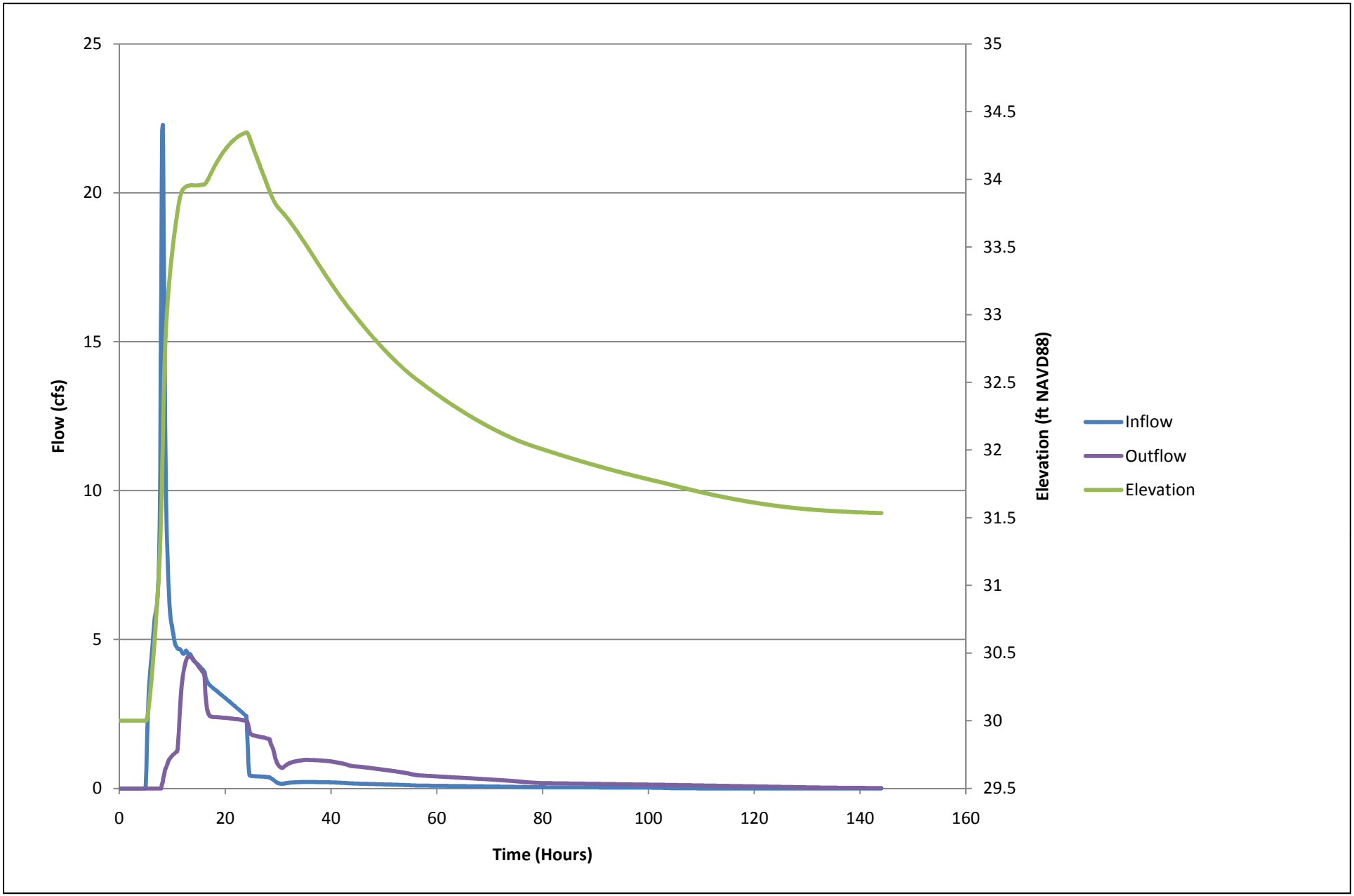


Figure 6-8
10-Year Detention Basin Outlet Hydrograph
Final Design Report
Stormwater Source Control Measures

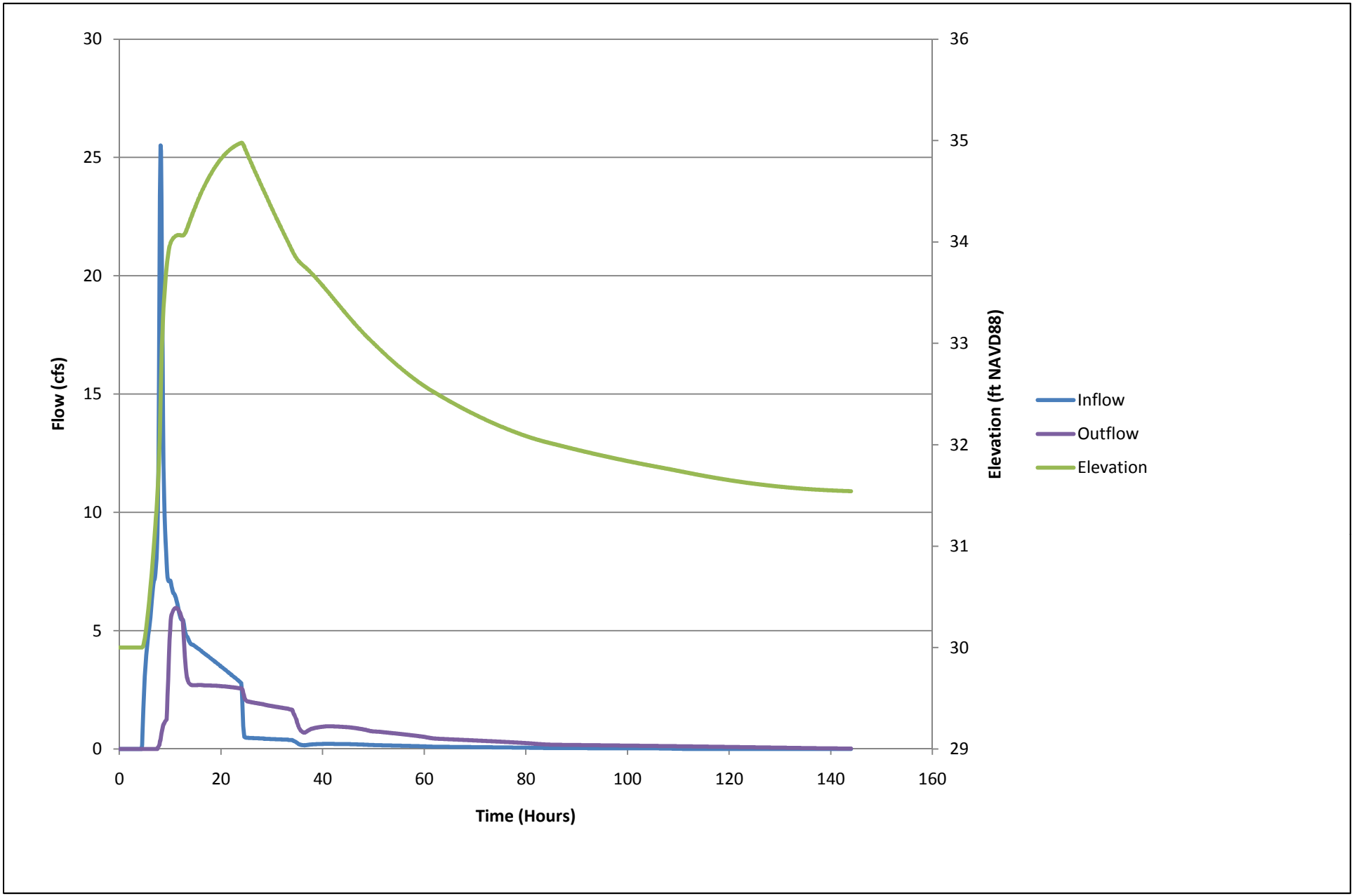


Figure 6-9
25-Year Detention Basin Outlet Hydrograph
Final Design Report
Stormwater Source Control Measures

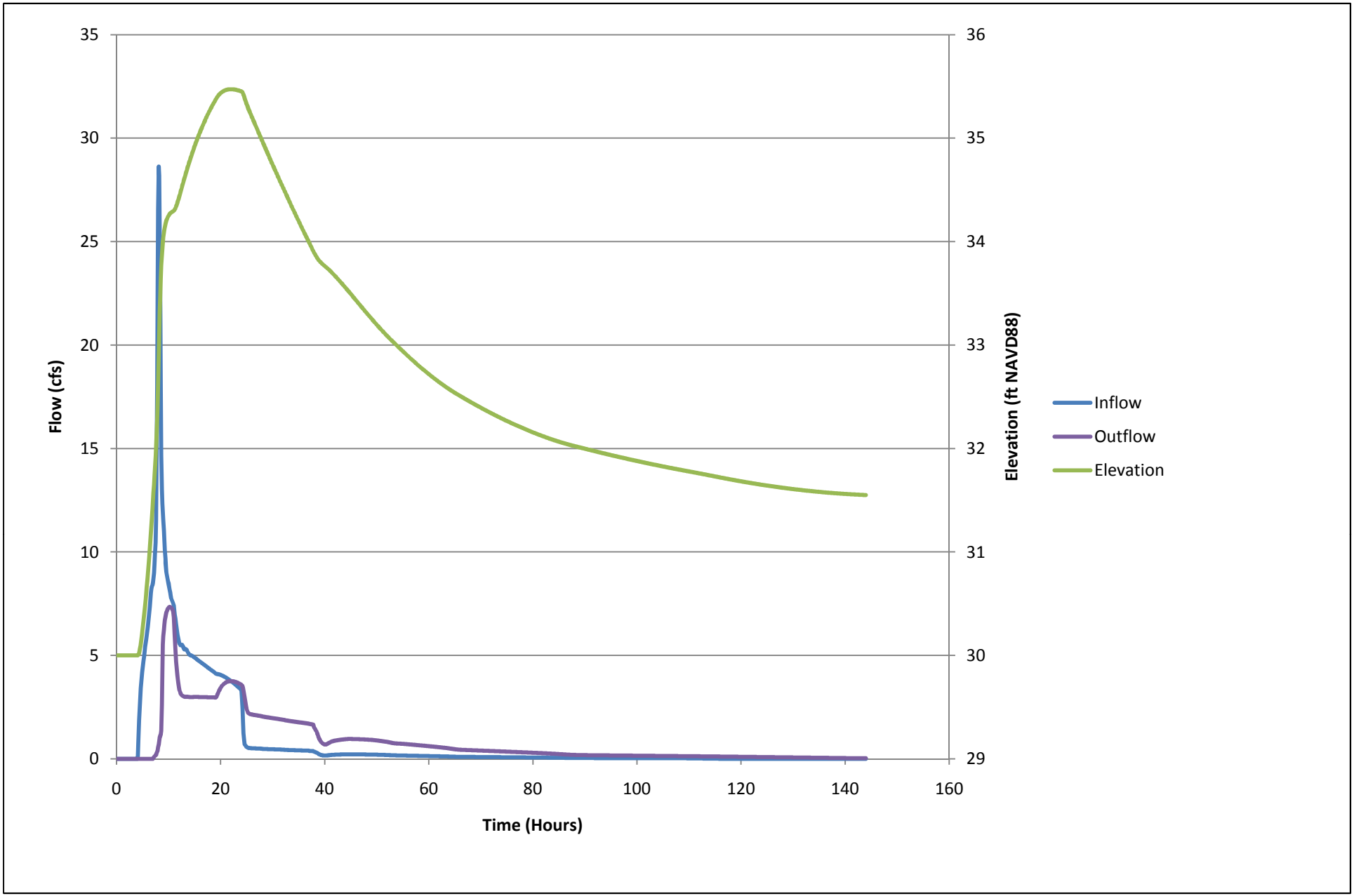
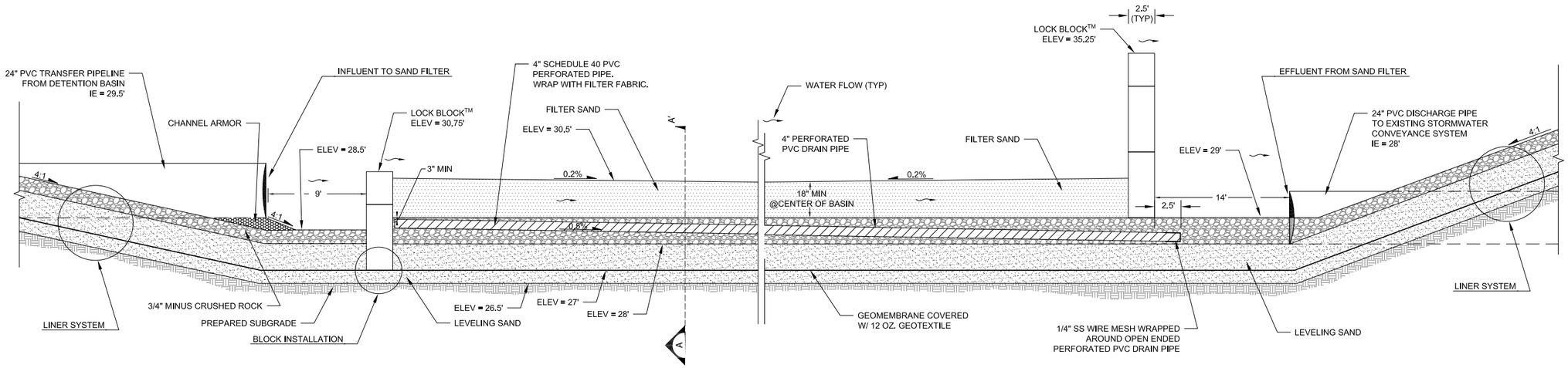
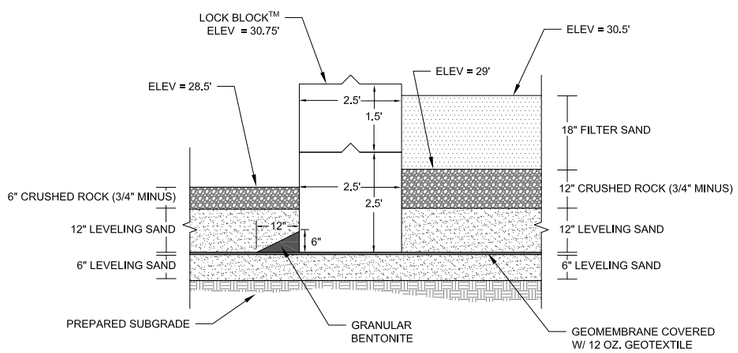


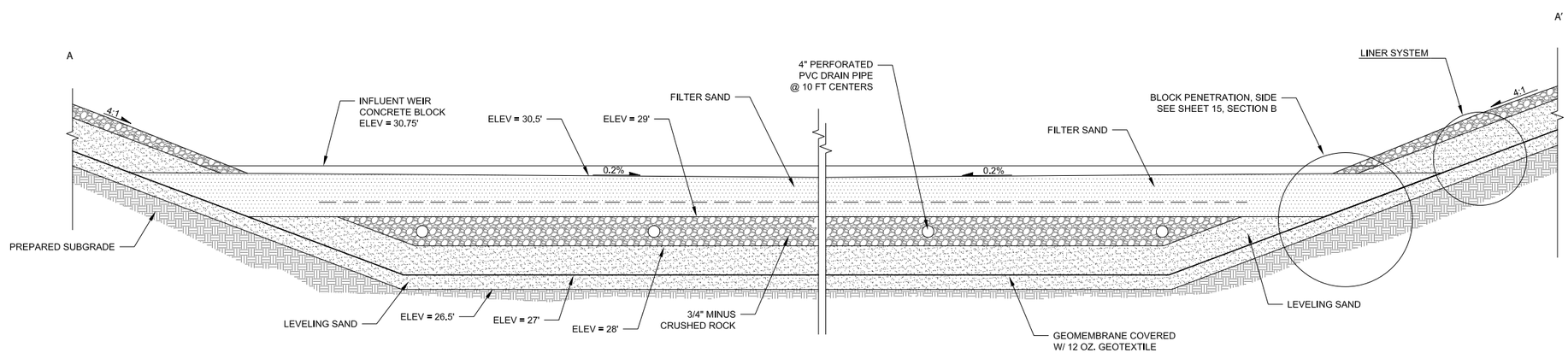
Figure 6-10
100-Year Detention Basin Outlet Hydrograph
Final Design Report
Stormwater Source Control Measures



SAND FILTER DETAIL
N.T.S.



BLOCK INSTALLATION
N.T.S.



SAND FILTER CROSS SECTION
N.T.S.

integral consulting inc.

Figure 6-11
Sand Filter Cross Sections
Final Design Report
Stormwater Source Control Measures

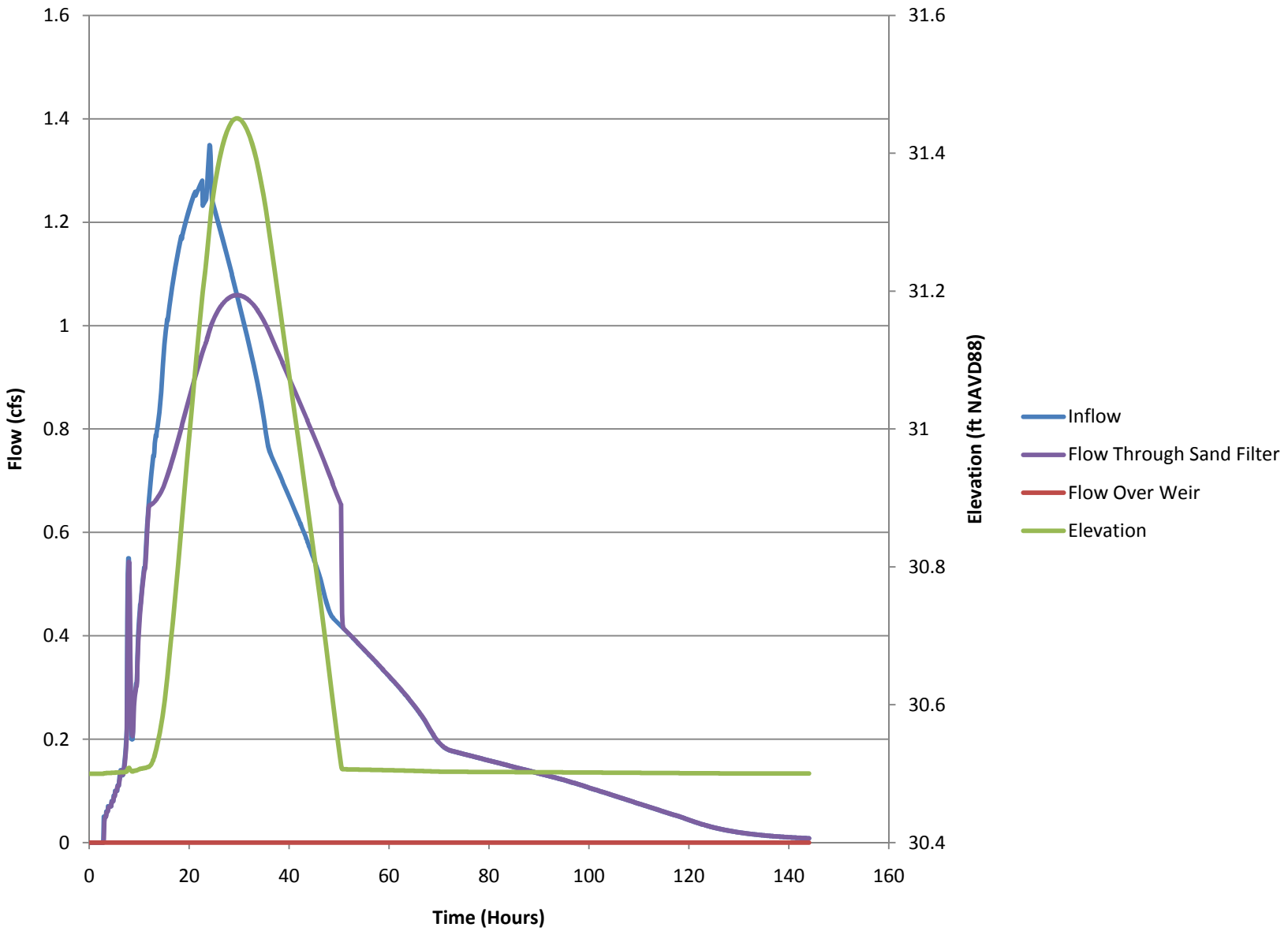


Figure 6-12
2-Year Sand Filter Outlet Hydrograph
Final Design Report
Stormwater Source Control Measures

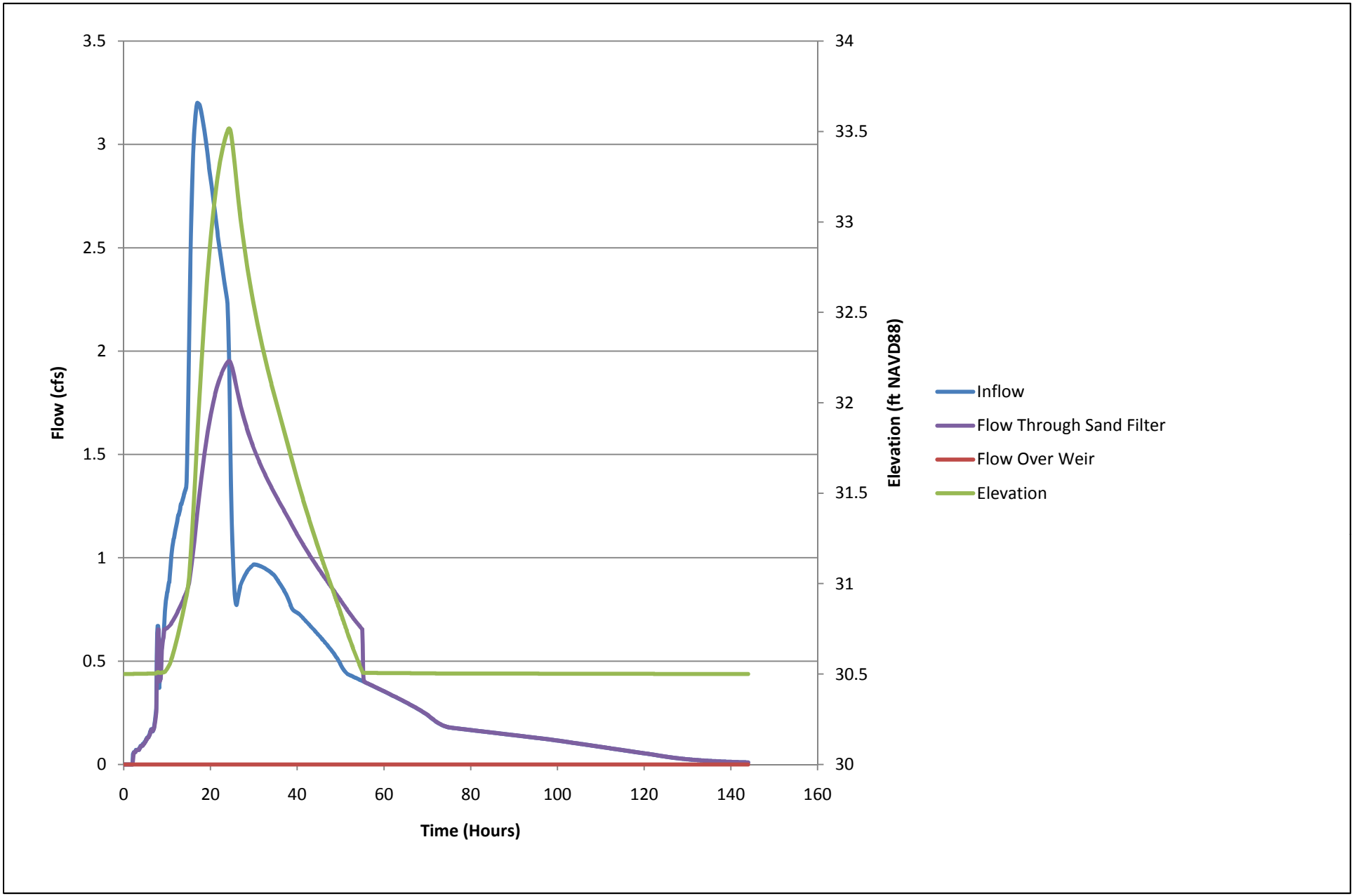


Figure 6-13
5-Year Sand Filter Outlet Hydrograph
Final Design Report
Stormwater Source Control Measures

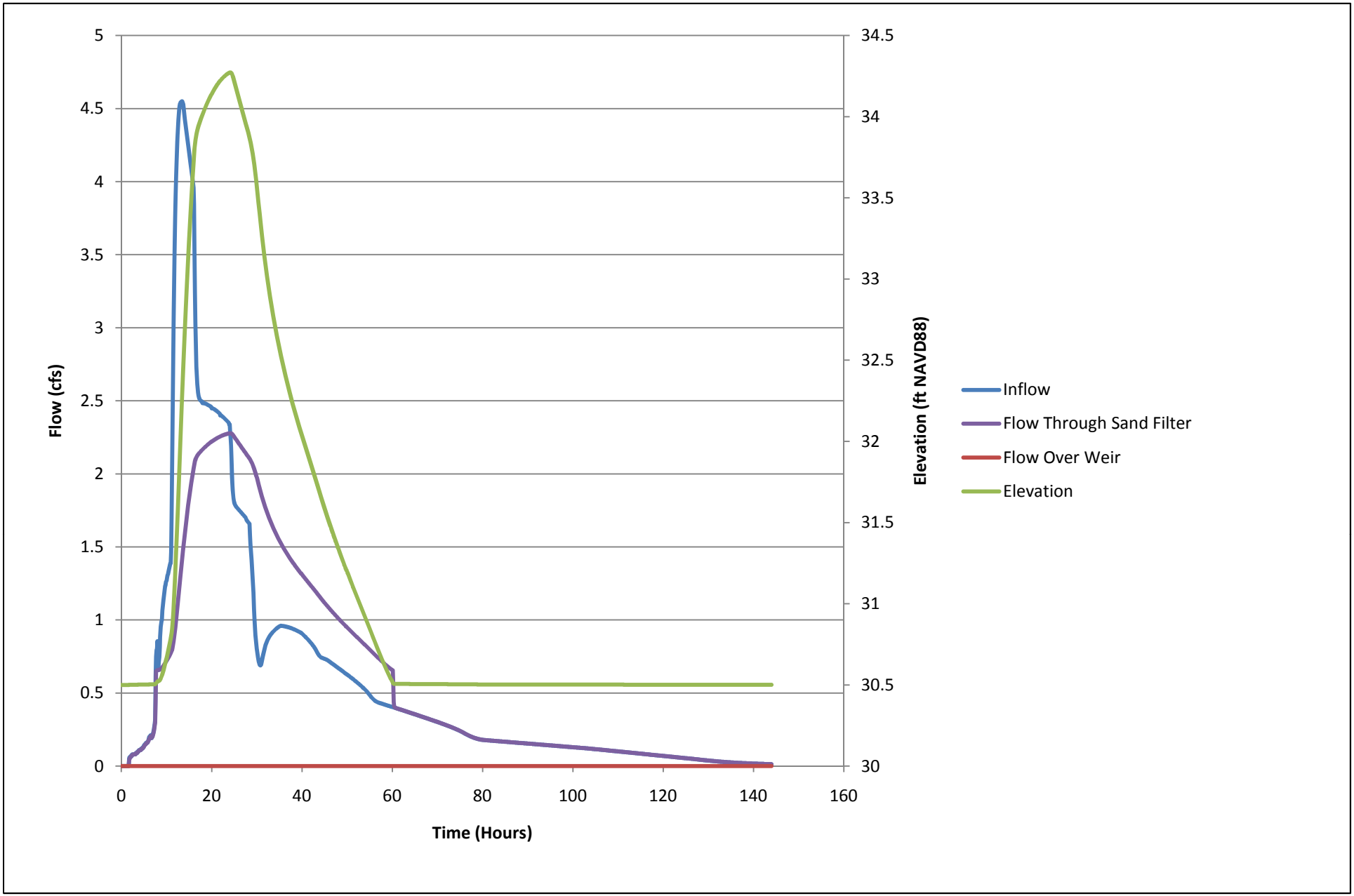


Figure 6-14
10-Year Sand Filter Outlet Hydrograph
Final Design Report
Stormwater Source Control Measures

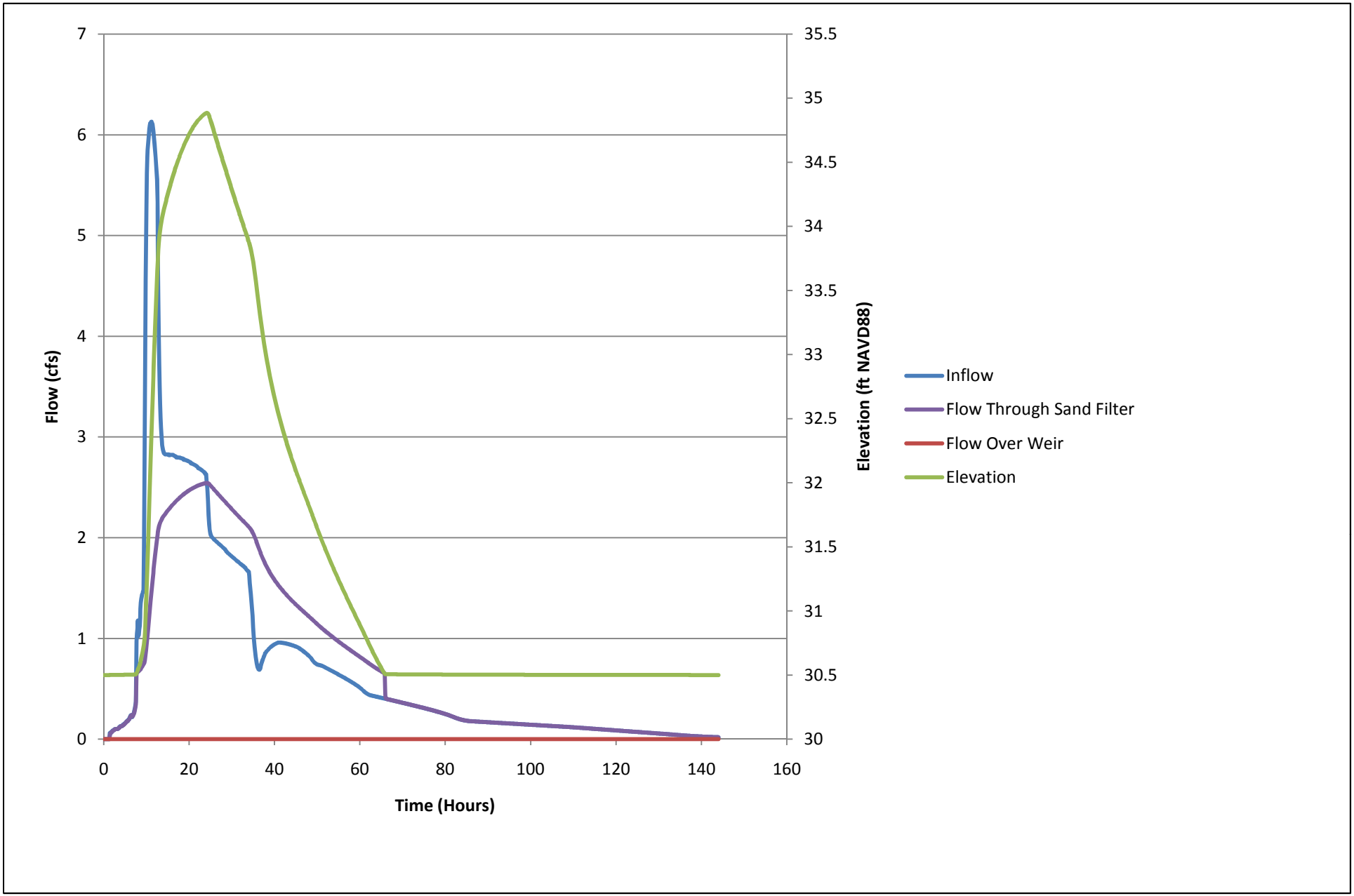


Figure 6-15
25-Year Sand Filter Outlet Hydrograph
Final Design Report
Stormwater Source Control Measures

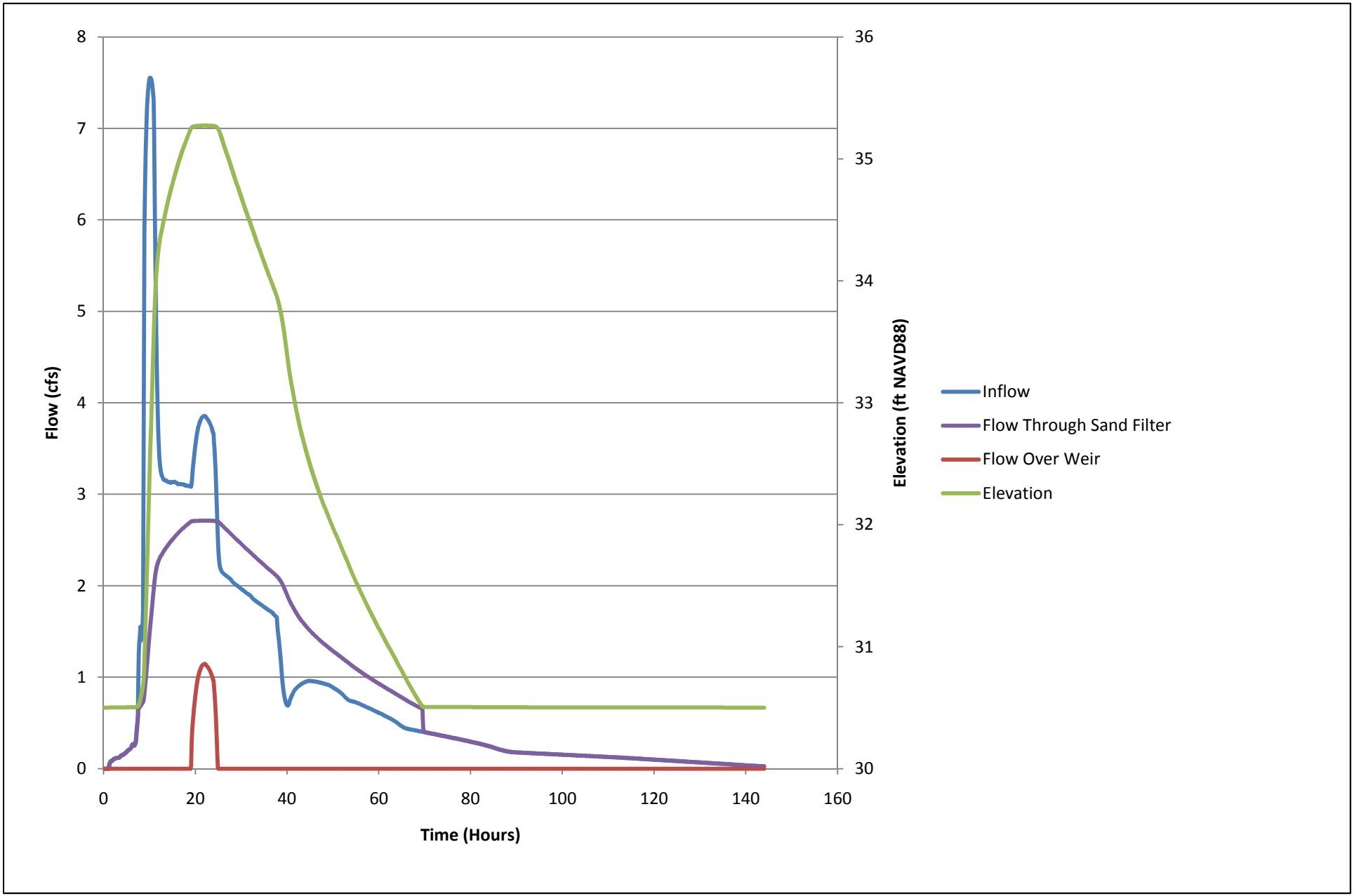
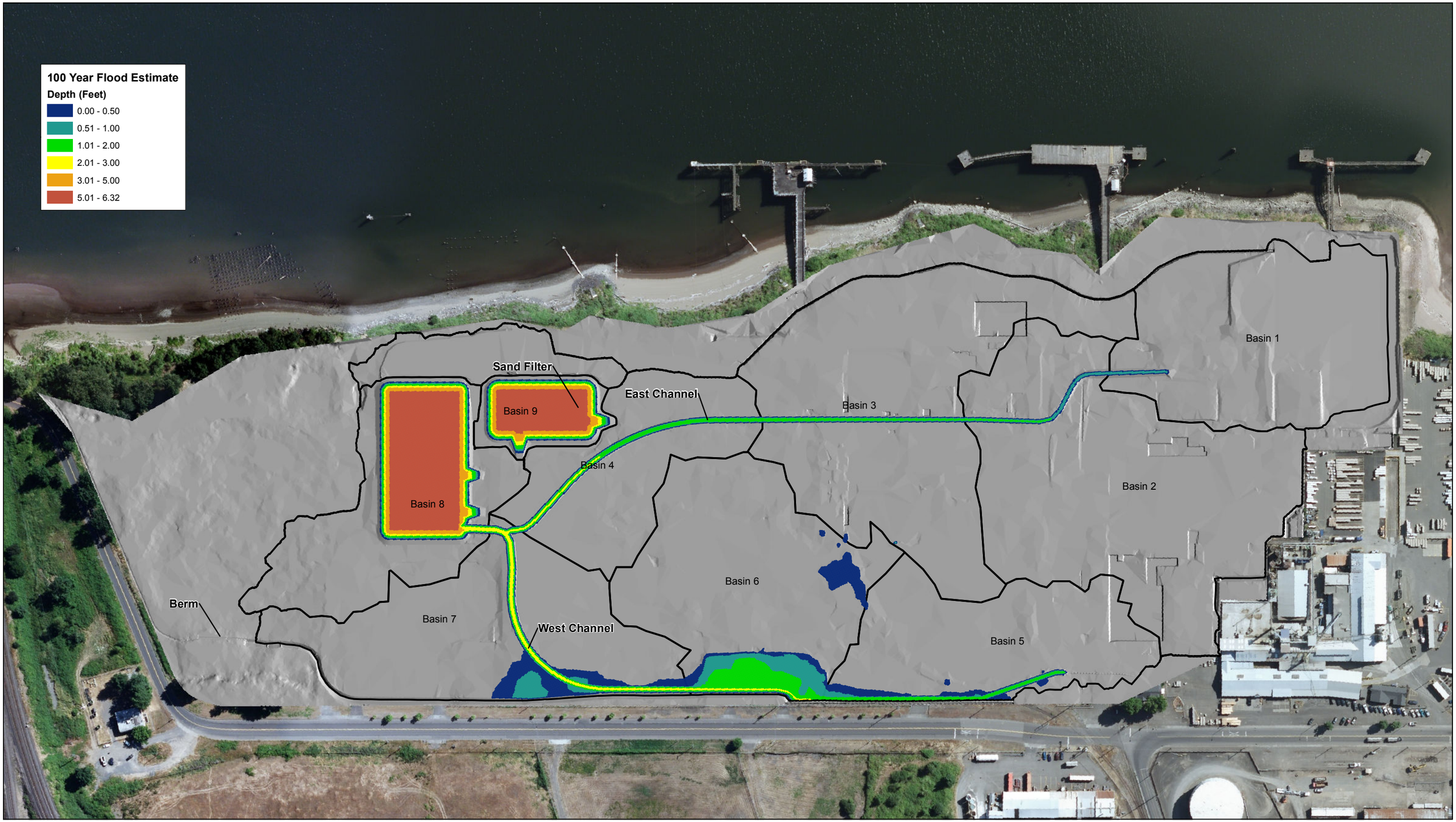


Figure 6-16
100-Year Sand Filter Outlet Hydrograph
Final Design Report
Stormwater Source Control Measures

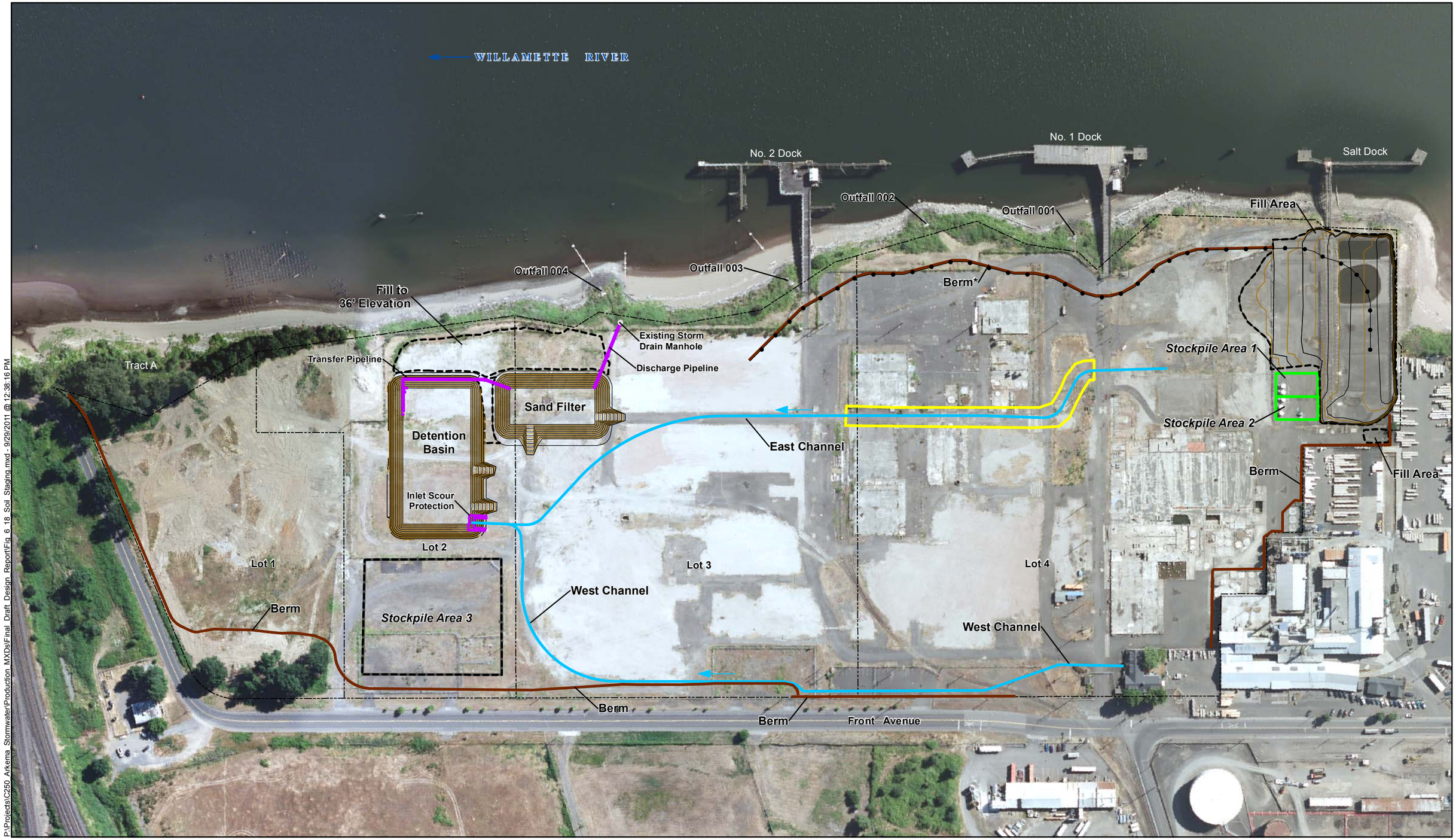


Catchments

integral consulting inc.

0 100 200
Feet

Figure 6-17
100 Year Flooding Estimate
Final Design Report
Stormwater Source Control Measures



P:\Projects\C250 Arkema Stormwater\Production MXDs\Final Draft Design Report\Fig 6 18 Soil Staging.mxd - 9/29/2011 @ 12:38:16 PM

integral consulting inc.

FEATURE SOURCES:
Aerial: Metro, June-July 2009
Property Boundaries: DEA Survey

N

0 100 200 400 Feet

Map Features

- Channel
- Berm
- Detention Basin/Sand Filter Feature
- Areas to be Filled
- Potential DDT Containing Areas
- Excavated Soils for Stockpile Area 1
- Additional Stockpile Area
- Barrier Wall
- Property and Lot Boundary

*Berm follows alignment of proposed groundwater barrier wall and cap.

Figure 6-18
Soil Staging Areas
Final Design Report
Stormwater Source Control Measures

ID	Task Name	Duration	Start	Finish
1	**Stormwater Source Control Measures Final Design**	**182 days**	**Fri 7/1/11**	**Thu 12/29/11**
2	Stormwater SCM Final Design	92 days	Fri 7/1/11	Fri 9/30/11
3	DEQ Review of Stormwater SCM Final Design	60 days	Sat 10/1/11	Tue 11/29/11
4	Negotiation and Approval of Final Design	30 days	Wed 11/30/11	Thu 12/29/11
5	**Bidding & Construction of Stormwater Source Control Measures**	**270 days**	**Fri 12/30/11**	**Mon 9/24/12**
9	**Groundwater SCM Construction**	**220 days**	**Fri 6/15/12**	**Sun 1/20/13**
10	**System Monitoring and Optimization**	**347 days**	**Tue 2/19/13**	**Sun 6/1/14**
11	Implement Performance Monitoring Plan	365 edays	Tue 2/19/13	Wed 2/19/14
12	**Monthly Monitoring Reports**	**241 days**	**Wed 5/15/13**	**Tue 4/15/14**
25	Data Receipt/Analysis and Optimization Report Preparation	72 days	Thu 2/20/14	Fri 5/30/14
26	Submit System Monitoring and Optimization Report	1 day	Sun 6/1/14	Sun 6/1/14

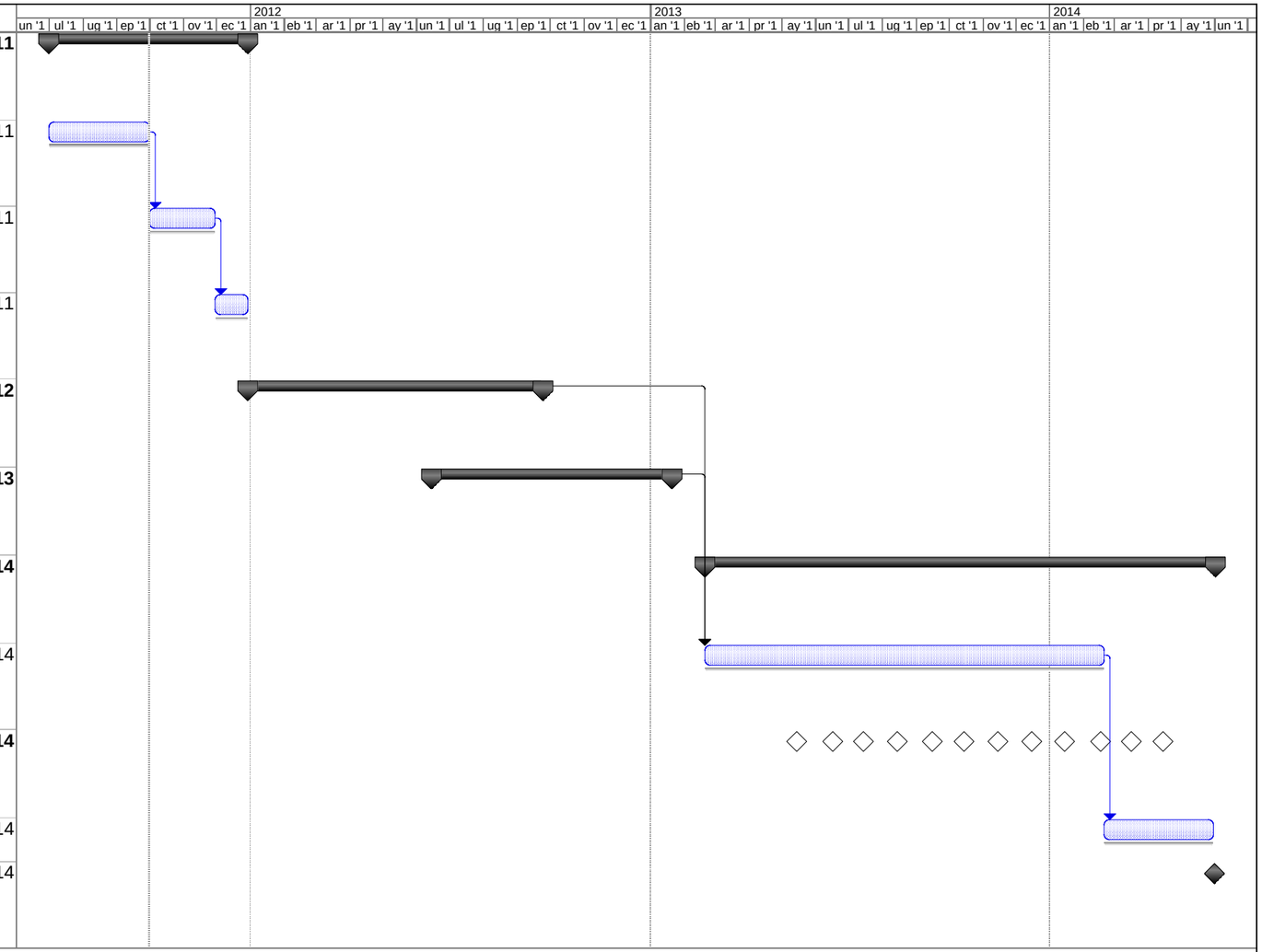


Figure 9-1
Project Schedule
Final Design Report
Stormwater Source Control Measures

integral consulting inc.

TABLES

Table 1-1. Stormwater Treatment System Effluent Goals

Parameter	Analytical Method	Daily Maximum ACG[a] Effluent Level	Monthly Maximum ACG[b] Effluent Level
Conventionals			
pH	SM 4500H$^+$ B	Within range of 6.5–8.5 S.U. at all times	6.5 - 8.5 [c]
Total suspended solids	SM 2540D	130 mg/L	130 mg/L [c]
Metals			
Chromium VI	EPA Method 218.6/SM3500	16 µg/L	10 µg/L
Copper (total recoverable)	EPA Method 200.8	18 µg/L	10 µg/L
Lead (total recoverable)	EPA Method 200.8	5 µg/L	5 µg/L
Manganese (dissolved)	EPA Method 200.8	87 µg/L	50 µg/L
Zinc (total recoverable)	EPA Method 200.8	117 µg/L	68 µg/L
Polycyclic Aromatic Hydrocarbons			
Benzo(a)anthracene	EPA Method 625	Below PQL (1 µg/L)	Below PQL (1 µg/L)
Benzo(a)pyrene	EPA Method 625	Below PQL (1 µg/L)	Below PQL (1 µg/L)
Benzo(k)fluoranthene	EPA Method 625	Below PQL (1 µg/L)	Below PQL (1 µg/L)
Chrysene	EPA Method 625	Below PQL (1 µg/L)	Below PQL (1 µg/L)
Dibenzo(a,h)anthracene	EPA Method 625	Below PQL (1 µg/L)	Below PQL (1 µg/L)
Indeno(1,2,3-cd)pyrene	EPA Method 625	Below PQL (1 µg/L)	Below PQL (1 µg/L)
Semivolatile Organic Compounds			
Pentachlorophenol	EPA Method 625	Below PQL (2 µg/L)	Below PQL (2 µg/L)
Organochlorine Pesticides			
2,4' and 4,4'-DDD	EPA Method 625	Below PQL (0.05 µg/L)	Below PQL (0.01 µg/L)
2,4' and 4,4'-DDE	EPA Method 625	Below PQL (0.05 µg/L)	Below PQL (0.01 µg/L)
2,4' and 4,4'-DDT	EPA Method 625	Below PQL (0.05 µg/L)	Below PQL (0.01 µg/L)

Notes

ACG = analytical concentration goal

PQL = practical quantification limit

[a] ACGs are the daily maximum effluent level he June 16, 2009 DEQ Memorandum from Matt McClincy, NWR Cleanup, to Rob Burkhart, NWR Water Quality, except for arsenic which is the MCL.

[b] ACGs are the monthly average effluent levels from the June 16, 2009 DEQ Memorandum from Matt McClincy, NWR Cleanup, to Rob Burkhart, NWR Water Quality, except for arsenic which is the MCL.

[c] Analyte benchmarks listed from the National Pollution Discharge Elimination System permit for the Arkema facility (No. 100752).

Table 2-1 Comparison of Model-Predicted Fully Mixed Surficial Sediment Concentrations with Portland Harbor Sediment PRGs and RALs

	PH Draft PRGs	PH Draft RALs					Model Predicted Existing Conditions	Model Predicted Meeting Stormwater Effluent Goals
Analyte	PRG[a] (µg/kg)	LWG Alt. B[b] (µg/kg)	LWG Alt. C[b] (µg/kg)	LWG Alt. D[b] (µg/kg)	EPA Alt. E[b] RAL (µg/kg)	EPA Alt. F[b] RAL (µg/kg)	Predicted Sediment Concentration (µg/kg) for "Best Estimate" Sedimentation Rate	Target Sediment Concentration (µg/kg) for "Best Estimate" Sedimentation Rate
Sum DDT	62.9	NA	NA	NA	150	60	19.8	10.6
Sum DDE	31.3	1,000	1,000	200	50	20	24.6	16.8
Sum DDD	28	NA	NA	NA	100	50	13.8	15.0

Notes:

PH = Portland Harbor
PRG = preliminary remediation goal
RAL = remedial action level

[a] These benthic ecological PRG values are highly conservative. The DDx no-effect level to the benthic community was presented in the proceedings of the 2011 Battelle Sediment Conference in New Orleans by Becker et al. (see below). Based on the false-positive responses caused by other sediment contaminants (non-DDx related), a conservatively estimated no-effect level of 4.6 ppm (4,600 µg/kg) DDx was calculated.

Becker, S., L. Williams, and M. Aldea. 2011. Site-specific evaluation of the Portland Harbor sediment quality guidelines. Paper presented at the Sixth International Conference on Remediation of Contaminated Sediments, New Orleans, LA. Integral Consulting Inc., Seattle, WA.

[b] Wyatt, B. 2011. Personal communication from the LWG (letter to K. Koch, U.S. Environmental Protection Agency, Seattle, WA, dated August 23, 2011, regarding EPA letter dated August 11, 2011 providing direction to the LWG on alternatives to be evaluated in the Draft Feasibility Study). Lower Willamette Group, Portland, OR.

Table 3-1. Estimated Size of Particle Removed by Settling in the Detention Basin

	Discharge (cfs)	Length (ft)	Width (ft)	Surface Area (As, ft^2)	Settling Velocity (V, feet/second)	Safety Factor (SF)	Particle Size (µm)	Particle Size (inches)
25-Year Storm	6.30	150	300	45,000	0.000140	1.5	**7.9**	0.00031
10-Year Storm	4.77	150	300	45,000	0.000106	1.5	**6.9**	0.00027
5-Year Storm	3.37	150	300	45,000	0.000075	1.5	**5.8**	0.00023
2-Year Storm	1.76	150	300	45,000	0.000039	1.5	**4.2**	0.00016

Notes:

Bold text indicates the value calculated.

cfs = cubic feet per second

Table 3-2. Sand Filter Sizing, Stormwater Source Control Measures

Flow Rate at Sand Filter Surface Q (cfs)	Conductivity K (ft/day)	Max. Head H_m (ft)	Sand Depth d_f (ft)	Gradient i (ft/ft)	Area A (ft^2)	Width W (ft)	Length L (ft)	Velocity V (ft/sec)
1.0	3.5	1.5	1.5	2	12,343	79	157	0.292
3.0	3.5	6	1.5	5	12,800	80	160	0.844

Notes:
cfs = cubic feet per second

Table 3-3. Filtration Removal Mechanism, Stormwater Source Control Measures[a]

Removal Mechanism	Description	Particle Size (µm)
Straining	Particle is removed by lodging in a space smaller than particle. Affected by media size relative to particle size; size of void space; surface irregularity of the media; presence of surface cake; size distribution of the media.	2 - 50
Sedimentation	Particles settle on the media at the entry surface to the filter. Affected by settling velocity of particles relative to drawdown rate of pool; degree of natural flocculation.	2 - 50
Hydrodynamic	Force of flowing water traps particle against media. Affected by flow rate; size of media relative to particles; surface irregularities of media.	0.2 - 50
Electrokinetic	Particles bind to media by electrostatic forces. Affected by surface chemistry of particles and media; chemistry of water such as pH, ionic strength, calcium, and humics; stability of the suspension.	<0.2 - 2
van der Waals	Particles bind to media by forces between atoms on the electron level. Affected by surface chemistry of particles and media; chemistry of water such as pH, ionic strength, calcium, and humics; stability of the suspension.	<0.2 - 2
Chemical	Particles attach via a chemical process such as bonding or hydration, hydrophobic, and steric interactions. Affected by surface chemistry of particles and media; chemistry of water such as pH, ionic strength, calcium, and humics; stability of the suspension.	<0.2 - 2
Precipitation	Dissolved pollutants precipitate onto the filter media. Affected by chemistry of the media and water, in particular calcium, iron, carbonate, and pH.	Dissolved Metals
Biological	Biological growth on the surface traps small particles and degrades organic pollutants. Affected by water temperature; presence of nutrients and carbon sources.	<0.2; organics

Notes:
[a] Minton (2005)

Table 3-4. Areas of Outfall Drainage Basin and Temporary Capping

		Capped Areas				Estimated Reduction in DDx Loads	
Outfall/ Drainage Area ID	Drainage Basin Area (acres)	Temporary Cap Area (acres)	Previously Capped Area (acres)	Uncapped Area (acres)	Basin Area to be Capped	Individual Drainage Area	Over Entire Site Drainage Area
001	18.12	1.34	0.06	16.72	7%	7%	3.4%
002	1.72	1.72	0	0	100%	100%	4.3%
003	7.89	0.7	0.44	6.75	9%	9%	1.9%
004	12.15	2.3	0	9.85	19%	19%	5.8%
Total	39.88	6.06	0.5	33.32			15.3%

Table 3-5 Summary of DDx Concentrations in Suspended Sediment in Stormwater Discharge

		Total Suspended Solids	Stormwater Concentration				Suspended Sediment Concentration			
Outfall	SampleDate	(mg/L)	4,4'-DDD µg/L	4,4'-DDE µg/L	4,4'-DDT µg/L	Total DDx [a] µg/L	4,4'-DDD µg/kg	4,4'-DDE µg/kg	4,4'-DDT µg/kg	Total DDx µg/kg
001	2/15/2007	2 *U*	0.0374	0.148	0.132 *J*	0.3174	18,700	74,000	66,000	158,700
	3/2/2007	3.2	0.0448 *J*	0.216	0.161 *J*	0.4218 *J*	14,000	67,500	50,313	131,813
	3/19/2007	8.2	0.0592 *U*	0.228	0.157	0.4146	3,610	27,805	19,146	50,561
	6/5/2007	57.6	0.0333 *J*	0.0928 *J*	0.18 *J*	0.3061 *J*	578	1,611	3,125	5,314
002	2/15/2007	2 *U*	0.0429	0.229	0.373 *J*	0.6449 *J*	21,450	114,500	186,500	322,450
	3/2/2007	2 *U*	0.054 *J*	0.249	0.478 *J*	0.781 *J*	27,000	124,500	239,000	390,500
	3/19/2007	3	0.226 *U*	2	2.48	4.593	37,667	666,667	826,667	1,531,000
	6/5/2007	9.4	0.133	0.147 *J*	1.11	1.39 *J*	14,149	15,638	118,085	147,872
003	2/15/2007	2.2	0.0304	0.108 *U*	0.188 *J*	0.2724 *J*	13,818	24,545	85,455	123,818
	3/2/2007	2 *U*	0.0244 *J*	0.275	0.202 *J*	0.5014 *J*	12,200	137,500	101,000	250,700
	3/19/2007	5.1	0.0278 *U*	0.24 *J*	0.214 *J*	0.4679 *J*	2,725	47,059	41,961	91,745
004	2/15/2007	3.2	0.0634	0.0843 *U*	0.0843	0.18985	19,813	13,172	26,344	59,328
	3/2/2007	2 *U*	0.0545 *J*	0.134	0.122 *J*	0.3105 *J*	27,250	67,000	61,000	155,250
	3/19/2007	3.8	0.0409 *U*	0.157	0.127	0.30445	5,382	41,316	33,421	80,118

Notes:
J = Estimated
U = Non-detect

[a] Total DDx calculated assuming non-detects at 1/2 detection limit.

Table 3-6. Summary of DDx Concentrations in Sediments Collected from Catch Basin Filter Socks

			DDx Concentrations (µg/kg)				Sediment Size Distribution (percent)							Fines Normalized
Outfall	Sample ID	Sample Date	4,4'-DDD	4,4'-DDE	4,4'-DDT	Total DDx	Clay	Silt	Fine Sand	Medium Sand	Coarse Sand	Gravel	Total Fines	Total DDx (µg/kg)
001	CB-001-01	10/19/2006	26.1	161	99.1	286.2	2.1	10.8	18	50.4	16.6	2.3	30.9	926
	CB-001-02	10/17/2006	1330	767	2480	4577	5.4	50.4	21.4	19.1	1.7	1.9	77.2	5929
	CB-001-03	10/19/2006	169	174	211	554	3.1	12.6	32.9	44.6	6.6	0.2	48.6	1140
	CB-001-05	10/19/2006	296	446	751	1493	9.5	75.2	1.5	0.6	11.5	1.7	86.2	1732
	CB-001-06	10/19/2006	52.6	43.3	273	368.9	2.5	34.2	22.1	31.4	5.8	4	58.8	627
	CB-001-07	10/19/2006	11.9	24.4	29.1	65.4	1	21	36.3	38.1	3.6	0	58.3	112
002	CB-002-01	10/17/2006	1240	2660	7190	11090	3.1	18.7	30.1	40.2	7.35	0.75	51.9	21368
	CB-002-02	10/18/2006	840	3020	16100	19960	3.05	15.3	23.4	42.1	12	4.2	41.75	47808
	CB-002-03	10/18/2006	314	284	204	802	20.4	46.7	13.8	8.9	3.3	6.9	80.9	991
003	CB-003-01	10/17/2006	278	300	2810	3388	1.9	6	3.7	6.4	12.8	69.2	11.6	29207
	CB-003-02	10/17/2006	165 *J*	335	2430	2930	1.1	18.9	20.5	44.1	14.9	0.55	40.5	7235
	CB-003-03	10/17/2006	162	92.3	206	460.3	5.4	28.1	22.5	29.3	11.8	3	56	822
	CB-003-06	10/16/2006	22.2	24.2	61.6	108	4.1	24.5	20	34.3	13.2	3.9	48.6	222
	CB-003-08	10/20/2006	13.9	13	47.3	74.2	3.3	47	28.2	17.2	2.8	1.6	78.5	95
004	CB-004-01	10/16/2006	21.8	22.1	60.4	104.3	16.1	39.7	24.3	17.6	1.2	1.1	80.1	130
	CB-004-02	10/16/2006	124	153	728	1005	2.3	16.5	31.4	40.6	8.2	0.9	50.2	2002
	CB-004-03	10/16/2006	53.6	118	594	765.6	1.4	3.3	8.7	6.6	7.8	72.3	13.4	5713

Notes:
J = Estimated

Table 3-7. Summary of Stormwater Sediment DDx Concentrations Entering and Exiting the Existing Stormwater Conveyance System

	Influent Sediments (Filter Sock Sediments)	Effluent Sediments (Suspended Sediment in Outfall Discharge)	
Outfall	Average Fines Normalized DDx Concentration (µg/kg)	Average DDx Concentration (µg/kg)	Estimated Percentage DDx Load from Existing Stormwater Conveyance System
001	1,744	86,597	98%
002	23,389	597,956	96%
003	7,516	155,421	95%
004	2,615	98,232	97%
All Outfalls	7,415	249,941	97%

Table 3-8. Summary of Detention Pond TSS Removal Performance from BMP Database

		Influent TSS (mg/L)				Effluent TSS (mg/L)				
Facility Name	BMP Type	Number of Samples	Minimum	Median	Maximum	Number of Samples	Minimum	Median	Maximum	TSS Removal (median)
Key Colony Detention Pond	DB	9	2.7	11.2	39.1	9.0	0.3	3.1	39.0	72%
The Reserve at DeBary	DB	39	1.2	77.3	3408.0	48	1.3	25.5	109.0	67%
Oakhampton Dry Basin	DB	11	13.0	92.0	192.0	11	2.0	10.0	20.0	89%
B504-03-00 Detention Basin	DB	22	6.0	27.4	200.0	22	2.5	18.5	171.0	32%
BMP37	DB	5	25.0	58.1	202.6	19	10.0	45.7	420.6	21%
Greenville Pond	DB	8	52.0	98.5	233.0	8	18.0	28.0	65.0	72%
Manchester	DB	14	76.0	180.0	400.0	14	18.0	58.5	100.0	68%
5/605 EDB	DC	13	19.0	71.0	208.0	13	12.0	44.0	190.0	38%
Lex Hills Pond	DB	13	11.0	60.8	214.0	13	10.0	26.0	114.0	57%
Whitaker PRF	DU	3	90.3	163.0	1040.0	3	91.5	163.0	1140.0	0%
BMP 12	DB	15	5.5	75.6	203.4	16	3.0	24.5	63.4	68%
15/78	DB	19	48.0	130.0	500.0	19	14.0	38.0	260.0	71%
Brooke Detention Pond	DB	2	180.0	195.0	210.0	10	1.8	9.0	120.0	95%
605/91 edb	DB	13	24.0	74.0	165.0	11	9.0	22.0	94.0	70%
Twin Towers Dry Pond	DB	4	6.1	14.5	26.1	3	7.0	7.3	31.4	49%
5/56	DB	17	46.0	86.0	125.0	12	12.0	30.0	220.0	65%
BMP 13	DB	13	1.3	40.2	455.0	13	3.5	13.4	113.6	67%
BMP 74	DB	3	10.7	25.9	47.8	3	4.5	12.1	15.2	53%

Notes:
BMP = best management practice
DB = Detention Basin (Dry) - Surface Grass-Lined Basin that Empties Out after a Storm
DC = Detention Basin (Dry) - Concrete or Lined Tank/Basin with Open Surface
DU = Detention - Underground Vault, Tank or Pipe(s)
TSS = total suspended solids

Table 3-9. Summary of Media Filter Design Information from BMP Database

		Influent TSS (mg/L)				Effluent TSS (mg/L)				
Facility Name	BMP Type	Number of Samples	Minimum	Median	Maximum	Number of Samples	Minimum	Median	Maximum	TSS Removal (median)
Foothill SF	FS	13	38	75	168	12	5	10	21	86.7%
La Costa PR	FS	26	28	64	270	17	1	6	10	90.6%
Eastern SF	FS	11	23	44	103	10	5	11	20	75.0%
Delaware Sand Filter	FS	11	4	32	152	10	2	6.5	31	79.7%
5/78	FS	18	1	9	78	18	18	125	420	-1288.9%
Mt. Shasta Maintenance Station Sand Filter	FS	25	1	18	98	25	0.5	1	35.5	94.4%
Mountain Gate Partial Sedimentation Austin Sand Filter	FS	28	4	32.95	172	28	1	4.65	28.6	85.9%
Termination	FS	9	14	28	100	9	1	4	6.2	85.7%
Lakewood Sand Filter (95)	--	--	--	--	--	--	--	--	--	--
Escondido	FS	17	34	90	220	16	1	17	250	81.1%
Airpark Sand Filter	FS	20	12	47	230	20	1.25	14	40	70.2%

Notes:
-- = no data available
BMP = best management practice
FS = Filter, sand
TSS = total suspended solids

Table 3-10. Estimated Required Percent Reduction in Stormwater Concentrations to Meet Effluent Level Goals

					Reduction Required To Meet Effluent Level Goal (Below PQL, 0.05 µg/L)		
Location ID	Sample Date	4,4'-DDD	4,4'-DDE	4,4'-DDT	4,4'-DDD	4,4'-DDE	4,4'-DDT
001	2/15/2007	0.0374	0.148	0.132 *J*	0%	66%	62%
	3/2/2007	0.0448 *J*	0.216	0.161 *J*	0%	77%	69%
	3/19/2007	0.0592 *U*	0.228	0.157	16%	78%	68%
	6/5/2007	0.0333 *J*	0.0928 *J*	0.18 *J*	0%	46%	72%
002	2/15/2007	0.0429	0.229	0.373 *J*	0%	78%	87%
	3/2/2007	0.054 *J*	0.249	0.478 *J*	7%	80%	90%
	3/19/2007	0.226 *U*	2	2.48	78%	98%	98%
	6/5/2007	0.133	0.147 *J*	1.11	62%	66%	95%
003	2/15/2007	0.0304	0.108 *U*	0.188 *J*	0%	54%	73%
	3/2/2007	0.0244 *J*	0.275	0.202 *J*	0%	82%	75%
	3/19/2007	0.0278 *U*	0.24 *J*	0.214 *J*	0%	79%	77%
004	2/15/2007	0.0634	0.0843 *U*	0.0843	21%	41%	41%
	3/2/2007	0.0545 *J*	0.134	0.122 *J*	8%	63%	59%
	3/19/2007	0.0409 *U*	0.157	0.127	0%	68%	61%
Average		0.0623	0.3077	0.4292	14%	70%	73%
95th Percentile		0.1656	0.8787	1.5895	68%	87%	96%

Notes:
J = Estimated
PQL = practical quantification limit
U = Non-detect

Table 3-11. Summary Table of Estimated Design Effectiveness

Description of Design Element	Reduction in DDx Concentration		
	Best Estimate	Range	
		Minimum	Maximum
Source Control Controls			
Capping	15%	15%	15%
Stormwater System Decommissioning	50%	25%	90%
Total Source Control Reduction	58%	36%	92%
Stormwater Conveyance and Treatment			
Detention Basin	67%	21%	95%
Sand Filter	86%	70%	94%
Total Treatment Reduction	95%	76%	99.7%
Full SCM Reduction	98%	85%	99.97%

Notes:
SCM = source control measure

Table 6-1. Subcatchment Characteristics

Basin	Pervious/ Impervious	Land Use Type	Area (acres)	Hydrologic Soil Group[a]	Curve Number (CN)
Basin 1	Pervious	Graded[b]	1.21	D	94
	Impervious	Paved[c]	1.49	D	98
	Impervious	Gravel[d]	2.00	D	91
		Total:	4.70	Weighted CN:	94
Basin 2	Pervious	Brush[e]	0.65	D	77
	Pervious	Graded	1.20	D	94
	Impervious	Paved	5.26	D	98
	Impervious	Gravel	0.23	D	91
		Total:	7.34	Weighted CN:	95
Basin 3	Pervious	Graded	1.06	D	94
	Impervious	Paved	5.80	D	98
	Impervious	Gravel	0.11	D	91
		Total:	6.97	Weighted CN:	97
Basin 4	Pervious	Graded	2.70	D	94
	Pervious	Brush	0.01	D	77
	Impervious	Paved	0.21	D	98
		Total:	2.92	Weighted CN:	94
Basin 5	Pervious	Graded	1.92	D	94
	Impervious	Paved	1.59	D	98
		Total:	3.51	Weighted CN:	96
Basin 6	Pervious	Graded	3.18	D	94
	Impervious	Paved	1.76	D	98
		Total:	4.94	Weighted CN:	95
Basin 7	Pervious	Graded	2.10	D	94
	Pervious	Brush	2.58	D	77
	Impervious	Paved	0.09	D	98
		Total:	4.77	Weighted CN:	85
Basin 8	Pervious	Brush	2.00	D	77
	Pervious	Graded	0.09	D	94
	Impervious	Gravel	0.04	D	91
	Detention	Basin[f]	1.80	D	100
		Total:	3.93	Weighted CN:	88
Basin 9	Sand Filter	Basin[f]	0.99	D	98[g]
		Total:	0.99	Weighted CN:	98[g]

Notes:

[a] Hydrological Soil Type – D, from City of Portland, Bureau of Development Services website http://www.portlandonline.com/bds/POindex.cfm accessed on November 19, 2010.

[b] Includes area of crushed concrete from demolition activities.

[c] Includes all paved areas in the former plant area.

[d] Includes area of temporary capping.

[e] Includes open, non-maintained areas of the former plant.

[f] Includes direct rainfall on detention basin and sand filter.

[g] Maximum curve number possible to input into TR-55. Time of Concentration also set at minimum (0.1hrs)

Table 6-2. 24-Hour Rainfall Depths at Portland Airport

	Recurrence Interval (years)				
	2	5	10	25	100
24-Hour Depth (inches)	2.4	2.9	3.4	3.9	4.4

Table 6-3. Conveyance System Outlet Flow Characteristics from WinTR-55 Model

Storm	Maximum Flowrate (cfs)	Total Volume Discharge (cubic feet)
2-Year	15.72	241,926
5-Year	20.20	310,170
10-Year	24.72	378,713
25-Year	29.25	447,818
100-Year	33.77	516,017

Notes:
cfs = cubic feet per second

Table 6-4. Hydraulic Modeling Results

Parameter	Storm Event	Description
Design storm of detention basin	25-yr, 24-hour storm	3.9 inches over 24 hours
Design storm of sand filter	25-yr, 24-hour storm	3.9 inches over 24 hours
Design storm for site runoff	>100-yr, 24-hour storm	4.4 inches over 24 hours
Design storm that exceeds conveyance channel capacity	1-inch, 24-hour storm[a]	1.0 inch over 24 hours
River stage that impairs discharge of stormwater	> 25-yr, 24-hour storm	~27.7 ft NAVD88
River stage that prevents discharge of stormwater	>50-yr, 24-hour storm	29.28 ft NAVD88

Notes:
NAVD88 = North American Vertical Datum of 1988
[a]Note that this over-flow is only for a small portion of the channel near the former BPA substation.

Table 6-5. Design of Surface Channels and Lining

Reach	Modeled Discharge (Q, cfs)	Slope (S_o, ft/ft)	Bottom (b, ft)	Side Slope (Z, H:1V)	Lining Type ($D_{b,\ 50}$, ft)	Estimated Depth (d_i, ft)	Mannings (η)	Area (A, ft^2)	Hydraulic Radius (R, ft)	Calculated Discharge (Q_i)	Is Q_i with 5% of Q?	Velocity (V, ft/s)
Reach 1	3.87	0.001	2	2.5	0.17	1.04	0.042	4.75	0.63	3.87	Yes	0.81
Reach 2	9.86	0.001	2	2.5	0.17	1.91	0.064	12.99	1.06	9.86	Yes	0.76
Reach 3	15	0.001	2	2.5	0.17	2.49	0.078	20.47	1.33	15.00	Yes	0.73
Reach 4	3.1	0.001	2	2.5	0.17	0.89	0.039	3.76	0.55	3.10	Yes	0.82
Reach 5	7.16	0.001	2	2.5	0.17	1.56	0.056	9.19	0.88	7.16	Yes	0.78
Reach 6	26.85	0.001	4	2.5	0.17	3.06	0.090	35.65	1.74	26.86	Yes	0.75

Notes:
cfs = cubic feet per second

Table 6-6. Design of Channel, Side Slope Analysis

Reach	Side Slope (Z, H:1V)	Ratio of Side to Bottom Shear Stress (K_1)	Angle of Side Slope (Θ)	Angle of Repose (Φ)	Tractive Force Ratio (K_2)	Median Stone Size ($D_{50,S}$, feet)	Median Stone Size ($D_{50,S}$, inches)	Less than 2 Inches?
Reach 1	2.5	0.835	21.80	42	0.98	0.14	1.71	Yes
Reach 2	2.5	0.835	21.80	42	0.98	0.14	1.71	Yes
Reach 3	2.5	0.835	21.80	42	0.98	0.14	1.71	Yes
Reach 4	2.5	0.835	21.80	42	0.98	0.14	1.71	Yes
Reach 5	2.5	0.835	21.80	42	0.98	0.14	1.71	Yes
Reach 6	2.5	0.835	21.80	42	0.98	0.14	1.71	Yes

Table 6-7. Specific Detention Basin Design Criteria

Component	Criteria	Reference
Surrounding Slopes	<10%	City of Portland (2008)
	200 feet unless geotechnical report	City of Portland (2008)
Slopes within Pond	<3H:1V	City of Portland (2008)
Pond Depth	<4 feet 0 - 2 feet evenly around perimeter	City of Portland (2008)
Length-to-Width Ratio	3L:1W	City of Portland (2008)
Baffle	75% - 90% of width	Orozco (2006)
Minimum Freeboard	1 foot	City of Portland (2008)
Sediment Bay	~10% of design surface area Provide at least 0.5 foot of dead storage	City of Portland (2008)
Weir/Orifice	Pass 100-year storm without causing flooding	City of Portland (2008)
Orifices	>1 inch diameter w/ additional clogging prevention	City of Portland (2008)
	Protected within manhole or 18-inch thick layer of 1 1/2 to 3-inch evenly graded washed rock	City of Portland (2008)
	Externally protected by stainless steel or galvanized wire screen, mesh 3/4-inch or less	City of Portland (2008)
	Diameter ≥ thickness of plate	City of Portland (2008)
	Made of thin material (HDPE or PVC)	City of Portland (2008)
	Protected with anti-vortex plate	City of Portland (2008)
Emergency Overflow	Pass 100-year 24-hour storm	City of Portland (2008)
	Subgrade set at 100-year overflow of orifice/weir	City of Portland (2008)
Berms	On compacted native soil or compacted stable fill free of loose surface soil, roots and other organic debris	City of Portland (2008)
	Constructed by excavating key equal to 50% of berm x-section height and width	City of Portland (2008)
	Made of compacted soil (95 percent maximum dry density, modified proctor method per ASTM D1557. 6- to 8-inch lifts (hand-held) or 10 to 12 inches with heavy equipment	City of Portland (2008)
	Maximum slope 3H:1V	City of Portland (2008)
	Minimum top width of 6 feet For access - minimum width 15 feet	City of Portland (2008)

Table 6-8. Specific Sand Filter Design Criteria

Component	Criteria	Reference
Pipe Slope	0.50%	King County (2005)
Pipe Slope	1.00%	City of Portland (2008)
Pipe - Material	4 inch - PVC Sch40	City of Portland (2008)
Drain Rock - Material	3/4-inch washed rock	City of Portland (2008)
Drain Rock - Thickness	2 to 3 inches	City of Portland (2008)
Pipes - Lateral Spacing	10 feet	City of Portland (2008)
Clean Outs	Accessible without removing media	City of Portland (2008)
Ponding after Storm Event	less than 4 hours	City of Portland (2008)
Sand Filter Depth	Min. 18 inches	City of Portland (2008)
Head above Sand Filter	6 feet maximum	King County (2005)
Slope of Facility	< 0.5%	City of Portland (2008)
Inlet Structure	Spread flow uniformly across the surface	City of Portland (2008)
Liner	30 mil PVC or equivalent	City of Portland (2008)
L:W Ratio	2:1 or greater	City of Portland (2008)
Sand Surface	Level	City of Portland (2008)
Filter Media	Consist of clean medium to fine sand with no organic material or other deleterious materials, and shall meet the following gradation:	City of Portland (2008)
	Sieve Size — Percent Passing	
	3/8” — 100	
	#4 — 95-100	
	#8 — 80-100	
	#16 — 45-85	
	#30 — 15-60	
	#50 — 3-15	
	#100 — < 4	

Table 6-9. Relevant River Stages

	Annual Probability of Occurrence in a Given Year (%)	Water Surface Elevation (NAVD88)
Ordinary High Water	NA	20.08
10-Year Flood	10	24.98
50-Year Flood	2	29.28
100-Year Flood	1	31.28

Source: Hydraulic Analysis. Prepared for McCormick and Baxter Creosoting Company Portland Plant. Parsons Brinckerhoff. March 19, 2002.

Notes:

NA = not applicable

NAVD88 = North American Vertical Datum of 1988

Table 8-1. Stormwater Monitoring Requirements

Parameter	Minimum Frequency	Sample Type
Visual Observations[a]		
Oil and grease sheen	1/Month	Grab
Floating solids	1/Month	Grab
Conventionals		
Oil and grease	1/Month	Composite
pH	1/Month	Grab
Total suspended solids (TSS)	1/Month	Composite
Hardness (as $CaCO_3$)	1/Month	Composite
Metals		
Arsenic (total recoverable)	1/Month	Composite
Arsenic (inorganic)	1/Month	Composite
Chromium VI	1/Month	Composite
Copper (total recoverable)	1/Month	Composite
Lead (total recoverable)	1/Month	Composite
Manganese (dissolved)	1/Month	Composite
Zinc (total recoverable)	1/Month	Composite
Polycyclic Aromatic Hydrocarbons		
Benzo(a)anthracene	1/Month	Composite
Benzo(a)pyrene	1/Month	Composite
Benzo(k)fluoranthene	1/Month	Composite
Chrysene	1/Month	Composite
Dibenzo(a,h)anthracene	1/Month	Composite
Indeno(1,2,3-cd)pyrene	1/Month	Composite
Semivolatile Organic Compounds		
Pentachlorophenol	1/Month	Composite
Organochlorine Pesticides		
2,4' and 4,4'-DDD	1/Month	Composite
2,4' and 4,4'-DDE	1/Month	Composite
2,4' and 4,4'-DDT	1/Month	Composite
Dioxins and Furans		
Chlorodibenzo-p-dioxins	1/Quarter	Composite
Chlorodibenzo-p-furans	1/Quarter	Composite

Notes:

Additional details are contained in Appendix B.

[a] Visual observations will be noted upon sample collection.

Table 8-2. Performance Monitoring Decision Tree

No.	Issue	Means of Initial Identification	Proposed Performance Monitoring Action	Corrective Action Decision Tree
I	COPC effluent concentrations exceed target levels and have stabilized or are trending upward.[a]	Effluent monitoring at Outfall 004.	Perform monitoring of "first flush" events,[b] total suspended solids, and particle size distribution at three locations during the three subsequent stormwater monitoring events. Conduct COPC analysis on total and dissolved fractions of stormwater sample to evaluate COPC distribution between solid and aqueous phase. Collect stormwater samples at three monitoring locations (per event, as needed): detention basin inflow, in-between detention basin and sand filter, and system effluent discharge. Use data to assess potential for additional source control ("first flush" data) and system performance relative to particulate and dissolved phase chemicals. Determine need for corrective action based on Corrective Action Decision Tree.	CADT 1a, 1b, 1c or 1d.
2	Stormwater flow exceeds the sand filter hydraulic capacity. Sand filter is bypassed.	To the extent feasible, conduct effluent monitoring at Outfall 004 during bypass event.	Perform monitoring of standard stormwater monitoring parameters during specified bypass event.	CADT 2a or 2b
3	Accumulated sediment in detention basin.	Periodic visual inspections based on PMP-specified frequency.	Evaluate the need to remove the accumulated sediment from the detention basin. If needed for assessment, collect and analyze a sample of accumulated sediment to determine whether COPCs are present at concentrations that could impact stormwater system performance. If sediment removal is needed, conduct cleaning per O&M plan.	None
4	Accumulated sediment on sand filter.	Periodic visual inspections based on PMP-specified frequency.	Evaluate the need to remove the accumulated sediment from the sand filter. If needed for assessment, collect and analyze a sample of accumulated sediment to determine whether COPCs are present at concentrations that could impact stormwater system performance. If sediment removal is needed, conduct cleaning per O&M plan.	None

Table 8-2. Performance Monitoring Decision Tree

No.	Issue	Means of Initial Identification	Proposed Performance Monitoring Action	Corrective Action Decision Tree
5	Blockage of system components (i.e., no or reduced flow in influent pipes, etc.).	Periodic visual inspections based on PMP-specified frequency.	Conduct system cleaning per O&M Plan.	None
6	Preferential flow paths through the system.	Periodic visual inspections based on PMP-specified frequency.	Evaluate whether preferential pathway is a result of system design or from other factors.	CADT 6a
7	Erosion of system (i.e., channels, side slopes, around inlets/outlets, etc.).	Periodic visual inspections based on PMP-specified frequency.	Evaluate whether erosion is a result of system design or from other factors (i.e., debris, blockage).	CADT 7a or 7b
8	Sand Filter breakthrough (i.e., increasing COPC concentrations over time).	Effluent monitoring at Outfall 004.	Evaluate data to determine whether the change is a result of influent variations or treatment system performance.	CADT 8a or 8b
9	Long-term inability to meet target levels.	Effluent monitoring at Outfall 004.	Evaluate data from long-term monitoring (>1 year) and supplemental corrective actions (e.g., see CADT 1a, 1b, 1c).	CADT 9a or 9b
10	One or more COPCs are not detected.	Influent monitoring to detention basin and/or effluent data at Outfall 004	Evaluate data from monitoring. If non-detect in both influent and effluent for 4 or more consecutive events, discontinue sampling. If non-detect in effluent for 1 year, discontinue sampling based on agreement from DEQ.	None

Notes:

CADT = Corrective Action Decision Tree
COPC = constituent of potential concern
DEQ = Oregon Department of Environmental Quality
O&M = operation and maintenance
PMP = performance monitoring plan

[a] Note that a 3- to 6-month shakedown period will be allowed after installation to allow for proper sand filter conditioning. The amount of time required for the sand filter to condition will be dependent on amount of rainfall/runoff and amount and nature of suspended solids loading to the sand filter.

[b] First flush event sampling will consist of collecting grab samples at the influent to the detention basin during the first 30 minutes of a runoff event.

Table 8-3. Corrective Action Decision Tree

No.	Issue	Means of Identification	Proposed System Design Action
1a	COPC concentration in effluent is primarily in a dissolved phase.	Performance Monitoring Decision Tree (1).	Reassess sand filter media mixture. Evaluate the addition of granular activated carbon or other filter media which could more actively adsorb dissolved-phase hydrophobic chemicals (i.e., DDx) to the sand filter. Alternatively, assess the sources of dissolved-phase COPCs into the stormwater system through additional sampling along the length of the stormwater collection system to determine whether other source control actions (i.e., temporary capping) could more effectively increase system performance.
1b	COPC concentrations in effluent is primarily in a particulate phase.	Performance Monitoring Decision Tree (1).	Reassess detention basin and sand filter performance expectations and design basis based on system performance monitoring data. Add sediment traps to stormwater effluent to sample COPCs above criteria in specific particle size ranges. Evaluate the need to change detention basin flow characteristics (e.g., addition of hydraulic curtain) or sand filter media size distribution based on performance monitoring data. Also evaluate the need for additional temporary capping in selected areas of the site to further limit contact of stormwater with erodible surface soil particulates that might also have high concentrations of COPCs.
1c	COPC concentrations in effluent is evenly mixed between the particulate and aqueous phase.	Performance Monitoring Decision Tree (1).	Conduct design evaluations summarized in Corrective Action Decision Tree items 1a and 1b.
1d	“First Flush” data indicates first flush concentrations significantly above event mean concentrations.	Performance Monitoring Decision Tree (1).	Conduct an evaluation of potential source control measures to decrease initial loading to the treatment measures (e.g., temporary capping). This will include sampling within the stormwater conveyance channel to identify location of additional measures to be employed.
2a	One or more monitoring parameters exceed historical concentration range for that parameter since system installation.	Performance Monitoring Decision Tree (2).	Evaluate whether increase in parameter concentration during the specified event can be addressed based on modifications to the stormwater treatment system design.

Table 8-3. Corrective Action Decision Tree

No.	Issue	Means of Identification	Proposed System Design Action
2b	None of the monitoring parameters exceed historical concentration ranges for that parameter since system installation.	Performance Monitoring Decision Tree (2).	No corrective action required. Include monitoring data in DEQ monitoring reports.
6a	Preferential flow paths through the system.	Performance Monitoring Decision Tree (6).	If preferential flow is a result of system design, evaluate redesign of component for which preferential pathway is occurring.
7a	Erosion of system (i.e., channels, side slopes, around inlets/outlets, etc.) as a result of system design.	Performance Monitoring Decision Tree (7).	If erosion is a result of system design, evaluate redesign of component where erosion is occurring.
7b	Erosion of system (i.e., channels, side slopes, around inlets/outlets, etc.) as a result of blockages, debris, etc.	Performance Monitoring Decision Tree (7).	Conduct system cleaning per O&M Plan.
8a	Increasing concentrations of effluent are the result of decreased performance from sand filter.	Performance Monitoring Decision Tree (8).	Evaluate the need to redesign sand or sand/alternate media mixture and remove and replace the sand filter media.
8b	Increasing concentrations of effluent are the result of changing influent concentrations over time.	Performance Monitoring Decision Tree (8).	Continue monitoring of influent to try to determine source of change in influent characteristics and concentrations. Evaluate whether additional temporary capping could control changes in influent concentration.

Table 8-3. Corrective Action Decision Tree

No.	Issue	Means of Identification	Proposed System Design Action
9a	Based on monitoring, additional modifications to the stormwater treatment system are technically practicable.	Performance Monitoring Decision Tree (9).	Evaluate the elements of the system which are not operating optimally and consider the redesign, replacement, or supplement of stormwater treatment system, including the following possible additional components: • Addition of coagulant to destabilize smaller particles and provide better removal. This could be accomplished at either the sediment forebay to the dention basin or between the detention basin and sand filter. • Addition of more active treatment systems (such as a polymer addition, pressure sand filter, following by carbon). This could be accomplished by pumping and treating discharge from either the detention basin or the sand filter. • Splitting off smaller, more frequent storms through a more rigorous, passive filtration process (e.g., StormFilter®) specifically designed to remove COPCs that are exceeding criteria. Evaluate whether additional source control actions (i.e., temporary capping) could more effectively increase system performance.
9b	Based on monitoring, additional modifications to the stormwater treatment system are not technically practicable.	Performance Monitoring Decision Tree (9).	Continue to monitor treatment system. Keep treatment system in optimal treatment capacity based on system performance monitoring and regular system operation and maintenance. Evaluate whether additional source control actions (i.e., temporary capping) could more effectively increase system performance.

Notes:
COPC = constituent of potential concern
DEQ = Oregon Department of Environmental Quality
O&M = operation and maintenance

APPENDIX A

CONSTRUCTION QUALITY ASSURANCE PLAN

CONSTRUCTION QUALITY ASSURANCE PLAN
FOR
STORMWATER SOURCE CONTROL MEASURES

Former Arkema Inc. Facility
Portland, Oregon

Prepared for

Legacy Site Services LLC
468 Thomas Jones Way
Exton, PA 19341-2528

Prepared by

integral consulting inc

319 SW Washington St
Suite 1150
Portland, OR 97204

September 30, 2011

CONTENTS

LIST OF FIGURES ..... **iv**
ACRONYMS AND ABBREVIATIONS ..... **v**

1 INTRODUCTION **1-1**
1.1 CONSTRUCTION ACTIVIES ADDRESSED BY THE CONSTRUCTION QUALITY ASSURANCE PLAN 1-1
1.2 DOCUMENT ORGANIZATION 1-2

2 PROJECT ORGANIZATION AND RESPONSIBILITIES **2-1**
2.1 CONSTRUCTION REGULATORY PERSONNEL 2-1
2.2 SOURCE CONTROL MEASURE CONSTRUCTION IMPLEMENTATION PERSONNEL 2-1
2.2.1 Owner's Representative (Todd Slater, LSS) 2-1
2.2.2 Owner's Site Representative (Larry Patterson, ERM) 2-1
2.2.3 Quality Assurance Officer (Integral) 2-2
2.2.4 Field QAO/Field Supervisor 2-3
2.2.5 Site Safety Officer (Integral) 2-3
2.3 CONSTRUCTION CONTRACTOR 2-3
2.3.1 Contractor Project Manager (TBD) 2-4
2.3.2 Contractor Quality Control Representative (TBD) 2-5
2.3.3 Contractor Site Health and Safety Supervisor (TBD) 2-6
2.3.4 Other Contractor Personnel 2-7
2.3.5 Subcontractors 2-7

3 INSPECTION, SAMPLING, AND VERIFICATION ACTIVITES **3-1**

4 DOCUMENTATION AND REPORTING **4-1**
4.1 PRE-CONSTRUCTION DOCUMENTATION 4-1
4.1.1 Contractor Submittals 4-1
4.2 CONSTRUCTION DOCUMENTATION 4-3
4.2.1 Weekly Contractor Quality Control Report 4-4
4.2.2 Weekly Disposal Reports 4-4
4.2.3 Topographic Survey Reporting 4-4
4.2.4 Import Material Characterization Reports 4-4
4.2.5 Waste Characterization Testing Reports and Waste Manifests 4-5
4.2.6 Field Change Documentation 4-5

4.3 POST-CONSTRUCTION DOCUMENTATION 4-5
4.3.1 Record Drawings and As-Built Survey 4-5

5 CONSTRUCTION ELEMENTS 5-1
5.1 SURVEY CONTROLS AND PROJECT LIMITS 5-1
5.1.1 Description 5-1
5.1.2 Potential Concerns and Quality Control Measures 5-2
5.1.3 Environmental Controls, Monitoring, and Corrective Action 5-2
5.2 REPAIR OF ASPHALT PAVEMENT 5-2
5.2.1 Description 5-2
5.2.2 Potential Concerns and Quality Control Measures 5-2
5.2.3 Environmental Controls, Monitoring, and Corrective Action 5-3
5.3 PLACEMENT OF TEMPORARY CAP 5-3
5.3.1 Description 5-3
5.3.2 Potential Concerns and Quality Control Measures 5-3
5.3.3 Environmental Controls, Monitoring, and Corrective Action 5-4
5.4 DECOMMISSIONING OF EXISTING STORMWATER COLLECTION SYSTEM 5-4
5.4.1 Description 5-4
5.4.2 Potential Concerns and Quality Control Measures 5-4
5.4.3 Environmental Controls, Monitoring, and Corrective Action 5-5
5.5 STORMWATER CONVEYANCE AND TREATMENT 5-5
5.5.1 Description 5-5
5.5.2 Potential Concerns and Quality Control Measures 5-6
5.5.3 Environmental Controls, Monitoring, and Corrective Action 5-7

Attachment A. Erosion, Sediment, and Pollution Control Plan
Attachment B. Emergency Response and Spill Contingency Plan
Attachment C. Dust Monitoring Plan

LIST OF FIGURES

Figure 1 Project Organization Chart

ACRONYMS AND ABBREVIATIONS

CFR	Code of Federal Regulations
Consent Order	Order on Consent DEQ No. LOVC-NWR-08-04
CQAP	construction quality assurance plan
CQC	contractor quality control
CQCR	construction contractor quality control representative
DEQ	Oregon Department of Environmental Quality
EHS	environmental health and safety
HAZWOPER	hazardous waste operations and emergency response
Integral	Integral Consulting Inc.
LSS	Legacy Site Services LLC
MAO	Mutual Agreement and Order No. WQ/I-NWR-10-175
OSHA	U.S. Occupational Safety and Health Administration
QAO	quality assurance officer
QA/QC	quality assurance/quality control
SCM	source control measures
SHSP	site health and safety plan
SHSS	site health and safety supervisor
SSO	site safety officer
TBD	to be determined

1 INTRODUCTION

On behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc., Integral Consulting Inc. has prepared this construction quality assurance plan (CQAP) in support of the implementation of the stormwater source control measures (SCMs) at the former Arkema Portland Plant (the site) located at 6400 NW Front Avenue, Portland, Oregon. This CQAP is prepared pursuant to the Order on Consent, requiring SCMs, issued by the Oregon Department of Environmental Quality (DEQ), signed October 31, 2008 (DEQ No. LQVC-NWR-08-04) (Consent Order), and the new stormwater Mutual Agreement and Order No. WQ/I-NWR-10-175 (MAO) executed by DEQ and LSS on August 4, 2010. Refer to the contract documents for all locations and details of the work.

This CQAP provides direction for LSS' onsite quality assurance (QA) representative and details the verification methods and approaches to QA during construction activities in the project area. The plan describes the methods used to measure compliance with performance and method requirements. It specifies how modifications to the construction procedures will be directed, as necessary. It provides a summary of the required inspections, surveys, reporting mechanisms, and documentation. Further, it delineates the QA protocols necessary for project personnel to understand the construction quality control (QC) issues, monitoring and feedback processes, and potential corrective actions. This CQAP will be executed in conjunction with the contract drawings and specifications.

LSS will assume overall responsibility for management of the construction contract and contractor. LSS will be responsible for directing the Contractor's activities and responding to any recommendations made by Integral. Under this task, Integral will assume responsibility for management of the construction QA program to ensure that the work is completed in accordance with the construction contract documents. Integral will be onsite to observe the Contractor's actions and make recommendations to LSS to modify the Contractor's procedures. Construction activities will be documented.

1.1 CONSTRUCTION ACTIVIES ADDRESSED BY THE CONSTRUCTION QUALITY ASSURANCE PLAN

This CQAP addresses QA of the following construction activities/elements at the site:

- Establishment of survey controls
- Asphalt pavement repair
- Decommissioning of the existing stormwater collection system
- Construction of soil berms

- Excavation and construction of channels
- Excavation and construction of a detention basin, including installation of liner system and outlet structure
- Installation of a sand filter and associated structures, including installation of liner system, influent and effluent weirs, filtration media, and drainage pipe
- Management of excavated materials onsite
- Installation of underground piping
- Placement of the temporary cap
- Transportation and offsite disposal of construction debris.

1.2 DOCUMENT ORGANIZATION

The remaining sections of this document summarize the elements of the CQAP that are intended to ensure that quality construction practices are used and appropriate documentation is prepared, as required by the MAO. These sections are as follows:

- Section 2—Presents the roles, responsibilities, and qualifications of the parties involved in the removal action
- Section 3—Summarizes the inspections and verification activities to verify compliance with contract documents
- Section 4—Describes the documentation submittal requirements before, during, and after construction activities
- Section 5—Provides a task-by-task description of construction elements, their associated QC and QA measures, environmental monitoring requirements, and potential corrective actions.

2 PROJECT ORGANIZATION AND RESPONSIBILITIES

This section provides the organizational structure of the construction activities. The project organization is shown in Figure 1 and described in this section. Note that an individual on the stormwater SCMs implementation team may be responsible for more than one role while onsite.

2.1 CONSTRUCTION REGULATORY PERSONNEL

DEQ is the regulatory authority and responsible agency for overseeing and authorizing the implementation of the SCMs. In this capacity, DEQ will review and approve the design documents, and other Contractor submittals, to ensure that the Contractor's QA/QC program is consistent with the objectives of the SCMs. The project manager for DEQ is Matt McClincy.

2.2 SOURCE CONTROL MEASURE CONSTRUCTION IMPLEMENTATION PERSONNEL

The construction will be managed by the Owner's Representative, overseen by the Owner's Site Representative, LSS's QA officer, and executed by the construction Contractor.

2.2.1 Owner's Representative (Todd Slater, LSS)

2.2.1.1 Roles

The Owner's Representative will have overall responsibility for managing the schedule, budget, and project deliverables for stormwater SCMs implementation. The Owner's Representative will oversee program activities and perform management oversight and consultation for stormwater SCM implementation activities. He will be the main point of contact with the agencies for final approval of necessary actions and adjustments of activities to accomplish project objectives.

2.2.2 Owner's Site Representative (Larry Patterson, ERM)

2.2.2.1 Roles

The Owner's Site Representative will have overall responsibility for coordinating the stormwater SCMs implementation oversight activities in the work area. The Owner's Site Representative will be the point of contact for the Contractor.

2.2.3 Quality Assurance Officer (Integral)

2.2.3.1 Roles

LSS's Quality Assurance Officer (QAO) will be an employee of Integral. He/she will manage the QA program during construction of the remedy. The QAO will report directly to the Owner's Representative. The QAO will direct Integral project personnel assigned to the construction project (Integral Field QAO).

Responsibilities of the QAO include, but are not limited to, the following:

- Implementing and ensuring effective execution of all QA program activities defined herein
- Monitoring Contractor QC activities to ensure conformance with the construction contract documents (drawings and specifications), authorized policies, procedures, and sound construction practices, as well as recommending improvements, as necessary
- Conducting meetings with site personnel covering the requirements of the contract documents, Contractor's QC procedures, and CQAP
- Performing QA monitoring of the Contractor's construction activities, as well as those of its subcontractors, to ensure compliance with the contract documents
- Identifying, and informing LSS of non-conformances in accordance with the requirements of the contract documents, Contractor's QC procedures, and CQAP
- Providing recommendations to the Owner's Representative for the response actions in the event of nonconformance with the contract documents and prescribed procedures
- Maintaining awareness of the entire project to detect conditions that may adversely affect the quality and/or progress of the work
- Monitoring corrective action documentation for conditions adversely affecting the quality of the work, verifying implementation of corrective actions, tracking and analyzing corrective actions, and providing closeout corrective action documentation upon completion
- Provide required Professional Engineer's certification that the stormwater SCMs implementation was completed in general accordance with the intent of the contract documents.

2.2.3.2 Qualifications

The QAO will be a licensed Professional Engineer in the state of Oregon who has been involved in development of the design drawings and specifications for the site. The QAO will have at

least 10 years of professional experience, including design and/or construction oversight experience.

2.2.4 Field QAO/Field Supervisor

2.2.4.1 Roles

The Field QAO/Field Supervisor will report to the QAO and will be responsible for performing quality assurance monitoring and verifying the work is being completed in general accordance with the design drawings and specifications. These requirements include compiling and maintaining construction records, including but not limited to, import material testing reports, daily excavation and backfill progress reports, and excavation and backfill acceptance surveys.

2.2.4.2 Qualifications

The Field QAO/Field Supervisor will have at least 5 years of experience leading environmental field investigations, will have completed training in accordance with U.S. Occupational Safety and Health Administration (OSHA) Standard 29 Code of Federal Regulations (CFR) 1910.120 (e), and will have had 24 hours of supervised field training. The Field QAO/Field Supervisor will have completed an additional 8-hour OSHA supervisor training course.

2.2.5 Site Safety Officer (Integral)

2.2.5.1 Roles

Each company or organization working on the site will be responsible for developing and implementing its own site health and safety program. Integral's Site Safety Officer (SSO) will have the authority to implement and oversee the health and safety program for Integral personnel associated with completing the oversight activities. He/she will provide support to ensure that the site health and safety plan (SHSP) is implemented. For this project the Field QAO/Field Supervisor will also serve the role as the SSO.

2.2.5.2 Qualifications

The SSO will have completed training in accordance with OSHA Standard 29 CFR 1910.120 (e) and, at a minimum, will have had 24 hours of supervised field training. The SSO will also hold a current certificate for first aid/CPR training.

2.3 CONSTRUCTION CONTRACTOR

The Contractor will perform the construction activities, including demolition, placement of temporary cap, asphalt repair, sewer decommissioning, berm construction, channel construction, excavation and construction of a detention basin, and installation of a sand filter.

The Contractor will also conduct import material testing and waste disposal testing (as required by the approved receiving facilities).

These activities will be conducted in accordance to the contract drawings and specifications, as approved by DEQ. The Contractor will comply with Oregon law, DEQ requirements, and federal, state, and local laws regarding air pollution, noise control, water pollution, oil spillage, and used oil disposal, as they apply to the project. The following paragraphs describe the general functions of staff the Contractor will provide to the project. Specific individuals and functions will be described in the Contractor's required submittals.

All onsite Contractor and subcontractor personnel will be required to have current health and safety training required by the Oregon State Department of Labor and Industries and as listed below:

- 29 CFR 1910.120, Hazardous Waste Operations and Emergency Response (HAZWOPER)
- 29 CFR 1926, Safety and Health Regulations for Construction
- ORS Chapter 654, Oregon Occupational Safety and Health
- OAR Chapter 437, Division 3, Oregon Safety and Health Regulations for Construction.

2.3.1 Contractor Project Manager (TBD)

The Contractor Project Manager will report directly to the Owner's Site Representative and regularly interact and communicate with the QAO and Field QAO/Field Supervisor. The Contractor's Project Manager will provide management of and direction to the Contractor personnel assigned to the construction project site. In addition, the Contractor Project Manager will have overall responsibility for executing the work in compliance with the contract.

The Contractor Project Manager will also provide onsite management of and direction to the Contractor personnel, including craft labor and subcontractors. The Contractor Project Manager will be responsible for executing the work in full compliance with the contract drawings and specifications. In addition, the Contractor Project Manager responsibilities include verifying proper operation and maintenance of equipment, managing subcontractors, coordinating with the Owner's Site Representative and QAO, and providing weekly reports to the Owner's Site Representative, QAO, and Field QAO/Field Supervisor. The Contractor Project Manager will be responsible for the following:

- Supervising the site health and safety of construction personnel, including personnel in craft supervision, field engineering, quality, and administration.
- Coordinating with home office staff.

- Managing and coordinating all stormwater SCMs implementation subcontractors on the site.
- Ensuring completion of the construction in accordance with the contract documents and applicable codes and standards.
- Ensuring completion of the project on schedule and within budget.
- Ensuring that appropriate change management procedures are in place.
- Ensuring compliance with all environmental health and safety (EHS) requirements, including corporate, OSHA, HAZWOPER, and any project-specific requirements.
- Ensuring that adequate site security, appropriate for the activities being performed, is maintained.
- Ensuring that construction equipment is properly serviced and used.
- Ensuring that permanent equipment is properly stored and maintained consistent with the manufacturers' instructions and good warehousing practices.
- Resolving labor disputes and grievances and maintaining good labor relations.
- Ensuring that an adequate labor force is assigned to the project with the proper training, education, experience, skills, tools, equipment, and materials to complete the construction and minimize potential impacts to the environment.
- Preparing and submitting (electronically) the weekly production report to the Owner's Site Representative and the QAO or Field QAO/Field Supervisor.
- Ensuring that representatives of the Owner and their consultants are notified in advance of key actions. A schedule will be maintained and updated by the Contractor Site Supervisor reflecting these key actions.
- Overseeing Contractor quality control (CQC) program and CQC staff.

The Contractor shall comply with all federal, state, city, county, and other local laws, ordinances, statutes, rules, or regulations applicable to execution of the work.

2.3.2 Contractor Quality Control Representative (TBD)

The Contractor Quality Control Representative (CQCR) will report to the Contractor Project Manager on all matters affecting project CQC and will be responsible for implementation and maintenance of the CQC plan. Responsibilities of the CQCR include, but are not limited to, the following:

- Providing and maintaining an effective CQC system for all construction tasks
- Coordinating CQC monitoring and testing activities, and preparing construction submittals

- Monitoring CQC activities to ensure conformance with authorized policies, procedures, and sound construction practices, as well as recommending improvements, as necessary
- Conducting the weekly CQC meeting and submitting the meeting minutes electronically to the Owner's Site Representative, Owner's Representative's designee(s), and the Contractor Project Manager
- Conducting other meetings with the construction team covering the requirements of the CQC procedures and CQAP, as appropriate
- Informing, identifying, and resolving nonconformances in accordance with the requirements of the CQC procedures and CQAP
- Recommending stop work, or re-performance, with concurrence of the Contractor Site Supervisor, of any nonconforming activity resulting from improper application of prescribed procedures
- Maintaining awareness of the entire project to detect conditions that may adversely affect quality
- Monitoring corrective action documentation for conditions adverse to quality, verifying implementation of corrective actions, tracking and analyzing corrective actions, and providing corrective action documentation upon completion
- Preparing and submitting electronically the weekly construction QC reports to the Owner's Site Representative, Owner's Representative's designee(s), and the Contractor Project Manager
- Functioning as a liaison with the QAO and/or Field QAO/Field Supervisor.

2.3.3 Contractor Site Health and Safety Supervisor (TBD)

The Contractor Site Health and Safety Supervisor (SHSS) will also fulfill the duties and responsibilities of the environmental and safety supervisor. The SHSS will report to the Contractor Project Manager and assist with the implementation of the construction team's EHS programs and procedures. The SHSS will help to ensure that operations are performed in compliance with applicable client and site-specific requirements and government regulations. The SHSS will be responsible for the following:

- Ensuring that construction team members understand the requirements of the LSS' EHS policies and procedures through training and communications
- Assisting the Contractor Project Manager with implementation of the SHSP portions of the project plans
- Conducting daily EHS briefings

- Assisting the Contractor Project Manager with weekly health and safety inspections for construction team members
- Exercising stop work authority when warranted by conditions, in accordance with the project plans
- Performing specific tasks in accordance with the project plans
- Ensuring that site personnel have received required EHS regulatory and program training
- Supporting the Contractor Project Manager in accident and incident investigations
- Functioning as a technical resource for all environmental, safety, loss, industrial, and hygiene issues
- Ensuring that the specific responsibilities for EHS personnel identified in the SHSP are implemented.

The SHSS will have completed training in accordance with OSHA Standard 29 CFR 1910.120 (e) and, at a minimum, will have had 24 hours of supervised field training. The SHSS will also hold a current certificate for first aid/CPR training.

2.3.4 Other Contractor Personnel

Other site personnel (craft labor) may be added as deemed necessary by the Contractor. Additional responsibilities of the Contractor Project Manager and/or Contractor Site Supervisor and responsibilities of other site personnel will be determined by the Contractor.

2.3.5 Subcontractors

The Contractor Project Manager will identify any subcontractors the Contractor intends to employ in the work. The subcontractors are responsible to the prime Contractor for the quality of their work, protection of the environment, and the health and safety of their personnel. The subcontractor's principals will designate a job site foreman who will coordinate with the Contractor and be responsible to see that the work is conducted in accordance with the contract requirements.

The Contractor will employ an independent licensed land surveyor as a subcontractor for key surveying tasks that will be used for calculation of payment quantities, acceptance of the work (dredging and capping), and preparation of record drawings. The independent surveyor will be a licensed land surveyor in the state of Oregon qualified in land survey work, as defined in Specification Section 01724 – Field Engineering and Surveying.

The Contractor will use an analytical laboratory for certain testing requirements. The Contractor's Laboratory for all required chemical analyses must be listed in the National

Environmental Laboratory Accreditation Program and all soil and materials testing shall be performed under the direction of a professional geotechnical engineer with registration in the State of Oregon, in accordance with Specification Section 01450 – Quality Control.

3 INSPECTION, SAMPLING, AND VERIFICATION ACTIVITES

The Contractor will conduct inspections, sampling and testing, and monitoring activities to ensure compliance with the terms and conditions of the contract. The QAO and/or Field QAO/Field Supervisor will monitor the Contractor's QC activities to verify compliance with the contract requirements. Monitoring activities and frequencies for each of the construction elements will be provided in the final design package. Documentation of these activities is discussed in Section 4.

Inspection, sampling, and verification activities include the following:

- Verification of horizontal and vertical control survey procedures for excavation, backfill, and topographic surveying
- Verification that designated structures and debris have been properly removed and disposed of
- Verification that adjacent structures are protected during the work
- QC checks on the location of the excavation areas (stationing, offset, and elevation)—this may be done through independent means or verification of the Contractor's QC surveys
- QC checks on the onsite management of soils
- QC checks that stormwater and erosion control management requirements have been implemented in upland Contractor work areas, including loading areas
- Verification that side slopes have been excavated to final slope subgrade configuration
- Verification that geotextile materials comply with contract requirements, handling of these materials meet with manufacturer's recommendations, and proper installation occurs
- Verification that imported backfill materials comply with contract requirements for quality, durability, gradation, and chemical quality prior to delivery to the job site
- Verification of placed backfill thicknesses, limits, extents, and compaction
- Verification of proper installation of underground piping, including bedding, invert elevations, and compaction requirements
- Verification of proper tie-in to existing outfall (Outfall 004).
- Inspection and verification of proper erosion and sediment control measures as per the Contractor-developed, Owner's Agent-approved erosion, sediment, and pollution control plan for construction developed in accordance with the erosion, sediment, and

pollution control plan provided as Attachment A. These inspections will occur, at a minimum, weekly and after all precipitation events that produce runoff.

4 DOCUMENTATION AND REPORTING

Prior to the start of construction, various documents will be prepared by the Contractor to support the construction activities. The Contractor will be primarily responsible for QC during construction. The QAO and the Contractor will be responsible for QA (i.e., to verify that the required QC measures have been implemented). Contractor submittals are discussed below. A submittal check list will be provided in the final design package. Additional details are provided in the contract specifications.

4.1 PRE-CONSTRUCTION DOCUMENTATION

4.1.1 Contractor Submittals

In accordance with the contract specifications, the Contractor will submit several documents to support the construction. These documents will include descriptions of the specific means, methods, disposal facilities, schedule, personnel, etc. Required elements of the Contractor's submittals will be part of the Construction Work Plan prepared by the Contractor. A brief description of the construction work plan and its elements is provided below.

4.1.1.1 Construction Work Plan

The construction work plan will be prepared in accordance with Specification Section 01400 – Coordination and Construction Work Plan and will describe, in narrative form, the methods to be employed in the stormwater SCMs implementation, including equipment types, modes of operation, general schedules, sequence of activities, proposed personnel and subcontractors, disposal facilities and materials suppliers, and other aspects necessary to describe how and when the specified work will be performed. The construction work plan will also include a site plan showing locations of all temporary facilities and upland staging and access areas, including work areas, onsite equipment and material storage areas, temporary facilities, access and haul routes, etc.

The plan shall include the following construction documents either as one document or as separate documents included as part of the construction work plan by reference:

- Construction Schedule
- Contractor Quality Control Plan
- Environment Pollution Control, including:
  - Erosion, Sediment, and Pollution Control Plan
  - Emergency Response and Spill Contingency Plan

  - Dust Control Plan
  - Air Monitoring Plan
- Waste Material Disposal Plan
- Equipment Decontamination Plan
- Site Health and Safety Plan.

The contract specifications provide detailed submittal content requirements. In some cases, additional requirements are referenced in related sections of the contract specifications. Plans listed under the environmental pollution control must meet the minimum requirements presented in Attachments A through C. A brief description of the contents of each component of the construction work plan is provided below.

Construction Schedule

The project schedule will be prepared in accordance with Specification Section 01400 – Coordination and construction work plan. A detailed initial critical path project schedule will be submitted by the Contractor showing each construction element. Periodic schedule updates will be submitted by the Contractor following progress meetings with the Owner's Site Representative and the QAO.

Contractor Quality Control Plan

The CQC plan will present the system through which the Contractor assures that construction activities are being implemented in compliance with the requirements of the contract. The CQC plan will identify personnel, procedures, methods, instructions, inspections, records, and forms to be used in the CQC system. Specifically, the CQC plan will include a description of procedures for maintaining and updating activity logs; procedures for reporting emergencies of out-of-specification conditions; record-keeping procedures for personnel, equipment, maintenance, and calibration; and weekly reporting requirements. The CQC plan also includes a description of the analytical testing to be conducted by the Contractor, including analysis of:

- Imported materials
- Waste materials (as required by the landfill)
- Wastewater (as required for discharge).

Environmental Pollution Control

The Contractor will be required to submit several plans describing the environmental protection measures and monitoring activities that will accompany all construction activities as defined in Specification Section 01355 – Environmental Pollution Protection Control and in Attachments A through C. The plans will cover potential environmental releases as a result of the construction operations, as well as monitoring and corrective actions necessary to control such releases. The

plans will address contamination prevention, containment and cleanup, stormwater control and pollution prevention, and air pollution and dust control.

Waste Material Disposal Plan

This plan will address the requirements of the Specification Section 01574 – Waste Material Disposal. The plan will address the handling, storage, transportation, and disposal of non-hazardous and hazardous wastes generated at the site. The plan will comply with regulations administered by DEQ, the U.S. Department of Transportation, and the Oregon Department of Transportation. The waste material disposal plan will identify the types and quantities of each waste stream, describe the Contractor's proposed disposal or recycling facilities for each waste stream, subcontractors to be employed, transportation methods, and equipment. All proposed disposal and recycling facilities are subject to the Owner's Site Representative and QAO acceptance.

Equipment Decontamination Plan

This plan will address the requirements of equipment decontamination as set forth in Specification Section 0355 – Environmental Pollution Protection Control. The plan will document the proposed methods, equipment, and operating sequences to be used in performance of the decontamination of equipment.

Survey Plan

The survey plan will describe the methods to perform topographic surveying as a way of accurately monitoring excavation and backfill activities. The plan will be developed following the requirements of Specification Section 01724 – Field Engineering and Surveying. The plan will provide the name and qualifications of the independent surveyor and the Contractor's survey crew, equipment, and methods to be used, and schedule and format for survey-related submittals.

Site Health and Safety Plan

The Contractor will submit a SHSP presenting the minimum health and safety requirements for the job site activities, and the measures and procedures to be employed for protection of onsite personnel. The plan will cover the controls, work practices, personal protective equipment, and other health and safety requirements that will be implemented by the Contractor in connection with the stormwater SCMs implementation construction activities.

4.2 CONSTRUCTION DOCUMENTATION

During construction activities, the Contractor will be required to submit weekly reports to the Owner's Site Representative and/or Field QAO/Field Supervisor. These reports are intended to summarize weekly work conditions, progress, deviations, and corrective measures. A brief

description of the contents of the general documentation that will be submitted during construction is provided below. Additional documentation required by the Contractor for specific construction elements is discussed in Section 5. Furthermore, the contract specifications describe Contractor submittal requirements in detail.

4.2.1 Weekly Contractor Quality Control Report

During construction activities, the Contractor will prepare weekly contractor QC reports and submit them to the Field QAO/Field Supervisor. The reports will summarize the work performed by the Contractor, the equipment used, and the results of any QC inspections, tests, or other monitoring activities. The reports will also document any noncompliant conditions, communication of such conditions to the Owner's Site Representative and Field QAO/Field Supervisor, and corrective actions taken to attain compliance.

4.2.2 Weekly Disposal Reports

Weekly disposal reports shall be submitted to the Owner for all waste material, wastewater, and debris transferred to approved upland disposal or recycling facilities. The weekly reports shall include the total number of truckloads, total estimated volume, total tons of material received at the disposal facilities, and a copy of the completed waste disposal tracking sheets.

4.2.3 Topographic Survey Reporting

Post-topographic surveys (acceptance surveys) that are used for payment and acceptance of the work will be completed by an independent professional surveyor under contract to the Contractor, as specified in Specification Section 01724 – Field Engineering and Surveying. The Contractor will complete weekly progress surveys. Progress and acceptance surveys will be reported in the weekly construction QC reports. Drawings, field notes, and quantity computations will be submitted within 7 calendar days after completion of each survey.

4.2.4 Import Material Characterization Reports

Prior to any onsite placement of import materials, the Contractor shall supply to the Owner's Site Representative copies of test certificates for materials or equipment from suppliers indicating that such material or equipment is in compliance with contract requirements.

All characterization will be in accordance with the requirements of contract specifications. No material will be brought onsite or placed until the Owner's Site Representative has accepted the test results.

4.2.5 Waste Characterization Testing Reports and Waste Manifests

Existing site characterization information shall be used to the extent possible for disposal characterization. The Contractor will coordinate with the disposal facilities on any additional testing required.

The Contractor shall supply weekly disposal reports for all waste material, wastewater, and debris transferred to approved upland disposal or recycling facilities. The weekly reports shall include the total number of truckloads, total estimated volume, total tons of material received at the disposal facilities, and a copy of the completed waste disposal tracking sheets.

All transportation-related shipping documents shall be submitted to the Owner—including draft manifests for waste; draft bills of lading; lists of proposed labels, packages, markings, and placards to be used for shipment; and any waste profiles and/or supporting waste analysis documents—for a review a minimum of 5 days prior to anticipated shipment. Generator copies of manifests used for initiating shipments of waste, bill of ladings, and supporting waste analysis documents shall be furnished when shipments are originated. The Contractor shall not allow any waste to leave the project site until shipping documents have been accepted by the Owner.

Receipt copies of waste shipment records at the designated disposal facility shall be furnished no later than 30 days after acceptance of the shipment. When required by law, waste shipping papers shall be returned to the Owner within the legally specified time.

4.2.6 Field Change Documentation

In the event that a change or changed condition is encountered by the Contractor as defined in the contract documents, the Contractor Project Manager and the Owner's Site Representative will review the condition and jointly make a determination as to what revision in the construction activity or construction product will be required, consistent with the intent of the design documents. This process will be documented on field change request form by the Owner's Site Representative. A sample form will be provided by the contractor

4.3 POST-CONSTRUCTION DOCUMENTATION

4.3.1 Record Drawings and As-Built Survey

The Contractor will be required to submit record drawings for the final acceptance survey in accordance with Specification Section 01724 – Field Engineering and Surveying. The Contractor shall also compile a final as-built survey and plan drawings of the work for inclusion in the construction records report to be prepared by the Owner. The final as-built survey shall be a compilation of the baseline survey, progress surveys, and final backfill acceptance survey.

5 CONSTRUCTION ELEMENTS

The Contractor will be required to perform the following construction activities in accordance with the contract drawings and specifications:

- Establishment of survey controls
- Repair of asphalt pavement
- Placement of the temporary cap
- Decommissioning of the existing stormwater collection system
- Construction of stormwater conveyance and treatment system.

The Contractor's work will be conducted in accordance with the contract drawings and specifications, including implementation of QA/QC procedures specified therein, as necessary to build a successful remedy. A narrative of the work and QA/QC procedures to be completed by the Contractor will be presented in the Construction Work Plan and supporting documents. Several work items for which the Owner's Site Representative has primary responsibility are discussed in greater detail below. Included below for each of these construction elements is a summary of the following items:

- Task Description—Brief description of the construction task, the equipment, and general procedures that will be utilized to accomplish the activity
- Potential Concerns and QC Measures—Description and evaluation of potential construction concerns; measurements, procedures, or inspections to verify compliance with contract drawings and specifications; and anticipated remedies to correct QC deviations
- Environmental Controls, Monitoring, and Corrective Actions—Brief description of measures necessary to prevent environmental pollution and minimize environmental degradation during and as a result of construction operations as described in Specification Section 01355 – Environmental Pollution Protection Control.

5.1 SURVEY CONTROLS AND PROJECT LIMITS

5.1.1 Description

The Contractor will employ an independent surveyor to perform a topographic survey for the final as-built survey and plan drawings. All surveys will be conducted as required by Specification Section 01724 – Field Engineering and Surveying.

5.1.2 Potential Concerns and Quality Control Measures

The Contractor shall exercise care during the execution of the work to minimize any disturbance to existing property and to the landscape and waters in the areas surrounding the work site. Survey crews shall not traverse into controlled or contaminated areas without approval from the QAO. All topographic survey, layout, and related work will be performed and signed by a Professional Land Surveyor registered in the state of Oregon.

5.1.3 Environmental Controls, Monitoring, and Corrective Action

The Owner's Site Representative reserves the right to retain an independent surveyor to periodically check surveys and verify that the design grades have been achieved prior to placement of import materials. The Contractor shall protect survey control points prior to starting site work and preserve permanent reference points during construction. The Contractor shall not relocate site reference points without prior approval from the QAO. The Contractor shall promptly report to the QAO the loss, damage, or destruction of any reference point or relocation required because of changes in grades or other reasons. The Contractor shall replace dislocated survey control points based on original survey control at no additional cost to the Owner. Replacement of dislocated survey control points shall be done by a Professional Land Surveyor registered in the state of Oregon.

5.2 REPAIR OF ASPHALT PAVEMENT

5.2.1 Description

This element includes asphalt pavement repair in the former DDT storage area. Asphalt cracks that are substantial enough to expose surficial soil to stormwater flows will be sealed to prevent the movement of potentially contaminated surface soil in stormwater. Asphalt maintenance areas are shown in the contract drawings, and the process for crack repair is described in Specification Section 02510 – Environmental Cap.

5.2.2 Potential Concerns and Quality Control Measures

Additional cracks and/or asphalt deterioration may require repair if encountered during the repair operations. Asphalt repair activities will not be initiated until required construction activities related to the groundwater barrier wall or extraction and treatment system are completed in these areas. All import materials used for asphalt repair will be verified through Contractor submittals to conform to Specification Section 02510 – Environmental Cap.

5.2.3 Environmental Controls, Monitoring, and Corrective Action

The FieldQAO/Field Supervisor will observe activities to verify that asphalt repair is conducted following the contract drawings and specifications.

Temporary enclosures and other suitable methods shall be employed to limit to the lowest practical level the amount of dust and dirt rising and scattering in the air during cleaning of the cracks prior to repair. The Contractor will comply with Specification Section 01355 – Environmental Pollution Protection Control and all governing regulations pertaining to environmental protection.

5.3 PLACEMENT OF TEMPORARY CAP

5.3.1 Description

This element includes the placement of the geotextile-gravel cover system in unpaved areas as depicted in the contract drawings and specifications.[1] This element will also require filling in of areas with a clean borrow material to allow for cap placement on a smooth surface. Placement of the cap shall be to the grades, lines, and limits shown on the contract drawings.

5.3.2 Potential Concerns and Quality Control Measures

Placement of the temporary cap on areas that could potentially expose underlying soils to stormwater is required throughout the portion of the site designated to be capped in the contract drawings. During construction, additional areas of exposed soils may be encountered that require placement of a temporary cap.

The temporary cap is designed to be placed on a smooth, level, or gradually sloping (maximum 2 horizontal: 1 vertical) surface. Areas requiring import fill to allow for the placement of the cap have been designated in the contract drawings. Additional areas of import fill may be required for correct placement of the cap. The chemical and physical characteristics of the berm and channel materials will be verified through Contractor submittals, to conform to Specification Section 02510 – Environmental Cap.

Construction of temporary caps will not be initiated until all required construction activities related to the groundwater barrier wall or extraction and treatment system are completed.

[1] Temporary caps will be place in the area of the former DDT manufacturing building. This is a building foundation with several former equipment pads and a retaining wall that may require demolition prior to placement of the temporary cap.

5.3.3 Environmental Controls, Monitoring, and Corrective Action

The Field QAO/Field Supervisor will observe activities to verify that the temporary cap is placed according to the contract drawing and specifications.

Temporary enclosures and other suitable methods shall be employed to limit the amount of dust and dirt rising and scattering in the air during clearing, cleaning, and potential demolition of the areas to be capped. The Contractor will comply with Specification Section 01355 – Environmental Pollution Protection Control and all governing regulations pertaining to environmental protection.

5.4 DECOMMISSIONING OF EXISTING STORMWATER COLLECTION SYSTEM

5.4.1 Description

The decommissioning of the existing stormwater collection system will be coordinated with work conducted on the groundwater barrier wall and installation of the stormwater conveyance system. Some of the existing system will require decommissioning prior to the installation of the groundwater barrier wall. The remainder of the existing stormwater collection system will be decommissioned after the proposed stormwater conveyance system is in place. Methods for decommissioning (i.e., abandoning-in-place) are described in the Specification Section 0222 – Abandonment of Storm Drain System.

5.4.2 Potential Concerns and Quality Control Measures

The locations of the existing stormwater collection system structures were identified, to the extent practicable, by reviewing old facility drawings, interviewing past facility employees, and conducting a site survey. Additional structure decommissioning may be required if collection system structures are encountered during construction activities. The chemical and physical characteristics of the decommissioning materials (controlled low strength material and pea gravel) will be verified through Contractor submittals, to conform to Specification Section 0222 – Abandonment of Storm Drain System.

The Contractor will keep records during construction using the weekly construction QC report, as described in Specification Section 01450 - Quality Control. The weekly construction QC reports will include the following specifics regarding the placement of the temporary cap:

- Shipping receipts and material volumes for all shipments of import fill materials
- Construction progress, volume estimates, and locations of material placed onsite
- Weekly summaries of progress and material quantities.

The Field QAO/Field Supervisor will observe activities to verify that construction of the stormwater conveyance and treatment system is performed in accordance with the contract drawings and specifications.

5.4.3 Environmental Controls, Monitoring, and Corrective Action

The Field QAO/Field Supervisor will observe activities to verify that demolition, debris removal, and sewer abandonment is performed at the correct locations.

Potential environmental concerns include releases of turbidity, debris, or hazardous materials into the Willamette River during demolition or sewer abandonment activities. Control measures to prevent such releases will be outlined in the construction work plan and the health and safety plan, as per the requirements of Specification Section 01566 – Erosion and Sediment Control.

Observed turbidity or sheens during demolition and removal activities will trigger a cease to all demolition activities to determine the source of turbidity and/or sheens and the appropriate corrective action.

5.5 STORMWATER CONVEYANCE AND TREATMENT

5.5.1 Description

The stormwater conveyance and treatment system will be constructed to divert stormwater from the existing stormwater collection system to a network channels draining to a treatment system. The treatment system will consist of a detention basin and aboveground sand filter. The following elements are part of the construction of the system:

- Construction of soil berms in designated areas
- Excavation and construction of channels in designated areas
- Excavation and construction of a detention basin, including installation of a liner system and outlet structure
- Installation of a sand filter and associated structures, including installation of a liner system, weir system, and drainage pipe (underground)
- Installation of underground piping
- Tie-in to existing Outfall 004
- Onsite management of excavate soils
- Transportation and offsite disposal of construction debris

5.5.2 Potential Concerns and Quality Control Measures

The main concerns associated with the construction of the stormwater conveyance and treatment system are the following:

- **Coordination with construction activities related to barrier wall construction.** Constructions activities will be sequenced with other work being conducted at the site following Specification Section 01400 – Coordination and Construction Work Plan
- **Achieving specified excavation depths, slopes, and limits.** The Contractor will be required to perform progress surveys to ensure that excavations proceed to the depths and limits specified in the drawings.
- **Proper installation of geotextile and geomembrane materials within the detention basin and sand filter.** The contractor will be required to follow manufacturer's recommendations for handling and installation of geotextile materials within the detention basin and sand filter. The installation shall conform to the contract drawings and Specification Section 02501 – Storm Drainage and Treatment System.
- **Proper installation of underground piping including meeting all specified invert elevations and bedding requirements.** The Contractor will be required to perform progress surveys to ensure that piping installation proceeds at the depths and limits specified in the drawings. Piping will be installed as per the contract drawings and Specification Section 02501 – Storm Drainage and Treatment System.
- **Control of onsite stormwater during construction.** Best management practices will be put in place to manage stormwater during construction activities following Specification Section 01566 –Erosion and Sediment Control.
- **Onsite management of soils.** Excavated soils will be managed onsite following the contaminated materials management plan in Appendix B of the Final Design Report and Specification Section 02325 – Excavation and Backfill.
- **Spillage of soils during handling or drag-out of contaminants from improperly decontaminated trucks.** To minimize any potential for spillage from rehandling of soils, the Contractor will be required to provide methods for preventing soil loss during onsite management of excavated soils. The Contractor will also be required to control the release of soils and any associated liquids around the soil staging areas.
- **Verification of import materials.** The chemical and physical characteristics of the berm and channel materials will be verified through Contractor submittals, to conform to Specification Section 02501 – Storm Drainage and Treatment System
- **Installation of liner system.** The liner system will be installed following the manufacturer's specifications, and contract drawings and specifications, as set forth in

Specification Section 02501 – Storm Drainage and Treatment System. The system will be tied into an existing outfall onsite, as shown on the contract drawings.

5.5.3 Environmental Controls, Monitoring, and Corrective Action

The Field QAO/Field Supervisor will observe activities to verify that construction of the stormwater conveyance and treatment system is performed in accordance with the contract drawings and specifications. The Contractor and Field QAO/Field Supervisor will also continuously monitor the soil handling operations and inspect all equipment as they leave the site. If any leakage or track-out is detected, the Contractor will take the necessary actions to stop the leakage and immediately clean any leakage or track-out. All repairs and corrective measures will be accomplished to the satisfaction of LSS and DEQ.

Potential environmental concerns include releases of turbidity, debris, or hazardous materials into the Willamette River during construction activities. Control measures to prevent such releases will be outlined in the construction work plan and the health and safety plan, as per the requirements of Specification Section 01566 – Erosion and Sediment Control.

The Contractor will keep records during construction using the weekly construction QC report, as described in Specification Section 01450 – Quality Control. The weekly construction QC reports will include the following specifics regarding the placement of the temporary cap:

- Shipping receipts and material volumes for all shipments of import fill materials
- Construction progress, volume estimates, and locations of material placed onsite
- Weekly summaries of progress and on-site soil management volumes.

FIGURES

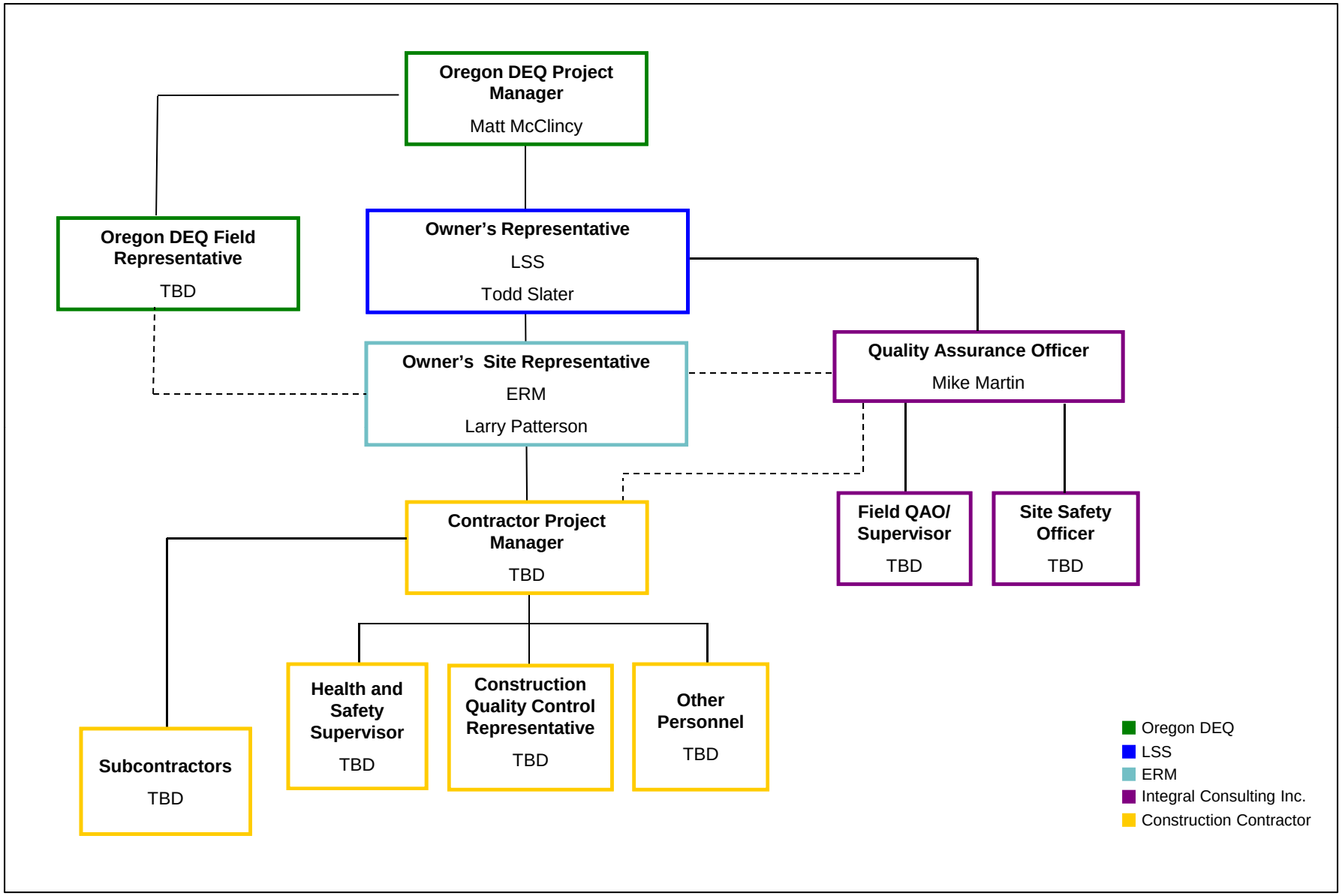


Figure 1
Project Organization Chart
Construction Quality Assurance Plan
Final Design Report
Stormwater Source Control Measures

ATTACHMENT A

EROSION, SEDIMENT, AND POLLUTION CONTROL PLAN

ATTACHMENT A

EROSION, SEDIMENT, AND POLLUTION CONTROL PLAN

INTRODUCTION

The Contractor will be required to submit an erosion, sediment, and pollution control plan (ESPCP) that describes the environmental protection measures and monitoring activities that will accompany all construction activities as defined in the technical Specification Section 01566 – Erosion and Sediment Control. This plan is an element of environmental pollution control described in Section 4.1.1.1 of the Construction Quality Assurance Plan. The ESPCP will cover potential environmental releases as a result of the construction operations, as well as monitoring and corrective actions necessary to control such releases. The ESPCP will address contamination prevention, containment and cleanup, stormwater pollution prevention, stormwater control, and water quality.

PLAN REQUIREMENTS

The ESPCP will address elements related to the management of erosion and sediment controls to prevent releases during construction activities. Construction activities related to stormwater management will follow permit requirements. The ESPCP will at a minimum address the requirements described in the City of Portland Erosion and Sediment Control Manual (City of Portland 2008), Section 3.2.

The Contractor will review the Erosion and Sediment Control Manual for the development of the ESPCP and selection of best management practices (BMPs) for use during construction activities. The plan shall also be sequenced to identify when specific BMPs will be implemented, coinciding with ground-disturbing activities. At a minimum, the ESPCP will include the items described below.

CONSTRUCTION PLANNING

The ESPCP will identify the name, address and telephone number of all responsible parties, including the developer and property owner. The Contractor will also identify the individual responsible for preparing and implementing the ESPCP. This individual must be a Certified Professional in Erosion and Sediment Control or licensed Professional Engineer with the State of Oregon.

The Contractor will demonstrate an understanding of the existing site conditions, proposed design, and critical areas that may be subject to erosion and sedimentation. The ESPCP will include a narrative, which identifies and describes the following:

- Any wetlands, water bodies, or outfalls within 200 ft of the ground-disturbing activity
- Existing and proposed land uses
- Existing and proposed ground contours and drainage patterns within the area of ground-disturbance
- Slopes that are steeper than 10 percent (1 vertical: 10 horizontal)
- Vegetated areas to remain undisturbed.

In addition, the Contractor will provide a preliminary construction schedule, including anticipated start and completion dates for all ground-disturbing activities and the associated dates for installation, maintenance, and removal of erosion, sediment, and pollution control BMPs. The schedule will also include decommissioning of the existing stormwater collection system, as well as other items identified in technical Specification Section 01110 – Summary of Work.

When preparing the schedule, the Contractor will attempt to limit ground-disturbing activities between October 1 and April 30; however, it is recognized that additional factors may influence the schedule. The Contractor will update the schedule as appropriate throughout the duration of work. Changes to and deviations from the schedule will be reported through the designated Owner's Site Representative as work on the site progresses (see Construction Quality Assurance Plan, Section 2.2).

The ESPCP will contain procedures for routine maintenance of all BMPs to be provided at the site. The construction schedule will include weekly inspections for BMPs between May 1 and September 30, and daily inspections between October 1 and April 30. All BMPs will be kept in proper functioning order. The Contractor will maintain, adjust, repair, and replace BMPs within 24 hours following a storm event to ensure that they are functioning properly through all phases of construction. The Contractor will include a sample inspection log in the ESPCP to be used during construction activities. Completed inspection logs will be made available to agencies upon request.

MOBILIZATION

The ESPCP will identify BMPs to be provided during mobilization and prior to any other ground-disturbing activities. At a minimum, the plan will include the following:

- Demarcation/flagging of construction limits
- Rock construction entrance and stabilized construction access ways

- Wheel wash structures
- Storm drain inlet protection at existing storm structures
- Armoring (e.g., riprap) at existing outlets
- Perimeter sediment controls (e.g., silt fences, filtration bags, wattles)
- Designated stockpile location(s) and temporary stabilization measures that will be used to secure stockpiles
- Demarcation / signage of exclusion, contaminate reduction, and support zones
- Project signage displaying the City's erosion control complaint hotline number and Contractor's 24-hour emergency contact number.

In addition to the above, the Contractor will prepare a sketch of the staging area(s) indicating how jobsite materials will be managed. At a minimum the sketch will include the location of the jobsite trailer, parking areas, refuse containers, sanitary facilities, boot washes, equipment fueling areas, fuel and jobsite chemical storage, and construction water treatment facility (e.g., baker tanks) for trench/excavation dewatering, wheel wash water, and decontamination rinsate.

DEMOLITION, DECOMMISSIONING, AND EXCAVATION

It is acknowledged that stormwater from work areas cannot be discharged to surface waters without treatment. As an alternative, it may be discharged to an approved facility that can accept the water. The ESPCP will identify BMPs to be provided to control, treat, and dispose of stormwater from the site while future control measures are under construction. At a minimum, the plan will include the following:

- Interceptor dikes and swales to be placed on the upland side of work areas in order to isolate construction areas from drainage pathways. Runoff from areas will be collected onsite and stored until it can be treated and discharged through the newly constructed detention basin and sand filter.
- A dewatering system to collect accumulated storm water from excavated areas and stored until it can be treated and discharge through the newly constructed detention basin and sand filter.
- Dust control measures to be implemented between May 1 and September 30 or as otherwise needed.
- Temporary stabilization measures to be implemented between October 1 and April 30 for unstabilized areas to be left unworked for longer than 48 hours.
- Housekeeping protocols to mitigate spillage and clean up any soil tracked from the work areas by construction vehicles.

BACKFILL AND CAPPING

At a minimum, the plan will include the following:

- New detention basin will be constructed first and will initially serve as a settling pond. Sand filter will be installed with the detention basin. Stormwater from the disturbed areas will be collected and stored until completion of the detention basin, sand filter, and associated transfer/discharge piping. Upon completion, site stormwater will be discharged near the inlet of the detention basin to all for treatment through the detention basin and sand filter system.
- Primary treatment of stormwater prior to discharge to the detention basin, including installation of silt fences, straw bales, or other filtering mechanism prior to entry into the detention basin. Alternatively, water may be collected and stored in baker tanks to allow for settling prior to discharge to the detention basin.
- Untreated runoff from unstabilized ground-disturbance areas will not be allowed to discharge from the site without treatment through the detention basin/sand filter system.
- Check dams in new drainage channels.
- Armoring at discharge points from new drainage channels and outlet pipes.
- Storm drain inlet protection at new storm structures and outlet control risers.
- Dust control measures to be implemented between May 1 and September 30 or as otherwise needed.
- Placement of stabilizing groundcover at finished grade.

SITE STABILIZATION

The ESPCP will identify BMPs to be provided upon completion of major ground-disturbing activities and upon establishment of groundcover at final grade. At a minimum, the plan will include the following:

- Removal and disposal of accumulated sediments and debris from the detention basin and sand filter and check dams after all site work (including installation of groundwater source control measures) has been completed.
- Removal and disposal of storm drain inlet control devices and accumulated sediment or debris from storm drains and pipes.
- Removal and disposal of perimeter sediment controls, silt fences, straw bales, rock construction entrance, etc.
- Implementation of the operation and maintenance plan.

ATTACHMENTS

The ESPCP will include construction drawings indicating the location of all structural BMPs and their position in relation to ground-disturbing activities. The drawings will identify which BMPs are permanent rather than temporary controls. Details of the installation method, including sizing calculations, will be included for each structural BMP and/or reference made to those provided in Section 4 of the Erosion and Sediment Control Manual (City of Portland 2008), as appropriate.

REFERENCES

City of Portland. 2008. Erosion and Sediment Control Manual. Prepared by City of Portland, Bureau of Development Services, Bureau of Environmental Services, Portland Office of Transportation, and the Portland Water Bureau. Portland, OR.

ATTACHMENT B

EMERGENCY RESPONSE AND SPILL CONTINGENCY PLAN

ATTACHMENT B

EMERGENCY RESPONSE AND SPILL CONTINGENCY PLAN

INTRODUCTION

The Contractor will be required to submit an emergency response and spill contingency plan that describes the response measures that will accompany all construction activities as defined in Specification Section 01355 – Environmental Pollution Protection Control of the contract specification document. The emergency response and spill contingency plan will ensure an effective, comprehensive response to prevent injury or damage to construction personnel, the public, and the environment during the project. The Contractor shall comply will all elements of the plan and the contract documents.

PLAN REQUIREMENTS

The City of Portland Bureau of Environmental Services provides guidance on the development of emergency response and spill cleanup plans (City of Portland 2000). This information has been summarized below and should, at a minimum, be included in the Contractor's plan:

- Identify and protect areas where spilled material can impact stormwater runoff.
- Propose methods to prevent spills, along with cleanup and notification procedures.
- Provide a site plan showing location of chemical storage areas (if any), location of storm drains, and direction of slope of site toward drains, water bodies, or offsite.
- Indicate location of any structures or devices on site, such as control valves or lined sumps, to prevent spills leaving the site.
- Provide notification procedures to be used in the event of a spill for contacting key personnel.
- Provide notification instruction regarding cleanup procedures, including how to handle fires and explosions should they occur.
- Identify the person with overall spill response cleanup responsibility.
- Describe training program that will be implemented for key personnel. All employees should have basic knowledge of spill control procedures.
- Provide information on cleanup kits located on the site.

REFERENCES

City of Portland. 2000. Environmentally Responsible Best Management Practices. ISW 0007-4. Prepared by City of Portland Bureau of Environmental Services. Portland, OR.

ATTACHMENT C

DUST CONTROL PLAN

ATTACHMENT C

DUST CONTROL PLAN

INTRODUCTION

The Contractor will be required to submit a dust control plan that describes the measures that will be put in place to address the control of fugitive and airborne dust emissions during construction activities as described in Specification Section 01355 – Environmental Pollution Protection Control. The primary objective of the plan is to develop a strategy for controlling, to the greatest extent practicable, fugitive or airborne emissions at the site. The Contractor will identify specific sources and activities that have the potential to produce or generate fugitive or airborne dust emissions. The plan will identify engineering controls necessary to minimize and control dust emissions from those sources and activities. As site conditions or activities change, the scope of the Contractor's plan will be revised.

PLAN REQUIREMENTS

The Contractor's dust control plan will be used to:

- To eliminate origins of dust from the site
- To identify potential dust migration pathways
- To visually monitor for dust produced by site activates
- To implement corrective actions as the need arises.

Potential Sources

At a minimum, the Contractor will employ dust control techniques in following locations:

- Areas of heavy equipment and vehicular traffic
- Transport routes, which shall be clean of tracked soils or excavated fill materials
- Soil and fill excavation sites
- Exposed excavation faces or disturbed ground surfaces
- Soil and fill stockpiles
- Soil and fill loading and unloading operations
- Soil backfill placement, grading, and compacting.

Best Management Practices

The Contractor will provide dust control methods for each activity. These best management practices shall at a minimum include the following:

- Administrative Control Methods—These methods concentrate on preventative controls such as enacting traffic restrictions/speed limits, reducing work activities when wind speeds increase, enclosing bulk soil, and enclosing soil movement operations.
- Structural and Mechanical Control Methods—These methods concentrate on actions taken to reduce exposure during site work operations. Options include:
  - Stabilizing storage, vehicle movement, and parking areas by installing gravel surfaces over geotextile fabric.
  - Sweeping paved surfaces to remove tracked soil.
  - Using plastic sheeting for dust control on temporary stockpiles.
- Water—Water is the wetting agent of choice to use on soils to resist wind erosion. Ensure that spray types and flow volumes and rate do not cause soil wash off.
- Properly decontaminate all construction equipment and vehicles prior to leaving the site as described in Specification Section 01355 – Environmental Pollution Protection Control.

APPENDIX B

CONTAMINATED MATERIAL MANAGEMENT PLAN

CONTAMINATED MATERIAL MANAGEMENT PLAN
FOR
STORMWATER SOURCE CONTROL MEASURES

Former Arkema Inc. Facility
Portland, Oregon

Prepared for
Legacy Site Services LLC
468 Thomas Jones Way
Exton, PA 19341-2528

Prepared by

integral consulting inc
319 SW Washington St
Suite 1150
Portland, OR 97204

September 30, 2011

CONTENTS

FIGURES ..... **iii**

ACRONYMS AND ABBREVIATIONS ..... **iv**

1 INTRODUCTION **1-1**

2 SOIL EXCAVATION, SCREENING, AND HANDLING **2-1**

2.1 SOIL EXCAVATION 2-1
2.2 SOIL SCREENING 2-1
2.3 SOIL HANDLING 2-2

3 DEBRIS AND OTHER MATERIAL SCREENING AND HANDLING **3-1**

3.1 DEBRIS AND OTHER MATERIAL SCREENING 3-1
3.2 DEBRIS AND OTHER MATERIAL HANDLING 3-1

4 MATERIAL SEGREGATION AND STOCKPILING **4-1**

5 TRANSPORTATION AND OFFSITE DISPOSAL **5-1**

5.1 TRANSPORTATION 5-1
5.2 OFFSITE DISPOSAL 5-1

6 HANDLING AND DISPOSAL OF OTHER WASTE STREAMS **6-1**

6.1 DECONTAMINATION WATER 6-1
6.2 SOLID WASTES 6-1
6.3 SANITARY WASTES 6-1

Attachment A PID and FID Specifications
Attachment B Headspace Screening for VOCs

FIGURES

Figure 1. Soil Staging Areas

ACRONYMS AND ABBREVIATIONS

CFR	Code of Federal Regulations
CMM	contaminated material management
DEQ	Oregon Department of Environmental Quality
FID	flame ionization detector
LDPE	low-density polyethylene
LSS	Legacy Site Services LLC
PID	photo-ionization detector
ppm	parts per million
RCRA	Resource Conservation and Recovery Act
SCM	source control measure

1 INTRODUCTION

On behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc., Integral Consulting Inc. has prepared this contaminated materials management (CMM) plan in support of the implementation of the stormwater source control measures (SCMs) at the former Arkema Portland Plant (the site) located at 6400 NW Front Avenue, Portland, Oregon. This CMM plan is prepared pursuant to the Order on Consent, requiring SCMs, issued by the Oregon Department of Environmental Quality (DEQ), signed October 31, 2008 (DEQ No. LQVC-NWR-08-04), and the new stormwater Mutual Agreement and Order No. WQ/I-NWR-10-175 executed by DEQ and LSS on August 4, 2010. Refer to the contract documents for all locations and details of the work.

The CMM plan describes the procedures for the management and handling of site soil and other materials excavated for the stormwater SCM. The elements of this CMM plan include:

- Soil excavation, handling, and screening
- Debris and other material handling and screening
- Soil stockpiling
- Transportation and offsite disposal
- Handling and disposal of other waste streams.

In order to be comprehensive, this plan addresses the handling of all material to be excavated as part of the installation of the stormwater SCMs, regardless of the existence of contamination. All soil and debris excavated during the installation of the SCMs will be managed and used as fill or temporarily stockpiled onsite until the final site remedy or properly characterized and disposed of in accordance with all state and federal regulations at an appropriate offsite disposal facility.

2 SOIL EXCAVATION, SCREENING, AND HANDLING

A summary of the onsite soil excavation, screening, and handling procedures is provided in this section.

2.1 SOIL EXCAVATION

The contractor will be responsible for the proper handling of all excavated material generated during the course of construction. Soil, and possibly other debris, will be generated during the excavation for the following elements of the stormwater SCMs:

- Channels
- Detention basin
- Sand filter.

Handling and screening procedures outlined in this plan apply to all materials excavated during stormwater SCMs construction. This section discusses the handling and screening of soil. The following section of the plan discusses the segregation and handling of debris and other material.

2.2 SOIL SCREENING

While the alignment and locations of the channels and basins were selected to avoid, to the extent feasible, areas with observed elevated DDT concentrations, as a precaution, monitoring and screening of the excavated soil will be conducted to allow for the segregation and handling of these materials.

Soil and debris excavated from the east[1] and west channels, detention basin, and sand filter will be field screened to determine if they will be immediately used as fill material or placed in Stockpile Areas 1 or 2 for additional characterization. Soil and debris will be visually inspected for contamination, such as free product, dark staining, pink or white soil staining indicative of elevated DDT contamination, or odors. Soil and debris that exhibit pink or white staining will be treated as State-only pesticide residue and placed in Stockpile Area 1. DEQ representatives will be notified when field observations indicate the possible presence of unanticipated contaminated material.

[1] Except for the portions of the east channel transecting the old Caustic Tank Farm and the Acid Plant area, which are assumed to be contaminated. The soil and debris from these areas will automatically be placed in Stockpile Area 1 for additional characterization.

Soil[2] will also be screened with a photo-ionization detector (PID) equipped with an 11.7 eV lamp and/or a flame ionization detector (FID) during soil excavation activities. Specifications and response factors for the selected PID and FID meters are presented in Attachment A. Each location of excavation of soil will be screened periodically using the PID and/or FID meter within 6 in. of the freshly excavated soil, approximately every 30 minutes. The soil will be considered potentially contaminated if the meter reading is 10 parts per million (ppm) over background levels for 10 seconds. If this threshold is exceeded, headspace testing for volatile organic compounds (VOCs) will be conducted on a representative sample of this material in accordance with site-specific operating procedure 1 (Attachment B). If the headspace reading is 10 ppm or higher, the soil will be considered potentially contaminated with VOCs. The field screener shall note that erratic meter responses may occur at high organic vapor concentrations or conditions of elevated headspace moisture, in which case headspace data will be discounted. As previously noted, DEQ representatives will be notified when field screening indicates the possible presence of unanticipated contaminated material. Soils that do not pass field screening tests will be placed in Stockpile Area 2.

Air monitoring will also be conducted during all excavation activities for health and safety purposes in accordance with the site health and safety plan (Appendix H of the Design Report).

All other soils (i.e., with no white or pink staining, not from former Acid Plant area or old Caustic Tank Farm, and passes field screening test) will be used as fill throughout the site as per the Drawings.

2.3 SOIL HANDLING

If the soil is temporarily staged adjacent to the excavation, the soil staging area will consist of a temporarily constructed, bermed area lined with plastic sheeting. The temporarily staged soil will also be covered with 6-mil low-density polyethylene (LDPE) sheeting at the end of each work day. Potential fugitive dust will be mitigated by ensuring that excavated soil remains covered or sufficiently moist until it is transported to the soil fill or stockpile area as described in Specification Section 01355 – Environmental Pollution Control.

Based on Remedial Investigation soil sample data, soil and debris from the east drainage channel excavation transecting the former Acid Plant area will be considered to potentially contain elevated DDT concentrations. Soil and debris from the old Caustic Tank Farm area that are excavated for the east channel may contain elevated concentrations of DDT and oil and diesel-range petroleum hydrocarbons. In addition, any soils and debris excavated from other areas of the site that are visually observed to have a pink or white color will be considered to

[2] Except for the portions of the east channel transecting the old Caustic Tank Farm and the Acid Plant area, which are assumed to be contaminated. The soil and debris from these areas will automatically be placed in Stockpile Areas 1 and 2 for additional characterization.

potentially contain elevated DDT concentrations. All of these soils will be treated as State-only pesticide residue and stored in Stockpile Area 1 for additional characterization. LSS will develop a Resource Conservation and Recovery Act (RCRA) characterization and management plan after stockpiling has been completed to determine the nature of the hazardous waste and provide a plan for managing the waste. The plan will be submitted to DEQ for review and approval.

All soil and debris with headspace screening results exceeding the criteria stated above will be considered potentially contaminated with VOCs. These materials will be stored in Stockpile Area 2 for additional characterization. LSS will develop a characterization and management plan for the waste in Stockpile Area 2 and submit it to DEQ for approval.

The soil in Stockpile Areas 1 and 2 will be managed in accordance with 40 Code of Federal Regulations (CFR) 265.250, 265.251, and 265.253 through 265.260 (without the leachate collection system). In accordance with the above-referenced CFRs, the soils will be capped as described in Section 4. No liquid wastes or free liquids will be placed in Stockpile Areas 1 and 2. No leachate will be generated from the stockpile since the soils are not expected to be saturated and the soil piles will be capped. The final disposition of temporarily stockpiled soil is outlined in Section 4 of this CMM plan.

3 DEBRIS AND OTHER MATERIAL SCREENING AND HANDLING

Excavated materials may include debris and other material. Examples of debris and other material include: concrete, asphalt, rebar, construction material, construction debris, demolition debris, and other non-soil materials. This section of the CMM plan addresses the screening and handling of these materials.

3.1 DEBRIS AND OTHER MATERIAL SCREENING

Debris and other excavated non-soil material will be visually/olfactorily inspected for contamination, such as free product, dark staining, attached soil, or odors. If this inspection indicates that the debris or other material is contaminated, then the debris will be stockpiled separately as described in Section 4.

3.2 DEBRIS AND OTHER MATERIAL HANDLING

Debris will be handled in the same manner as the excavated soils around the debris; however, debris may be segregated from excavated soil within the designated stockpile areas. If the debris is temporarily staged adjacent to the excavation, the debris staging area will consist of a temporarily constructed, bermed area lined with plastic sheeting. Potential fugitive dust will be mitigated by ensuring that excavated debris or other materials remain covered or sufficiently moist until transported to the stockpile area, as described in Specification Section 01355 – Environmental Pollution Control.

Debris and other materials that are suspected to be or identified as contaminated will be staged separately from other soil and debris. The final disposition of temporarily stockpiled debris is outlined in Section 4 of this plan.

4 MATERIAL SEGREGATION AND STOCKPILING

Excavation and screening of soil during the stormwater SCMs construction will generate the following materials:

- Soil/fill
- Soil and debris with potentially elevated concentrations of DDT
- Debris and other material/fill
- Potentially contaminated debris and other material.

All excavated material will remain onsite and be stockpiled or used as fill.[3] All soil stockpiles will be covered with 6-mil LDPE sheeting at the end of each work day. Areas of the site that will be used for fill or to stockpile soil are shown on Figure 1.

Fill areas consist of low-elevation depressions that are located throughout Lots 2, 3, and 4, as identified on Figure 1. These areas will be filled to prevent ponding and to promote drainage into the new SCMs system. Two fill areas (former Salt Pads and area adjacent to the sand filter) have been identified for potential use during SCMs construction. Soil, debris, and other material will be placed in the appropriate stockpile areas as follows:

- Soil and debris to be treated as a State-only pesticide residue: Stockpile Area 1 (northern Salt Pad; estimated 300 yd^3)
- Soil and debris potentially contaminated with VOCs: Stockpile Area 2 (northern Salt Pad; estimated 50 yd^3)
- Soil and debris without contamination: Stockpile Area 3 (unpaved portion of Lot 2).

Stockpile Areas 1 and 2 will be placed on a physical subbasin feature within the northern Salt Pad area as shown on Figure 1. Stockpile Area 3 consists of an unpaved area in Lot 2. Stockpile Area 3 is reserved for potential use and, if needed, will be delineated by the field engineer, and the limits of the stockpile area will be demarcated with berms by the contractor.

Debris and other material with visual contamination can be taken to the decontamination area and be decontaminated as per Specification Section 01355 – Environmental Pollution Control and following the decontamination be stockpiled with clean debris. If this material is not decontaminated, it shall be stockpiled and handled in the same manner as the potentially contaminated soil.

[3] Except for demolition debris from the former DDT process building, which will be transported to an appropriate offsite disposal facility. If necessary, this material will be stockpiled within the footprint of the former DDT process building during demolition activities prior to disposal. Any stockpiled material will be covered daily with 6-mil LDPE sheeting.

Most of the soil and debris volume is not anticipated to be contaminated. An estimated 15,000 yd^3 of uncontaminated material will be placed in fill areas or in Stockpile Area 3, if needed. Soil Stockpile Area 3 will not exceed 6 ft height above the surrounding grade. Once all soil and other debris have been placed in Stockpile Area 3 and fill areas, each of the areas will be covered with a temporary cap to prevent erosion and vegetation growth. The cap will consist of 6-mil plastic sheeting between two layers of geotextile fabric. Crushed rock will be placed over the liner to provide weighting and an armored surface for the cap.

Potentially contaminated materials will be placed in Stockpile Areas 1 and 2. Prior to the placement of any soil in Stockpile Areas 1 and 2, the condition of the northern Salt Pad area will be assessed and any cracking will be sealed with a liquid sealant, following the temporary capping protocol in Specification Section 02510 – Temporary Environmental Cap. Soil in Stockpile Areas 1 and 2 will be placed on a heavy duty plastic (minimum 20 mil), tear-resistant (fiber-reinforced) plastic liner. After the filling and subsequent characterization sampling activities are completed and it is determined that soil can remain onsite, the soil and debris in Stockpile Areas 1 and 2 will be capped with a 6-mil plastic sheeting between two layers of geotextile fabric to prevent breaching of the cap. Crushed rock will be placed over the liner to provide weighting and an armored surface for the cap. The cap will be constructed in accordance with Specification Section 02510 – Temporary Environmental Cap. Stockpile Areas 1 and 2 will be separated by berms and capped separately from adjacent Salt Pad fill areas.

Some small aboveground structures on the former DDT manufacturing building foundation will be demolished as part of the stormwater SCMs. Demolition debris from the former DDT manufacturing building will be assumed to contain U061 hazardous waste and will be transported to an appropriate offsite disposal facility. If necessary, this material will be stockpiled within the footprint of the former DDT process building during demolition activities prior to disposal. Any stockpiled material will be covered daily with 6-mil LDPE sheeting.

5 TRANSPORTATION AND OFFSITE DISPOSAL

No transport or offsite disposal of generated soil or debris is anticipated as part of this work except for demolition debris from some small aboveground structures on the former DDT manufacturing building foundation. However, other materials may be transferred offsite if LSS, in consultation with DEQ, determines offsite transportation and disposal of some of the excavated or other materials (e.g., Stockpile 1) encountered during stormwater SCMs construction is desirable. The following minimum requirements will apply to the transportation and offsite disposal of soil and debris.

5.1 TRANSPORTATION

The Contractor will be responsible for transportation of all materials to an appropriate offsite disposal facility, as specified in Specification Section 02250 – Transportation and Disposal of Materials. A properly licensed waste hauler, depending on the type of waste, will be used to transport all waste materials. No queuing of trucks shall be permitted on NW Front Avenue during waste hauling operations. All loads will be covered prior to leaving the site. No waste will be permitted to leave the site unless it has been properly manifested, in accordance with all applicable regulations and disposal facility requirements.

5.2 OFFSITE DISPOSAL

Waste facilities that may be used for offsite disposal will be identified to the LSS and DEQ prior to commencement of the work. These facilities must be approved by LSS. These facilities will meet the environmental, grading, safety and health requirements of the state, county, and local political subdivision where located. All disposal facilities will be legally licensed and permitted. Disposal facilities with significant RCRA violations or compliance problems (such as facilities known to be releasing hazardous constituents into groundwater, surface water, soil, or air) will not be used.

6 HANDLING AND DISPOSAL OF OTHER WASTE STREAMS

Other waste streams that will be generated during the stormwater SCM work include:

- Decontamination water
- Solid wastes
- Sanitary wastes.

Each of these waste streams will be managed in accordance with applicable federal, state, and local regulations and as described below and in Specification Section 02250 – Transportation and Disposal of Materials.

6.1 DECONTAMINATION WATER

To the extent possible, truck traffic will be restricted to paved areas of the site to minimize the need for equipment decontamination. Water generated from the cleaning of construction and excavation equipment and/or from the cleaning of debris that may be encountered during soil excavation will be containerized and stored onsite. Once the stormwater treatment systems are completed, equipment decontamination water will be treated through the available treatment systems (detention basin/sand filtration). This water shall be subject to primary treatment (e.g., settling via baker tank or similar) prior to discharge to the stormwater treatment system. In the event that offsite disposal of decontamination water is desired, the containerized decontamination water will be sampled and disposed of offsite in accordance with Specifications Section 01355 – Environmental Pollution Protection Control.

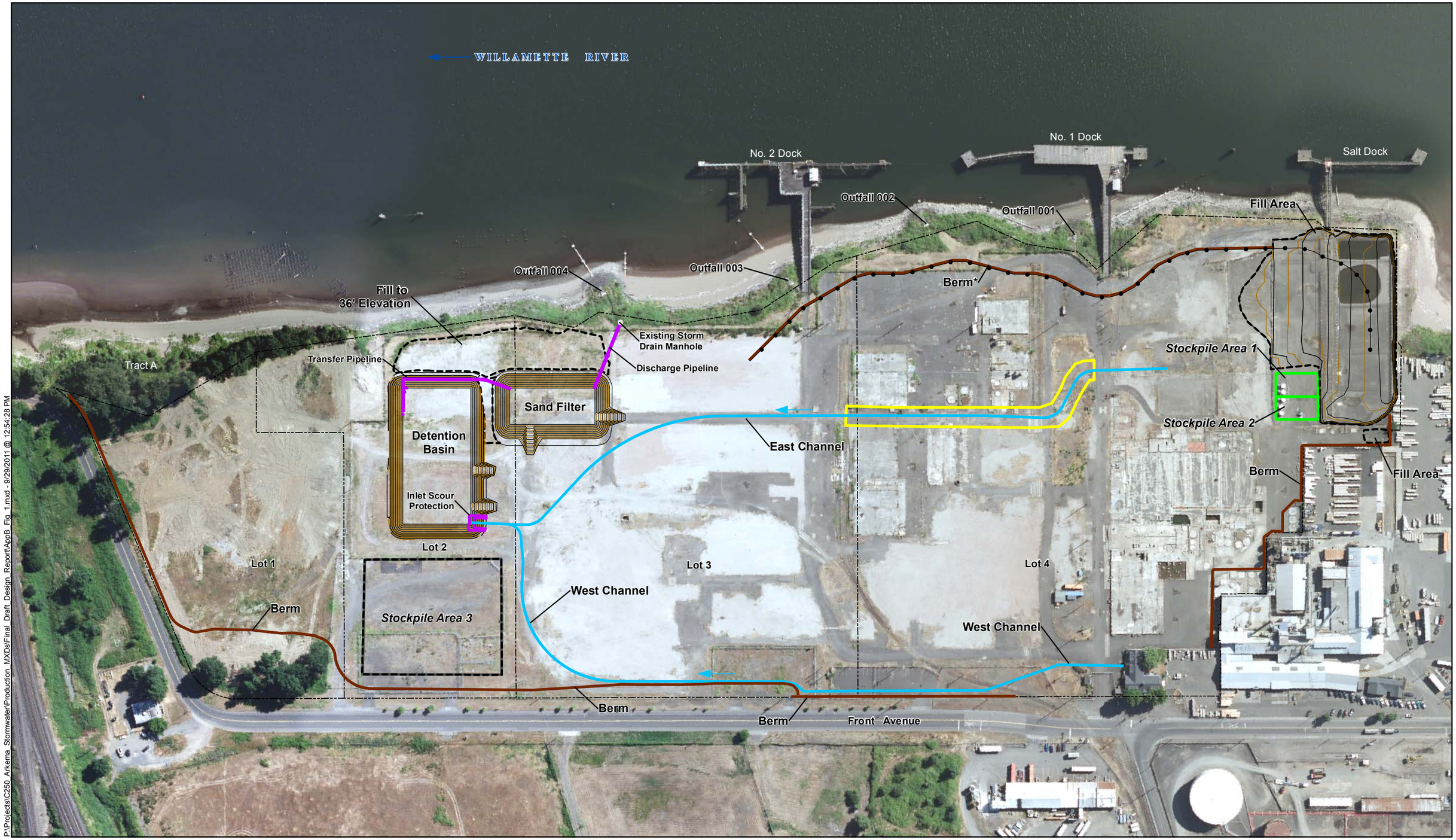
6.2 SOLID WASTES

All solid waste, including waste paper, garbage, and other non-hazardous debris, will be double-bagged in plastic garbage bags and placed in a solid waste dumpster provided by the Contractor.

6.3 SANITARY WASTES

The Contractor will be required to provide a sanitary portable restroom facility. Cleaning of the restroom and disposal of the restroom waste will be conducted by a licensed and bonded sanitary restroom provider and in accordance with a schedule that is based on the number of onsite workers. The sanitary restroom waste disposal and cleaning will occur at a minimum of once per week.

FIGURES



P:\Projects\C250 Arkema Stormwater\Production MXDs\Final Draft Design Report\AppB Fig 1.mxd - 9/29/2011 @ 12:54:28 PM

integral consulting inc.

N

FEATURE SOURCES:
Aerial: Metro, June-July 2009
Property Boundaries: DEA Survey

0 100 200 400 Feet

Map Features

- Channel
- Berm
- Detention Basin/Sand Filter Feature
- Areas to be Filled
- Potential DDT Containing Areas
- Excavated Soils for Stockpile Area 1
- Additional Stockpile Area
- Barrier Wall
- Property and Lot Boundary

*Berm follows alignment of proposed groundwater barrier wall and cap.

Figure 1
Soil Staging Areas
Contaminated Material Management Plan
Stormwater Source Control Measures

ATTACHMENT A

PID AND FID SPECIFICATIONS

MiniRAE 3000

Portable Handheld VOC Monitor

The MiniRAE 3000 is the most advanced handheld volatile organic compound (VOC) monitor on the market. Its photoionization detector's (PID) extended range of **0 to 15,000 ppm** makes it an ideal instrument for applications from industrial hygiene to leak detection and HazMat.

The **RF modem allows real-time data transmissions** with a base controller located up to 500 feet away from the MiniRAE 3000 (or two miles with optional RAELink3 portable modem). A personal computer can be used as the base station for a MiniRAE 3000 system. The standard ProRAE Remote software is capable of monitoring the input of up to 64 remotely located monitors, including MiniRAE 3000, AreaRAE, etc.

Wireless

AutoRAE Compatible

ver1_05.07

Key Features

- **Proven PID technology**
  The patented sensor provides the following unique features:
  - 3-second response time
  - Extended range up to 15,000 ppm with improved linearity
  - Humidity compensation with integral humidity and temperature sensors
- **Real-time wireless** data transmission with built-in RF modem or Bluetooth
- **Designed for simple service** Easy access to lamp and sensor in seconds without tools
- **Big graphic display** for easy overview of gas type, Correction Factor and concentration
- **Field-interchangeable battery pack** replaced in seconds without tools
- **Integrated flashlight** for better view in dark conditions
- **User-friendly screens, including dataplot chart view**
- **Integrated RAE Systems Correction Factors list for more than 200 compounds** to measure more chemicals than any other PID
- **Multi-language support** with 12 languages encoded
- **Rugged housing** withstands use in harsh environments
  - IP67 waterproof design for easy cleaning and decontamination in water
  - Strong protective removable rubber boot

Additional Advantages

- View real-time sensor data and alarm status at headquarters or command center
- Automatic lamp type recognition
- Duty-cycling™ lamp and sensor auto-cleaning technology
- Tough, flexible inlet Flexi-Probe™
- 3 large keys operable with 3 layers of gloves
- Strong, built-in sample pump draws up to 100 feet (30m) horizontally or vertically
- Loud, 95dB audible alarm
- Bright red flashing visual alarm
- Interchangeable drop-In lithium-ion and alkaline battery packs
- Charging cradle doubles as an external battery charger
- Compatible with AutoRAE™ calibration station
- ProRAE Remote software simultaneously controls and displays readings for up to 64 remote detectors
- License-free, ISM band RF transmission with communication range up to 500 feet (2 miles with optional RAELink3 modem)
- Optional RAELink3 modem provides GPS capability to track and display readings from remote detectors and provide up to 2 miles' long-distance transmission
- Datalogging with up to 6 months of data at one-minute intervals
- 3-year 10.6eV lamp warranty

MiniRAE 3000

Specifications*

Detector Specifications

Size	10" L x 3.0" W x 2.5" H (25.5 cm x 7.6 cm x 6.4 cm)
Weight	26 oz (738 g)
Sensors	Photoionization sensor with standard 10.6 eV or optional 9.8 eV or 11.7 eV lamps
Battery	• Rechargeable, external field-replaceable Lithium-Ion battery pack • Alkaline battery adapter
Operating Hours	16 hours of operation (12 hours with alkaline battery)
Display Graphic	4 lines, 28 x 43 mm, with LED backlight for enhanced display readability
Keypad	1 operation and 2 programming keys, 1 flashlight on/off
Direct Readout	Instantaneous reading • VOCs as ppm by volume • High values • STEL and TWA • Battery and shutdown voltage • Date, time, temperature
Alarms	95 dB (at 30 cm) buzzer and flashing red LED to indicate exceeded preset limits • High: 3 beeps and flashes per second • Low: 2 beeps and flashes per second • STEL and TWA: 1 beep and flash per second • Alarms latching with manual override or automatic reset • Additional diagnostic alarm and display message for low battery and pump stall
EMI/RFI	Highly resistant to EMI/RFI Compliant with EMC Directive 89/336/EEC
IP Rating	• IP67 unit off and without flexible probe • IP65 unit running
Datalogging	Standard 6 months at one-minute intervals
Calibration	Two-point or three-point calibration for zero and span. Calibration memory for 8 calibration gases, alarm limits, span values and calibration dates
Sampling Pump	• Internal, integrated flow rate at 400 cc/mn • Sample from 100' (30m) horizontally and vertically
Low Flow Alarm	• Auto pump shutoff at low-flow condition
Communication	• Download data and upload instrument set-up from PC through charging cradle or optional Bluetooth™ • Wireless data transmission through built-in RF modem
Frequency	902 to 928 MHz (license-free), 2.400 to 2.4835 GHz (license-free), 433 MHz, 869 MHz
RF Range	Up to 500' (900 MHz, 433 Mhz, 869 Mhz), extendable with RAELink3 Repeater to 2 miles
Hazard Area Approval	• **US and Canada:** UL, cUL, Classified as Intrinsically Safe for use in Class I, Division I Groups A, B, C, D • **Europe:** ATEX II 1G EEx ia IIC T4 (pending) • **IECEx:** II 1G EEx ia IIC T4 (pending)
Temperature	-4° to 113° F (-20° to 50° C)
Humidity	0% to 95% relative humidity (non-condensing)
Attachments	Durable bright yellow rubber boot with belt clip
Warranty	Lifetime on non-consumable components (per RAE Systems Standard Warranty), 3-year warranty for 10.6 eV lamp, 1 year for pump and battery

*Specifications are subject to change

Sensor Specifications

Gas Monitor	Range	Resolution	Response Time T90
VOCs	0 to 999.9 ppm 1000 to 15,000 ppm	0.1 ppm 1 ppm	< 3 s < 3 s

Monitor only includes:

- MiniRAE 3000 Monitor, Model PGM-7320
- Wireless communication module built in, as specified
- Datalogging with ProRAE Studio Package for Windows™ 95, 98, 2000, NT, ME & XP
- Charging/download adapter
- RAE UV lamp, as specified
- Flex-I-Probe™
- External filter
- Rubber boot with belt clip and straps
- Alkaline battery adapter
- Lamp-cleaning kit
- Tool kit
- Lithium-ion (Li-ion) battery with universal AC/DC charger and international plug kit
- Operation CD-ROM
- Operation & Maintenance manual
- Soft leather case

Monitor with accessories kit adds:

- Hard transport case with pre-cut foam padding
- Charging/download cradle
- 5 Porous metal filters and O-rings
- Organic vapor zeroing kit
- Gas outlet port adapter and tubing

Optional calibration kit adds:

- 100 ppm isobutylene calibration gas, 34L
- Calibration regulator and flow controller

Optional Guaranteed Cost of Ownership Program:

- 4-year repair and replacement guarantee
- Annual maintenance service

DISTRIBUTED BY:

ver1_05.07

RAE Systems Inc.
3775 North First Street
San Jose, CA 95134 USA
raesales@raesystems.com

USA/Canada 1-877-723-2878
Europe/Russia +45 8652 5155
Middle East/Australia 971 50 429 1385
China 8610 58858788
Asia +852 2669 0828

www.raesystems.com

RAE SYSTEMS

CORRECTION FACTORS, IONIZATION ENERGIES, AND CALIBRATION CHARACTERISTICS

Correction Factors and Ionization Energies

RAE Systems PIDs can be used for the detection of a wide variety of gases that exhibit different responses. In general, any compound with ionization energy (IE) lower than that of the lamp photons can be measured.* The best way to calibrate a PID to different compounds is to use a standard of the gas of interest. However, correction factors have been determined that enable the user to quantify a large number of chemicals using only a single calibration gas, typically isobutylene. In our PIDs, correction factors can be used in one of three ways:

1) Calibrate the monitor with isobutylene in the usual fashion to read in isobutylene equivalents. Manually multiply the reading by the correction factor (CF) to obtain the concentration of the gas being measured.

2) Calibrate the unit with isobutylene in the usual fashion to read in isobutylene equivalents. Call up the correction factor from the instrument memory or download it from a personal computer and then call it up. The monitor will then read directly in units of the gas of interest.

3) Calibrate the unit with isobutylene, but input an equivalent, "corrected" span gas concentration when prompted for this value. The unit will then read directly in units of the gas of interest.

* *Some inorganic compounds like H_2O_2 and NO_2 give weak response at photon energies well above those of their ionization energies. The term "ionization energy" replaces the old term "ionization potential."*

Example 1:

With the unit calibrated to read isobutylene equivalents, the reading is 10 ppm with a 10.6 eV lamp. The gas being measured is butyl acetate, which has a correction factor of 2.6. Multiplying 10 by 2.6 gives an adjusted butyl acetate value of 26 ppm. Similarly, if the gas being measured were trichloroethylene (CF = 0.54), the adjusted value with a 10 ppm reading would be 5.4 ppm.

Example 2:

With the unit calibrated to read isobutylene equivalents, the reading is 100 ppm with a 10.6 eV lamp. The gas measured is m-xylene (CF = 0.43). After downloading this factor, the unit should read about 43 ppm when exposed to the same gas, and thus read directly in m-xylene values.

Example 3:

The desired gas to measure is ethylene dichloride (EDC). The CF is 0.6 with an 11.7 eV lamp. During calibration with 100 ppm isobutylene, insert 0.6 times 100, or 60 at the prompt for the calibration gas concentration. The unit then reads directly in EDC values.

Conversion to mg/m^3

To convert from ppm to mg/m^3, use the following formula:

$$\text{Conc. (mg/m}^3) = \frac{[\text{Conc.(ppmv) x mol. wt. (g/mole)}]}{\text{molar gas volume (L)}}$$

For air at 25 °C (77 °F), the molar gas volume is 24.4 L/mole and the formula reduces to:

$$\text{Conc.(mg/m}^3) = \text{Conc.(ppmv) x mol. wt. (g/mole) x } 0.041$$

For example, if the instrument is calibrated with a gas standard in ppmv, such as 100 ppm isobutylene, and the user wants to display to read in mg/m3 of hexane, whose m.w. is 86 and CF is 4.3, the overall correction factor would be 4.3 x 86 x 0.041 equals 15.2.

Correction Factors for Mixtures

The correction factor for a mixture is calculated from the sum of the mole fractions Xi of each component divided by their respective correction factors CFi:

$$CFmix = 1 / (X_1/CF_1 + X_2/CF_2 + X_3/CF_3 + ... Xi/CFi)$$

Thus, for example, a vapor phase mixture of 5% benzene and 95% n-hexane would have a CFmix of
CFmix = 1 / (0.05/0.53 + 0.95/4.3) = 3.2. A reading of 100 would then correspond to 320 ppm of the total mixture, comprised of 16 ppm benzene and 304 ppm hexane.

For a spreadsheet to compute the correction factor and TLV of a mixture see the appendix at the end of the CF table.

TLVs and Alarm Limits for Mixtures

The correction factor for mixtures can be used to set alarm limits for mixtures. To do this one first needs to calculate the exposure limit for the mixture. The Threshold Limit Value (TLV) often defines exposure limits. The TLV for the mixture is calculated in a manner similar to the CF calculation:

$$TLV\ mix = 1 / (X_1/TLV_1 + X_2/TLV_2 + X_3/TLV_3 + ... Xi/TLVi)$$

In the above example, the 8-h TLV for benzene is 0.5 ppm and for n-hexane 50 ppm. Therefore the TLV of the mixture is TLVmix = 1 / (0.05/0.5 + 0.95/50) = 8.4 ppm, corresponding to 8.0 ppm hexane and 0.4 ppm benzene. For an instrument calibrated on isobutylene, the reading corrsponding to the TLV is:

$$\text{Alarm Reading} = TLVmix / CFmix = 8.4 / 3.2 = 2.6 \text{ ppm}$$

A common practice is to set the lower alarm limit to half the TLV, and the higher limit to the TLV. Thus, one would set the alarms to 1.3 and 2.6 ppm, respectively.

1339 Moffett Park Drive, Sunnyvale CA 94089 U.S.A.
Tel: 1.408.752.0723 | Fax: 1.408.752.0724 | E-mail: raesales@raesystems.com
www.raesystems.com | rev.11.wh.8-01

Calibration Characteristics

a) Flow Configuration. PID response is essentially independent of gas flow rate as long as it is sufficient to satisfy the pump demand. Four main flow configurations are used for calibrating a PID:

1) **A pressurized gas cylinder (Fixed-flow regulator):** The flow rate of the regulator should match the flow demand of the instrument pump or be slightly higher.
2) **A pressurized gas cylinder (Demand-flow regulator):** A demand-flow regulator better matches pump speed differences, but results in a slight vacuum during calibration and thus slightly high readings.
3) **A collapsible gas bag:** The instrument will draw the calibration gas from the bag at its normal flow rate, as long as the bag valve is large enough. The bag should be filled with enough gas to allow at least one minute of flow (~ 0.6 L for a MiniRAE, ~0.3 L for MultiRAE).
4) **The T (or open tube) method:** The T method uses a T-junction with gas flow higher than the pump draw. The gas supply is connected to one end of the T, the instrument inlet is connected to a second end of the T, and excess gas flow escapes through the third, open end of the T. To prevent ambient air mixing, a long tube should be connected to the open end, or a high excess rate should be used. Alternatively, the instrument probe can be inserted into an open tube slightly wider than the probe. Excess gas flows out around the probe.

The first two cylinder methods are the most efficient in terms of gas usage, while the bag and T methods give slightly more accurate results because they match the pump flow better.

b) Pressure. Pressures deviating from atmospheric pressure affect the readings by altering gas concentration and pump characteristics. It is best to calibrate with the instrument and calibration gas at the same pressure as each other and the sample gas. (Note that the cylinder pressure is not relevant because the regulator reduces the pressure to ambient.) If the instrument is calibrated at atmospheric pressure in one of the flow configurations described above, then 1) pressures slightly above ambient are acceptable but high pressures can damage the pump and 2) samples under vacuum may give low readings if air leaks into the sample train.

c) Temperature. Because temperature effects gas density and concentration, the temperature of the calibration gas and instrument should be as close as possible to the ambient temperature where the unit will be used. We recommend that the temperature of the calibration gas be within the instrument's temperature specification (typically 14°-113° F or -10°- 45° C). Also, during actual measurements, the instrument should be kept at the same or higher temperature than the sample temperature to avoid condensation in the unit.

d) Matrix. The matrix gas of the calibration compound and VOC sample is significant. Some common matrix components, such as methane and water vapor can affect the VOC signal. PIDs are most commonly used for monitoring VOCs in air, in which case the preferred calibration gas matrix is air. For a MiniRAE, methane, methanol, and water vapor reduce the response by about 20% when their concentration is 15,000 ppm and by about 40% at 30,000 ppm. Despite earlier reports of oxygen effects, RAE PID responses with 10.6 eV lamps are independent of oxygen concentration, and calibration gases in a pure nitrogen matrix can be used. H_2 and CO_2 up to 5 volume % also have no effect.

e) Concentration. Although RAE Systems PIDs have electronically linearized output, it is best to calibrate in a concentration range close to the actual measurement range. For example, 100 ppm standard gas for anticipated vapors of 0 - 250 ppm, and 500 ppm standard for expected concentrations of 250 - 1000 ppm.

f) Filters. Filters affect flow and pressure conditions and therefore all filters to be used during sampling should also be in place during calibration. Using a water trap (hydrophobic filter) greatly reduces the chances of drawing water aerosols or dirt particles into the instrument. Regular filter replacements are recommended because dirty filters can adsorb VOCs and cause slower response time and shifts in calibration.

Table Abbreviations:

CF =Correction Factor (multiply by reading to get corrected value for the compound when calibrated to isobutylene)
NR =No Response
IE =Ionization Energy (values in parentheses are not well established)
C =Confirmed Value; all others are preliminary or estimated values and are subject to change
ne =Not Established ACGIH 8-hr. TWA
C## =Ceiling value, given where 8-hr.TWA is not available

Disclaimer:

Actual readings may vary with age and cleanliness of lamp, relative humidity, and other factors. For accurate work, the instrument should be calibrated regularly under the operating conditions used. The correction factors in this table were measured in dry air at room temperature.

Updates:

The values that are indicated by a "plus" sign in the "C" columns are confirmed values; all others are preliminary and subject to change. Watch for updates of this table on the Internet at **http://www.raesystems.com**

IE data are taken from the CRC Handbook of Chemistry and Physics, 73rd Edition, D.R. Lide (Ed.), CRC Press (1993) and NIST Standard Ref. Database 19A, NIST Positive Ion Energetics, Vers. 2.0, Lias, et.al., U.S. Dept. Commerce (1993). Exposure limits (8-h TWA and Ceiling Values) are from the 1997 ACGIH TLVs and BEIs, Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. ACGIH, Cincinnati, OH 1997.

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Acetaldehyde		75-07-0	C_2H_4O	NR	+	6	+	3.3	+	10.23	C25
Acetic Acid	Ethanoic Acid	64-19-7	$C_2H_4O_2$	NR	+	22	+	2.6	+	10.66	10
Acetic Anhydride	Ethanoic Acid Anhydride	108-24-7	$C_4H_6O_3$	NR	+	6.1	+	2.0	+	10.14	5
Acetone	2-Propanone	67-64-1	C_3H_6O	1.2	+	1.1	+	1.4	+	9.71	500
Acetonitrile	Methyl cyanide, Cyanomethane	75-05-8	C_2H_3N					100		12.19	40
Acetylene	Ethyne	74-86-2	C_2H_2					2		11.40	ne
Acrolein	Propenal	107-02-8	C_3H_4O	42	+	3.9	+	1.4	+	10.10	0.1
Acrylic Acid	Propenoic Acid	79-10-7	$C_3H_4O_2$			12	+	2.0	+	10.60	2
Acrylonitrile	Propenenitrile	107-13-1	C_3H_3N			NR	+	1.2	+	10.91	2
Allyl alcohol		107-18-6	C_3H_6O			2.4	+	1.7		9.67	2
Allyl chloride	3-Chloropropene	107-05-1	C_3H_5Cl			4.3		0.7		9.9	1
Ammonia		7664-41-7	H_3N	NR	+	9.7	+	5.7	+	10.16	25
Amyl acetate	mix of n-Pentyl acetate & 2-Methylbutyl acetate	628-63-7	$C_7H_{14}O_2$	11	+	2.3	+	0.95	+	<9.9	100
Amyl alcohol	1-Pentanol	75-85-4	$C_5H_{12}O$			5				10.00	ne
Aniline	Aminobenzene	62-53-3	C_7H_7N	0.50	+	0.48	+	0.47	+	7.72	2
Anisole	Methoxybenzene	100-66-3	C_7H_8O			0.8				8.21	ne
Arsine	Arsenic trihydride	7784-42-1	AsH_3			1.9	+			9.89	0.05
Benzaldehyde		100-52-7	C_7H_6O					1		9.49	ne
Benzene		71-43-2	C_6H_6	0.55	+	0.53	+	0.6	+	9.25	0.5
Benzonitrile	Cyanobenzene	100-47-0	C_7H_5N			1.6				9.62	ne
Benzyl alcohol	α-Hydroxytoluene, Hydroxymethylbenzene, Benzenemethanol	100-51-6	C_7H_8O	1.4	+	1.1	+	0.9	+	8.26	ne
Benzyl chloride	α-Chlorotoluene, Chloromethylbenzene	100-44-7	C_7H_7Cl	0.7	+	0.6	+	0.5	+	9.14	1
Benzyl formate	Formic acid benzyl ester	104-57-4	$C_8H_8O_2$	0.9	+	0.73	+	0.66	+		ne
Boron trifluoride		7637-07-2	BF_3	NR		NR		NR		15.5	C1
Bromine		7726-95-6	Br_2	NR	+	1.30	+	0.74	+	10.51	0.1
Bromobenzene		108-86-1	C_6H_5Br			0.6		0.5		8.98	ne
2-Bromoethyl methyl ether		6482-24-2	C_3H_7OBr			0.84	+			~10	ne
Bromoform	Tribromomethane	75-25-2	$CHBr_3$	NR	+	2.5	+	0.5	+	10.48	0.5
Bromopropane,1-	n-Propyl bromide	106-94-5	C_3H_7Br	150	+	1.5	+	0.6	+	10.18	ne
Butadiene	1,3-Butadiene, Vinyl ethylene	106-99-0	C_4H_6	0.8		0.85	+	1.1		9.07	2
Butadiene diepoxide, 1,3-	1,2,3,4-Diepoxybutane	298-18-0	$C_4H_6O_2$	25	+	3.5	+	1.2		~10	ne
Butane		106-97-8	C_4H_{10}			67	+	1.2		10.53	800
Butanol, 1-	Butyl alcohol, n-Butanol	71-36-3	$C_4H_{10}O$	70	+	4.7	+	1.4	+	9.99	C50
Butanol, t-	tert-Butanol, t-Buty alcohol	75-65-0	$C_4H_{10}O$	6.9	+	2.9	+			9.90	100
Butene, 1-	1-Butylene	106-98-9	C_4H_8			0.9				9.58	ne
Butoxyethanol, 2-	Butyl Cellosolve, Ethylene glycol monobutyl ether	111-76-2	$C_6H_{14}O_2$	1.8	+	1.2	+	0.6	+	<10	25
Butyl acetate, n-		123-86-4	$C_6H_{12}O_2$			2.6	+			10	150
Butyl acrylate, n-	Butyl 2-propenoate, Acrylic acid butyl ester	141-32-2	$C_7H_{12}O_2$			1.6	+	0.6	+		10
Butylamine, n-		109-73-9	$C_4H_{11}N$	1.1	+	1.1	+	0.7	+	8.71	C5
Butyl cellosolve	see 2-Butoxyethanol	111-76-2									
Butyl hydroperoxide, t-		75-91-2	$C_4H_{10}O_2$	2.0	+	1.6	+			<10	1
Butyl mercaptan	1-Butanethiol	109-79-5	$C_4H_{10}S$	0.55	+	0.52	+			9.14	0.5
Carbon disulfide		75-15-0	CS_2	4	+	1.2	+	0.44		10.07	10
Carbon tetrachloride	Tetrachloromethane	56-23-5	CCl_4	NR	+	NR	+	1.7	+	11.47	5
Carbonyl sulfide	Carbon oxysulfide	463-58-1	COS							11.18	
Cellosolve see 2-Ethoxyethanol											
CFC-14 see Tetrafluoromethane											
CFC-113 see 1,1,2-Trichloro-1,2,2-trifluoroethane											
Chlorine		7782-50-5	Cl_2					1.0	+	11.48	0.5
Chlorine dioxide		10049-04-4	ClO_2	NR	+	NR	+	NR		10.57	0.1
Chloro-1,3-butadiene, 2-	Chloroprene	126-99-8	C_4H_5Cl			3					10

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Chlorobenzene	Monochlorobenzene	108-90-7	C_6H_5Cl	0.44	+	0.40	+	0.39	+	9.06	10
Chloro-1,1-difluoroethane, 1-	(R-142B)	75-68-3	$C_2H_3ClF_2$			NR		NR		12.0	ne
Chlorodifluoromethane	HCFC-22, R-22	75-45-6	$CHClF_2$	NR		NR		NR		12.2	1000
Chloroethane	Ethyl chloride	75-00-3	C_2H_5Cl	NR	+	NR	+	1.1	+	10.97	100
Chloroethanol	Ethylene chlrohydrin	107-07-3	C_2H_5ClO							10.52	C1
Chloroethyl ether, 2-	bis(2-chloroethyl) ether	111-44-4	$C_4H_8Cl_2O$	8.6	+	3.0	+				5
Chloroethyl methyl ether, 2-	Methyl 2-chloroethyl ether	627-42-9	$C3H_7ClO$			3					ne
Chloroform	Trichloromethane	67-66-3	$CHCl_3$	NR	+	NR	+	3.5	+	11.37	10
Chloropicrin			CCl_3NO_2	NR	+	~400	+	7	+	?	0.1
Chlorotoluene, o-	o-Chloromethylbenzene	95-49-8	C_7H_7Cl			0.5		0.6		8.83	50
Chlorotoluene, p-	p-Chloromethylbenzene	106-43-4	C_7H_7Cl					0.6		8.69	ne
Crotonaldehyde	*trans*-2-Butenal	123-73-9 4170-30-3	C_4H_6O	1.5	+	1.1	+	1.0	+	9.73	2
Cumene	Isopropylbenzene	98-82-8	C_9H_{12}	0.58	+	0.54	+	0.4	+	8.73	50
Cyanogen bromide		506-68-3	CNBr	NR		NR		NR		11.84	ne
Cyanogen chloride		506-77-4	CNCl	NR		NR		NR		12.34	C0.3
Cyclohexane		110-82-7	C_6H_{12}	3.3	+	1.4	+	0.64	+	9.86	300
Cyclohexanol	Cyclohexyl alcohol	108-93-0	$C_6H_{12}O$					1.1		9.75	50
Cyclohexanone		108-94-1	$C_6H_{10}O$	1.0	+	0.9	+	0.7	+	9.14	25
Cyclohexene		110-83-8	C_6H_{10}			0.8	+			8.95	300
Cyclohexylamine		108-91-8	$C_6H_{13}N$			1.2				8.62	10
Cyclopentane		287-92-3	C_5H_{10}					0.6		10.51	600
Decane		124-18-5	$C_{10}H_{22}$	4.0	+	1.4	+	0.35	+	9.65	ne
Diacetone alcohol	4-Methyl-4-hydroxy-2-pentanone	123-42-2	$C_6H_{12}O_2$			0.7					50
Dibromochloromethane	Chlorodibromomethane	124-48-1	$CHBr_2Cl$	NR	+	5.3	+	0.7	+	10.59	ne
Dibromoethane, 1,2-	EDB, Ethylene dibromide, Ethylene bromide	106-93-4	$C_2H_4Br_2$	NR	+	1.7	+	0.6	+	10.37	ne
Dichlorobenzene, o-	1,2-Dichlorobenzene	95-50-1	$C_6H_4Cl_2$	0.54	+	0.47	+	0.38	+	9.08	25
Dichlorodifluoromethane	CFC-12	75-71-8	CCl_2F_2			NR	+	NR	+	11.75	1000
Dichloroethane, 1,2-	EDC, 1,2-DCA, Ethylene dichloride	107-06-2	$C_2H_4Cl_2$			NR	+	0.6	+	11.04	10
Dichloroethene, 1,1-	1,1-DCE, Vinylidene chloride	75-35-4	$C_2H_2Cl_2$			0.9				9.79	5
Dichloroethene, c-1,2-	*c*-1,2-DCE, *cis*-Dichloroethylene	156-59-2	$C_2H_2Cl_2$			0.8				9.66	200
Dichloroethene, t-1,2-	*t*-1,2-DCE, *trans*-Dichloroethylene	156-60-5	$C_2H_2Cl_2$			0.45	+	0.34	+	9.65	200
Dichloro-1-fluoroethane, 1,1-	R-141B	1717-00-6	$C_2H_3Cl_2F$	NR	+	NR	+	2.0	+		ne
Dichloromethane	see Methylene chloride										
Dichloropentafluoropropane	AK-225, mix of ~45% 3,3-dichloro-1,1,1,2,2-pentafluoro-propane (HCFC-225ca) & ~55% 1,3-Dichloro-1,1,2,2,3-pentafluoropropane (HCFC-225cb)	442-56-0 507-55-1	$C_3HCl_2F_5$	NR	+	NR	+	25	+		ne
Dichloropropane, 1,2-		78-87-5	$C_3H_6Cl_2$					0.7		10.87	75
Dichloro-1-propene, 1,3-		542-75-6	$C_3H_4C_{12}$	1.3	+	0.96	+			<10	1
Dichloro-1-propene, 2,3-		78-88-6	$C_3H_4Cl_2$	1.9	+	1.3	+	0.7	+	<10	ne
Dichloro-1,1,1-trifluoroethane,2,2-	R-123	306-83-2	$C_2HCl_2F_3$	NR	+	NR	+	10.1	+	11.5	ne
Dichlorvos	Vapona; O,O-dimethyl O-dichlorovinyl phosphate	62-73-7	$C_4H_7Cl_2O_4P$			0.9	+			<9.4	0.1
Dicyclopentadiene	DCPD, Cyclopentadiene dimer	77-73-6	$C_{10}H_{12}$	0.57	+	0.48	+	0.43	+	8.8	5
Diesel Fuel #1		68334-30-5	m.w. 226			0.9	+				11
Diesel Fuel #2		68334-30-5	m.w. 216			0.7	+	0.4	+		11
Diethylamine		109-89-7	$C_4H_{11}N$			1	+			8.01	5
Diethylaminopropylamine, 3-		104-78-9	$C_7H_{18}N_2$			1.3					ne

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Diethylmaleate		141-05-9	$C_8H_{12}O_4$			4					ne
Diethyl sulfide	see Ethyl sulfide										
Diisopropylamine		108-18-9	$C_6H_{15}N$	0.84	+	0.74	+	0.5	+	7.73	5
Diketene	Ketene dimer	674-82-8	$C_4H_4O_2$	2.6	+	2.0	+	1.4	+	9.6	0.5
Dimethylacetamide, N,N-	DMA	127-19-5	C_4H_9NO	0.87	+	0.8	+	0.8	+	8.81	10
Dimethylamine		124-40-3	C_2H_7N			1.5				8.23	5
Dimethyl carbonate	Carbonic acid dimethyl ester	616-38-6	$C_3H_6O_3$	NR	+	~70	+	1.7	+	~10.5	ne
Dimethyl disulfide	DMDS	624-92-0	$C_2H_6S_2$	0.2	+	0.20	+	0.21	+	7.4	ne
Dimethyl ether	see Methyl ether										
Dimethylethylamine	DMEA	598-56-1	$C_4H_{11}N$	1.1	+	1.0	+	0.9	+	7.74	~3
Dimethylformamide, N,N-	DMF	68-12-2	C_3H_7NO			0.8				9.13	10
Dimethylhydrazine, 1,1-	UDMH	57-14-7	$C_2H_8N_2$			0.8	+	0.8	+	7.28	0.01
Dimethyl methylphosphonate	DMMP, methyl phosphonic acid dimethyl ester	756-79-6	$C_3H_9O_3P$	NR	+	4.3	+	0.74	+	10.0	ne
Dimethyl sulfate		77-78-1	$C_2H_6O_4S$	~23		~20	+	2.3	+		0.1
Dimethyl sulfide	see Methyl sulfide										
Dimethyl sulfoxide	DMSO, Methyl sulfoxide	67-68-5	C_2H_6OS			1.4	+			9.10	ne
Dioxane, 1,4-		123-91-1	$C_4H_8O_2$			1.3				9.19	25
Dioxolane, 1,3-	Ethylene glycol formal	646-06-0	$C_3H_6O_2$	4.0	+	2.3	+	1.6	+	9.9	20
Dowtherm A see Therminol			C3H6O2								
DS-108F Wipe Solvent	Ethyl lactate/Isopar H/ Propoxypropanol ~7:2:1	97-64-3 64742-48-9 1569-01-3	m.w. 118	3.3	+	1.6	+	0.7	+		ne
Epichlorohydrin	ECH Chloromethyloxirane, 1-chloro2,3-epoxypropane	106-89-8	C_2H_5ClO	~200	+	8.5	+	1.4	+	10.2	0.5
Ethane		74-84-0	C_2H_6			NR	+	15	+	11.52	ne
Ethanol	Ethyl alcohol	64-17-5	C_2H_6O			12	+	8		10.47	1000
Ethanolamine	MEA, Monoethanolamine	141-43-5	C_2H_7NO	5.6	+	1.6	+			8.96	3
Ethene	Ethylene	74-85-1	C_2H_4			10	+	3		10.51	ne
Ethoxyethanol, 2-	Ethyl cellosolve, Ethylene glycol monoethyl ether	110-80-5	$C_4H_{10}O_2$			1.3				9.6	5
Ethyl acetate		141-78-6	$C_4H_8O_2$			4.6	+			10.01	400
Ethyl acrylate		140-88-5	$C_5H_8O_2$			2.4	+	1.0	+	<10.3	5
Ethylamine		75-04-7	C_2H_7N			0.8				8.86	5
Ethylbenzene		100-41-4	C_8H_{10}	0.52	+	0.52	+	0.51	+	8.77	100
Ethylene glycol	1,2-Ethanediol	107-21-1	$C_2H_6O_2$			16	+	6	+	10.16	C100
Ethylene glycol dimethyl ether	1,2-Dimethoxyethane, Monoglyme	110-71-4	$C_4H_{10}O_2$	1.1		0.86		0.7		9.2	ne
Ethylene oxide	Oxirane, Epoxyethane	75-21-8	C_2H_4O			13	+	3.5	+	10.57	1
Ethyl ether	Diethyl ether	60-29-7	$C_4H_{10}O$			1.1	+			9.51	400
Ethyl 3-ethoxypropionate	EEP	763-69-9	$C_7H_{14}O_3$	1.2	+	0.75	+				ne
Ethyl formate		109-94-4	$C_3H_6O_2$					1.9		10.61	100
Ethyl hexyl acrylate, 2-	Acrylic acid 2-ethylhexyl ester	103-11-7	$C_{11}H_{20}O_2$			1.1	+	0.5	+		ne
Ethyl (S)-(-)-lactate see also DS-108F	Ethyl lactate, Ethyl (S)-(-)-hydroxypropionate	687-47-8 97-64-3	$C_5H_{10}O_3$	13	+	3.2	+	1.6	+	~10	ne
Ethyl mercaptan	Ethanethiol	75-08-1	C_2H_6S	0.60	+	0.56	+			9.29	0.5
Ethyl sulfide	Diethyl sulfide	352-93-2	$C_4H_{10}S$			0.5	+			8.43	ne
Formaldehyde	Formalin	50-00-0	CH_2O					0.6		10.87	C0.3
Formic acid		64-18-6	CH_2O_2	NR	+	NR	+	9	+	11.33	5
Furfural	2-Furaldehyde	98-01-1	$C_5H_4O_2$			0.92	+	0.8	+	9.21	2
Furfuryl alcohol		98-00-0	$C_5H_6O_2$			0.80	+			<9.5	10
Gasoline #1		8006-61-9	m.w. 72			0.9	+				300
Gasoline #2, 92 octane		8006-61-9	m.w. 93	1.3	+	1.0	+	0.5	+		300
Glutaraldehyde	1,5-Pentanedial, Glutaric dialdehyde	111-30-8	$C_5H_8O_2$	1.1	+	0.8	+	0.6	+		C0.0 5
Halothane	2-Bromo-2-chloro-1,1,1-trifluoroethane	151-67-7	$C_2HBrClF_3$					0.6		11.0	50
HCFC-22 see Chlorodifluoromethane											

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
HCFC-123 see 2,2-Dichloro-1,1,1-trifluoroethane											
HCFC-141B see 1,1-Dichloro-1-fluoroethane											
HCFC-142B see 1-Chloro-1,1-difluoroethane											
HCFC-134A see 1,1,1,2-Tetrafluoroethane											
HCFC-225 see Dichloropentafluoropropane											
Heptane, n-		142-82-5	C_7H_{16}	45	+	2.8	+	0.60	+	9.92	400
Hexamethyldisilazane, 1,1,1,3,3,3-	HMDS	999-97-3	$C_6H_{19}NSi_2$			0.2	+	0.2	+	~8.6	
Hexane, n-		110-54-3	C_6H_{14}	350	+	4.3	+	0.54	+	10.13	50
Hexanol, 1-	Hexyl alcohol	111-27-3	$C_6H_{14}O$	9	+	2.5	+	0.55	+	9.89	ne
Hexene, 1-		592-41-6	C_6H_{12}			0.8				9.44	30
Hydrazine		302-01-2	H_4N_2	>8	+	2.6	+	2.1	+	8.1	0.01
Hydrazoic acid	Hydrogen azide		HN_3							10.7	
Hydrogen	Synthesis gas	1333-74-0	H_2	NR	+	NR	+	NR	+	15.43	ne
Hydrogen cyanide	Hydrocyanic acid	74-90-8	HCN	NR	+	NR	+	NR	+	13.6	C4.7
Hydrogen peroxide		7722-84-1	H_2O_2	NR	+	NR	+	NR	+	10.54	1
Hydrogen sulfide		7783-06-4	H_2S	NR	+	3.3	+	1.5	+	10.45	10
Iodine		7553-56-2	I_2	0.1	+	0.1	+	0.1	+	9.40	C0.1
Iodomethane	Methyl iodide	74-88-4	CH_3I	0.21	+	0.22	+	0.26	+	9.54	2
Isoamyl acetate	Isopentyl acetate	123-92-2	$C_7H_{14}O_2$	10.1		2.1		1.0		<10	100
Isobutane	2-Methylpropane	75-28-5	C_4H_{10}			100	+	1.2	+	10.57	ne
Isobutanol	2-Methyl-1-propanol	78-83-1	$C_4H_{10}O$	19	+	3.8	+	1.5		10.02	50
Isobutene	Isobutylene, Methyl butene	115-11-7	C_4H_8	1.00	+	1.00	+	1.00	+	9.24	ne
Isobutyl acetate		110-19-0	$C_6H_{12}O_2$			2.6					150
Isobutyl acrylate	Isobutyl 2-propenoate, Acrylic acid Isobutyl ester	106-63-8	$C_7H_{12}O_2$			1.5	+	0.60	+		ne
Isoflurane	1-Chloro-2,2,2-trifluoroethyl difluoromethyl ether, forane	26675-46-7	$C_3H_2ClF_5O$							~11.7	ne
Isooctane	2,2,4-Trimethylpentane	540-84-1	C8H18			1.2				9.86	ne
Isopar E Solvent	Isoparaffinic hydrocarbons	64741-66-8	m.w.121	1.7	+	0.8	+				ne
Isopar G Solvent	Photocopier diluent	64742-48-9	m.w. 148			0.8	+				ne
Isopar K Solvent	Isoparaffinic hydrocarbons	64742-48-9	m.w. 156	0.9	+	0.5	+	0.27	+		ne
Isopar L Solvent	Isoparaffinic hydrocarbons	64742-48-9	m.w. 163	0.9	+	0.5	+	0.28	+		ne
Isopar M Solvent	Isoparaffinic hydrocarbons	64742-47-8	m.w. 191			0.7	+	0.4	+		ne
Isopentane	2-Methylbutane	78-78-4	C_5H_{12}			8.2					ne
Isophorone		78-59-1	$C_9H_{14}O$					3		9.07	C5
Isoprene	2-Methyl-1,3-butadiene	78-79-5	C_5H_8	0.69	+	0.63	+	0.60	+	8.85	ne
Isopropanol	Isopropyl alcohol, 2-propanol, IPA	67-63-0	C_3H_8O	500	+	6.0	+	2.7		10.12	400
Isopropyl acetate		108-21-4	$C_5H_{10}O_2$			2.6				9.99	250
Isopropyl ether	Diisopropyl ether	108-20-3	$C_6H_{14}O$			0.8				9.20	250
Jet fuel JP-4	Jet B, Turbo B, Wide cut type aviation fuel	8008-20-6 + 64741-42-0	m.w. 115			1.0	+	0.4	+		ne
Jet fuel JP-5	Jet 5, Kerosene type aviation fuel	8008-20-6 + 64747-77-1	m.w. 167			0.6	+	0.5	+		15
Jet fuel JP-8	Jet A-1, Kerosene type aviation fuel	8008-20-6 + 64741-77-1	m.w. 165			0.6	+	0.3	+		15
Limonene, D-	(R)-(+)-Limonene	5989-27-5	$C_{10}H_{16}$			0.33	+			~8.2	ne
Kerosene C10-C16 petro.distillate – see Jet Fuels		8008-20-6									
MDI - see 4,4'-Methylenebis(phenylisocyanate)											
Mesitylene	1,3,5-Trimethylbenzene	108-67-8	C_9H_{12}	0.36	+	0.35	+	0.3	+	8.41	ne
Methane	Natural gas	74-82-8	CH_4	NR	+	NR	+	NR	+	12.51	ne
Methanol	Methyl alcohol, carbinol	67-56-1	CH_4O	NR	+	NR	+	2.5	+	10.85	200
Methoxyethanol, 2-	Methyl cellosolve, Ethylene glycol monomethyl ether	109-86-4	$C_3H_8O_2$	4.8	+	2.4	+	1.4	+	10.1	5
Methoxyethoxyethanol, 2-	2-(2-Methoxyethoxy)ethanol Diethylene glycol monomethyl ether	111-77-3	$C_7H_{16}O$	2.3	+	1.2	+	0.9	+	<10	ne

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Methyl acetate		79-20-9	$C_3H_6O_2$	NR	+	6.6	+	1.4	+	10.27	200
Methyl acrylate	Methyl 2-propenoate, acrylic acid methyl ester	96-33-3	C4H6O2			3.7	+	1.2	+	(9.9)	2
Methylamine	Aminomethane	74-89-5	CH_5N			1.2				8.97	5
Methyl bromide	Bromomethane	74-83-9	CH_3Br	110	+	1.7	+	1.3	+	10.54	1
Methyl t-butyl ether	MTBE, *tert*-Butyl methyl ether	1634-04-4	$C_5H_{12}O$			0.9	+			9.24	40
Methyl cellosolve	see 2-Methoxyethanol										
Methyl chloride	Chloromethane	74-87-3	CH_3Cl	NR	+	NR	+	0.74	+	11.22	50
Methylcyclohexane		107-87-2	C_7H_{14}	1.6	+	0.97	+	0.53	+	9.64	400
Methylene bis(phenyl-isocyanate), 4,4'-	MDI, Mondur M		$C_{15}H_{10}N_2O_2$	Very slow ppb level response							0.005
Methylene chloride	Dichloromethane	75-09-2	CH_2Cl_2	NR	+	NR	+	0.89	+	11.32	25
Methyl ether	Dimethyl ether	115-10-6	C_2H_6O	4.8	+	3.1	+	2.5	+	10.03	ne
Methyl ethyl ketone	MEK, 2-Butanone	78-93-3		0.86	+	0.9	+	1.1	+	9.51	200
Methylhydrazine	Monomethylhydrazine, Hydrazomethane	60-34-4	$C_2H_6N_2$	1.4	+	1.2	+	1.3	+	7.7	0.01
Methyl isobutyl ketone	MIBK, 4-Methyl-2-pentanone	108-10-1	$C_6H_{12}O$	0.9	+	0.8	+	0.6	+	9.30	50
Methyl isocyanate	CH_3NCO	624-83-9	C_2H_3NO	NR	+	4.6	+	1.5		10.67	0.02
Methyl isothiocyanate	CH_3NCS	551-61-6	C_2H_3NS	0.5	+	0.45	+	0.4	+	9.25	ne
Methyl mercaptan	Methanethiol	74-93-1	CH_4S	0.65		0.54		0.66		9.44	0.5
Methyl methacrylate		80-62-6	$C_5H_8O_2$	2.7	+	1.5	+	1.2	+	9.7	100
Methyl nonafluorobutyl ether	HFE-7100DL	163702-08-7, 163702-07-6	$C_5H_3F_9O$			NR	+	~35	+		ne
Methyl-1,5-pentane-diamine, 2- (coats lamp)	Dytek-A amine, 2-Methyl pentamethylenediamine	15520-10-2	$C_6H_{16}N_2$			~0.6	+			<9.0	ne
Methyl propyl ketone	MPK, 2-Pentanone	107-87-9	$C_5H_{12}O$			0.93	+	0.79	+	9.38	200
Methyl-2-pyrrolidinone, N-	NMP, N-Methylpyrrolidone, 1-Methyl-2-pyrrolidinone, 1-Methyl-2-pyrrolidone	872-50-4	C_5H_9NO	1.0	+	0.8	+	0.9	+	*9.17*	ne
Methyl salicylate	Methyl 2-hydroxybenzoate	119-36-8	C_8H_8O3	1.3	+	0.9	+	0.9	+	~9	ne
Methylstyrene, α-	2-Propenylbenzene	98-83-9	C_9H_{10}			0.5				8.18	50
Methyl sulfide	DMS, Dimethyl sulfide	75-18-3	C_2H_6S	0.49	+	0.44	+	0.46	+	8.69	ne
Mineral spirits	Stoddard Solvent, Varsol 1	8020-83-5 8052-41-3 68551-17-7	m.w. 144			0.7	+	0.39	+		100
Mineral Spirits - Viscor 120B	Calibration Fluid, b.p. 156-207°C	8052-41-3	m.w. 142	1.0	+	0.7	+	0.3	+		100
Mustard	HD, Bis(2-chloroethyl) sulfide	505-60-2 39472-40-7 68157-62-0	$C_4H_8Cl_2S$			0.6					0.0005
Naphthalene	Mothballs	91-20-3	$C_{10}H_8$	0.45	+	0.42	+	0.40	+	8.13	10
Nitric oxide		10102-43-9	NO	~6		5.2	+	2.8	+	9.26	25
Nitrobenzene		98-95-3	$C_6H_5NO_2$	2.6	+	1.9	+	1.6	+	9.81	1
Nitroethane		79-24-3	$C_2H_5NO_2$					3		10.88	100
Nitrogen dioxide		10102-44-0	NO_2	23	+	16	+	6	+	9.75	3
Nitromethane		75-52-5	CH_3NO_2					4		11.02	20
Nitropropane, 2-		79-46-9	$C_3H_7NO_2$					2.6		10.71	10
Nonane		111-84-2	C_9H_{20}			1.4				9.72	200
Octane, n-		111-65-9	C_8H_{18}	13	+	1.8	+			9.82	300
Pentane		109-66-0	C_5H_{12}	80	+	8.4	+	0.7	+	10.35	600
Peracetic acid	Peroxyacetic acid, Acetyl hydroperoxide	79-21-0	$C_2H_4O_3$	NR	+	NR	+	2.3	+		ne
Peracetic/Acetic acid mix	Peroxyacetic acid, Acetyl hydroperoxide	79-21-0	$C_2H_4O_3$			50	+	2.5	+		ne
Perchloroethene	PCE, Perchloroethylene, Tetrachloroethylene	127-18-4	C_2Cl_4	0.69	+	0.57	+	0.31	+	9.32	25
PGME	Propylene glycol methyl ether, 1-Methoxy-2-propanol	107-98-2	$C_6H_{12}O_3$	2.4	+	1.5	+	1.1	+		100

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
PGMEA	Propylene glycol methyl ether acetate, 1-Methoxy-2-acetoxypropane, 1-Methoxy-2-propanol acetate	108-65-6	$C_6H_{12}O_3$	1.65	+	1.0	+	0.8	+		ne
Phenol	Hydroxybenzene	108-95-2	C_6H_6O	1.0	+	1.0	+	0.9	+	8.51	5
Phosgene in Nitrogen	Dichlorocarbonyl	75-44-5	CCl_2O	NR	+	NR	+	7	+	11.2	0.1
Phosphine		7803-51-2	PH_3	28		3.9	+	1.1	+	9.87	0.3
Photocopier Toner	Isoparaffin mix					0.5	+	0.3	+		ne
Picoline, 3-	3-Methylpyridine	108-99-6	C_6H_7N			0.9				9.04	ne
Pinene, α-		2437-95-8	$C_{10}H_{16}$			0.31	+	0.47		8.07	ne
Pinene, β-		18172-67-3	$C_{10}H_{16}$	0.38	+	0.37	+	0.37	+	~8	100
Piperylene, isomer mix	1,3-Pentadiene	504-60-9	C_5H_8	0.76	+	0.69	+	0.64	+	8.6	100
Propane		74-98-6	C_3H_8			NR	+	1.8	+	10.95	2500
Propanol, n-	Propyl alcohol	71-23-8	C_3H_8O			5		1.7		10.22	200
Propene	Propylene	115-07-1	C_3H_6	1.5	+	1.4	+	1.6	+	9.73	ne
Propionaldehyde	Propanal	123-38-6	C_3H_6O			1.9				9.95	ne
Propyl acetate, n-		109-60-4	$C_5H_{10}O_2$			3.5				10.04	200
Propylene carbonate		108-32-7	$C_4H_6O_3$			62	+	1	+	10.5	ne
Propylene glycol	1,2-Propanediol	57-55-6	$C_3H_8O_2$	18		5.5	+	1.6	+	<10.2	ne
Propylene oxide	Methyloxirane	75-56-9 16088-62-3 15448-47-2	C_3H_6O	~240		6.6	+	2.9	+	10.22	20
Propyleneimine	2-Methylaziridine	75-55-8	C_3H_7N	1.5	+	1.3	+	1.0	+	9.0	2
Propyl mercaptan, 2-	2-Propanethiol, Isopropyl mercaptan	75-33-2	C_3H_8S	0.64	+	0.66	+			9.15	ne
Pyridine		110-86-1	C_5H_5N	0.78	+	0.7	+	0.7	+	9.25	5
Pyrrolidine (coats lamp)	Azacyclohexane	123-75-1	C_4H_9N	2.1	+	1.3	+	1.6	+	~8.0	ne
RR7300 (PGME/PGMEA)	70:30 PGME:PGMEA (1-Methoxy-2-propanol:1-Methoxy-2-acetoxypropane)	107-98-2	$C_4H_{10}O_2$ / $C_6H_{12}O_3$			1.4	+	1.0	+		ne
Sarin	GB, Isopropyl methylphosphonofluoridate	107-44-8 50642-23-4	$C_4H_{10}FO_2P$			~3					
Stoddard Solvent - see Mineral Spirits		8020-83-5									
Styrene		100-42-5	C_8H_8	0.45	+	0.40	+	0.4	+	8.43	20
Sulfur dioxide		7446-09-5	SO_2			NR	+	NR	+	12.32	2
Sulfur hexafluoride		2551-62-4	SF_6	NR		NR		NR		15.3	1000
Sulfuryl fluoride	Vikane	2699-79-8	SO_2F_2	NR		NR		NR		13.0	5
Tabun	Ethyl N, N-dimethylphosphoramidocyanidate	77-81-6	$C_5H_{11}N_2O_2P$			0.8					15ppt
Tetrachloroethane, 1,1,1,2-		630-20-6	$C_2H_2Cl_4$					1.3		~11.1	ne
Tetrachloroethane, 1,1,2,2-		79-34-5	$C_2H_2Cl_4$	NR	+	NR	+	0.60	+	~11.1	1
Tetraethyllead	TEL	78-00-2	$C_8H_{20}Pb$	0.4		0.3		0.2		~11.1	0.008
Tetraethyl orthosilicate	Ethyl silicate, TEOS	78-10-4	$C_8H_{20}O_4Si$			0.7	+	0.2	+	~9.8	10
Tetrafluoroethane, 1,1,1,2-	HFC-134A	811-97-2	$C_2H_2F_4$			NR		NR			ne
Tetrafluoroethene	TFE, Tetrafluoroethylene, Perfluoroethylene	116-14-3	C_2F_4			~15				10.12	ne
Tetrafluoromethane	CFC-14, Carbon tetrafluoride	75-73-0	CF_4			NR	+	NR	+	>15.3	ne
Tetrahydrofuran	THF	109-99-9	C_4H_8O	1.9	+	1.7	+	1.0	+	9.41	200
Tetramethyl orthosilicate	Methyl silicate, TMOS	681-84-5	$C_4H_{12}O_4Si$	10	+	1.9	+			~10	1
Therminol VP-1	Dowtherm,3:1 Diphenyl oxide: Biphenyl	101-84-8 92-52-4	$C_{12}H_{10}O$ $C_{12}H_{10}$			0.4	+				ne
Toluene	Methylbenzene	108-88-3	C_7H_8	0.54	+	0.50	+	0.51	+	8.82	50
Tolylene-2,4-diisocyanate	TDI, 4-Methyl-1,3-phenylene-2,4-diisocyanate	584-84-9	$C_9H_6N_2O_2$	1.4	+	1.4	+	2.0	+		0.002
Trichlorobenzene, 1,2,4-	1,2,4-TCB	120-82-1	$C_6H_3Cl_3$	0.7	+	0.46	+			9.04	C5
Trichloroethane, 1,1,1-	1,1,1-TCA, Methyl chloroform	71-55-6	$C_2H_3Cl_3$			NR	+	1	+	11	350
Trichloroethane, 1,1,2-	1,1,2-TCA	79-00-5	$C_2H_3Cl_3$	NR	+	NR	+	0.9	+	11.0	10
Trichloroethene	TCE, Trichoroethylene	79-01-6	C_2HCl_3	0.62	+	0.54	+	0.43	+	9.47	50

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Trichlorotrifluoroethane, 1,1,2-	CFC-113	76-13-1	$C_2Cl_3F_3$			NR		NR		11.99	1000
Triethylamine	TEA	121-44-8	$C_6H_{15}N$	0.95	+	0.9	+	0.65	+	7.3	1
Triethyl borate	TEB; Boric acid triethyl ester, Boron ethoxide	150-46-9	$C_6H_{15}O_3B$			2.2	+	1.1	+	~10	ne
Triethyl phosphate	Ethyl phosphate	78-40-0	$C_6H_{15}O_4P$	~50	+	3.1	+	0.60	+	9.79	ne
Trifluoroethane, 1,1,2-		430-66-0	$C_2H_3F_3$					34		*12.9*	ne
Trimethylamine		75-50-3	C_3H_9N			0.9				7.82	5
Trimethylbenzene, 1,3,5- - see Mesitylene		108-67-8									25
Trimethyl borate	TMB; Boric acid trimethyl ester, Boron methoxide	121-43-7	$C_3H_9O_3B$			5.1	+	1.2	+	10.1	ne
Trimethyl phosphate	Methyl phosphate	512-56-1	$C_3H_9O_4P$			8.0	+	1.3	+	9.99	ne
Trimethyl phosphite	Methyl phosphite	121-45-9	$C_3H_9O_3P$			1.1	+		+	*8.5*	2
Turpentine	Pinenes (85%) + other diisoprenes	8006-64-2	$C_{10}H_{16}$	0.4	+	0.3	+			~8	100
Undecane		1120-21-4	$C_{11}H_{24}$			2				9.56	ne
Varsol – see Mineral Spirits											
Vinyl actetate		108-05-4	$C_4H_6O_2$	1.5	+	1.2	+	1.0	+	9.19	10
Vinyl bromide	Bromoethylene	593-60-2	C_2H_3Br			0.4				9.80	5
Vinyl chloride	Chloroethylene, VCM	75-01-4	C_2H_3Cl			2.0	+	0.6	+	9.99	5
Vinylidene chloride - see 1,1-Dicholorethene											
Vinyl-2-pyrrolidinone, 1-	NVP, N-vinylpyrrolidone, 1-ethenyl-2-pyrrolidinone	88-12-0	C_6H_9NO	1.0	+	0.8	+	0.9	+		ne
Viscor 120B - see Mineral Spirits - Viscor 120B Calibration Fluid											
Xylene, m-	1,3-Dimethylbenzene	108-38-3	C_8H_{10}	0.50	+	0.43	+	0.40	+	8.56	100
Xylene, o-	1,2-Dimethylbenzene	95-47-6	C_8H_{10}	0.57	+	0.59	+	0.69		8.56	100
Xylene, p-	1,4-Dimethylbenzene	106-42-3	C_8H_{10}			0.45	+	0.62	+	8.44	100
None				1		1		1			
Undetectable				1E+6		1E+6		1E+6			

Appendix I:

Example of Automatic Calculation of Correction Factors, TLVs and Alarm Limits for Mixtures

(Calculations performed using Excel version of this database, available on request)

Compound	CF 9.8 eV	CF 10.6 eV	CF 11.7eV	Mol. Frac	Conc ppm	TLV ppm	STEL Ppm
Benzene	0.55	0.53	0.6	0.01	1	0.5	2.5
Toluene	0.54	0.5	0.51	0.06	10	50	150
Hexane, n-	300	4.3	0.54	0.06	10	50	150
Heptane, n-	45	2.8	0.6	0.28	50	400	500
Styrene	0.45	0.4	0.42	0.06	10	20	40
Acetone	1.2	1.1	1.4	0.28	50	750	1000
Isopropanol	500	6	2.7	0.28	50	400	500
None	1	1	1	0.00	0	1	
Mixture Value:	2.1	1.5	0.89	1.00	181	56	172
TLV Alarm Setpoint when					ppm	ppm	ppm
Calibrated to Isobutylene:	26 ppm	37 ppm	62 ppm				
STEL Alarm Setpoint, same Calibration	86 ppm	115 ppm	193 ppm				

MicroFID™

FLAME IONIZATION MONITOR

Photovac is MORE than instruments.

Photovac delivers PROVEN solutions.

PHOTOVAC, Inc.

SUPERIOR VOC

For accurate, reliable detection of VOCs, the Photovac MicroFID is the right choice in flame ionization detection. At just 8.1 lb. (3.7 kg.), the MicroFID is the smallest and lightest datalogging Flame Ionization Detector (FID) available.

Easy to learn and use

The MicroFID is easy to use. One tutor key prompts you through basic operations. Critical data is displayed and logged in less than 3 seconds within the concentration range of 0.5 -50,000 PPM. A simple two-step calibration holds for a full workday.

Designed for field use

The MicroFID is completely self-contained in a single hand-held package, so transportation and operation are simplified. The MicroFID's ergonomic design includes a built-in handle and a rubberized keypad that can be used while wearing protective equipment.

The MicroFID has an integrated,refillable fuel gas (hydrogen) mini-cylinder to allow up to 12 hours of field operation. The sample air serves as the oxygen source to start the flame. Replaceable and rechargeable battery packs operate for 15 hours.

Dependable results

With a wide linear range, the MicroFID responds to almost all VOCs. The flame ionization detector is stable and virtually immune to possible interferences such as water vapor.

Datalogging flexibility

Monitor fugitive emissions with ease and confidence with the MicroFID. Using the built-in datalogger, sample points can be recorded. In Interval Mode, the MicroFID records the date, time and minimum, average and maximum readings during user-selectable intervals. Or use the datalogger in U.S. EPA Method 21 Mode with Background, Sample and Difference readings. The data can then be down-loaded to a PC using Windows HyperTerminal and any Windows-based software package can be used for data management.

Intrinsically Safe

The MicroFID is classified as Intrinsically Safe in both North America [Class I, Division 1, Groups A, B, C, and D] and Europe [EEx nA II T5] for potentially hazardous environments.

Rely on results that measure up

For trouble-free measurement of soil gases where the response factor consistency of a FID is mandatory, or where methane must be included in the total reading, the MicroFID has no equal. Make EPA Method 21 Fugitive Emissions Monitoring easy with the smallest and lightest FID, the MicroFID.

Detect up to 50,000 PPM VOCs including methane CONFIDENTLY AND RELIABLY

MicroFID

Solutions

- Leak Detection and Repair (U.S. EPA Method 21)
- Landfill monitoring
- Natural gas leak detection
- Petroleum products tank entry
- Emergency response
- Soil headspace screening
- Hazardous waste site delineation
- Solvent storage and piping
- Confined space pre-entry
- Underground storage tanks (UST)
- Transportation vessels
- Storage tank maintenance
- OSHA Compliance
- EPA Compliance
- Remediation efficiency

INDUSTRIES & Applications

Fugitive Emissions/EPA Method 21

When calibration to methane is a must and detection levels range to 10,000 PPM or more, the MicroFID is the right choice in Method 21 compliance. The MicroFID meets or exceeds all Method 21 instrument requirements while giving the convenience of the smallest and lightest datalogging FID.

Landfill Monitoring

In landfill monitoring, the detection of methane may be required, or exclusion of methane from the readings may be required. The MicroFID does respond well to methane, and when equipped with a charcoal filter can be used to obtain non-methane Total VOC. The manual datalogging mode does this calculation for the user. The filter is placed on the MicroFID and a background reading is taken. The filter is then removed and a sample reading is taken. The MicroFID automatically subtracts the background from the sample and records the Difference, or the non-methane VOC reading.

Emergency Response -- HAZMAT

In HazMat applications, it is possible that the spilled material may not be known. Since the MicroFID responds relatively equally to a wide variety of compounds, it is suitable to situations that can be quite different.

Natural Gas Pipeline Leak Detection

In North America, Natural Gas is composed almost entirely of Methane. The MicroFID is the detector of choice for this application. The MAX feature combined with the user adjustable, audible alarm make it easy to pinpoint leaks. Automated datalogging with selectable recording intervals make record keeping simple.

Arson Investigations (Accelerants)

Quite simply, the MicroFID is the detector to use for this application because anything that will burn will be detected. MicroFID's optional 6' telescoping extension wand allows the user to reach into areas that otherwise would be inaccessible.

Tank Entry Petroleum Products

Since Petroleum products are mixtures of Aromatics, Alkenes and Alkanes, either detector would be suitable. The MicroFID will respond almost equally to the short chain Alkanes and the more toxic Aromatics.

Soil/Water Jar Headspace Screening

The range of the MicroFID is from 0.5 to 50,000 PPM with manual datalogging capacity to allow independent storage of the Background, Sample, and calculated Difference from each jar. This convenient feature condenses the data to one line per jar sample.

FLAME IONIZATION MONITOR

FLAME IONIZATION MONITOR

MicroFID

MicroFID

Detectable Compounds

Saturated Hydrocarbons - Methane, Ethane, Propane, n-Hexane

Aromatics - Benzene, Toluene, Naphthalene

Unsaturated Hydrocarbons -Acetylene, Ethylene, 1,3-Butadiene

Chlorinated Hydrocarbons- Vinyl Chloride, Chloroform, Trichloroethylene, Methylene Chloride

Ketones - Acetone, Methyl Ethyl Ketone, Methyl Isobutyl Ketone

Alcohols - Methanol, Ethanol, Isopropanol, n-Butanol

Please note: This list provides examples of the types of compounds detectable by the MicroFID. Please contact Photovac Technical Support for details on specific compound detection.

For further information on Photovac products, or to arrange a product demonstration, please contact a Photovac representative near you, email us at admin@photovac.com or contact Photovac, Inc.

Specifications

Size
43.4 cm (17.1“) long, 9.8 cm (3.85“) wide, 18.8 cm (7.4“) high

Weight
8.1 lb (3.7 kg)

Keypad
16-key, fixed function

Display
2-line, 16-character LCD with alphanumeric readout

Hydrogen Cylinder Discharge
Greater than 12 hours

Hydrogen Cylinder Capacity
9.2 liters

Battery Capacity
15 hours (snap-on replacement)

Serial Output
RS – 232, 1200-19200 baud with no parity, for tabular and graphic printouts and connection to a Windows® compatible computer.

Audio Output
On Alarm, LoBatt and NoFlm

Analog Output
0 to 1 volt full scale

Operating Temperature Range
41°F to 105°F (5°C to 45°C)

Operating Humidity
0-100% Relative Humidity (non-condensing)

Operating Concentration Range
0.5 PPM to 2000 PPM methane equivalent (Low Range)
10 PPM to 50,000 PPM methane equivalent (High Range)

Detection Limit
0.5 PPM methane

Accuracy
Methane (after calibration with zero air and 500 PPM methane gas): within ± 0.5 PPM or ± 10% of actual methane concentration (0.5 PPM to 2000 PPM range).

Response Time
Less than 3 seconds

Intrinsic Safety
Class I, Division 1, Groups A, B, C, & D
CENELEC Certified according to EN50021, EEx nA II T5, Demko No. 00Y127355X

PHOTOVAC, Inc.

PHOTOVAC, Inc. 176 Second Avenue | Waltham, MA 02451-1166 USA | Phone: 781-290-0777 Fax: 781-290-4884
PHOTOVAC Europa Bredabaan 885 | B-2170 Antwerp BELGIUM | Phone: +32-3-646-0456 Fax: +32-3-646-0095
visit us at www.Photovac.com

Voyager is a trademark of Photovac, Inc.
Microsoft Windows is a registered trademark of The Microsoft Corporation.
Photovac is a trademark of Photovac, Inc. | © 2002 Photovac, Inc. Printed in U.S.A.
MX792000

TechTIPs

The latest from Photovac

Volume 3, Number 2

MicroFID Response Factors

Compound	Response Factor	Compound	Response Factor
Acetaldehyde	**6.9**[C]	Epichlorohydrin	**2.4**[L]
Acetone	**2.7**[G]	Ethanol	**5.2**[C]
Acetonitrile (Methyl Cyanide)	**1.0**[C]	Ethyl Acrylate	**2.7**[C]
Acrolein (2-Propenal)	**6.9**[C]	Ethylbenzene	**1.0**[L]
Acrylonitrile (Vinyl Cyanide)	**1.3**[C]	Ethyl Cellosolve (2-Ethoxyethanol)	**4.3**[L]
Allyl Chloride (3-Chloro-1-Propene)	**2.7**[C]	Ethyl Chloride (Chloroethane)	**1.9**[C]
Aniline (Benzenamine)	**3.0**[L]	Ethyl Mercaptan (Ethanethiol)	**3.7**[L]
Benzene	**0.7**[C]	Ethylene	**2.2**[G]
Benzyl Chloride (Chloromethyl Benzene)	**1.2**[L]	Ethylene Dibromide (1,2-Dibromoethane)	**2.0**[L]
Bromoform (Tribromomethane)	**7.2**[L]	Ethylene Dichloride (1,2-Dichloroethane)	**1.7**[C]
1,3-Butadiene	**2.7**[C]	n-Heptane	**1.3**[L]
iso-Butane	**1.8**[G]	n-Hexane	**1.6**[G]
n-Butane	**1.9**[G]	Isobutylene	**2.2**[C]
n-Butanol	**2.6**[L]	Isoprene (2-Methyl-1,3-Butadiene)	**2.2**[L]
n-Butyl Mercaptan (Butanethiol)	**2.6**[L]	Isopropanol	**2.4**[C]
Carbon Tetrachloride	**25.9**[C]	Methanol	**23.8**[L]
Chlorobenzene	**0.8**[C]	Methyl Bromide (Bromomethane)	**3.9**[C]
Chloroform (Trichloromethane)	**3.5**[L]	Methyl Ethyl Ketone (2-Butanone)	**1.9**[C]
Cumene (Isopropyl Benzene)	**1.0**[L]	Methyl Isobutyl Ketone	**1.9**[L]
Cyclohexane	**1.4**[C]	Methyl Methacrylate	**2.8**[L]
1,2-Dichlorobenzene (ortho-)	**0.7**[L]	Methyl tert-Butyl Ether (MTBE)	**2.0**[C]
cis-1,2-Dichloroethylene	**2.6**[C]	Methyl Cellosolve (2-Methoxyethanol)	**9.1**[L]
trans-1,2-Dichloroethylene	**2.7**[C]	Methylene Chloride (Dichloromethane)	**1.4**[C]
N,N-Dimethylformamide (DMF)	**2.3**[L]	n-Nonane	**1.1**[L]
1,4-Dioxane	**4.6**[C]	iso-Octane (2,2,4-Trimethylpentane)	**1.2**[L]

Compound	Response Factor	Compound	Response Factor
n-Pentane	**1.6**[L]	1,1,2-Trichloroethane	**1.7**[L]
Propane	**1.8**[G]	Trichloroethylene (TCE)	**2.8**[C]
Propionaldehyde (Propanal)	**3.6**[C]	Triethylamine	**1.1**[L]
Propylene	**2.6**[G]	Vinyl Acetate	**4.4**[L]
Propylene Dichloride (1,2-DCP)	**2.0**[C]	Vinyl Bromide	**1.5**[C]
Propylene Oxide	**2.5**[C]	Vinyl Chloride (Chloroethylene)	**2.1**[C]
Styrene	**1.2** [L]	Vinylidene Chloride (1,1-DCE)	**2.6**[C]
1,1,2,2-Tetrachloroethane	**1.8**[L]	ortho-Xylene	**1.1**[L]
Tetrachloroethylene (Perchloroethylene)	**2.9**[C]	meta-Xylene	**1.2**[L]
Toluene	**0.9**[C]	para-Xylene	**1.2**[L]
1,1,1-Trichloroethane	**1.4**[C]		
1,2,4 Trichlorobenzene	**1.1**		

This list of *Micro*FID Response Factors was determined at (nominally) 500 PPM, based on a 500 PPM Methane calibration. Methane RF = 1.0. The following formula was used for calculation of Response Factors:

$$\text{Response Factor} = \frac{\text{Actual Concentration}}{\textit{Micro}\text{FID Response}}$$

A Response Factor less than 1.0 indicates a compound response better than that of Methane. A Response Factor greater than 1.0 indicates a lower response than that of Methane.

When using Response Factors, results are expected to be accurate to +/- 10 PPM or +/- 25%, whichever is greater.

Standards used for determination of *Micro*FID Response Factors were derived from a variety of sources as referenced below:

C - Certified gas cylinder, +/- 2% analytical accuracy (Isobutylene +/- 5% analytical accuracy)
G - From standard prepared by dilution of neat gas into Zero Air, accuracy unknown
L - From standard prepared by addition of neat liquid to Zero Air, accuracy unknown

For further information contact your area representative or Photovac:

Photovac, Inc.
176 Second Avenue
Waltham, MA 02451
Phone: 781-290-0777
Fax: 781-290-4884
www.photovac.com

ATTACHMENT B

HEADSPACE SCREENING FOR VOCS

SITE-SPECIFIC OPERATING PROCEDURE SSOP-1: HEADSPACE SCREENING FOR VOCs

Scope and Application

The purpose of this site-specific operating procedure is to present a standard method for headspace screening of excavated soils for volatile organic compounds. The headspace screening data will be used to determine if soils need to be segregated and placed in Stockpile Area 3 for additional characterization.

Soil and other debris will be generated during the excavation work for the following elements of the stormwater source control measure:

- Channels
- Detention basin
- Sand filter.

Each bucket load of soil/debris will be screened initially using a photo-ionization detector (PID) or flame ionization detector (FID) meter within 6 inches of the freshly excavated soil[1]. The soil will be considered potentially contaminated if the meter reading is 10 parts per million over background levels for 10 seconds. If this threshold is exceeded, headspace testing will be initiated in accordance with the procedures presented below.

Headspace Screening Procedures

1. Partially fill a clean sample jar with soil to be screened (one third to half full). Collect the soil sample from a freshly uncovered location to minimize volatilization.

2. Cover the jar with clean aluminum foil and tightly seal the jar lid.

3. Allow headspace vapors to accumulate in the jar for at least 10 minutes, but no more than 60 minutes.

[1] Except for the portions of the east channel transecting the old Caustic Tank Farm and the Acid Plant Area, which are assumed to be contaminated. The soil and debris from these areas will automatically be placed in Stockpile Areas 1 and 2 for additional characterization.

4. Shake or agitate the soil jar for 15 seconds at the beginning and end of the headspace development period. Temperatures of the headspace must be warmed to at least 40 degrees F.

5. Calibrate the vapor meter (FID or PID with an 11.7 eV lamp) in accordance with the manufacturer's recommendations at the temperature that will be used for the field screening.

6. After headspace development, insert the meter's sampling probe to a point about one-half the headspace depth. The sample jar opening will be minimized.

7. Record the highest meter reading in the site logbook or sampling form. The highest reading generally occurs within 2-5 seconds after the probe is inserted.

APPENDIX C

SITE MANAGEMENT PLAN

APPENDIX C

SITE MANAGEMENT PLAN

On behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc., Integral Consulting Inc. has prepared this site management plan in support of the implementation of the stormwater source control measures (SCMs) at the former Arkema Portland Plant (the site) located at 6400 NW Front Avenue, Portland, Oregon. This site management plan is prepared pursuant to the Order on Consent, requiring SCMs, issued by the Oregon Department of Environmental Quality (DEQ), signed October 31, 2008 (DEQ No. LQVC-NWR-08-04) (Consent Order), and the new stormwater Mutual Agreement and Order No. WQ/I-NWR-10-175 (MAO) executed by DEQ and LSS on August 4, 2010. Refer to the contract documents for all locations and details of the work.

This site management plan outlines the security provisions, work area management, and contractor coordination practices that will be followed during stormwater SCM construction at the site.

SECURITY DURING STORMWATER SCM CONSTRUCTION

The stormwater SCMs are located on the Arkema property at 6400 NW Front Avenue, Portland, Oregon. The Arkema property is fenced with a locked front gate so that access to the property is restricted. Construction activities will take place within the fenced property boundary, to the extent feasible based on the stormwater SCMs design, and construction equipment will be stored inside the fence line. The Contractor in charge of stormwater SCMs construction will be responsible for security of the construction site and equipment as provided in Specification Section 01510 – Temporary Facilities and Controls.

If stormwater SCMs activities require removal of existing site fencing, temporary chain link fencing and gate locks (or other appropriate controls) will be used to restrict access and minimize the potential for vandalism or trespasser ingress and injury.

Additional security measures that will be required as part of the stormwater SCMs include the following:

- The Arkema site office building will be locked and alarmed by the Owner's Site Representative during non-work hours. During work hours, access to the office building will be allowed as determined by the Owner's Site Representative and Field Quality Assurance Officer (Field QAO).

- To the extent possible, all equipment related to the stormwater SCMs will be secured by the contractor in a locked and secured site trailer or storage container, provided by the Contractor. Any equipment not stored within the locked and secured trailer or storage container will be stored within the fenced Arkema property.
- A monthly inspection and review of the security provisions will be performed by the Contractor during the stormwater SCMs construction period. Additional provisions and required maintenance actions will be implemented as necessary.

WORK AREA MANAGEMENT

The Contractor shall maintain the work area such that the area will be free of hazards, debris, and garbage at all times in accordance with specification Section 01510 – Temporary Facilities and Controls. If the Field QAO observes any condition that is deemed to be unsafe, potentially hazardous, or is in any way deemed to be improper housekeeping, the Field QAO will notify the Contractor's representative, and the unsafe, potentially hazardous, or improper housekeeping condition will be immediately corrected by the Contractor.

All potentially contaminated material encountered during construction will be handled and managed in accordance with the contaminated materials management (CMM) plan (Appendix B of the Final Design Report). All wastes generated during construction will also be handled in accordance with the procedures provided in the CMM plan and specification Section 01575 – Waste Material Disposal. Site safety procedures for Integral Consulting personnel and for subcontractors working under Integral's direction are provided in the site health and safety plan (HASP) (Appendix H of the Final Design Report). The Contractor will be required to provide a site-specific health and safety plan that meets the minimum requirements provided in the Integral Consulting HASP.

COORDINATION WITH OTHER SUBCONTRACTORS

Construction of the stormwater SCM may be conducted, in whole or in part, during the construction of groundwater SCMs that include the construction of a groundwater barrier wall and a groundwater extraction and treatment system as described in Specification Section 01400 – Coordination and Construction Work Plan. In some cases, the stormwater SCM and groundwater SCM construction areas overlap and, therefore, the timing of the work in these overlapping areas will need to be closely coordinated with the Field QAO. At a minimum, the construction of the temporary cap elements of the stormwater SCMs will not be initiated until groundwater SCMs construction activities are completed in the temporary capping areas, as defined in the Final Design Report.

If any concerns or disputes arise as a result of the coordination of construction or other related activities with the groundwater SCM contractor, the stormwater SCM contractor will notify the Field QAO as soon as there is an identified concern or dispute, such that the efficient coordination and completion of construction for both SCMs projects can be maintained.

APPENDIX D

AIR MONITORING PLAN

APPENDIX D

AIR MONITORING PLAN

On behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc., Integral Consulting Inc. has prepared this air monitoring plan in support of the implementation of the stormwater source control measures (SCMs) at the former Arkema Portland Plant (the site) located at 6400 NW Front Avenue, Portland, Oregon. This air monitoring plan is prepared pursuant to the Order on Consent, requiring SCMs, issued by the Oregon Department of Environmental Quality (DEQ), signed October 31, 2008 (DEQ No. LQVC-NWR-08-04) (Consent Order), and the new stormwater Mutual Agreement and Order No. WQ/I-NWR-10-175 (MAO) executed by DEQ and LSS on August 4, 2010. Refer to the contract documents for all locations and details of the work.

This air monitoring plan outlines the requirements and methods for monitoring the air quality during the construction phase of the SCMs. Air monitoring activities described below will be conducted by Integral. This air monitoring plan has been designed for the site and is composed of two parts:

- Part A – Exposure monitoring and air sampling for site workers
- Part B – Air monitoring to assist in segregation of contaminated soils.

PART A – EXPOSURE MONITORING AND AIR SAMPLING FOR SITE WORKERS

Exposure monitoring and air sampling for site workers is described in the site health and safety plan (SHSP; Appendix H of the Final Design Report). The SHSP describes the exposure monitoring and air sampling that will be conducted within the active work areas to ensure that proper engineering controls, work practices, and personal protective equipment are implemented for site workers involved with the SCMs implementation activities at the site. The SHSP identifies the instrumentation, monitoring frequency, location, and required documentation for air monitoring. The SHSP is intended to monitor exposure for Integral Consulting personnel and provides minimum contractor site construction worker contractor safety requirements. Site contractor personnel exposure monitoring is the responsibility of the Contractor performing the construction activities.

Air monitoring will be conducted during all excavation activities in accordance with the SHSP (Appendix H of the Final Design Report).

PART B – AIR MONITORING FOR CONTAMINATED SOIL SEGREGATION

Air monitoring to assist in segregation of potentially contaminated soils at the site is described in the contaminated materials management (CMM) plan (Appendix B of the Final Design Report). Air monitoring will be conducted during excavation and stockpiling of soils using a photo-ionization detector (PID) equipped with an 11.7 eV lamp and/or a flame ionization detector (FID). Specifications and response factors for the selected PID and FID meters are presented in the CMM plan (Appendix B, Attachment A).

Each location of excavation of soil will be screened periodically using the PID and/or FID meter within 6 in. of the freshly excavated soil, approximately every 30 minutes. The soil will be considered potentially contaminated if the meter reading is 10 parts per million (ppm) over background levels for 10 seconds. If this threshold is exceeded, headspace testing for volatile organic compounds (VOCs) will be conducted on a representative sample of this material in accordance with site-specific operating procedure 1 (CMM plan, Appendix B, Attachment B). If the headspace reading is 10 ppm or higher, the soil will be considered potentially contaminated with VOCs and will be placed in Stockpile Area 2 for additional characterization. The field screener shall note that erratic meter responses may occur at high organic vapor concentrations or conditions of elevated headspace moisture, in which case headspace data will be discounted

All air monitoring equipment will be used and calibrated following manufacturer's specifications. Results will be recorded in the field log book and/or in field documentation logs as specified in the SHSP.

APPENDIX E

OPERATION AND MAINTENANCE PLAN

OPERATION AND MAINTENANCE PLAN
FOR
STORMWATER SOURCE CONTROL MEASURES

Former Arkema Inc. Facility
Portland, Oregon

Prepared for
Legacy Site Services LLC
468 Thomas Jones Way
Exton, PA 19341-2528

Prepared by

integral consulting inc.
319 SW Washington St
Suite 1150
Portland, OR 97204

September 30, 2011

CONTENTS

LIST OF TABLES ..... **iii**

ACRONYMS AND ABBREVIATIONS ..... **iv**

1 INTRODUCTION **1-1**

2 TEMPORARY CAPPING MAINTENANCE **2-1**

2.1 DESCRIPTION OF THE CAP 2-1
2.2 CAP MAINTENANCE 2-1
2.3 FUTURE WORK 2-2
2.4 REPORTING AND SCHEDULE 2-2

3 FORMER STORMWATER COLLECTION SYSTEM DECOMMISSIONING MAINTENANCE **3-1**

4 STORMWATER CONVEYANCE AND TREATMENT SYSTEM **4-1**

4.1 DESCRIPTION OF THE CONVEYANCE AND TREATMENT SYSTEM 4-1
4.2 CONVEYANCE AND TREATMENT SYSTEM MAINTENANCE 4-1
4.2.1 Conveyance System 4-1
4.2.2 Treatment System 4-2
4.3 DISPOSAL OF MAINTENANCE GENERATED MATERIALS 4-4
4.4 NUISANCE VECTOR CONTROL 4-4
4.5 FUTURE WORK 4-4
4.6 REPORTING AND SCHEDULE 4-4

5 REFERENCES **5-1**

LIST OF TABLES

Table 1. Berm and Channel Inspection and Maintenance

Table 2. Detention Basin and Sand Filter Inspection and Maintenance

ACRONYMS AND ABBREVIATIONS

DEQ	Oregon Department of Environmental Quality
LSS	Legacy Site Services LLC
O&M	operation and maintenance
SCM	source control measure

1 INTRODUCTION

On behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc., Integral Consulting Inc. has prepared this operation and maintenance (O&M) plan in support of the implementation of the stormwater source control measures (SCMs) at the former Arkema Portland Plant (the site) located at 6400 NW Front Avenue, Portland, Oregon. This O&M plan is prepared pursuant to the Order on Consent, requiring SCMs, issued by the Oregon Department of Environmental Quality (DEQ), signed October 31, 2008 (DEQ No. LQVC-NWR-08-04), and the new stormwater Mutual Agreement and Order No. WQ/I-NWR-10-175 executed by DEQ and LSS on August 4, 2010. Refer to the contract documents for all locations and details of the work.

The O&M plan describes the operation and maintenance of the stormwater SCM implemented at the site, including O&M for the following SCM elements:

- Temporary caps
- The decommissioned existing stormwater collection system
- The new stormwater conveyance and treatment system.

2 TEMPORARY CAPPING MAINTENANCE

This section details the tasks and deliverables that will be required for the maintenance of the temporary cap component of the stormwater SCMs.

2.1 DESCRIPTION OF THE CAP

The temporary cap consists of asphalt pavement repair and a geotextile-plastic sheeting-gravel cover over exposed soil in the former drainage basin for Outfall 002 and the former DDT manufacturing areas. The extents of the temporary cap are indicated in the contract drawings. For the purposes of maintenance, the temporary cap does not include the building foundations in this area.

2.2 CAP MAINTENANCE

The cap will be maintained in a condition that prevents exposure of site stormwater to soil beneath the cap. The cap maintenance will include the following activities:

- Visual inspection of the cap. Cap inspection will consist of visual observation of the asphalt pavement and the geotextile-plastic sheeting-gravel cover for significant cracks, signs of excessive deterioration, and signs of damage, on an annual basis.
- Inspections will be conducted on an annual basis, after storm events that generate more than 1.0 in. of precipitation over a 24-hour time period, and after seismic activity that registers 4.0 or higher on the Richter scale. Observations will be recorded in the maintenance logbook.
- Repair of any breaches, e.g., holes, gaps, cracks that are sufficient in size to allow for direct contact of stormwater with soil beneath the cap.
- Visual inspection of the concrete sealer on Warehouse No. 2 foundation. Inspection will consist of visual observation of the foundation and sealer for any damage, significant cracks, or signs of excessive deterioration, on an annual basis.
- The observations made during the annual visual inspection and any maintenance activities performed on the cap will be included in a maintenance logbook, which will be submitted to DEQ on an annual basis (see Section 4.4).

2.3 FUTURE WORK

There may be an instance in the future when work beneath the cap needs to be performed (i.e., additional site remediation), requiring removal of a portion of the cap. In these instances, DEQ will be notified prior to any work beneath the cap. Such additional work will be conducted in accordance with a work plan approved by DEQ, and performed in a manner to minimize overland stormwater flows from contacting exposed soil (that is typically beneath the cap) during such construction. Further, any stormwater that contacts exposed soil will be routed to a detention facility and treated and disposed of outside of the newly installed stormwater conveyance and treatment system (see Section 4).

2.4 REPORTING AND SCHEDULE

Annual summary reports will be submitted to DEQ within 1 year of approval of the final Stormwater SCMs Completion Report, and on an annual basis thereafter. The annual report will describe the following:

- Current site activities
- Current conditions of the cap, based on visual observation
- Specific actions related to cap observation or maintenance taken during the previous year
- Anticipated cap maintenance activities to be performed prior to submittal of the next annual report.

3 FORMER STORMWATER COLLECTION SYSTEM DECOMMISSIONING MAINTENANCE

The former collection system will be abandoned in place by, in general, filling with a controlled low-strength material. No additional maintenance is required. In the case that additional work needs to be completed at the site (i.e., additional remedial activities), a set of as-built drawings documenting the locations and methods of abandonment will be maintained onsite to facilitate such work.

4 STORMWATER CONVEYANCE AND TREATMENT SYSTEM

This section details the tasks and deliverables that will be required for the maintenance of the stormwater conveyance and treatment system component of the stormwater SCMs.

4.1 DESCRIPTION OF THE CONVEYANCE AND TREATMENT SYSTEM

The stormwater conveyance and treatment system consists of a network of channels draining to a treatment system, which is composed of a detention basin and aboveground sand filter. The treatment system will tie into existing Outfall 004. The location of the system is indicated in the contract drawings.

4.2 CONVEYANCE AND TREATMENT SYSTEM MAINTENANCE

The berms, channels, and treatment system will be maintained in a condition that provides for proper operation and stability of the system.

4.2.1 Conveyance System

The conveyance system consists of the berms and channels. The berms will be constructed of import soil material and covered with a geotextile and gravel layer to prevent erosion. The berms will direct stormwater flow to the channel system. The channels will be gravel-lined and will be used to direct stormwater to the treatment system.

The conveyance system will be maintained in a way that directs stormwater to the treatment system, and otherwise prevents stormwater from leaving the site. Inspection will consist of visual observation of the berms and channels for erosion, vegetative growth, and signs of damage. Table 1 summarizes the O&M measures that will be conducted to ensure the integrity of the system.

Inspections will be made on an annual basis and after storm events that generate more than 1.0 in. of precipitation over a 24-hour time period. The observations made during the visual inspections and any maintenance activities performed on the system will be included in a maintenance logbook, which will be submitted to DEQ on an annual basis (see Section 4.4).

Table 1. Berm and Channel Inspection and Maintenance

Inspection	Maintenance
General	
Standing water	Remove blockages if standing water is observed more than 48 hours following a storm event.
Structural Components	
Clogged inlets or outlets[a]	Remove sediment and debris to maintain at least 50% conveyance capacity at all times.
Vegetation	
Weeds, large shrubs, trees	Remove vegetation if it impairs stormwater treatment system function
Soil and Rock Medium	
Gullies[a]	Fill and lightly compact with material used for construction (or equivalent).
Erosion (undercutting, scouring, slumping)	Fill eroded area with soil, lightly compact, cover with rock. Restore lining materials (as per construction drawings or equivalent) where necessary.
Slope Slippage	Stabilize at original slope (see construction drawings) slope/banks with additional rock (as per construction drawings or equivalent).

Source: Portland Stormwater Management Manual – August 1, 2008.
Notes:
[a] Inspection and maintenance for channels only

All sediment removed from the stormwater conveyance and treatment system will be characterized for proper disposal.

4.2.2 Treatment System

The treatment system consists of the detention basin, sand filter and associated piping, and Outfall 004. A detailed description of the system is provided in the Final Design Report. The treatment system will be maintained in a way that stormwater discharge meets the requirements of the National Pollution Discharge Elimination System permit. O&M measures will be conducted to ensure the integrity of the system

Inspection will consist of visual observation of the detention basin, sand filter and filter media, piping system, and outfall for sediment buildup, erosion, vegetative growth, and signs of damage. At a minimum, inspections will be made on an annual basis and after storm events that generate more than 1.0 in. of precipitation over a 24-hour time period. In addition, inspections shall follow the contract drawings and specifications and the manufacturer's specifications. Table 2 summarizes inspection and maintenance activities for the detention basin and sand filter.

The observations made during the visual inspections and any maintenance activities performed on the system will be included in a maintenance logbook, which will be submitted to DEQ on an annual basis (see Section 4.4).

Table 2. Detention Basin and Sand Filter Inspection and Maintenance

Inspection	Maintenance
General	
Standing water	Remove blockages and/or replace filter medium as needed if standing water is observed more than 48 hours following a storm event.
Structural Components	
Clogged inlets or outlets	Remove sediment and debris to maintain at least 50% conveyance capacity at all times.
	Manually remove sediment accumulation.
Cracked drain pipes, liners, walls, or traps	Repair/seal cracks. Replace when repair is insufficient.
Vegetation	
Weeds, large shrubs, trees	Remove vegetation if it impairs stormwater treatment system function.
Filter Medium	
Ponding	Remove layer of sediment and restore infiltration rate.
Gullies	Fill, lightly compact, and install flow spreader to disperse flow.
Erosion	Restore lining materials (as per construction drawings or equivalent) where necessary.
Slope Slippage	Stabilize at original slope (see construction drawings) slope/banks with additional rock (as per construction drawings or equivalent).

Source: Portland Stormwater Management Manual – August 1, 2008.

4.3 DISPOSAL OF MAINTENANCE GENERATED MATERIALS

Routine maintenance of conveyance and treatment systems will generate waste materials that must be properly disposed. Removed vegetation will be collected and transported to a nearby transfer facility where it will be recycled as yard waste. Accumulated sediment, trash, debris and damaged lining materials that have no recyclable value will be collected and transported to a Subtitle D landfill. Water collected during routine maintenance (e.g., via vactor truck) will be stored onsite until maintenance is complete and then discharged to the sediment forebay portion of the detention basin.

4.4 NUISANCE VECTOR CONTROL

Stormwater conveyance and treatment systems will not be allowed to harbor mosquitoes, rodents, or other invasive wildlife. When performing maintenance activities, standing water will be noted and checked against the design parameters to ensure that the systems are functioning properly. Standing water will be monitored for the presence of mosquito larvae. The systems will also be checked for the presence of rodent holes or burrows around the facility. Observed burrows will be filled in.

The time, date, weather, and site conditions of vector activity will be recorded. If mosquito or rodent vectors are observed, Multnomah County Vector Control will be contacted for assistance in eradicating those vectors. Contact will be made to the Oregon Department of Wildlife for species other than rodents and mosquitoes.

4.5 FUTURE WORK

There may be an instance in the future when work beneath the conveyance and treatment system needs to be performed (i.e., additional site remediation), requiring removal of a portion or all of the system. Such additional work will be performed in a manner to minimize overland stormwater flows from contacting exposed soil during such construction.

4.6 REPORTING AND SCHEDULE

Annual summary reports will be submitted to DEQ within 1 year of approval of the final Stormwater Source Control Measures Completion Report, and on an annual basis thereafter. The annual report will describe the following:

- Current site activities
- Current conditions of the conveyance and treatment system, based on visual observation
- Specific actions related to observation or maintenance taken during the previous year

- Anticipated maintenance activities to be performed prior to submittal of the next annual report.

5 REFERENCES

City of Portland. 2008. Stormwater Management Manual. Available at: www.portlandonline.com/bes/index.cfm?c=47952&. City of Portland, Bureau of Environmental Services, Portland, OR.

APPENDIX F

PERFORMANCE MONITORING PLAN

PERFORMANCE MONITORING PLAN
FOR
STORMWATER SOURCE CONTROL MEASURES

Former Arkema Inc. Facility

Portland, Oregon

Prepared for
Legacy Site Services LLC
468 Thomas Jones Way
Exton, PA 19341-2528

Prepared by

integral consulting inc
319 SW Washington Street
Suite 1150
Portland, OR 97204

September 30, 2011

CONTENTS

LIST OF FIGURES ..... **iii**

LIST OF TABLES ..... **iii**

ACRONYMS AND ABBREVIATIONS ..... **iv**

1 INTRODUCTION **1-1**

1.1 PERFORMANCE MONITORING PLAN FRAMEWORK 1-2

2 STORMWATER SAMPLING **2-1**

2.1 SAMPLING LOCATIONS 2-1
2.2 SAMPLING FREQUENCY 2-1
2.2.1 Detailed Sampling Schedule 2-2
2.2.2 Sample Collection Criteria 2-3
2.3 SAMPLE COLLECTION AND HANDLING 2-3
2.3.1 Automated Sampling 2-3
2.3.2 Manual Sampling 2-4
2.3.3 Sample Handling 2-4
2.4 FLOW MEASUREMENTS 2-5
2.5 VISUAL INSPECTIONS 2-5
2.6 ANALYTICAL METHODS 2-6
2.7 QUALITY ASSURANCE / QUALITY CONTROL 2-6
2.8 INVESTIGATION-DERIVED WASTE 2-7

3 MONITORING CRITERIA **3-1**

3.1 EVALUATION OF TREATMENT SYSTEM PERFORMANCE 3-1
3.2 POTENTIAL ADDITIONAL SAMPLING 3-2

4 REPORTING **4-1**

5 REFERENCES **5-1**

Attachment A. Standard Operating Procedures

Attachment B. Sampling Forms

Attachment C. Sampling Equipment User Manuals (on CD)

LIST OF FIGURES

Figure 1. Stormwater Sampling Location

LIST OF TABLES

Table 1. Stormwater Treatment System Effluent Goals

Table 2. Summary of the DQOs Developed for the LSS Stormwater Source Control Measures

Table 3. Stormwater Treatment System Effluent Concentrations

Table 4. Performance Monitoring Decision Tree

Table 5. Corrective Action Decision Tree

ACRONYMS AND ABBREVIATIONS

BMP	best management practice
COPC	constituent of potential concern
DEQ	Oregon Department of Environmental Quality
LSS	Legacy Site Services LLC
MAO	Mutual Agreement and Order No. WQ/I-NWR-10-175
NPDES	National Pollution Discharge Elimination System
QA/QC	quality assurance and quality control
QAPP	quality assurance project plan
SCM	source control measure
SOP	standard operating procedure

1 INTRODUCTION

On behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc., Integral Consulting Inc. has prepared this performance monitoring plan in support of the implementation of the stormwater source control measures (SCMs) at the former Arkema Portland Plant (the site) located at 6400 NW Front Avenue, Portland, Oregon. This performance monitoring plan is prepared pursuant to the Order on Consent, requiring SCMs, issued by the Oregon Department of Environmental Quality (DEQ), signed October 31, 2008 (DEQ No. LQVC-NWR-08-04), and the new stormwater Mutual Agreement and Order No. WQ/I-NWR-10-175 (MAO) executed by DEQ and LSS on August 4, 2010. Refer to the contract documents for all locations and details of the work.

This performance monitoring plan presents the proposed approach for sampling stormwater to evaluate the presence of constituents of potential concern (COPCs) in treated stormwater and to evaluate the performance of the stormwater SCMs. The final list of COPCs, as documented in Attachment A of the MAO, is included as Table 1-1. The final list also includes the parameters that require monitoring on a monthly or quarterly basis under Schedule B of the site National Pollution Discharge Elimination System (NPDES) permit. This plan provides a detailed description of sample collection and handling procedures, analytical methods, and quality assurance and quality control (QA/QC) protocols. Sampling procedures will also be conducted under a health and safety plan, which is provided as Appendix H of the Final Design Report.

The goal of the stormwater SCMs is to eliminate the potential for migration of COPCs in stormwater to the Willamette River at concentrations greater than values presented in Section 1 of the Final Design Report by implementing best management practices (BMPs), including erosion control and decommissioning the existing stormwater collection system, and structural treatment BMPs, including detention basin and filtration. Because this stormwater treatment system is being implemented in accordance with the MAO, and in conjunction with the facility's existing NPDES permit, new or revised numerical discharge limits are not part of the design basis for these SCMs; however, LSS has agreed to conduct performance monitoring of the SCMs and use an adaptive management approach to optimize performance of the stormwater treatment, based on comparisons of effluent concentrations to values presented in Section 1 of the Final Design Report. Stormwater treatment system effluent concentrations are provided in Section 3 as treatment system goals.

This performance monitoring plan will be initiated upon completion of all work related to SCMs being implemented at the site. This includes all the stormwater SCMs as presented in the Final Design Report as well as groundwater source control measures, including the installation of the groundwater barrier wall and the groundwater extraction and treatment system. As described in Attachment A to Appendix A (Erosion and Sediment Pollution Control Plan) of the Final Design Report, LSS intends to utilize components of the stormwater SCMs, including the detention basin and sand filter, to control and treat site stormwater during implementation of

the stormwater and groundwater SCMs. LSS will monitor the system during this period and implement BMPs as necessary; however, the results of this monitoring will not be indicative of final site conditions. Therefore, this performance monitoring plan will not be initiated until all site construction has been completed and the treatment system components have been inspected and, if necessary, cleaned of all excess debris and sediment accumulated during the construction process.

1.1 PERFORMANCE MONITORING PLAN FRAMEWORK

This performance monitoring plan proposes the following approach to monitoring COPCs in stormwater at the site following implementation of the stormwater SCMs:

- Collect stormwater samples following implementation of the stormwater SCMs. For the initial year of operation, stormwater treatment system influent and effluent samples will be collected at an average rate of one sample per month (see Section 2.2) and analyzed for COPCs in accordance with Table 1. In addition, stormwater flow rate will be measured approximately monthly, coincident with sample collection. Composite stormwater samples will be used to monitor the performance of the stormwater SCMs and determine whether influent and effluent concentrations of COPCs in stormwater have decreased following implementation of the stormwater SCMs and to monitor stormwater treatment system performance.
- If the BMPs implemented as part of the stormwater SCMs design for this site are not successful in reducing DDT and other COPCs in stormwater discharges to the Willamette River from the site, an adaptive management approach will be used to optimize the stormwater treatment system at the site.

Details regarding how this approach will be implemented are documented in Sections 2 through 4 below. Supporting documentation is also provided in the following attachments:

- Attachment A – Standard Operating Procedures (SOPs)
- Attachment B – Sampling Forms
- Attachment C – Sampling Equipment User Manuals.

2 STORMWATER SAMPLING

Stormwater influent and effluent will be sampled as part of the stormwater SCMs compliance and performance monitoring program. Stormwater effluent will be sampled for compliance purposes prior to its conveyance to the Willamette River at Outfall 004. Outfall 004 will be the only remaining operating outfall at the site following implementation of the stormwater SCMs. Stormwater treatment system influent monitoring samples will also be collected to measure treatment system performance. Approximately monthly composite stormwater samples will be collected during the first year of operation of the stormwater SCMs and analyzed for total or dissolved-phase stormwater COPCs and conventional parameters including total suspended solids. Stormwater flow rates will be measured concurrent with stormwater sample collection events. Stormwater monitoring sample data will be used to assess the effectiveness of the stormwater treatment system to meet treatment system goals, and to assess treatment system performance with respect to treatment system optimization and adaptive management approaches, if needed.

To ensure that stormwater monitoring data are of sufficient quality and quantity to support the goals of the stormwater SCMs design, project-specific data quality objectives have been developed and are included in Table 2.

2.1 SAMPLING LOCATIONS

Stormwater samples will be collected for stormwater SCMs performance monitoring at locations shown on Figure 1. Stormwater will be collected from two sample locations: one representative of stormwater treatment system influent and one representative of stormwater treatment system effluent. The influent sampling location will be collected in the stormwater SCMs conveyance channel system, immediately hydraulically upgradient of the inlet to the stormwater detention basin. The effluent sampling location will be at a manhole hydraulically downgradient from the stormwater treatment sand filter. Automatic samplers will be used for collection of stormwater treatment system influent and effluent samples and will be located either within the structure (e.g., manhole, channel) being sampled (above the expected water levels) or at a secure site on the ground surface immediately adjacent to the structure. The sampling tube will be placed inside the structure with the intake screen for the tube close to, but not in contact with, the bottom of the structure.

2.2 SAMPLING FREQUENCY

Influent and effluent composite stormwater treatment system samples will be collected at a target frequency of 12 sampling events (discussed below) within the first year following implementation of the stormwater SCMs. This sampling frequency, on average, meets the

sampling basis of at least one sampling event per month specified in Attachment A of the MAO. Each sampling event will include collection of a 24-hour (or total rainfall duration, whichever is less) composite sample for all analytes[1] except for pH. These samples provide information on the "average" stormwater quality during a storm event and will be used to evaluate stormwater discharge concentrations and performance of stormwater SCMs. Composite sampling will proceed at both influent and effluent sample locations.

2.2.1 Detailed Sampling Schedule

Stormwater sampling will commence within 30 days following completion of stormwater and groundwater SCMs construction. To collect a minimum of 12 stormwater samples distributed over the first year following implementation of the stormwater SCMs, the following numbers of samples will be targeted for each period of the year:

- November, December, January, February, and March—Target 16 composite samples (8 influent and 8 effluent) over this period.
- April and May—Target 2 composite samples (1 influent and 1 effluent) over this period.
- June, July, and August—Target 2 composite samples (1 influent and 1 effluent) over this period.
- September and October—Target 4 composite samples (2 influent and 2 effluent) over this period.

The sampling schedule has been established so that a reasonable distribution of samples will be collected over the entire first year of stormwater SCMs operation.

For at least one of the 12 targeted sampling events, an attempt will be made to sample a storm event greater than the 2-year, 24-hour storm (i.e., storm event predicted to be greater than 2.4 in. over a 24-hour period) to assess the effects of larger storm events on COPC loading in stormwater discharges to the Willamette River. Note that this event may or may not occur within the preliminary monitoring period. If deemed necessary based on this sampling event, LSS may propose modifications to the stormwater treatment system, such as additional temporary capping, to address these storm events. Performance monitoring criteria are presented in Section 3.

The schedule for stormwater monitoring after the first year will be based on the analysis of data from the first year of stormwater sampling and determined in consultation with DEQ.

[1] All parameters will be analyzed during each sampling event with the exception of dioxins and furans. Dioxins and furans will be analyzed on a quarterly basis per the MAO.

2.2.2 Sample Collection Criteria

The ability to collect stormwater samples will be dependent on rainfall and associated runoff during the period of collection. Sampling events will be scheduled when it is predicted that the following storm event criteria will be met:

- Storm event is preceded by a dry period (less than 0.1 in. rainfall) of at least 24 hours
- Storm event is predicted to produce more than 0.2 in. rainfall
- Storm event is predicted to occur over a minimum of 3 hours.

The storm event criteria listed above are considered goals. Each storm event sampled will be evaluated relative to these goals, although circumstances may arise where not all of these criteria can be met (e.g., a storm event of less than 0.2 in. rainfall during drier periods). In the latter case, professional judgment will be used to evaluate whether sampling or storm conditions that substantially do not meet the target storm conditions should be considered prior to analyzing stormwater samples collected under these conditions. The justification for accepting samples that deviate from these target conditions will be provided in the monthly discharge monitoring report and the performance monitoring report.

If, by the last week of a given month or the last month of a given period, the target number of samples has not been collected, one or more of the aforementioned storm event criteria may be ignored in order to obtain the number of target samples for that period. Note that ignoring these criteria does not necessarily mean that the targeted number of 12 samples can be collected over the year, or that the targeted number of samples will be collected for a given period, as adequate rainfall to produce runoff is required to collect samples.

2.3 SAMPLE COLLECTION AND HANDLING

Samples will be collected using both automated samplers (composite samples) and manual sampling techniques (grab samples). Sample collection using both techniques along with sample handling procedures are described in this section.

2.3.1 Automated Sampling

Prior to the initial sampling event, the sampling equipment (e.g., ISCO 6712 automatic samplers and ISCO 750 area velocity modules or equivalent) will be decontaminated in accordance with the manufacturer's equipment user manual (Attachment C). If needed, the sample collection vessels will be sent to the analytical laboratory for decontamination, and initial programming of the automatic samplers will be completed (see Attachment C). Initial programming may include entering such information as site identification, alarm dial out numbers, storm event data collection frequency, and a series of programs to cover the collection of first flush grab

samples (when applicable), the collection of periodic discrete grab samples for manual compositing (when applicable), and a range of potential runoff volumes in response to a precipitation event. Upon installation of the samplers, additional programming entries for installation site-specific characteristics, such as measured pipe diameter (if applicable), the offset of the flow meter (if not installed in the bottom of the pipe or drainage channel), and the length of the sample pickup tube, may be required. All field activities, including sampler programming entries and installation details, will be documented in the site logbook in accordance with the SOP (SOP AP-02, Attachment A).

Whole water (unfiltered) stormwater samples will be collected in accordance with the ISCO 6712 automatic sampler, or equivalent, user manual (Attachment C). When it is anticipated that a storm event fitting the criteria listed in Section 2.2.2 will occur, the ISCO automatic sampler will be activated remotely and then triggered by the flow meter (once a certain level is reached) to begin sample collection. Following a storm event, the sample collection device will be accessed and the discrete grab sample bottles within the automated sampler will be retrieved and shipped to the analytical laboratory (Section 2.3.3). The discrete, time-based sample aliquots collected by the automatic samplers will be manually combined by the analytical laboratory to produce flow-weighted composite samples representative of stormwater treatment system influent or effluent. Flow-weighted composites will be based on stormwater flow rate data (see Section 2.4). Sample filtration, when needed, will also be done by the analytical laboratory.

2.3.2 Manual Sampling

Manual samples (grab samples) will be collected from locations within the stormwater conveyance channel system and from the treatment system influent as necessary. Manual samples may be necessary in the case that the automated sampler is malfunctioning and adequate sampling cannot be completed by this method. Samples will be collected in accordance with the U.S. Environmental Protection Agency protocols for the collection of surface water samples (USEPA 1999, 2002). Per these protocols the sample will be collected by 1) reaching upstream or up-current with the sample bottle, 2) submerging the closed sample bottle quickly under the water with the cap on to avoid collection of any surface scum and avoid contact with the bottom of the structure or any debris, 3) removing the cap while the bottle is underwater, 4) collecting the water sample, and 5) re-capping the bottle while it is still under the water surface.

2.3.3 Sample Handling

Each sample collected in the field will be labeled in accordance with the SOP for sampling labeling (SOP AP-04, Attachment A). Samples will be managed according to the protocols described in SOP AP-01, sample packing and shipping (Attachment A), and SOP AP-03, sample custody (Attachment A), as well as the quality assurance project plan (QAPP; Appendix G of

the Final Design Report). Examples of relevant sampling forms and documents are provided in Attachment B.

2.4 FLOW MEASUREMENTS

Flow meters (ISCO 750 area velocity flow module or equivalent) will be used in conjunction with the automatic samplers to determine the flow rate of the stormwater treatment system influent and effluent and, ultimately, allow for calculation of flow-weighted average composite stormwater samples (event mean concentrations). Flow data will be continuously recorded for the duration of measured storm events. A user manual for the ISCO 750 is provided in Attachment C. Given the size of the detention and filtration systems, low volume storm events will result in a long lag time before discharge and, therefore, flow rates may be difficult to measure.[2]

2.5 VISUAL INSPECTIONS

Formal visual inspections of the physical aspects of the stormwater treatment system will be performed quarterly during storm events and will include observations along the entire length of the stormwater treatment system. Informal visual inspections consisting of observations of nearby and/or previously noted or suspected problematic portions of the stormwater treatment system will be performed each time field activities, such as stormwater sample collection, occur. Formal visual inspections will include, but may not necessarily be limited to, observations focusing on the following:

- Accumulated sediment within the stormwater treatment system
- Blockages of any structures
- Buildup of fines on the surfaces of filter fabric, which may cause reduced filtering or screening
- Buildup of fines in the detention basin, which may reduce capacity and detention time and could allow for resuspension of sediment during high flows
- Issues that may promote the formation of preferential flow paths and/or filter bypass, such as uneven buildup of fines on filters, passage around filter fabric through an adjacent gravel layer, or material interfaces that allow water to easily pass through the filter
- Erosion on side slopes, the facility bottom, the collection channel, or around inlets, outlets, and overflows

[2] A low profile flow sensor will be used to monitor low-volume flows. If necessary, additional measures can be implemented to monitor low-volumes flows (e.g., inserts within the existing Parshall Flume discharge).

- Stormwater treatment system structural failures
- Water levels within the detention basin and above the sand filter, consisting of reading staff gages in the detention basin and sand filter and recording drawdown or filling to assess hydraulic performance.

Visual observations of the portions of the stormwater treatment system that are underwater will not be feasible.

Notes from each visual inspection will be included in the subsequent monthly discharge monitoring report, as well as in the performance monitoring report. Stormwater treatment system maintenance issues identified during visual inspections of the treatment system will be responded to within 30 days to ensure operational efficiency during storm events. Maintenance issue responses will include either immediate correction of the identified issue(s), or submission to DEQ of a plan for corrective action and an implementation schedule for more complex corrective actions. Either the report summarizing the corrective actions taken, or the corrective action plan for addressing more complex corrective actions, will be submitted to DEQ within 30 days of the identified issue.

2.6 ANALYTICAL METHODS

Stormwater samples will be analyzed for the constituents listed in Table 1. Unless otherwise specified in Table 1, samples will be analyzed on an approximately monthly basis for total constituent concentration. Additional information regarding analytical methods is provided in the QAPP (Appendix G of the Final Design Report).

2.7 QUALITY ASSURANCE / QUALITY CONTROL

As described in the QAPP (Appendix G of the Final Design Report), one set of QA/QC samples will be collected for each stormwater sampling event for the first four events. This will consist of the following:

- One field duplicate
- One unfiltered field equipment rinsate blank (deionized water rinsed over decontaminated sampling equipment and poured into a sample bottle with preservative).

Following the first four stormwater sampling events, if field QA/QC samples have established good quality control, the frequency of field QA/QC samples will be reduced to one set of QA/QC samples per quarter until a maximum of one year of sampling is completed. The schedule for QA/QC sample collection after the first year will be based on the analysis of data from the first year of stormwater sampling.

Because there are no clearly defined QA/QC requirements for stormwater sampling under the NPDES program, the proposed QA/QC sampling schedule is expected to meet or exceed what is typically performed under NPDES permitting. In addition, the following field-related sampling factors are anticipated to reduce the likelihood of resulting QA/QC issues: the stormwater sampling equipment is automated (see Section 2.3.1), the automated samplers that will be used perform two purges (pre-sample and post-sample) during the sampling cycle to clear the sampler suction line of residual liquid, and cleaned sample bottles will be provided new for each sampling event by the analytical laboratory. Once field-related sampling factors have been disregarded as QA/QC issues, QA/QC sampling should only need to be performed to maintain continuity in QA/QC evaluation. Note that all analyses will continue to be subject to the analytical laboratory's QA/QC program. Any reduction in QA/QC sampling frequency will be subject to DEQ approval.

2.8 INVESTIGATION-DERIVED WASTE

All investigation-derived waste (e.g., decontamination water, etc.) will be handled in accordance with the contaminated materials management plan (Appendix B of the Final Design Report).

3 MONITORING CRITERIA

Because this stormwater treatment system is being implemented in accordance with the MAO and in conjunction with the facility's existing NPDES permit, new or revised numerical discharge limits are not yet part of the design basis for the SCMs. However, LSS has agreed to conduct performance monitoring of the SCMs to confirm that the goal of the stormwater SCMs is being met and that, if needed, adaptive management of the stormwater SCMs can be implemented to improve system performance.

3.1 EVALUATION OF TREATMENT SYSTEM PERFORMANCE

The objectives of the stormwater system design are to eliminate discharge of COPCs in stormwater discharges to the Willamette River above treatment system effluent goals. Stormwater treatment system effluent goals are provided in Table 3. These effluent goals are not stormwater system effluent benchmarks for the purposes of NPDES permit compliance; however, the concentrations will be used as treatment system goals and to measure the effectiveness of the stormwater system during performance monitoring. Attaining these concentrations for certain constituents (e.g., DDx) may not be technically feasible and/or practicable. On the other hand, attaining effluent concentrations for other parameters (e.g., total suspended solids) is achievable using established, proven, stormwater treatment methods

The performance of the stormwater treatment system, specifically the limits of the structural treatment BMPs to remove site COPCs from stormwater discharges, will also be assessed using stormwater treatment system influent and effluent data. This evaluation may include, but will not necessarily be limited to, the following:

- Comparison of individual storm composite concentrations to effluent concentration goals.
- Utilization of individual storm influent and effluent composite concentrations to evaluate the efficacy of the treatment system (e.g. percent removal) and compare to estimated efficacy (Section 3.5 of Final Design Report).
- Determination and evaluation of total COPC loading to the Willamette River.
- Evaluation of total flow of the measured storm event flow; the maximum storm intensity measured; and the antecedent ground conditions (amount of time since the last rainfall that produced runoff) on influent and effluent composite concentrations.

3.2 POTENTIAL ADDITIONAL SAMPLING

In addition to the evaluation of the stormwater SCMs' effectiveness and stormwater concentration trends, the monthly discharge reports and the performance monitoring report will assess the need for modification and/or optimization of the stormwater treatment system (i.e., adaptive management). Table 4 provides a list of certain performance issues that could arise during system performance monitoring that may require action. Table 4 is a decision tree that will be followed in evaluation the performance issue. In some cases, the performance issue can be addressed during the normal course of operation and maintenance of the stormwater treatment system as discussed further in the operation and maintenance plan (Appendix E of the Final Design Report). In other cases, the performance issue may indicate that a further evaluation of the treatment system design is required and that design modifications may need to be implemented. In these latter cases, the performance monitoring decision tree directs the analysis to several outcomes that could be considered as listed in Table 5, the corrective action decision tree. Through ongoing evaluation of the system through the performance monitoring decision tree and evaluation and application of corrective actions through the corrective action decision tree, the stormwater SCMs can be adaptively managed to provide maximum feasible performance for the design life of the system.

If future modifications to the current treatment system design require consideration because of exceedances of stormwater treatment system target effluent concentrations, additional data may need to be collected as specified in the Final Design Report, Section 8.0. The following presents data that may need to be collected to assess the feasibility of implementing these potential modifications:

- Collection of influent grab stormwater samples at the treatment system influent sample during separate "first flush" (i.e., within the first 30 minutes of stormwater runoff) stormwater events. Data from "first flush" events will be used to determine if additional source control measures (e.g., additional temporary capping) would be successful at reducing COPC loading to the treatment components of the SCMs.

- Additional sampling within the stormwater conveyance channels to identify additional source areas contributing to COPCs in stormwater, including collecting stormwater samples from the stormwater conveyance channel system to determine if asphalt pavement around the perimeter of the former Acid Plant is a potential source of DDx contamination to the treatment system.
- Total and dissolved concentrations of COPCs to determine whether COPCs are associated with the particulate or aqueous phase.
- Particle size distributions, if COPCs are found to be associated with the particulate phase.

- Distribution of COPCs by particle size by collecting sediment trap data to fractionate sediment by particle size and analyze for COPCs of interest. Sediment traps shall be placed in the discharge pipeline of the sand filter system.
- Vendor-specific bench-scale testing with site stormwater from a particular location (e.g., before the detention basin, between the basins, or after sand filtration), to determine coagulant type and dosage to maximize the effectiveness of a coagulant addition.

In addition to potential modifications, performance monitoring may indicate that some COPCs are not present in stormwater discharges. LSS proposes that if one or more COPCs are not detected in both influent and effluent samples for four (4) consecutive sampling events, analysis for the specific COPC be discontinued. Further, if one or more COPCs are not detected in effluent samples for the first year of monitoring, analysis of the COPC would be discontinued. Discontinuing of analysis of any COPC will be made with the agreement of DEQ.

4 REPORTING

In accordance with the August 4, 2010, MAO, and subsequent agreements with DEQ, stormwater sampling activities will begin within 30 days following completion of construction of the stormwater and groundwater SCMs, including all site restoration and cleanup. Stormwater sample analytical data, stormwater flow rate data, and observations noted during visual inspections of the physical aspects of the stormwater treatment system will be provided to DEQ in monthly discharge monitoring reports. Given that validated analytical data are expected to be received from the laboratory within 30 days and stormwater sampling event summaries will be generated within 30 days following receipt of laboratory analytical reports, discharge monitoring reports will be provided to DEQ within approximately 60 days following each sampling event.

At the end of the first year of monitoring following implementation of the stormwater SCMs, a performance monitoring data summary report will be provided to DEQ[3] that includes analytical results from stormwater samples collected during the previous year, stormwater flow rate data collected coincident with stormwater sample collection, and a description of any stormwater treatment system maintenance issues identified during visual inspections of the treatment system and the subsequent resolution of those issues.

The performance monitoring report will include an evaluation of the effectiveness and treatment efficiency of the stormwater SCMs as well as any recommendations, if necessary, for modification and/or optimization of the stormwater treatment system (i.e., adaptive management). Performance monitoring results will also be compared to monitoring results from historical stormwater samples to determine if COPC concentrations have changed over time. Also, comparison of COPC concentrations to measured total suspended solids and stormwater system flow rates will help further assess other potential sources of COPCs in stormwater.

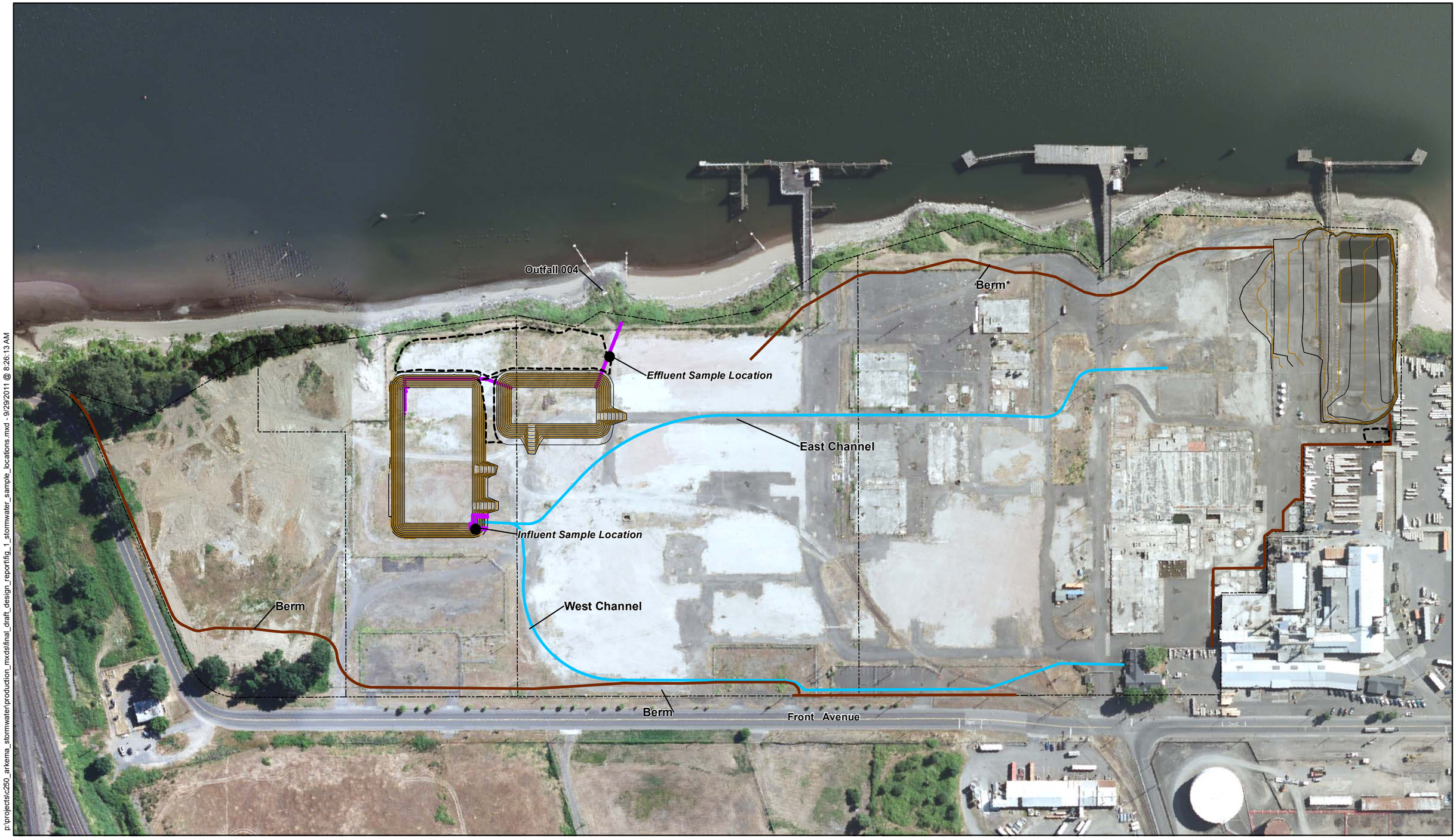
[3] Note that the MAO identifies a report due on June 1; however, this date is based on an outdated schedule and would not allow for collection of a full year of monitoring data and assessment of stormwater conditions during different seasons. The performance monitoring data summary report will be submitted within 3 months following the last monthly discharge sampling at the completion of the first year of monitoring.

5 REFERENCES

USEPA. 1999. Surface water sampling. Field Sampling Guidance Document #1225. Revision 1. U.S. Environmental Protection Agency Region 9, Richmond, CA.

USEPA. 2002. Standard operating procedure for the collection of chemical and biological ambient water samples. Revision 1, dated July 24, 2002. Office of Environmental Measurement and Evaluation, U.S. Environmental Protection Agency Region 1, North Chelmsford, MA.

FIGURES



p:\projects\c250_arkema_stormwater\production_mxds\final_draft_design_report\fig_1_stormwater_sample_locations.mxd - 9/29/2011 @ 8:26:13 AM

integral consulting inc.

FEATURE SOURCES:
Aerial: Metro, June-July 2009
Property Boundaries: DEA Survey

0 100 200 400 Feet

Channel
Berm
Detention Basin/Sand Filter Feature
Areas to be Filled
Property and Lot Boundary

*Berm follows alignment of proposed groundwater barrier wall and cap.

Figure 1
Stormwater Sampling Locations
Performance Monitoring Plan
Final Design Report
Stormwater Source Control Measures

TABLES

Table 1. Stormwater Treatment System Effluent Goals

Parameter	Analytical Method	Daily Maximum ACG[a] Effluent Level	Monthly Maximum ACG[b] Effluent Level
Conventionals			
pH	SM 4500H$^+$ B	Within range of 6.5–8.5 S.U. at all times	6.5 - 8.5 [c]
Total suspended solids	SM 2540D	130 mg/L	130 mg/L [c]
Metals			
Chromium VI	EPA Method 218.6/SM3500	16 µg/L	10 µg/L
Copper (total recoverable)	EPA Method 200.8	18 µg/L	10 µg/L
Lead (total recoverable)	EPA Method 200.8	5 µg/L	5 µg/L
Manganese (dissolved)	EPA Method 200.8	87 µg/L	50 µg/L
Zinc (total recoverable)	EPA Method 200.8	117 µg/L	68 µg/L
Polycyclic Aromatic Hydrocarbons			
Benzo(a)anthracene	EPA Method 625	Below PQL (1 µg/L)	Below PQL (1 µg/L)
Benzo(a)pyrene	EPA Method 625	Below PQL (1 µg/L)	Below PQL (1 µg/L)
Benzo(k)fluoranthene	EPA Method 625	Below PQL (1 µg/L)	Below PQL (1 µg/L)
Chrysene	EPA Method 625	Below PQL (1 µg/L)	Below PQL (1 µg/L)
Dibenzo(a,h)anthracene	EPA Method 625	Below PQL (1 µg/L)	Below PQL (1 µg/L)
Indeno(1,2,3-cd)pyrene	EPA Method 625	Below PQL (1 µg/L)	Below PQL (1 µg/L)
Semivolatile Organic Compounds			
Pentachlorophenol	EPA Method 625	Below PQL (2 µg/L)	Below PQL (2 µg/L)
Organochlorine Pesticides			
2,4' and 4,4'-DDD	EPA Method 625	Below PQL (0.05 µg/L)	Below PQL (0.01 µg/L)
2,4' and 4,4'-DDE	EPA Method 625	Below PQL (0.05 µg/L)	Below PQL (0.01 µg/L)
2,4' and 4,4'-DDT	EPA Method 625	Below PQL (0.05 µg/L)	Below PQL (0.01 µg/L)

Notes

ACG = analytical concentration goal

PQL = practical quantification limit

[a] ACGs are the daily maximum effluent level he June 16, 2009 DEQ Memorandum from Matt McClincy, NWR Cleanup, to Rob Burkhart, NWR Water Quality, except for arsenic which is the MCL.

[b] ACGs are the monthly average effluent levels from the June 16, 2009 DEQ Memorandum from Matt McClincy, NWR Cleanup, to Rob Burkhart, NWR Water Quality, except for arsenic which is the MCL.

[c] Analyte benchmarks listed from the National Pollution Discharge Elimination System permit for the Arkema facility (No. 100752).

Table 2. Summary of the DQOs Developed for the LSS Stormwater Source Control Measures

Problem Statement	Identify the Decision	Identify Inputs to the Decision	Define the Boundaries of the Study	Identify the Analytic Approach	Specify Performance or Acceptance Criteria	Develop the Plan for Obtaining Data
The objective of the stormwater SCMs design is to implement an adaptive management approach for addressing COPCs including DDx in stormwater discharges to the Willamette River from the site. The approach includes implementation of a stormwater SCM in accordance with an MAO with DEQ. The stormwater SCMs include erosion control, decommissioning the existing stormwater collection system, and structural treatment, including a detention basin and filtration.	The goal of the study is to collect stormwater samples following implementation of the groundwater and stormwater SCMs to evaluate the presence of COPCs in treated stormwater and to evaluate the performance of the stormwater SCMs.	Two types of site-specific data are needed to evaluate the presence of COPCs in treated stormwater: 1) approximately monthly influent and effluent samples analyzed for COPCs, and 2) monthly stormwater flow rate measurements. Monthly composite stormwater samples will be analyzed for total stormwater COPCs and conventional parameters, including total suspended solids. The performance monitoring data will be used to assess the effectiveness of the stormwater treatment system.	Periodic stormwater sampling activities will commence within 30 days following completion of construction of the groundwater and stormwater SCMs. Sampling events will be scheduled when it is predicted that the following storm event criteria will be met: • Storm event is preceded by a dry period (less than 0.1 in. rainfall) of at least 24 hours • Storm event is predicted to produce more than 0.2 in. rainfall • Storm event is predicted to occur over a minimum of 3 hours.	Stormwater sampling will include periodic composite samples. Periodic composite samples will consist of manually composited discrete grab samples collected over 24 hours (or the total rainfall duration, whichever is less), and will be collected on a basis that averages once per month. Composite samples will be collected approximately monthly and analyzed for conventionals, metals, PAHs, SVOCs, and pesticides (see Table A4-1); composite samples will be analyzed for dioxins and furans on a quarterly basis.	To monitor system performance, the system effluent monitoring data will be compared to the treatment system effluent goals presented in Table 1-1 of the Final Design Report.	Collect stormwater samples following implementation of the stormwater SCM. Twelve stormwater sampling events will be distributed over the first year. The following numbers of samples will be targeted for each month: • November, December, January, February, and March—Minimum of 9 composite samples over this period (target of 2 samples each month) • September, October, April, and May—Minimum of 2 composite samples over this period (target of 1 sample each month) • June, July, and August—Minimum of 1 composite sample over this period (target of 1 sample each month). In addition, stormwater flow rate will be measured monthly during sample collection. Composite stormwater samples will be used to monitor the performance of the stormwater SCMs and determine whether influent and effluent concentrations of COPCs in stormwater have decreased following implementation of the stormwater SCMs and to monitor stormwater treatment system performance.

Notes:
COPC = constituent of potential concern
DEQ = Oregon Department of Environmental Quality
DQO = data quality objective
MAO = Mutual Agreement and Order No. WQ/I-NWR-10-175
PAH = polycyclic aromatic hydrocarbon
SCM = source control measure
SVOC = semivolatile organic compound

Table 3. Stormwater Treatment System Effluent Concentrations

Parameter	Analytical Method	Effluent Level
Conventionals		
pH	SM 4500H$^+$ B	Within range of 6.5–8.5 S.U. at all times
Total suspended solids	SM 2540D	130 mg/L
Metals		
Chromium VI	EPA Method 218.6/SM3500	16 µg/L
Copper (total recoverable)	EPA Method 200.8	18 µg/L
Lead (total recoverable)	EPA Method 200.8	5 µg/L
Manganese (dissolved)	EPA Method 200.8	87 µg/L
Zinc (total recoverable)	EPA Method 200.8	117 µg/L
Polycyclic Aromatic Hydrocarbons		
Benzo(a)anthracene	EPA Method 625	Below PQL (1 µg/L)
Benzo(a)pyrene	EPA Method 625	Below PQL (1 µg/L)
Benzo(k)fluoranthene	EPA Method 625	Below PQL (1 µg/L)
Chrysene	EPA Method 625	Below PQL (1 µg/L)
Dibenzo(a,h)anthracene	EPA Method 625	Below PQL (1 µg/L)
Indeno(1,2,3-cd)pyrene	EPA Method 625	Below PQL (1 µg/L)
Semivolatile Organic Compounds		
Pentachlorophenol	EPA Method 625	Below PQL (2 µg/L)
Organochlorine Pesticides		
2,4' and 4,4'-DDD	EPA Method 625	Below PQL (0.05 µg/L)
2,4' and 4,4'-DDE	EPA Method 625	Below PQL (0.05 µg/L)
2,4' and 4,4'-DDT	EPA Method 625	Below PQL (0.05 µg/L)

Notes

PQL = practical quantification limit

Table 4. Performance Monitoring Decision Tree

No.	Issue	Means of Initial Identification	Proposed Performance Monitoring Action	Corrective Action Decision Tree
I	COPC effluent concentrations exceed target levels and have stabilized or are trending upward.[a]	Effluent monitoring at Outfall 004.	Perform monitoring of "first flush" events,[b] total suspended solids, and particle size distribution at three locations during the three subsequent stormwater monitoring events. Conduct COPC analysis on total and dissolved fractions of stormwater sample to evaluate COPC distribution between solid and aqueous phase. Collect stormwater samples at three monitoring locations (per event, as needed): detention basin inflow, in-between detention basin and sand filter, and system effluent discharge. Use data to assess potential for additional source control ("first flush" data) and system performance relative to particulate and dissolved phase chemicals. Determine need for corrective action based on Corrective Action Decision Tree.	CADT 1a, 1b, 1c or 1d.
2	Stormwater flow exceeds the sand filter hydraulic capacity. Sand filter is bypassed.	To the extent feasible, conduct effluent monitoring at Outfall 004 during bypass event.	Perform monitoring of standard stormwater monitoring parameters during specified bypass event.	CADT 2a or 2b
3	Accumulated sediment in detention basin.	Periodic visual inspections based on PMP-specified frequency.	Evaluate the need to remove the accumulated sediment from the detention basin. If needed for assessment, collect and analyze a sample of accumulated sediment to determine whether COPCs are present at concentrations that could impact stormwater system performance. If sediment removal is needed, conduct cleaning per O&M plan.	None
4	Accumulated sediment on sand filter.	Periodic visual inspections based on PMP-specified frequency.	Evaluate the need to remove the accumulated sediment from the sand filter. If needed for assessment, collect and analyze a sample of accumulated sediment to determine whether COPCs are present at concentrations that could impact stormwater system performance. If sediment removal is needed, conduct cleaning per O&M plan.	None

Table 4. Performance Monitoring Decision Tree

No.	Issue	Means of Initial Identification	Proposed Performance Monitoring Action	Corrective Action Decision Tree
5	Blockage of system components (i.e., no or reduced flow in influent pipes, etc.).	Periodic visual inspections based on PMP-specified frequency.	Conduct system cleaning per O&M Plan.	None
6	Preferential flow paths through the system.	Periodic visual inspections based on PMP-specified frequency.	Evaluate whether preferential pathway is a result of system design or from other factors.	CADT 6a
7	Erosion of system (i.e., channels, side slopes, around inlets/outlets, etc.).	Periodic visual inspections based on PMP-specified frequency.	Evaluate whether erosion is a result of system design or from other factors (i.e., debris, blockage).	CADT 7a or 7b
8	Sand Filter breakthrough (i.e., increasing COPC concentrations over time).	Effluent monitoring at Outfall 004.	Evaluate data to determine whether the change is a result of influent variations or treatment system performance.	CADT 8a or 8b
9	Long-term inability to meet target levels.	Effluent monitoring at Outfall 004.	Evaluate data from long-term monitoring (>1 year) and supplemental corrective actions (e.g., see CADT 1a, 1b, 1c).	CADT 9a or 9b
10	One or more COPCs are not detected.	Influent monitoring to detention basin and/or effluent data at Outfall 004	Evaluate data from monitoring. If non-detect in both influent and effluent for 4 or more consecutive events, discontinue sampling. If non-detect in effluent for 1 year, discontinue sampling based on agreement from DEQ.	None

Notes:

CADT = Corrective Action Decision Tree
COPC = constituent of potential concern
DEQ = Oregon Department of Environmental Quality
O&M = operation and maintenance
PMP = performance monitoring plan

[a] Note that a 3- to 6-month shakedown period will be allowed after installation to allow for proper sand filter conditioning. The amount of time required for the sand filter to condition will be dependent on amount of rainfall/runoff and amount and nature of suspended solids loading to the sand filter.

[b] First flush event sampling will consist of collecting grab samples at the influent to the detention basin during the first 30 minutes of a runoff event.

Table 5. Corrective Action Decision Tree

No.	Issue	Means of Identification	Proposed System Design Action
1a	COPC concentration in effluent is primarily in a dissolved phase.	Performance Monitoring Decision Tree (1).	Reassess sand filter media mixture. Evaluate the addition of granular activated carbon or other filter media which could more actively adsorb dissolved-phase hydrophobic chemicals (i.e., DDx) to the sand filter. Alternatively, assess the sources of dissolved-phase COPCs into the stormwater system through additional sampling along the length of the stormwater collection system to determine whether other source control actions (i.e., temporary capping) could more effectively increase system performance.
1b	COPC concentrations in effluent is primarily in a particulate phase.	Performance Monitoring Decision Tree (1).	Reassess detention basin and sand filter performance expectations and design basis based on system performance monitoring data. Add sediment traps to stormwater effluent to sample COPCs above criteria in specific particle size ranges. Evaluate the need to change detention basin flow characteristics (e.g., addition of hydraulic curtain) or sand filter media size distribution based on performance monitoring data. Also evaluate the need for additional temporary capping in selected areas of the site to further limit contact of stormwater with erodible surface soil particulates that might also have high concentrations of COPCs.
1c	COPC concentrations in effluent is evenly mixed between the particulate and aqueous phase.	Performance Monitoring Decision Tree (1).	Conduct design evaluations summarized in Corrective Action Decision Tree items 1a and 1b.
1d	“First Flush” data indicates first flush concentrations significantly above event mean concentrations.	Performance Monitoring Decision Tree (1).	Conduct an evaluation of potential source control measures to decrease initial loading to the treatment measures (e.g., temporary capping). This will include sampling within the stormwater conveyance channel to identify location of additional measures to be employed.
2a	One or more monitoring parameters exceed historical concentration range for that parameter since system installation.	Performance Monitoring Decision Tree (2).	Evaluate whether increase in parameter concentration during the specified event can be addressed based on modifications to the stormwater treatment system design.

Table 5. Corrective Action Decision Tree

No.	Issue	Means of Identification	Proposed System Design Action
2b	None of the monitoring parameters exceed historical concentration ranges for that parameter since system installation.	Performance Monitoring Decision Tree (2).	No corrective action required. Include monitoring data in DEQ monitoring reports.
6a	Preferential flow paths through the system.	Performance Monitoring Decision Tree (6).	If preferential flow is a result of system design, evaluate redesign of component for which preferential pathway is occurring.
7a	Erosion of system (i.e., channels, side slopes, around inlets/outlets, etc.) as a result of system design.	Performance Monitoring Decision Tree (7).	If erosion is a result of system design, evaluate redesign of component where erosion is occurring.
7b	Erosion of system (i.e., channels, side slopes, around inlets/outlets, etc.) as a result of blockages, debris, etc.	Performance Monitoring Decision Tree (7).	Conduct system cleaning per O&M Plan.
8a	Increasing concentrations of effluent are the result of decreased performance from sand filter.	Performance Monitoring Decision Tree (8).	Evaluate the need to redesign sand or sand/alternate media mixture and remove and replace the sand filter media.
8b	Increasing concentrations of effluent are the result of changing influent concentrations over time.	Performance Monitoring Decision Tree (8).	Continue monitoring of influent to try to determine source of change in influent characteristics and concentrations. Evaluate whether additional temporary capping could control changes in influent concentration.

Table 5. Corrective Action Decision Tree

No.	Issue	Means of Identification	Proposed System Design Action
9a	Based on monitoring, additional modifications to the stormwater treatment system are technically practicable.	Performance Monitoring Decision Tree (9).	Evaluate the elements of the system which are not operating optimally and consider the redesign, replacement, or supplement of stormwater treatment system, including the following possible additional components: • Addition of coagulant to destabilize smaller particles and provide better removal. This could be accomplished at either the sediment forebay to the dention basin or between the detention basin and sand filter. • Addition of more active treatment systems (such as a polymer addition, pressure sand filter, following by carbon). This could be accomplished by pumping and treating discharge from either the detention basin or the sand filter. • Splitting off smaller, more frequent storms through a more rigorous, passive filtration process (e.g., StormFilter®) specifically designed to remove COPCs that are exceeding criteria. Evaluate whether additional source control actions (i.e., temporary capping) could more effectively increase system performance.
9b	Based on monitoring, additional modifications to the stormwater treatment system are not technically practicable.	Performance Monitoring Decision Tree (9).	Continue to monitor treatment system. Keep treatment system in optimal treatment capacity based on system performance monitoring and regular system operation and maintenance. Evaluate whether additional source control actions (i.e., temporary capping) could more effectively increase system performance.

Notes:
COPC = constituent of potential concern
DEQ = Oregon Department of Environmental Quality
O&M = operation and maintenance

ATTACHMENT A

STANDARD OPERATING PROCEDURES

STANDARD OPERATING PROCEDURE (SOP) AP-01

SAMPLE PACKAGING AND SHIPPING

SCOPE AND APPLICATION

This SOP describes specific requirements for sample packaging and shipping to ensure the proper transfer and documentation of environmental samples collected during field operations. Procedures for the careful and consistent transfer of samples from the field to the laboratory are outlined herein. This SOP also presents the method to be used when packing samples that will either be hand delivered or shipped by commercial carrier to the laboratory.

EQUIPMENT AND SUPPLIES REQUIRED

Make sure that you have the equipment and supplies necessary to properly pack and ship environmental samples, including the following:

- Project-specific sampling and analysis plan (SAP)
- Project-specific field logbook
- Sealable airtight bags in assorted sizes (e.g., Ziploc®)
- Wet ice in doubled, sealed bags; frozen Blue Ice®; or dry ice
- Cooler(s)
- Bubble wrap
- Fiber-reinforced packing tape, clear plastic packing tape, and duct tape
- Scissors or knife
- Chain-of-custody (COC) forms
- COC seals
- Large plastic garbage bags (preferably 3 mil [0.003 in.] thick)
- Paper towels
- "Fragile," "This End Up," or "Handle With Care" labels
- Mailing labels
- Air bills for overnight shipment

PROCEDURE

Customize the logistics for sample packaging and shipping to each study. If necessary, transfer samples from the field to a local storage facility where they can be frozen or refrigerated. Depending on the logistics of the operation, field personnel may transport samples to the laboratory or use a commercial courier or shipping service. In the latter case, Integral field personnel must be aware of any potentially limiting factors to timely shipping, such as availability of overnight service and weekend deliveries to specific areas, and shipping regulations regarding "restricted articles" (e.g., dry ice, formalin) prior to shipping the samples.

SAMPLE PREPARATION

Take the following steps to ensure the proper transfer of samples from the field to the laboratories:

At the sample collection site:

1. Document all samples using the proper logbooks or field forms (see SOP AP-02), required sample container identification (i.e., sample labels with tag numbers), and COC form (example provided in SOP AP-03). Fill out the COC form as described in SOP AP-03, and use the sample labeling techniques provided in SOP AP-04.
2. Make all applicable laboratory quality control sample designations on the COC forms. Clearly identify samples that will be archived for future possible analysis. Label these samples as follows: "Do Not Analyze: Hold and archive for possible future analysis." Some laboratories interpret "archive" to mean that they should continue holding the residual sample after analysis.
3. Notify the laboratory contact and the Integral project quality assurance/quality control (QA/QC) coordinator that samples will be shipped and the estimated arrival time. Send copies of all COC forms to Integral's project QA/QC coordinator or project manager, as appropriate.
4. Keep the samples in the possession of the sampling personnel at all times. Lock and secure any temporary onsite sample storage areas to maintain sample integrity and COC requirements.
5. Clean the outside of all dirty sample containers to remove any residual material that may lead to cross-contamination.
6. Complete the COC form as described in SOP AP-03, and retain the back (pink) copy for project records prior to sealing the cooler. Check sample containers against the COC form to ensure all the samples that were collected are in the cooler.

7. Store each sample container in a sealed plastic bag that allows the sample label (example provided in SOP AP-03) to be read. Before sealing the bags, ensure that volatile organic analyte (VOA) vials are encased in a foam sleeve or in bubble wrap.
8. If the samples require storage at a specific temperature, place enough ice in the sample cooler to maintain the temperature (e.g., 4°C) throughout the sampling day.

At the sample processing area (immediately after sample collection) take the following steps:

1. If the samples require a specific storage temperature, then cool the samples and maintain the temperature prior to shipping. For example, place enough ice in each sample cooler to maintain the temperature at 4°C until processing begins at the testing laboratory.
2. Be aware of holding time requirements for project-specific analytes and arrange the sample shipping schedule accordingly.
3. Place samples in secure storage (i.e., locked room or vehicle) or keep them in the possession of Integral sampling personnel before shipment. Lock and secure any sample storage areas to maintain sample integrity and COC requirements.
4. Store samples in the dark (e.g., keep coolers shut).

At the sample processing area (just prior to shipping), do the following:

1. Check sample containers against the COC form to account for all samples intended for shipment.
2. Choose cooler(s) of appropriate size and make sure they are clean of gross contamination inside and out. If the cooler has a drain, close the drain and secure it with duct tape.
3. Line the cooler with bubble wrap and place a large plastic bag (preferably with a thickness of 3 mil), open, inside the cooler.
4. Individually wrap each glass container (which was sealed in a plastic bag at the collection site) in bubble wrap and secure with tape or a rubber band. Place the wrapped samples in the large plastic bag in the cooler, leaving room for ice to keep the samples cold (i.e., 4°C).
5. If temperature blanks have been provided by the testing laboratory, place one temperature blank in each sample cooler.
6. If the samples require a specific storage temperature, add enough wet ice or Blue Ice® to maintain that temperature during overnight shipping (i.e., 4°C). Always overestimate the amount of ice that will be required. Keep ice in a sealed plastic bag, which is placed in a second sealed plastic bag to prevent leakage. Avoid separating the samples from the ice with excess bubble wrap because it may insulate the samples from the ice. After adding all samples and ice to the cooler, use bubble wrap (or other

available clean packing material) to fill any empty space and prevent the samples from shifting during transport.

7. If possible, consolidate all VOA samples in a single cooler and ship them with (a) trip blank(s) if the project-specific QA project plan calls for them.
8. Sign, date, and include any tracking numbers provided by the shipper on the COC form. Remove the back (pink) copy of the original COC form and retain this copy for the project records.
9. Seal the rest of the signed COC form in a bag and tape the bag to the inside of the cooler lid. Each cooler should contain an individual COC form for the samples contained inside it. If time is short and it becomes necessary to combine all the samples onto a single set of COC forms and ship multiple coolers together, then indicate on the outside of the appropriate cooler, "Chain-of-Custody Inside."
10. After the cooler is sufficiently packed to prevent shifting of the containers, close the lid and seal it with fiber-reinforced packing tape. Tape the cooler around the opening, joining the lid to the bottom, and around the circumference of the cooler at both hinges.
11. As security against unauthorized handling of the samples, apply two COC seals across the opening of the cooler lid (provided with example field forms). Place one seal on the front right portion of the cooler and one on the back left. Be sure the seals are properly affixed to the cooler to prevent removal during shipment. Additional tape across the seal may be necessary if the outside of the cooler is wet.

SAMPLE SHIPPING

Hand Delivery to the Testing Laboratory

1. Notify the laboratory contact and the Integral project QA/QC coordinator that samples will be delivered to the laboratory and the estimated arrival time.
2. When hand-delivering environmental samples, make sure the testing laboratory receives them on the same day that they were packed in the coolers.
3. Fax or scan and e-mail copies of all COC forms to the Integral project QA/QC coordinator. Note: It may be necessary to photocopy the COC form on a slightly darker setting so the form is readable after it has been faxed. Never leave the original COC form in the custody of non-Integral staff.

Shipped by Commercial Carrier to the Laboratory

1. Apply a mailing label to the cooler with destination and return addresses, and add other appropriate stickers, such as "This End Up," "Fragile," and "Handle With Care." If the shipment contains multiple coolers, indicate on the mailing label the number of coolers that the testing laboratory should expect to receive (e.g., 1 of 2; 2 of 2). Place clear tape over the mailing label to firmly affix it to the cooler and to protect it from the weather. This is a secondary label in case the air bill is lost during shipment.
2. Fill out the air bill and fasten it to the handle tags provided by the shipper (or the top of the cooler if handle tags are not available).
3. If samples must be frozen (–20°C) during shipping, make sure that dry ice has been placed in the sample cooler. Be aware of any additional shipping, handling, and special labeling requirements that the shipper may require.
4. Make sure that benthic infauna samples have been preserved with formalin in the field prior to shipping. Be aware of any additional shipping, handling, and special labeling requirements that the shipper may require for these samples.
5. Notify the laboratory contact and the Integral project QA/QC coordinator that samples will be shipped and the estimated arrival date and time. If environmental samples must be shipped at 4°C or –20°C, choose overnight shipping for delivery next morning. Fax or scan and e-mail copies of all COC forms to the Integral project QA/QC coordinator. Note: It may be necessary to photocopy the COC form on a slightly darker setting so the form is readable after faxing. Never leave the original COC form in the custody of non-Integral staff.

STANDARD OPERATING PROCEDURE (SOP) AP-02

FIELD DOCUMENTATION

SCOPE AND APPLICATION

This SOP describes the Integral procedure for accurate record-keeping in the field for the purposes of ensuring that samples can be traced from collection to final disposition.

Document all information relevant to field operations properly to ensure that activities are accounted for in written records to the extent that someone not present at the site could reconstruct the activity without relying on the memory of the field crew. Several types of field documents are used for this purpose and should be consistently used by field personnel. Field documentation should include only a factual description of site-related activities and observations. Field personnel should not include superfluous comments or speculation regarding the field activities or observations.

FIELD LOGBOOKS

During field sampling events, field logbooks must be used to record all daily activities. The purpose of the field logbook is to document events and record data measured in the field to the extent that someone not present at the site could reconstruct the activity without relying on the memory of the field crew. The project manager (or designee) should issue a field logbook to the appropriate site personnel for the direction of onsite activities (e.g., reconnaissance survey team leader, sampling team leader). It is this designee's responsibility to maintain the site logbook while it is in his or her possession and return it to the project manager or turn it over to another field team.

Make entries in the field logbook as follows:

1. Document all daily field activities in indelible ink in the logbook and make no erasures. Make corrections with a single line-out deletion, followed by the author's initials and the date. The author must initial and date each page of the field logbook. The author must sign and date the last page at the end of each day, and draw a line through any blank space remaining on the page below the last entry.

2. Write the project name, dates of the field work, site name and location (city and state), and Integral job number on the cover of the field logbook. If more than one logbook is used during a single sampling event, then annotate the upper right-hand corner of the logbook (e.g., Volume 1 of 2, 2 of 2) to indicate the number of logbooks used during the field event. Secure all field logbooks when not in use in the field. The following is a list of the types of information that is appropriate for entry in the field notebook:
   - Project start date and end date
   - Date and time of entry (24-hour clock)
   - Time and duration of daily sampling activities
   - Weather conditions at the beginning of the field work and any changes that occur throughout the day, including the approximate time of the change (e.g., wind speed and direction, rain, thunder, wave action, current, tide, vessel traffic, air and water temperature, thickness of ice if present)
   - Name and affiliation of person making entries and other field personnel and their duties, including what times they are present
   - The location and description of the work area, including sketches, map references, and photograph log, if appropriate
   - Level of personal protection being used
   - Onsite visitors (names and affiliations), if any, including what times they are present
   - The name, agency, and telephone number of any field contacts
   - Notation of the coordinate system used to determine the station location
   - The sample identifier and analysis code for each sample to be submitted for laboratory analysis, if not included on separate field data sheets
   - All field measurements made (or reference to specific field data sheets used for this purpose), including the time of collection and the date of calibration, if appropriate
   - The sampling location name, date, gear, water depth (if applicable), and sampling location coordinates, if not included on separate field data sheets
   - For aquatic sampling, the type of vessel used (e.g., size, power, type of engine)
   - Specific information on each type of sampling activity
   - The sample type (e.g., groundwater, soil, surface sediment), sample number, sample tag number, and any preservatives used, if not included on separate field data sheets
   - Sample storage methods

- Cross-references of numbers for duplicate samples
- A description of the sample (source and appearance, such as soil or sediment type, color, texture, consistency, presence of biota or debris, presence of oily sheen, changes in sample characteristics with depth, presence/location/thickness of the redox potential discontinuity [RPD] layer, and odor) and penetration depth, if not included on separate field data sheets
- Estimate of length and appearance of recovered cores, if not included on separate field data sheets
- Photographs (uniquely identified) taken at the sampling location, if any
- Details of the work performed
- Variations, if any, from the project-specific sampling and analysis plan (SAP) or standard operating protocols and reasons for deviation
- Details pertaining to unusual events that might have occurred during sample collection (e.g., possible sources of sample contamination, equipment failure, unusual appearance of sample integrity, control of vertical descent of the sampling equipment)
- References to other logbooks or field forms used to record information (e.g., field data sheets, health and safety log)
- Any field results not appearing on the field data sheets (if used), including station identification and location, date, and time of measurement
- Sample shipment information (e.g., shipping manifests, chain-of-custody (COC) form numbers, carrier, air bill numbers, time addresses)
- A record of quantity of investigation-derived wastes (if any) and storage and handling procedures.

3. During the field day, as listed above, record in the logbook a summary of all site activities. Provide a date and time for each entry. The information need not duplicate anything recorded in other field logbooks or field forms (e.g., site health and safety officer's logbook, calibration logbook, field data sheets), but should summarize the contents of the other logbooks and refer to the pages in these logbooks for detailed information.
4. If measurements are made at any location, record the measurements and equipment used, or refer to the logbook and page number(s) or field forms on which they are recorded. All maintenance and calibration records for equipment should be traceable through field records to the person using the instrument and to the specific piece of instrumentation itself.

5. Upon completion of the field sampling event, the sampling team leader will be responsible for submitting all field logbooks to be copied. A discussion of copy distribution is provided below.

FIELD DATA FORMS

Occasionally, additional field data forms are generated during a field sampling event (e.g., groundwater monitoring form, sediment core profile form, water quality measurement form) to record the relevant sample information collected. For instructions regarding the proper identification of field data forms, sampling personnel should consult the project-specific SAP.

Upon completion of the field sampling event, the sampling team leader will be responsible for submitting all field data forms to be copied. A discussion of copy distribution is provided below.

PHOTOGRAPHS

In certain cases, photographs (print or digital) of sampling stations may be taken using a camera-lens system with a perspective similar to the naked eye. Ensure that photographs include a measured scale in the image, when practical. If you take photographs of sample characteristics and routine sampling activities, avoid using telephoto or wide-angle shots, because they cannot be used in enforcement proceedings. Record the following items in the field logbook for each photograph taken:

1. The photographer's name or initials, the date, the time of the photograph, and the general direction faced (orientation)
2. A brief description of the subject and the field work shown in the picture
3. For print photographs, the sequential number of the photograph and the roll number on which it is contained
4. For digital photographs, the sequential number of the photograph, the file name, the file location, and back-up disk number (if applicable).

Upon completion of the field sampling event, the sampling team leader is responsible for submitting all photographic materials to be developed (prints) or copied (disks). Place the prints or disks and associated negatives in the project files (at the Integral project manager's location). Make photocopies of photo logs and any supporting documentation from the field logbooks, and place them in the project files with the prints or disks.

EQUIPMENT CALIBRATION RECORDS

Record in the field logbook all equipment calibration records, including instrument type and serial number, calibration supplies used, calibration methods and calibration results, date, time, and personnel performing the calibration. Calibrate all equipment used during the investigation daily, at a minimum, in accordance with the manufacturers' recommendations.

DISTRIBUTION OF COPIES

At Integral offices, make two copies of all field logbooks and additional field data forms. Stamp the first copy with a "COPY" stamp, and place it in the project file to be available for general staff use. Stamp the second copy with a "FILE" stamp, and place it in the data management file with the laboratory data packages, to be used by the data management and quality assurance staff only. Place the original field logbooks and forms in a locked file cabinet.

SET-UP OF LOCKING FILE CABINET

Place each project in its own file folder in a locking file cabinet. On the folder label, include the project name and contract number. Each project folder will include up to six kinds of files:

- Field logbook(s)
- Additional field data forms
- Photographs
- COC forms
- Acknowledgment of Sample Receipt forms
- Archive Record form (to be completed only if samples are archived at an Integral field storage facility or Integral laboratory).

STANDARD OPERATING PROCEDURE (SOP) AP-03

SAMPLE CUSTODY

SCOPE AND APPLICATION

This SOP describes Integral procedures for custody management of environmental samples.

A stringent, established program of sample chain-of-custody will be followed during sample storage and shipping activities to account for each sample. The procedure outlined herein will be used with SOP AP-01, which covers sample packaging and shipping; SOP AP-02, which covers the use of field logbooks and other types of field documentation; and SOP AP-04, which covers sample labeling. Chain-of-custody (COC) forms ensure that samples are traceable from the time of collection through processing and analysis until final disposition. A sample is considered to be in a person's custody if any of the following criteria are met:

1. The sample is in the person's possession
2. The sample is in the person's view after being in his or her possession
3. The sample is in the person's possession and is being transferred to a designated secure area
4. The sample has been locked up to prevent tampering after it was in the person's possession.

At no time is it acceptable for samples to be outside of Integral personnel's custody unless the samples have been transferred to a secure area (i.e., locked up). If the samples cannot be placed in a secure area, then an Integral field team member must physically remain with the samples (e.g., at lunch time one team member must remain with the samples).

CHAIN-OF-CUSTODY FORMS

The COC form is critical because it documents sample possession from the time of collection through final disposition. The form also provides information to the laboratory regarding what analyses are to be performed on the samples that are shipped.

Complete the COC form after each field collection activity and before shipping the samples to the laboratory. Sampling personnel are responsible for the care and custody of the samples until they are shipped. The individuals relinquishing and receiving the samples must sign the

COC form(s), indicating the time and date of the transfer, when transferring possession of the samples.

A COC form consists of three-part carbonless paper with white, yellow, and pink copies. The sampling team leader keeps the pink copy. The white and yellow sheets are placed in a sealed plastic bag and secured inside the top of each transfer container (e.g., cooler). Field staff retain the pink sheet for filing at the Integral project manager's location. Each COC form has a unique four-digit number. This number and the samples on the form must be recorded in the field logbook. Integral also uses computer-generated COC forms. If computer-generated forms are used, then the forms must be printed in triplicate and all three sheets signed so that two sheets can accompany the shipment to the laboratory and one sheet can be retained on file. Alternatively, if sufficient time is available, the computer-generated forms will be printed on three-part carbonless paper.

Record on the COC form the project-assigned sample number and the unique tag number at the bottom of each sample label. The COC form also identifies the sample collection date and time, type of sample, project name, and sampling personnel. In addition, the COC form provides information on the preservative or other sample pretreatment applied in the field and the analyses to be conducted by referencing a list of specific analyses or the statement of work for the laboratory. The COC form is sent to the laboratory along with the sample(s).

PROCEDURES

Use the following guidelines to ensure the integrity of the samples:

1. Sign and date each COC form. Have the person who relinquishes custody of the samples also sign this form.
2. At the end of each sampling day and prior to shipping or storage, make COC entries for all samples. Check the information on the labels and tags against field logbook entries.
3. Do not sign the COC form until the team leader has checked the information for inaccuracies. Make corrections by drawing a single line through any incorrect entry, and then initial and date it. Make revised entries in the space below the entries. After making corrections, mark out any blank lines remaining on the COC form, using single lines that are initialed and dated. This procedure will prevent any unauthorized additions.

   At the bottom of each COC form is a space for the signatures of the persons relinquishing and receiving the samples and the time and date of the transfer. The time the samples were relinquished should match exactly the time they were received by another party. Under no circumstances should there be any time when custody of the samples is undocumented.

4. If samples are sent by a commercial carrier not affiliated with the laboratory, such as FedEx or United Parcel Service (UPS), record the name of the carrier on the COC form. Also enter on the COC form any tracking numbers supplied by the carrier. The time of transfer should be as close to the actual drop-off time as possible. After signing the COC forms and removing the pink copy, seal them inside the transfer container.
5. If errors are found after the shipment has left the custody of sampling personnel, make a corrected version of the forms and send it to all relevant parties. Fix minor errors by making the change on a copy of the original with a brief explanation and signature. Errors in the signature block may require a letter of explanation.
6. Provide a COC form and an Archive Record form for any samples that are archived internally at Integral.

Upon completion of the field sampling event, the sampling team leader is responsible for submitting all COC forms to be copied. A discussion of copy distribution is provided in SOP AP-02.

CUSTODY SEAL

As security against unauthorized handling of the samples during shipping, affix two custody seals to each sample cooler. Place the custody seals across the opening of the cooler (front right and back left) prior to shipping. Be sure the seals are properly affixed to the cooler so they cannot be removed during shipping. Additional tape across the seal may be prudent.

SHIPPING AIR BILLS

When samples are shipped from the field to the testing laboratory via a commercial carrier (e.g., FedEx, UPS), the shipper provides an air bill or receipt. Upon completion of the field sampling event, the sampling team leader will be responsible for submitting the sender's copy of all shipping air bills to be copied at an Integral office. A discussion of copy distribution is provided in SOP AP-02. Note the air bill number (or tracking number) on the applicable COC forms or, alternatively, note the applicable COC form number on the air bill to enable the tracking of samples if a cooler becomes lost.

ACKNOWLEDGMENT OF SAMPLE RECEIPT FORMS

In most cases, when samples are sent to a testing laboratory, an Acknowledgment of Sample Receipt form is faxed to the project QA/QC coordinator the day the samples are received by the laboratory. The person receiving this form is responsible for reviewing it, making sure that the laboratory has received all the samples that were sent, and verifying that the correct analyses were requested. If an error is found, call the laboratory immediately, and document

any decisions made during the telephone conversation, in writing, on the Acknowledgment of Sample Receipt form. In addition, correct the COC form and fax the corrected version to the laboratory.

Submit the Acknowledgment of Sample Receipt form (and any modified COC forms) to be copied. A discussion of copy distribution is provided in SOP AP-02.

ARCHIVE RECORD FORMS

On the rare occasion that samples are archived at an Integral office, it is the responsibility of the project manager to complete an Archive Record form. This form is to be accompanied by a copy of the COC form for the samples, and will be placed in a locked file cabinet. The original COC form remains with the samples in a sealed Ziploc® bag.

STANDARD OPERATING PROCEDURE (SOP) AP-04

SAMPLE LABELING

SCOPE AND APPLICATION

This SOP describes the general Integral procedures for labeling samples, and the three kinds of labels that can be used on a project (i.e., sample labels, sample tags, and internal sample labels). Consult the project-specific sampling and analysis plan (SAP) to determine the exact sample identifiers and sample labels that are required for a given project. If they are not specified in the SAP, then follow the designations below.

SAMPLE IDENTIFIERS

Before field sampling begins, establish sample identifiers to be assigned to each sample as it is collected. Sample identifiers consist of codes designed to fulfill three purposes: 1) to identify related samples (i.e., replicates) to ensure proper data analysis and interpretation, 2) to obscure the relationships between samples so that laboratory analysis will be unbiased by presumptive similarities between samples, and 3) to track individual sample containers to ensure that the laboratory receives all material associated with a single sample. To accomplish these purposes, each container may have three different codes associated with it: the sample identifier, the sample number, and the sample tag number. These codes and their use are described as follows:

- **Sample Identification Code**—The sample identification code (Sample ID) is a unique designation that identifies where and how the sample was collected. The sample identifier is recorded in the field logbook *only* and is not provided on the sample label or chain-of-custody (COC) form. The sample identifier is a multiple-part code. The first component begins with the letter abbreviation; for example, "SWNS" or "SWNB" to designate the surface water sample was collected from the near-surface or near-bottom of the water column. The second part could identify the sampling event; for example, "1" to designate Round 1 sampling. The third part could contain an abbreviation for whether the station is a single point (SP), a transect (TR), a composite (CO), or a vertically integrated station (VI). The station number would be the final component of the sample identifier. Use leading zeros for stations with numbers below 100 for ease of data management and correct data sorting.

  If appropriate, add a supplemental component to the sample identifier to code field

duplicate samples and splits. Use a single letter (i.e., a suffix of "A" and "B") to indicate field duplicates or splits in the final component of the sample identifiers. For equipment decontamination blanks, assign sequential numbers starting at 900 instead of station numbers. Use a sample type code that corresponds to the sample type for which the decontamination blank was collected. Additional codes may be adopted, if necessary, to reflect sampling equipment requirements (see project-specific SAP).

Examples of sample IDs are as follows:

- SWNS-1-SP-002: Surface water sample collected from the near-surface at a single point during Round 1 from Station 2.
- SWNB-1-TR-010-A: Duplicate surface water sample from the near-bottom transect during Round 1 from Station 10.

- **Sample Number**—The sample number is an arbitrary number assigned to each distinct sample or split that is shipped to the laboratory for separate analysis. The sample number appears on the sample containers and the COC forms. Each sample will be assigned a unique sample number. All aliquots of a composited field sample will have the same sample number. In cases where samples consist of multiple bottles from the same location, assign each bottle the same sample number and time. However, assign replicates from the same location different sample numbers and times. Sample numbers of related field replicates will not necessarily have any shared content.

  Each field split of a single sample will also have a different sample number and time. The sample number is generally a unique six-digit number that includes a two-digit media code and a four-digit number. The media code may be site-specific, but the Integral default codes are as follows:

  - SS—Surface soil
  - BH—Subsurface soil or rock (typically from borehole)
  - GW—Groundwater
  - SW—Surface water
  - PW—Pore water
  - SD—Sediment
  - BT—Biota or biological tissue

  The exact sample numbering scheme may vary from project to project. Variances in the sample numbering scheme will be described in the project-specific SAP for the field event. Example sample numbers are PW0001, PW0002, PW0003, etc.

- **Tag Number—**Attach a different tag number to each sample container. If the amount of material (i.e., everything associated with a single sample number) is too large for a single container, assign each container the same sample number and a different sample tag. A sample will also be split between containers if a different preservation technique is used for each container (i.e., because different analyses will be conducted).

  The sample tag number is a unique five- or six-digit number assigned to each sample label (or "tag") for multiple bottles per sample. Integral sample labels come with a preprinted sample tag number. The tag number provides a unique tracking number to a specific sample bottle. This allows for greater flexibility in tracking sample bottles and assists in field quality control when filling out documentation and shipping. Sample tags are not used by many other consultants, and there may be resistance from such firms during teaming situations. However, experience has shown that tags can be very valuable, both in the field and while processing data from field efforts.

  Record tag numbers on the COC form. Laboratories use tag numbers only to confirm that they have received all of the containers that were filled and shipped. Data are reported by sample number.

Assign sample numbers sequentially in the field; sample labels are preprinted with sequential tag numbers.

SAMPLE LABELS

Integral sample labels are designed to uniquely identify each individual sample container that is collected during a sampling event. Field sampling teams are provided with preprinted sample labels, which must be affixed to each sample container used. Fill out the labels at the time the samples are collected, documenting the following information:

- Sample number
- Site name or project number
- Date and time sample is collected
- Initials of the samplers
- Preservatives used, if any
- A unique number (commonly referred to as the "Tag Number") that is preprinted on the label consisting of five or six digits; used to identify individual containers.

SAMPLE TAGS

Integral sample tags are designed to be affixed to each container that is used for a sample. Sample tags are required only for environmental samples collected in certain U.S.

Environmental Protection Agency (EPA) regions (e.g., EPA Region 5). Field crews are provided with preprinted sample tags. Attach sample tags to each individual sample container with a rubber band or wire through a reinforced hole in the tag. Mark all sample tag entries with indelible ink. Fill out the tags at the time the samples are collected, documenting the following information:

- Sample number
- Site name or project number
- Date and time sample is collected
- Initials of the samplers
- Preservatives used, if any
- Type of analysis.

A space for the laboratory sample number (provided by the laboratory at log-in) will also be provided on the sample tag.

INTERNAL SAMPLE LABELS

For benthic infaunal samples, wash away the sediment from the sample and collect the remaining benthic infauna into a sample container. Affix sample label (as discussed above) to the outside of the sample container. In addition, place an internal sample label inside the sample container. This internal sample label is made of waterproof paper; be sure to make all internal sample label entries with pencil. Fill out the internal sample labels at the time the samples are collected, documenting the following information:

- Sample number
- Site name or project number
- Date and time sample is collected
- Initials of the samplers
- Preservative used (e.g., formalin).

ATTACHMENT B

SAMPLING FORMS

CHAIN OF CUSTODY FORM

0060

Project:

Samplers:

Integral Contact:

Office

Phone

Ship to: Lab Name

Address

Contact

Phone

ANALYSES REQUESTED

integral consulting inc.

Sample No.	Tag No.	Date	Time	Matrix							Extra Container	Archive	Comments

Analysis Turn Time: Normal Rush Rush Results Needed By:

Shipped by: Shipping Tracking No.

Condition of Samples Upon Receipt: Custody Seal Intact?

Matrix Code:	
SL - Soil	GW - Groundwater
SD -Sediment	SW - Surface water
	Other

Relinquished by: _____ (signature) Date/Time: _____ Received by: _____ (signature) Date/Time: _____

Relinquished by: _____ (signature) Date/Time: _____ Received by: _____ (signature) Date/Time: _____

Special Instructions:

Seattle
1001 1 12th Avenue NE, Ste 104
Bellevue, WA 98004

Portland
3011 NE 22nd Avenue
Portland, OR 97212

Boulder
1333 Pearl Street, Ste 210
Boulder, CO 80021

"Outdoor writing products for outdoor writing people"

J. L. DARLING CORPORATION

www.RiteintheRain.com

"Rite in the Rain"®

ALL-WEATHER WRITING PAPER

LEVEL

All-Weather Notebook

No. 311

4 1/4" x 7" - 48 Numbered Pages

SAMPLE COLLECTION FORM

Station ID _____

Sample No. _____

Date _____

Project Name:

Project Number:

Collector:

Field Parameters

pH	Temperature	Conductivity	D.O.	Comments
_____	_____	_____	_____	_____

Sampling Device

Filter:

Sample Containers Collection Time_____

Tag No.	Type		Preservative	Analytical Method	QA Remarks
	☐Amber	☐Poly			
	☐Amber	☐Poly			
	☐Amber	☐Poly			
	☐Amber	☐Poly			
	☐Amber	☐Poly			
	☐Amber	☐Poly			
	☐Amber	☐Poly			
	☐Amber	☐Poly			
	☐Amber	☐Poly			

Comments

Sample Location Sketch

Samplers' Signature_____ Date _____

integral consulting inc

Sample Label

Site: _____

Sample No.: _____

Matrix: _____

Date: _____

Filtered (Y/N): _____
(If applicable)

Time: _____

Analysis: _____
(optional)

Pres: _____

Sampler: _____

Tag Number: 1813

Custody Seal

CUSTODY SEAL

Date: _____ *Time:* _____

Sampler Signature: _____

ATTACHMENT C

SAMPLING EQUIPMENT USER MANUALS

6712 Portable Samplers

Installation and Operation Guide

TELEDYNE ISCO
A Teledyne Technologies Company

Part #69-9003-588 of Assembly #60-9004-334
Copyright © 2001. All rights reserved, Teledyne Isco, Inc.
Revision AA, May 14, 2010

Foreword

This instruction manual is designed to help you gain a thorough understanding of the operation of the equipment. Teledyne Isco recommends that you read this manual completely before placing the equipment in service.

Although Teledyne Isco designs reliability into all equipment, there is always the possibility of a malfunction. This manual may help in diagnosing and repairing the malfunction.

If the problem persists, call or e-mail the Teledyne Isco Technical Service Department for assistance. Simple difficulties can often be diagnosed over the phone.

If it is necessary to return the equipment to the factory for service, please follow the shipping instructions provided by the Customer Service Department, including the use of the **Return Authorization Number** specified. **Be sure to include a note describing the malfunction.** This will aid in the prompt repair and return of the equipment.

Teledyne Isco welcomes suggestions that would improve the information presented in this manual or enhance the operation of the equipment itself.

Teledyne Isco is continually improving its products and reserves the right to change product specifications, replacement parts, schematics, and instructions without notice.

Contact Information

Customer Service

Phone:	(800) 228-4373	(USA, Canada, Mexico)
	(402) 464-0231	(Outside North America)
Fax:	(402) 465-3022	
Email:	IscoCSR@teledyne.com	

Technical Support

Phone:	(800) 775-2965	(Analytical)
	(866) 298-6174	(Samplers and Flow Meters)
Email:	IscoService@teledyne.com	
Return equipment to:	4700 Superior Street, Lincoln, NE 68504-1398	

Other Correspondence

Mail to:	P.O. Box 82531, Lincoln, NE 68501-2531
Email:	IscoInfo@teledyne.com
Web site:	www.isco.com

Revised March 17, 2009

General Warnings

Before installing, operating, or maintaining this equipment, it is imperative that all hazards and preventive measures are fully understood. While specific hazards may vary according to location and application, take heed in the following general warnings:

⚠ WARNING

This instrument has not been certified for use in "hazardous locations" as defined by the National Electrical Code.

⚠ WARNING

Avoid hazardous practices! If you use this instrument in any way not specified in this manual, the protection provided by the instrument may be impaired; this will increase your risk of injury.

⚠ AVERTISSEMENT

Éviter les usages périlleux! Si vous utilisez cet instrument d'une manière autre que celles qui sont specifiées dans ce manuel, la protection fournie de l'instrument peut être affaiblie; cela augmentera votre risque de blessure.

This product is often installed in confined spaces. Some examples of confined spaces are manholes, pipelines, digesters, and storage tanks. These spaces may become hazardous environments that can prove fatal for those unprepared. These spaces are governed by OSHA 1910.146 and require a permit before entering.

Hazard Severity Levels

This manual applies *Hazard Severity Levels* to the safety alerts, These three levels are described in the following sample alerts.

⚠ CAUTION

Cautions identify a potential hazard, which if not avoided, may result in minor or moderate injury. This category can also warn you of unsafe practices, or conditions that may cause property damage.

⚠ WARNING

Warnings identify a potentially hazardous condition, which if not avoided, could result in death or serious injury.

⚠ DANGER

DANGER – limited to the most extreme situations to identify an imminent hazard, which if not avoided, will result in death or serious injury.

Hazard Symbols

The equipment and this manual use symbols used to warn of hazards. The symbols are explained below.

Hazard Symbols	
Warnings and Cautions	
	The exclamation point within the triangle is a warning sign alerting you of important instructions in the instrument's technical reference manual.
	The lightning flash and arrowhead within the triangle is a warning sign alerting you of "dangerous voltage" inside the product.
	Pinch point. These symbols warn you that your fingers or hands will be seriously injured if you place them between the moving parts of the mechanism near these symbols.
Symboles de sécurité	
	Ce symbole signale l'existence d'instructions importantes relatives au produit dans ce manuel.
	Ce symbole signale la présence d'un danger d'électocution.
	Risque de pincement. Ces symboles vous avertit que les mains ou les doigts seront blessés sérieusement si vous les mettez entre les éléments en mouvement du mécanisme près de ces symboles
Warnungen und Vorsichtshinweise	
	Das Ausrufezeichen in Dreieck ist ein Warnzeichen, das Sie darauf aufmerksam macht, daß wichtige Anleitungen zu diesem Handbuch gehören.
	Der gepfeilte Blitz im Dreieck ist ein Warnzeichen, das Sei vor "gefährlichen Spannungen" im Inneren des Produkts warnt.
	Vorsicht Quetschgefahr! Dieses Symbol warnt vor einer unmittelbar drohenden Verletzungsgefahr für Finger und Hände, wenn diese zwischen die beweglichen Teile des gekennzeichneten Gerätes geraten.

6712 Portable Sampler

Table of Contents

Section 1 Introduction

1.1 About this Manual. 1-1
1.2 About 700 Series Modules. 1-2
1.3 SDI-12 Sondes 1-2
1.4 Memory to Store Monitoring Data 1-2
1.5 Pump Requirements 1-3

Section 2 Installation/Preparation

2.1 Preparing the Sampler 2-1
2.2 Installing the Distributor Arm and Discharge Tube. 2-1
2.3 Installing Bottle Kits for Multiplex Sampling. 2-3
2.3.1 Aligning Bottle Kits in the Standard Tub 2-4
2.3.2 Aligning Bottle Kits in the Compact Tub 2-7
2.4 Installing Bottle Kits for Composite Sampling 2-7
2.4.1 Optional Jumbo Bottle Base 2-7
2.5 Installing a Power Source. 2-9
2.5.1 Connecting an External 12-Volt DC Source 2-9
2.6 Suction Line. 2-10
2.6.1 Attaching Suction Line to Pump Tube 2-10
2.7 Strainers 2-11
2.7.1 Alternative to Strainers 2-11
2.8 How Does the Sampler Work? 2-12
2.8.1 A Typical Sampling Cycle 2-12
2.8.2 Measuring Sample Volume 2-13
2.9 Installing the Sampler 2-13
2.9.1 Icing the Samples 2-13
2.9.2 Tips for Routing Suction Line 2-13
2.9.3 Intake Placement 2-13
2.9.4 Positioning a Sampler 2-13
2.9.5 Using the Suspension Harness or ProHanger 2-14
2.10 Connecting External Instruments 2-14
2.10.1 Flow Meter 2-14
2.10.2 Rain Gauge Connector 2-15
2.11 Locking the Sampler. 2-16
2.12 Servicing the Sampler. 2-16
2.13 Recovering the Sampler 2-17
2.14 Collecting Sample Bottles. 2-17
2.14.1 Compact Sampler Bottle Collection 2-17
2.14.2 Standard Sampler Bottle Collection 2-18

Section 3 Programming Introduction

3.1 Initial Operation 3-1
3.1.1 Selecting a Language 3-3
3.2 Using Menus and Entering Numbers 3-3
3.2.1 Selecting Menu Options 3-3
3.2.2 Entering Numbers 3-3

3.3 Quick View Screens . . . 3-4
3.3.1 Paging Through Quick View Screens . . . 3-4
3.3.2 Changing Settings in a Quick View Screen . . . 3-4
3.4 Clock and Calendar . . . 3-5
3.4.1 Setting the Clock and Calendar . . . 3-6
3.4.2 Menu Screens: Clock Start Times . . . 3-6
3.5 Menu Screens: Site Descriptions and Program Names . . . 3-7
3.6 Messages . . . 3-9
3.6.1 Information Messages . . . 3-9
3.6.2 Help Notes . . . 3-9
3.6.3 Warning Messages . . . 3-10
3.6.4 Operation Messages . . . 3-11
3.7 Menu Trees . . . 3-11

Section 4 Standard Programming

4.1 Switching Between Standard and Extended Modes . . . 4-1
4.2 Language Selection, Units of Length . . . 4-1
4.3 Programming Examples . . . 4-2
4.4 Pacing . . . 4-5
4.4.1 Trigger Pacing . . . 4-5
4.5 Distribution . . . 4-6
4.5.1 Sequential . . . 4-6
4.5.2 Bottles Per Sample . . . 4-6
4.5.3 Samples Per Bottle . . . 4-6
4.5.4 Composite . . . 4-6
4.5.5 Continuous Sampling . . . 4-6
4.6 Start Times . . . 4-8
4.6.1 How Do Start Times Work? . . . 4-8
4.6.2 Sampler Enable/Disable . . . 4-9
4.7 Running Programs . . . 4-10
4.7.1 Run Time Screens . . . 4-10
4.7.2 Module Readings . . . 4-11
4.8 Interrupting a Running Program . . . 4-12
4.8.1 Stop Program . . . 4-12
4.8.2 Resume Program . . . 4-13
4.8.3 View Data . . . 4-13
4.8.4 Grab Sample . . . 4-13
4.8.5 Pump Tube Alarm . . . 4-13
4.8.6 Calibrate Volume . . . 4-13
4.8.7 Cal/Adj Parameters . . . 4-13
4.8.8 Adjust Pacing . . . 4-13
4.8.9 Adjust Volume . . . 4-14
4.8.10 Power Used . . . 4-14
4.9 Other Functions . . . 4-14
4.10 Manual Functions . . . 4-14
4.11 Grab Samples . . . 4-15
4.12 Calibrate Volume . . . 4-16
4.12.1 Calibration Tips . . . 4-16
4.13 Operating the Pump . . . 4-17
4.14 Moving the Distributor Arm . . . 4-18
4.15 Reports . . . 4-19
4.15.1 Collecting Reports . . . 4-19
4.15.2 Viewing the Data . . . 4-19
4.15.3 Configuring Reports . . . 4-20
4.15.4 Sampling Results Report . . . 4-21
4.15.5 Combined Results Report . . . 4-21
4.15.6 Summary Report . . . 4-21

4.16 System IDs 4-29
4.17 Programming for 700 Series Modules 4-29

Section 5 Extended Programming

5.1 Extended and Standard Mode 5-1
5.2 One-Part and Two-Part Programs 5-1
5.3 Storage for Extended Programs 5-2
5.3.1 Selecting a Stored Program 5-2
5.4 Programming for 700 series Modules 5-4
5.5 Programming SDI-12 Sondes 5-4
5.6 Programming Examples 5-4
5.6.1 Storm Water Runoff Sampling 5-5
5.7 Suction Head 5-12
5.8 Rinses and Retries 5-12
5.9 Pacing 5-12
5.9.1 Event Pacing 5-12
5.9.2 Event Paced Sampling 5-13
5.9.3 Nonuniform Time Pacing 5-15
5.9.4 Nonuniform Clock Time Pacing 5-15
5.9.5 Nonuniform Interval Pacing 5-15
5.9.6 Random Interval Pacing 5-15
5.10 Distribution 5-16
5.10.1 Sequential 5-16
5.10.2 Bottles Per Sample 5-16
5.10.3 Samples Per Bottle 5-16
5.10.4 Composite 5-16
5.10.5 Multiple Bottle Compositing 5-16
5.10.6 Time Switching 5-16
5.10.7 Continuous Sampling 5-17
5.11 Flow Proportional Sample Volumes 5-19
5.11.1 Calculating Variable Sample Volume Settings 5-20
5.11.2 Calculations when Using an External Flow Meter 5-21
5.11.3 Calculations when Using a 700 Series Flow Module 5-22
5.12 Sampler Enable 5-23
5.12.1 Sampler Enable 5-24
5.13 Sampler Enable Responses 5-25
5.13.1 Once Enabled Stay Enabled 5-25
5.13.2 Repeatable Enable 5-25
5.13.3 Sample at Enable or Disable 5-25
5.13.4 Delay To Start Of Sampling 5-26
5.13.5 “Dry Period” Option 5-26
5.13.6 Resetting the Sample Interval at Enable 5-26
5.14 Pauses/Resumes 5-27
5.15 Running Programs 5-27
5.15.1 Run Time Screens 5-27
5.15.2 Interrupting a Running Program 5-27
5.16 Sampling Reports 5-28
5.17 Other Functions 5-28
5.18 Software Options 5-28
5.18.1 Liquid Detector Enable/Disable 5-28
5.18.2 Programming Style 5-29
5.18.3 Measurement Interval 5-29
5.18.4 Dual Sampler Mode 5-29
5.18.5 Pre-sample and Post-sample Purge Counts 5-31
5.18.6 Serial Output 5-32
5.18.7 Program Lock 5-34
5.19 Hardware Setup 5-36

5.19.1 SDI-12 Sonde Setup 5-36
5.19.2 Rain Gauge Setup 5-36
5.19.3 I/O Pin Programming 5-37
5.19.4 Dialout Alarms 5-39
5.19.5 Pager Numbers 5-40
5.19.6 Digital Modem Text Messaging 5-40
5.19.7 Refrigerator Temperature 5-41
5.19.8 Analog Output 5-41
5.20 Memory 5-42
5.21 Pressurized Lines 5-44
5.22 Command Driven Operation. 5-44
5.22.1 Command Driven Sampler Responses 5-45

Section 6 SDI-12 Sondes

6.1 SDI-12 Data Parameters 6-1
6.2 Scanning For Sondes. 6-2
6.3 Teledyne Isco Ready Sondes. 6-3
6.4 Other SDI-12 Sondes. 6-3
6.5 Sonde Setup - Storing Parameter Data 6-4
6.6 Sonde Calibration and Validation 6-5
6.6.1 The Calibration Screens 6-6
6.6.2 The Validation Screen 6-6
6.7 Disconnecting Sondes 6-7

Section 7 Remote Operation

7.1 Computer Operation 7-1
7.1.1 Menu Control 7-2
7.1.2 External Program Control 7-4
7.1.3 Remote Control of Sampler Keypad 7-8
7.2 Telephone Commands 7-9

Section 8 Maintenance

8.1 Maintenance Checklist 8-1
8.2 Cleaning Guidelines 8-1
8.2.1 Controller, Top Cover, Center Section, Retaining Ring, and Tub 8-1
8.2.2 Sample Bottles 8-1
8.2.3 Suction Line, Pump Tube, and Discharge Tube 8-2
8.2.4 Strainer 8-2
8.3 Cleaning Protocols for Priority Pollutants. 8-2
8.3.1 Teledyne Isco Glass Sample Bottles 8-2
8.3.2 Vinyl Suction Line 8-2
8.3.3 Teflon Suction Line 8-2
8.3.4 Teledyne Isco Pump Tube 8-2
8.4 Maintenance Screens 8-3
8.4.1 Set Clock 8-3
8.4.2 Pump Tube Alarm 8-4
8.4.3 Internal Battery Warning 8-6
8.4.4 Diagnostics 8-6
8.5 Replacing the Pump Tube. 8-8
8.5.1 Checklist For Replacing Pump Tube 8-9
8.6 Opening the Controller Case 8-11
8.7 Replacing the Desiccant 8-11
8.8 Replacing the Internal Battery 8-13
8.9 Error Messages 8-14
8.10 Pump Tube Warning. 8-15

Appendix A Menu Flowcharts

Appendix B Material Safety Data Sheets

Appendix C General Safety Procedures

C.1 Practical Safety Precautions C-1
C.1.1 Hazards C-1
C.1.2 Planning C-2
C.1.3 Adverse Atmospheres C-2
C.1.4 Entering Manholes C-2
C.1.5 Traffic Protection C-3
C.1.6 Falling Objects C-3
C.1.7 Removing the Covers C-3
C.1.8 Other Precautions C-3
C.1.9 Emergencies C-4
C.1.10 Field Equipment C-4
C.2 Lethal Atmospheres in Sewers C-4
C.3 Hazardous Gases C-6

Appendix D Replacement Parts List

D.1 Replacement Parts Diagrams and Listings D-1

Appendix E Accessories List

E.1 Order Information E-1
E.2 Controller, Center Sections, Top Covers, and Tubs E-1
E.3 Compact and Mini Sampler Bottle Kits E-1
E.4 Compact Sampler Bottle Kits E-2
E.5 Standard Sampler Bottle Kits E-2
E.6 Bottle Carriers, Retaining Rings and Racks, Bottle Inserts, Discharge Tubes . . E-3
E.7 Bulk Sets of Bottles with Lids E-3
E.8 General Accessories: Compact and Standard Samplers. E-4
E.9 Pump Tubes, Suction Line, Strainers E-4
E.10 Data Collection Devices and Cables E-5
E.11 Power Sources and Chargers E-5
E.12 Modules, Rain Gauges, & Interfacing Instruments E-6
E.13 SDI-12 Data Acquisition Connect Cables E-6

List of Illustrations

2-1 Installing the Distributor Arm 2-2
2-2 Placing the 24-Bottle Kit in a Standard Tub 2-4
2-3 Placing the 12-Bottle Kit in a Standard Tub 2-5
2-4 Placing the 8-Bottle Kit in a Standard Tub 2-5
2-5 Placing the 4-Bottle Kit in a Standard Tub 2-6
2-6 Placing the carrier in the compact tub 2-6
2-7 Installing the Composite Tube Guide 2-7
2-8 Composite Bottles 2-8
2-9 Attaching the suction line to the pump tubing 2-10
2-10 Identifying the Sampler Components 2-12
3-1 Menu Tree for Standard Programming 3-12
4-1 Sample Distribution 4-7
4-2 Start Time Diagram 4-10

4-3 Running a Program 4-11
4-4 Taking a Grab Sample 4-15
4-5 Report: Program Settings 4-24
4-6 Report: Sampling Results 4-25
4-7 Report: Combined Results 4-26
4-8 Report: Combined Results (continued) 4-27
4-9 Report: Summary 4-28
5-1 Sample Distribution 5-18
5-2 Factors Affecting Flow-Weighted Variable-Volume Samples 5-20
5-3 Variable-Volume Scenario 5-21
5-4 Start Time Diagram for Sampler Enable Settings 5-23
5-5 Event Mark Timing Diagram 5-31
5-6 Password Protected Functions 5-35
6-1 SDI-12 Sonde Parameters 6-2
7-1 Press and hold ?? to connect to the sampler 7-2
7-2 Example list of remote menu commands 7-2
8-1 Removing and Replacing the Pump Tube 8-10
8-2 Placing the Pump Tube in the Liquid Detector 8-10
8-3 Opening the Controller 8-12
8-4 Main Circuit Board Connections 8-13
A-1 6712 Menu Tree for Standard Programming A-1
A-2 Standard Programming: Programming Screens A-2
A-3 Standard and Extended Programming: Start Times A-3
A-4 Standard Programming: Quick View; Programming Screens A-4
A-5 Standard Programming: Quick View; Start Times A-5
A-6 View Report A-6
A-7 Maintenance Screens A-7
A-8 Manual Functions Screens A-8
A-9 Extended Programming: Programming Screens A-9
A-10 Extended Programming: Equipment Setup A-10
A-11 Extended Programming: Pacing and Distribution A-11
A-12 Extended Programming: Event Conditions A-12
A-13 Extended Programming: Programmed Sampler Enable A-13
A-14 Extended Programming: Quick View; Programming Screens A-14
A-15 Extended Programming: Quick View; Equipment Set-Up A-15
A-16 Extended Programming: Quick View; Pacing and Distribution A-16
A-17 Extended Programming: Quick View; Programmed Sampler Enable A-17
A-18 Extended Programming: Normal View; Software Options A-18
A-19 Extended Programming: Quick View; Software Options A-19
A-20 Extended Programming: Normal View; Hardware A-20
A-21 Extended Programming: Quick View; Hardware A-21
A-22 Analog and Dialout Screens A-22
A-23 Analog Output and Dialout Quick View Screens A-22
A-24 SDI-12 Sonde Screens A-23

List of Tables

1-1 6712 Standard and Compact Sampler Features 1-3
1-2 6712 Standard and Compact Sampler Construction Materials 1-7
1-3 Technical Specifications for the
6712C and Standard Samplers 1-8
1-4 Connector Specifications 1-16
2-1 Distributor Arm Adjustments and Discharge Tube Lengths for Bottle Kits 2-2
2-2 Discharge Tubes for Composite Sampling 2-8
2-3 Selecting the Right Strainer 2-11
2-4 Connecting Teledyne Isco Instruments to the Sampler 2-16
3-1 About the Keypad 3-2
4-1 Standard Program: Sample Every 15 Minutes, One Sample Per Bottle 4-2
4-2 Standard Program: Flow-Paced Sampling, Two Bottles Per Sample 4-3
4-3 Reports: Program Events, Source Codes, and Error Codes 4-22
4-4 Programming Example With 730 Module Installed 4-30
4-5 Programming Example With 750 Module Installed 4-33
5-1 Selecting a Stored Extended Program 5-3
5-2 Storm Water Runoff Sampling 5-6
5-3 Event Paced Sampling 5-13
5-4 Sampler Enable 5-24
5-5 Serial Data Codes 5-33
7-1 6712 Remote Menu Commands 7-3
7-2 Serial Data Codes 7-6
7-3 Remote Control of Sampler Keypad 7-8
7-4 6712 Remote Phone Commands 7-9
8-1 Setting the Clock and Calendar 8-4
8-2 Resetting the Pump Counter 8-5
8-3 Checking and Replacing the Internal Battery 8-6
C-1 Hazardous Gases C-6

6712 Portable Sampler

Section 1 Introduction

The 6712 Series Samplers are an integral part of Teledyne Isco's comprehensive sampling system. The system includes the 6712 Compact Sampler, the 6712 Standard Sampler and the 6712FR and 6712SR Refrigerated Samplers.

6712 Controller

The 6712 portable samplers are easily moved from site to site. Constructed from durable, corrosion-resistant materials, the samplers withstand the hostile environments of industrial and municipal monitoring sites.

The 6712 Compact differs from the 6712 Standard Sampler only in size and sampling capacity. Both samplers use the same controller and sample-delivery system. Both instruments accept a variety of composite and multiple bottle kits. Because the 6712 Compact and Standard Samplers share many features, this manual includes programming, operation, and maintenance information for both instruments. Except where specifically noted, the contents of this manual apply to both units.

1.1 About this Manual

This manual contains the information you will need to install, program, operate, and maintain a 6712 portable sampler. There are seven sections and five appendices:

- *Section 1, Introduction* lists the features and specifications of the 6712 portable samplers.
- *Section 2, Installation/Preparation* steps you through installing the sampler and preparing it for use.
- *Section 3, Getting Started* describes features that are common to both standard and extended programming modes.
- *Section 4, Standard Programming* shows how to program your sampler using standard programming mode.
- *Section 5, Extended Programming* shows how to program your sampler using extended programming mode.
- *Section 6, SDI-12 Sondes* provides information on setting up sondes to work with the 6712.
- *Section 7, Remote Operation* explains how the 6712 controller can be operated remotely from external devices.
- *Section 8, Maintenance* covers the basic maintenance required to keep your sampler in top operating condition.

The appendices are:

- *Appendix A, Menu Flowcharts*
- *Appendix B, Material Safety Data Sheets*
- *Appendix C, General Safety Procedures*
- *Appendix D, Replacement Parts*
- *Appendix E, Accessories List*

1.2 About 700 Series Modules

The bay on the controller's side accepts any of Teledyne Isco's 700 Series Modules. The 700 Series includes:

- 701 pH Parameter Module for monitoring pH and temperature.
- 710 Ultrasonic Module for monitoring a flow stream's level and flow rate with an ultrasonic level sensor.
- 720 Submerged Probe Module for monitoring a flow stream's level and flow rate with a submerged probe.
- 730 Bubbler Flow Module for monitoring a flow stream's level and flow rate with a bubbler system.
- 750 Area Velocity Module for monitoring a flow stream's level, velocity, and flow rate.
- 780 4-20mA Input Module for interfacing to non-Teledyne Isco devices with 4 to 20 milliampere output signals.

The modules are optional accessories. The samplers do not require them for operation. However, the modules offer a number of advantages: they are an economical way to combine flow-rate or parameter monitoring with sampling, and you can program the samplers and modules as a single unit. Finally, the samplers store the readings in memory.

1.3 SDI-12 Sondes

As an option, the sampler accepts up to 16 parameters from up to ten sensors with SDI-12 addresses from 0 - 9 (refer to SDI-12 Sonde Readings, page 1-11, for specific parameters).

The data parameters used by the sensing device (sonde) and recording device (sampler) must match. Certain vendors' sondes have enhanced commands that facilitate "plug and play" setup. These Teledyne Isco Ready sondes can tell the 6712 what values they have, their order, and units of measure. Other sondes can be used, but require manual setup to identify proper data types for each data value reported.

1.4 Memory to Store Monitoring Data

The samplers contain enough memory to store five sampling programs, sampling data, Teledyne Isco 700 Series Module readings, and SDI-12 parameter readings. You can view the readings on your sampler's display.

You can also retrieve the readings and reports so the information can be processed on a personal computer. Readings and reports may be collected with a computer running Teledyne Isco's Flowlink® software. Flowlink can download the information through a direct connection, a modem connection (when the

sampler is equipped with the optional 4200T dial-out modem or connected to the optional digital cellular modem), or from a 581 Rapid Transfer Device (RTD). The RTD is a quick and simple way to transfer the data from the field to your computer. Reports are easily collected with Teledyne Isco's Samplink software.

1.5 Pump Requirements

The sampler's peristaltic pump is extremely powerful. This pump requires a high capacity power source such as Teledyne Isco's model 913 or 923 power pack. Older model power packs do not provide the needed power. A list of recommended power packs and batteries can be found in *Installing a Power Source* on page 2-9.

The pump also requires a pump tube made specifically for the 6712 and 6700 Series samplers. These pump tubes are easily recognized by their blue alignment collars. The 6712 pump tubing is the same as that for Teledyne Isco's 6700 Series samplers, but different from Teledyne Isco's earlier model samplers, such as the 3700 Series. Other types of pump tubing will not work in the 6712. Refer to *Replacing the Pump Tube* on page 8-8.

⚠ CAUTION

This sampler has a high performance pump. As with all such pumps, it relies upon liquid to cool working components. If the sampler is programmed to pump in the absence of liquid in excess of 5 minutes, excessive heat buildup may damage the paddles, rollers, and housing. Ensure that the liquid inlet is completely immersed.

Table 1-1 6712 Standard and Compact Sampler Features

General Features	
Top Cover	• Protects pump, power source, and controller. • Lockable latches.
Controller	• Contains a rechargeable desiccant to prevent moisture damage to the electronics, pump, and distributor systems. • Control panel sloped 15 degrees for easy reading. • Keys labeled with large, vivid icons. • 80-character display (4 lines by 20 columns). • Display has selectable backlight: Always on or always off. Timed, switching off when keypad is inactive for 60 seconds. • Memory for program and data storage. • Flash memory for easy software upgrades. • NEMA 4X and 6 (IP67) ratings.
Center Section	• Secured to tub with lockable latches. • Large handles.

Table 1-1 6712 Standard and Compact Sampler Features (Continued)	
Adjustable Distributor Arm	• A single distributor arm adjusts quickly to fit all bottle kits. Easily removed for composite sampling.
Discharge Tube and Support Spring	• Routes sample liquid from pump tube, through distributor arm to sample bottle.
Composite Tube Guide for Composite Sampling	• Keeps discharge tube in place over composite bottles.
Tub	• Large, comfortable handles. • Both compact and standard samplers accept a variety of bottle kits. • **Compact Tubs Only**: Removable bottle-carrier insert. • **Standard Tubs Only**: Tub drain. • Optional five gallon bottle base: fits the standard sampler
Compatible Teledyne Isco Products	• 581 Rapid Transfer Device • 1640 Liquid Level Actuator • 674 Rain Gauge • 2100 Series Flow Modules • 700 Series Modules • 4100 Series Flow Loggers • SDI-12 Sondes • 4200 Series Flow Meters • Refrigerator Temperature Sensor • Flowlink, Samplink
Real-Time Displays	As the sampler runs a sampling program, it displays the program's status. The status display may include such information as the time of the next sample, the number of the next bottle, or whether the sampler is disabled or stopped. If the sampler encounters an error while running the program, it displays a message alerting you to the problem.
Programming for Modules	Program the modules from the sampler's control panel. The module's program settings become part of the sampling program.
Setup for SDI-12 Sondes	Calibrate and program SDI-12 sondes from the sampler's control panel. The program settings become part of the sampling program. See Section 6.
Memory for Stored Programs and Readings	512 kilobytes of battery-backed RAM (Random Access Memory), to store: • Five sampling programs. • A sampling report from the most recently run program. It records as many as 1000 sampling events; events can be the program start time, enable time, sample event information, etc. • 700 Series module readings. The readings can be: level, flow rate, velocity, pH, temperature, or the data collected by the 4-20 mA module. • Rain gauge and refrigerator temperature readings. • SDI-12 sonde readings.
Five Reports Available	• The Program Settings report, listing current program settings. • The Sampling Results report, listing the events occurring during the program. • The Combined Results report, combining sampling events with readings from a rain gauge, module, or SDI -12 sonde. • The Module Summary report, summarizing flow rate or parameter readings. • The Rainfall Summary report, listing a summary of rainfall readings.
Serial Data Output	• ASCII data output from the interrogator port.

Table 1-1 6712 Standard and Compact Sampler Features (Continued)	
Units of Measure	A variety of metric and English units of measure for length, flow rate, flow volume, and temperature.
External Sampler Enable	Teledyne Isco flow meters and flow loggers have a programmable sampler enable feature that lets them send an electronic signal to a 6712 that enables (starts) or disables (stops) a running sampling program.
Dual Sampler Mode	Dual Sampler Mode operates two samplers.
Command Driven Operation	• Operate sampler functions using RS-232 communications.
Warning Messages	• Pump Tube Warning. The 6712 displays a warning to inspect the tube. • Internal Battery Warning. From the Maintenance screen, the 6712 displays a warning when it is time to replace the internal battery. The internal battery preserves stored data when the 6712 is without external power.
Optional Dialout 4200T Modem	The 6712 controller can be ordered with a factory-installed 2400 baud dialout modem. With the modem you can: • connect to the sampler and download data using Flowlink software. • program the sampler to call a contact list when an “alarm” condition exists. • use the Remote Commands to control the sampler’s operation from a remote location.
On-Line Help Notes	When programming the sampler, press the [?] (Help) key for a brief help note. All help topics appear in the index.
Two Programming Levels	Standard programming lets you set up typical sampling programs quickly. Extended programming includes all features available in standard programming plus additional features.
Sample Delivery System Features	
Peristaltic Pump	• **Benefits**: Liquid moves continuously under pumped flow. The pump has no metering chambers or gravity fed internal tubing to trap sediment or residual liquid. Sample liquid contacts only the strainer, suction line, tube coupling, pump tube, bulkhead fitting, and sample bottles.
LD90 Liquid Detector	• **Non wetted Detection**: Sample liquid never touches the detector.
Two Line Purges in Sampling Cycle	The sampling cycle always includes a pre-sample purge and post-sample purge that clears the suction line of residual liquid.
Easy Grab Samples	Simply disconnect the pump tube from the bulkhead fitting on the center section, and place the pump tube over your sample container.
Vinyl and PTFE® Suction Lines	• 3/8-inch ID (Inside Diameter) vinyl line. • 3/8-inch ID PTFE lined with polyethylene jacket.
Standard Programming Features	
Pacing	• **Uniform Time Pacing**: Sampling at regular time intervals. • **Flow Pacing**: Sampling at regular flow-volume intervals.
Distribution Methods	• **Composite**: Samples deposited in a single large bottle. • **Sequential**: Only one sample placed in each bottle. • **Samples Per Bottle**: Multiple samples placed in each bottle. • **Bottles Per Sample**: One sample deposited in multiple bottles.

Table 1-1 6712 Standard and Compact Sampler Features (Continued)	
Three Flexible Start-Time Settings	• **Start Immediately**: Starts the sampling program immediately. • **Delayed Start**: Starts the sampling program after a user-definable delay of 1 to 999 minutes. • **Clock Time**: Starts the sampling program at a user-definable time on one or more days of the week.
Option for a Continuous Running Program	• **Continuous Sampling**: When sample bottles are regularly replaced, the sample distribution can restart with the first bottle set after the last bottle set is filled, without interrupting the running program.
Extended Programming Features	
Pacing	• **Uniform Time Pacing**: Sampling at regular time intervals. • **Nonuniform Time Pacing**: Sampling at irregular time intervals. • **Random Interval Pacing**: Sampling at unique random time intervals generated by the controller. • **Flow Pacing**: Sampling at regular flow-volume intervals. • **Event Pacing**: Sampling each time a user-definable event occurs.
Flow Proportional Sample Volumes	Allows for sample sizes to be based on flow. (This option is available only with uniform time pacing.)
Distribution Methods	• **Composite**: Samples deposited in a single large bottle. • **Sequential**: Only one sample placed in each bottle. • **Samples Per Bottle**: Multiple samples placed in each bottle • **Bottles Per Sample**: One sample deposited in multiple bottles • **Multiple Bottle Compositing**: A combination of samples per bottle and bottles per sample distribution methods. • **Time Switched Bottles or Bottle sets**: Control the sample distribution using clock times.
Programmable Sampler Enable	A 6712 sampler can be programmed to enable or disable a running sampling program when readings received from a connected rain gauge, module, or SDI-12 Sonde meet certain conditions.
Pauses and Resumes	Create intermittent sampling schedules.
Two-Part Programming	Two-part programming lets you set up a sampling program that divides the bottles into two groups, filling each group according to separate pacing, distribution, sampler enable, and pause and resume settings. This is ideal for storm-water run-off sampling.
Auto Suction Head or Fixed Suction Head	The suction head, is the vertical distance from the flow stream to the liquid detector. Extended programming has two settings. • **Auto-Suction Head**: The head is automatically determined. • **Fixed Suction Head**: A user-definable measurement for the head.
Suction Line Rinses	Program setting for the number of times (0 to 3) that the 6712 rinses the suction line before drawing a sample.
Sampling Retries	Program setting for the number of times (0 to 3) that the 6712 attempts to sample if it fails to deliver the entire sample volume.

Table 1-1 6712 Standard and Compact Sampler Features (Continued)	
Three Flexible Start Time Settings	• **Run Immediately**: Starts the sampling program immediately. • **Delayed Start**: Starts the sampling program after a user-definable delay of 1 to 999 minutes. • **Clock Time**: Starts the sampling program at a user-definable time on one or more days of the week.
Option for a Continuous Running Program	**Continuous Sampling**: When sample bottles are regularly replaced, the sample distribution can restart with the first bottle set after the last bottle set is filled, without interrupting the running program.

Table 1-2 6712 Standard and Compact Sampler Construction Materials	
Item	**Material**
Top Cover **Center Section** **Tubs** **Bottle Inserts** **Plastic Retaining Rings** **Bottle Carriers**	ABS (Acrylonitrile Butadiene Styrene) plastic
Bottle Rack	Powder coated steel
Controller Case **Distributor Arm**	Noryl®
Distributor Arm Nut **Pump Rollers**	Delrin®
Control Panel **Connector Labels**	Polyester
Distributor Shaft **Pump Shaft** **Pump Paddles** **Pump Band** **Bulkhead Fitting** **Latches** **Handles** **Metal Retaining Rings**	Stainless steel
Power-Source Draw Catches:	EPDM (Ethylene Propylene Diene Monomer) rubber
Amphenol Connectors	Cadmium Plated Aluminum
Retaining Ring Draw Cords (inside standard tub)	Polypropylene jacketed rubber with stainless steel clip
Retaining Ring Tie-Down (inside standard tub)	Iridited® aluminum

Table 1-2 6712 Standard and Compact Sampler Construction Materials (Continued)	
Drain Plug **(standard tub only)**	CPVC with polypropylene retaining strap
Webbing for Compact Bottle Carriers	Polypropylene.

Table 1-3 Technical Specifications for the 6712C and Standard Samplers	
General Notes: 1. All weights may vary ±1 lb (±1/2 kg). 2. All dimensions may vary ±1/4 inch (±0.64 cm). 3. Sample delivery specifications valid for the following conditions and ranges, unless otherwise stated: 75 °F (24 °C) ambient, sample liquid–tap water at 50 to 80 °F (10 to 27 °C), sample volumes from 50 ml to 1000 ml, suction line lengths of 25 ft (7.6 m) or less, suction heads from 1 to 20 ft (0.3 to 6.1 m), atmospheric pressure between 29.92 and 31.89 inHg (760 and 810 mmHg), and a power source of a Teledyne Isco High Capacity Power Pack at 12.5 volts DC no load output.	
6712 Controller, Pump, and Tubing: Mechanical Specifications	
Weight of Controller:	Controller only: 13.0 lbs (5.9 kg) With pump tube: 13.2 lbs (6.0 kg)
Weight of Nickel Cadmium Battery:	4.3 lbs (2.0 kg)
Weight of Lead Acid Battery:	5.7 lbs (2.6 kg)
Weight of Power Pack:	6.0 lbs (2.7 kg)
Weight of Battery Backed Power Pack:	6.6 lbs (3.0 kg)
Controller Dimensions:	Length: 10.3 in (26.0 cm) Width: 12.5 in (31.7 cm) Height: 10 in (25.4 cm)
Temperature Ranges:	Operational: 32 to 120 °F (0 to 49 °C) Storage: 0 to 140 °F (–18 to 60 °C)
Maximum Altitude:	2,000 Meters
Installation Category:	II
Pollution Degree:	2
Humidity:	95% RH Maximum
Enclosure:	NEMA 4X and 6 Pump: IP17 Enclosure: IP67
Typical Delivered Volume Accuracy:	(The ability to deliver the programmed sample volume.) ±10 ml or ±10% of programmed value, whichever is greater.
Typical Repeatability:	(The ability to repeat the delivered volume for a set of samples collected under the same conditions.) ±5 ml or ±5% of the average of the maximum and minimum sample volume in a sample set, whichever is greater, at lifts up to 25 feet.

Table 1-3 Technical Specifications for the 6712C and Standard Samplers (Continued)

Typical Pump Flow Rate and Line Transport Velocity:	Suction Head	Flow Rate	Line Transport Velocity
	3 feet	3.9 liters per minute	3.0 ft/s (0.91 m/s)
	5 feet	3.9 liters per minute	3.0 ft/s (0.90 m/s)
	10 feet	3.7 liters per minute	2.9 ft/s (0.87 m/s)
	15 feet	3.6 liters per minute	2.7 ft/s (0.83 m/s)
	20 feet	3.3 liters per minute	2.5 ft/s (0.77 m/s)
	23 feet	3.1 liters per minute	2.3 ft/s (0.71 m/s)
	25 feet	2.8 liters per minute	2.2 ft/s (0.66 m/s)
Maximum Suction Head:	(The maximum suction head is the vertical height at which a sample can be taken.) 28 ft (8.5 m) at 30 inHg (762 mmHg)		
Pump Tube Life:	Tube life may vary depending on the abrasiveness of the sample liquid. Recommended maximum 1,000,000 pump counts. This equates to 912 standard samples. A standard sample is 200 ml at 5 ft (1.5 m) suction head using a 10 ft (3 m) vinyl suction line.		
6712 Controller: Electrical Specifications			
Controller Internal Battery:	5 years minimum (maintains internal logic, program settings & stored data)		
Real Time Clock Accuracy:	1 minute per month		
Program Memory:	Nonvolatile programmable Flash. Can be field updated via interrogator connector.		
Sampler Power Requirements:	Nominal: 12 volts DC by battery or AC power converter Operational: 11 to 13 Volts DC Absolute Maximum: 14.4 Volts DC		
Power Pack Requirements: Use only Teledyne Isco-made power packs certified by UL. (P/N 60-1684-088)	120VAC ±12VAC, 60 Hz., 1.0 Amp. Note: This is the **only** version certified by UL. The line cord (mains connect cable) is the "Disconnect Device."		
Power Pack Requirements: (Use only Teledyne Isco-made CE certified power packs. (P/N 60-3004-190)	230VAC ±23VAC, 2.0 Amp, 50/60 Hz. Note: The line cord (mains connect cable) is the "Disconnect Device."		
Power Consumption[a]			
6712 Controller in Standby			10 mA
Average Current of Accessories			
Controller Display Backlight			228 mA
701 pH Module[b]			11 mA
710 Ultrasonic Module[b]			11 mA
720 Submerged Probe Module[b]			11 mA
730 Bubbler Module[b] — at 2 ft of liquid level — at 10 ft of liquid level			 24 mA 31 mA
750 Area Velocity Module[b]			12 mA
780 4-20 mA Module[b]			10 mA
YSI 600 with pH, DO, Conductivity, and Temperature[b]			11 mA

Table 1-3 Technical Specifications for the 6712C and Standard Samplers (Continued)

Programmable Analog 4-20 mA Output Option[c]	124 mA
CDMA cellular telephone modem — standby current — current while communicating	 35 mA 150 mA
GSM cellular telephone modem — standby current — current while communicating	 62 mA 230 mA

a. Current ratings when input power is 12.5 VDC and ambient temperature is 77 °F (25 °C)
b. Average current when programmed to take readings at 15 minute intervals.
c. Rating for three outputs.

Sampler Only Operating Current:	Approximately 30 mA based on 200 ml sample every hour, 10 ft (3 m) suction line, and 5 ft (1.5 m) suction head.

Teledyne Isco External Battery Capacity:Number of Complete Standard Sampling Routines

	Nickel-Cadmium Battery	Lead-Acid Battery
Sampler Only:	6	9
Sampler with pH Module:	6	9
Sampler with Ultrasonic Module:	6	9
Sampler with Submerged Probe Module:	6	9
Sampler with Bubbler Module (1-2 ft head):	3	5
Sampler with Area Velocity Module:	4	6
Sampler with 4-20 mA Module:	6	9

A Standard Sampling Routine is a 200 ml sample taken every hour in 24 bottle mode, with a 10 foot (3 m) vinyl suction line at 5 feet (1.5 m) of head. The module is set to take a reading every 15 minutes.

Flow Meter Signal Requirement:	5 to 15 volt DC pulse or isolated contact closure of at least 25 millisecond duration. (4 - 20 mA or pulse duration signal may be converted with optional interface unit.)

Table 1-3 Technical Specifications for the 6712C and Standard Samplers (Continued)

6712 Controller: Software Specifications	
Suction Line:	Programmable 3 to 99 ft (1 to 30 m) lengths of: • 3/8" (0.95 cm) I.D. Vinyl • 3/8" (0.95 cm) I.D. PTFE-lined with polyethylene jacket
Sample Frequency:	• From 1 minute to 99 hours and 59 minutes in 1 minute increments between consecutive samples. • Nonuniform times in minute intervals or clock time • Random time intervals between consecutive samples • From 1 to 9,999 flow pulses in single-pulse intervals • Flow paced in volume with attachable flow module
Rainfall Reading Units:	Inches or millimeters

Module Readings:		
pH	8 bits representing pH 16 bits representing temp.	0.1 pH storage resolution 0.1 °C storage resolution
Ultrasonic	16 bits representing level	0.0001 m storage resolution
Submerged Probe	16 bits representing level	0.0001 m storage resolution
Bubbler	16 bits representing level	0.0001 m storage resolution
Area Velocity	16 bits representing level 16 bits representing velocity	0.0001 m storage resolution 0.001 ft/s storage resolution
4–20 mA	16 bits representing percent 16 bits representing level 32 bits representing flow	0.1% storage resolution

SDI-12 Sonde Readings:

Parameter	Range	Resolution	Storage Bytes
Temperature	-40 - 100 °C	0.1 °C	2
Conductivity	0 - 100 mS/cm	0.01 mS/cm	2
Specific Conductance	0 - 100 mS/cm	0.01 mS/cm	2
Total Dissolved Solids	0 - 90 g/l	0.01 g/l	2
Salinity	0 - 70 ppt	0.1 ppt	2
Dissolved Oxygen	0 - 20 mg/l	0.1 mg/l	1
pH	0 - 14	0.1	1
ORP	-999 - 999 mv	0.1 mv	2
Level	0 - 6.5279 m	0.0001 m	2
Ammonium-Nitrogen	0 - 200 mgN/l	0.1 mgN/l	2
Ammonia-Nitrogen	0 - 200 mgN/l	0.1 mgN/l	2
Nitrate-Nitrogen	0 - 200mgN/l	0.1 mgN/l	2
Turbidity	0 - 5000 NTU	0.1 NTU	2
Chloride	0 - 1000 mg/l	0.1 mg/l	2
Chlorophyll	0-400 ug/l	0.1 ug/l	2
Other	-99999.0-99999.0	0.0001	4

Table 1-3 Technical Specifications for the 6712C and Standard Samplers (Continued)	
Module Reading Conversions:	• Level and 4–20 mA readings converted to flow rate units: gallons per second — gallons per minute million gallons per day — cubic feet per second cubic meters per second — cubic meters per hour cubic meters per day — liters per second • Velocity units: feet per second — meters per second • Totalized flow units: gallons — million gallons cubic feet — cubic meters liters • Devices supported in flow conversion: Weirs: V-notch; 22.5, 30, 45, 60, 90, and 120 degrees Rectangular; with and without end contractions Cipoletti. Flumes: Parshall; 1", 2", 3", 6", 9", 1.5', 2', 3', 4', 5', 6', 8', 10', 12' Palmer-Bowlus; 4", 6", 8", 12", 15", 18", 21", 24", 27", 30", 48" Trapezoidal; LG 60 V, 2" 45 WSC, 12" 45 SRCRC H; 0.5', 0.75', 1', 1.5', 2', 2.5', 3', 4.5' Equation: $Q = a \times H^{b+c} \times H^{d}$ where: Q = flow H = head a,b,c, and d = entered values Manning Formula: Round, U-channel, Rectangular, Trapezoidal Area Velocity: Round, U-channel, Rectangular, Trapezoidal Data Points: 50 level-flow rate points, 50 level-area points
Refrigerator Temperature Sensor	Optional sensor and 5 ft (1.55 m) cable to record temperature readings. Intended for use with fiberglass refrigerated (FR) samplers. Range: -40.0 °C to 100 °C Accuracy specification: ±0.3 °C over a range of 0.0 to 10.0 °C. Reading data is 2 bytes, with a storage resolution of 0.1 °C.
6712 Standard Portable Sampler: Physical Specifications	
Dimensions:	Height: 27 inches (68.6 cm) Diameter: 19.96 inches (50.7 cm)
Sampler Tub Configurations:	• 24 wedge polypropylene bottles, 1,000 ml • 24 round glass bottles, 350 ml • 12 round polypropylene bottles, 1,000 ml • 12 round glass bottles, 950 ml • 8 round polyethylene bottles, 2.0 liters • 8 round glass bottles, 1.8 liters • 4 round polyethylene bottles, 3.7 liters (1 gal) • 4 round glass bottles, 3.7 liters (1 gal) • 1 round polyethylene bottle, 9.4 liters (2.5 gal) • 1 round glass bottle, 9.4 liters (2.5 gal)
Dry Weight:	32 lbs (15 kg)
This includes the top cover, center section, tub, controller, pump tube, distributor arm, distributor arm nut, and discharge tube for the 24 bottle configuration.	

Table 1-3 Technical Specifications for the 6712C and Standard Samplers (Continued)

Dry Weight With:	24 plastic bottles, hold down, no caps	36 lbs	(17 kg)
	24 glass bottles, expander ring, no caps	55 lbs	(25 kg)
	12 plastic bottles, insert, expander ring, no caps	37 lbs	(17 kg)
	12 glass bottles, insert, expander ring, no caps	45 lbs	(21 kg)
	8 plastic bottles, insert, hold down, no caps	36 lbs	(17 kg)
	8 glass bottles, insert, hold down, no caps	46 lbs	(21 kg)
	4 plastic bottles, insert, hold down, no caps	36 lbs	(17 kg)
	4 glass bottles, insert, hold down, no caps	45 lbs	(21 kg)
	1 plastic bottle and composite tube guide, no cap, arm or nut	34 lbs	(16 kg)
	1 glass bottle and composite tube guide, no cap, arm or nut	38 lbs	(18 kg)
Filled Bottle Weight:	24 plastic bottles	101 lbs	(46 kg)
	24 glass bottles	104 lbs	(48 kg)
	12 plastic bottles	89 lbs	(41 kg)
	12 glass bottles	95 lbs	(43 kg)
	8 plastic bottles	84 lbs	(38 kg)
	8 glass bottles	90 lbs	(41 kg)
	4 plastic bottles	98 lbs	(45 kg)
	4 glass bottles	104 lbs	(48 kg)
	1 plastic bottle	90 lbs	(41 kg)
	1 glass bottle	94 lbs	(43 kg)
This includes everything in the Dry Weight, Dry Weight With, and Ice Capacity specifications, and the bottles are filled to the capacities listed in Sampler Tub Configurations. This weight does not include a power source.			
Ice Capacity:	24 plastic bottles	12 lbs	(5.4 kg)
	24 glass bottles	30 lbs	(13.6 kg)
	12 plastic bottles	16 lbs	(7.3 kg)
	12 glass bottles	16 lbs	(7.3 kg)
	8 plastic bottles	12 lbs	(5.4 kg)
	8 glass bottles	12 lbs	(5.4 kg)
	4 plastic bottles	28 lbs	(12.7 kg)
	4 glass bottles	25 lbs	(11.3 kg)
	1 plastic bottle	35 lbs	(15.9 kg)
	1 glass bottle	35 lbs	(15.9 kg)
3/4" × 3/4" × 1/4" approximate ice cube size. Ice capacity will vary with the size of the cubes.			

Cooling Capacity Configuration:	Sample Size	Cooling Water	Last Sample	Last Sample Temp
24 plastic bottles	500 ml Sample	61 °F (16 °C)	Sample 24	63 °F (17 °C)
24 glass bottles	175 ml Sample	39 °F (4 °C)	Sample 24	41 °F (5 °C)
12 plastic bottles	500 ml Sample	36 °F (2 °C)	Sample 12	54 °F (12 °C)
12 glass bottles	475 ml Sample	36 °F (2 °C)	Sample 12	54 °F (12 °C)
8 plastic bottles	1,000 ml Sample	50 °F (10 °C)	Sample 8	57 °F (14 °C)
8 glass bottles	900 ml Sample	37 °F (3 °C)	Sample 8	54 °F (12 °C)
4 plastic bottles	1,850 ml Sample	34 °F (1 °C)	Sample 4	34 °F (1 °C)
4 glass bottles	1,850 ml Sample	37 °F (3 °C)	Sample 4	37 °F (3 °C)
1 plastic bottle	12–400 ml Samples	37 °F (3 °C)	Composite Sample	37 °F (3 °C)
1 glass bottle	12–400 ml Samples	36 °F (2 °C)	Composite Sample	36 °F (2 °C)

The cooling capacity is the temperature of the sample and the cooling water 24 hours after the last sample is taken. The amount of ice specified for the ice capacity was used. The temperature of the sample liquid is 65 °F (18 °C). The ambient temperature is 75 °F (24 °C).

Average Thermal Resistance Factor:	R-10

The average R-value for a complete sampler. This includes a tub, center section, top cover, controller, pump tube, distributor arm, and discharge tube.

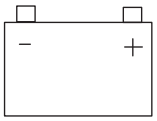
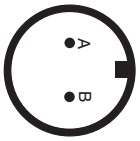
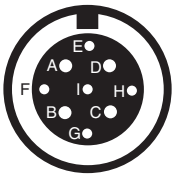
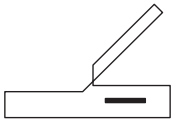
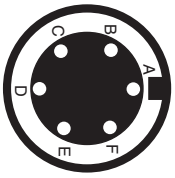
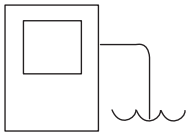
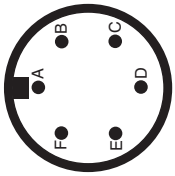
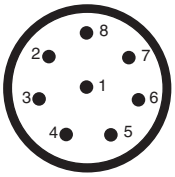
Table 1-3 Technical Specifications for the 6712C and Standard Samplers (Continued)

6712 Standard Sampler with Optional 5 Gallon Bottle: Physical Specifications	
Dimensions	
Base Alone:	Height: 15.4 inches (39.1 cm) Diameter: 19.9 inches (50.6 cm)
Assembled Sampler:	Height: 31.5 inches (80.0 cm) Diameter: 19.9 inches (50.6 cm)
Sampler Tub Configuration:	1 round glass bottle, 5 gallons (18.9 liters)
Dry Weight:	52 lbs (24 kg)
This includes the top cover, center section, bottle base, 5 gallon glass bottle, controller, pump tube, and discharge tube.	
Ice Capacity:	21 lbs (9.5 kg)
3/4" × 3/4" × 1/4" approximate ice cube size. Ice capacity will vary with the size of the cubes.	
Filled Bottle Weight:	115 lbs (52 kg)
This includes everything in the Dry Weight and the Ice Capacity specifications, and the bottle is filled to the capacities listed in Sampler Tub Configurations. This weight does not include a power source.	
Cooling Capacity:	Sample Size / Cooling Water / Composite Sample Temperature 12–800 ml Samples / 36 °F (2 °C) / 36 °F (2 °C)
The cooling capacity is the temperature of the sample and the cooling water 24 hours after the last sample is taken. The amount of ice used is specified in "ice capacity." The sampler is set up to take one sample every hour for twelve hours filling the bottle half full. The temperature of the incoming sample liquid is 65 °F (18 °C). The ambient temperature is 75 °F (24 °C).	
Average Thermal Resistance Factor:	R-10
This is the average R-value for the complete sampler. This includes a bottle base, center section, top cover, controller, pump tube, discharge tube, and composite tube guide.	
6712 Compact Portable Sampler: Physical Specifications	
Dimensions:	Height: 27.6 inches (70.1 cm) Diameter: 17.75 inches (45.1 cm)
Sampler Tub Configurations:	• 24 wedge polyethylene bottles, 500 ml • 12 round polyethylene bottles, 500 ml • 12 round glass bottles, 375 ml • 1 round polyethylene bottle, 9.4 liters (2.5 gallon) • 1 round glass bottle, 9.4 liters (2.5 gallon)
Dry Weight:	31 lbs (14 kg)
This includes the top cover, center section, tub, controller, pump tube, distributor arm, distributor arm nut, and discharge tube for the 24 bottle configuration.	
Dry Weight With:	24 plastic bottles, insert, hold down, no caps 35 lbs (16 kg) 12 plastic bottles, insert, expander ring, no caps 35 lbs (16 kg) 12 glass bottles, insert, expander ring, no caps 43 lbs (20 kg) 1 plastic bottle and composite tube guide, no cap, arm or nut 33 lbs (15 kg) 1 glass bottle and composite tube guide, no cap, arm or nut 37 lbs (17 kg)

Table 1-3 Technical Specifications for the 6712C and Standard Samplers (Continued)

Filled Bottle Weight:	24 plastic bottles	70 lbs	(32 kg)
	12 plastic bottles	62 lbs	(28 kg)
	12 glass bottles	66 lbs	(30 kg)
	1 plastic bottle	66 lbs	(30 kg)
	1 glass bottle	73 lbs	(33 kg)
This includes everything in the Dry Weight, Dry Weight With, and Ice Capacity specifications, and the bottles are filled to the capacities listed in Sampler Tub Configurations. This weight does not include a power source.			
Ice Capacity:	24 plastic bottles	8 lbs	(3.6 kg)
	12 plastic bottles	13 lbs	(5.9 kg)
	12 glass bottles	13 lbs	(5.9 kg)
	1 plastic bottle	12 lbs	(5.4 kg)
	1 glass bottle	15 lbs	(6.8 kg)
3/4" x 3/4" x 1/4" approximate ice cube size. Ice capacity may vary with the size of the cubes.			
Cooling Capacity:			
Configuration:	Sample Size	Cooling Water	Last Sample / Last Sample Temp
24 plastic bottles	250 ml Sample	41 °F (5 °C)	Sample 24 / 55 °F (13 °C)
12 plastic bottles	250 ml Sample	34 °F (1 °C)	Sample 12 / 41 °F (5 °C)
12 glass bottles	175 ml Sample	34 °F (1 °C)	Sample 12 / 43 °F (6 °C)
1 plastic bottle	12–400 ml Samples	43 °F (6 °C)	Composite Sample / 43 °F (6 °C)
1 glass bottle	12–400 ml Samples	39 °F (4 °C)	Composite Sample / 39 °F (4 °C)
The cooling capacity is the temperature of the sample and the cooling water 24 hour after the last sample is taken. The amount of ice specified for the ice capacity was used. The temperature of the sample liquid is 65 °F (18 °C). The ambient temperature is 75 °F (24 °C).			
Average Thermal Resistance Factor:	R-11		
The average R-value for a complete sampler. This includes a tub, center section, top cover, controller, pump tube, distributor arm, and discharge tube.			

Table 1-4 Connector Specifications

Connector Icon	Pin Location Diagram	Pin Function
POWER SOURCE 	**2-PIN MALE, SEALED** 	A Ground B +12 volts DC
RAIN GAUGE	**9-PIN FEMALE, SEALED** 	A +12 volts DC B Ground C 5V Programmable I/O1 pin D Rain gauge input E 12V switched F SDI-12 Data recv G SDI-12 Transmit H 5V Programmable I/O2 pin I 5V Programmable I/O3 pin
INTERROGATOR 	**6-PIN FEMALE, SEALED** 	A Switched +12 volts DC B Ground C Connection Sense D Transmit E Receive F NC
FLOW METER 	**6-PIN MALE, SEALED** 	A +12 volts DC B Ground C Flow Pulses In D Bottle Number Out Dual Sampler Out E Event Mark Out F Inhibit In
MODULE (IN MODULE BAY)	**8-PIN MALE, SEALED** 	1 NC 2 +12 volts DC 3 Ground 4 Module Sense 5 Receive 6 Transmit 7 Clock 8 Control

6712 Portable Sampler

Section 2 Installation/Preparation

2.1 Preparing the Sampler

When sampling with a single bottle, the composite tube guide is installed and the discharge tube is threaded through the guide.

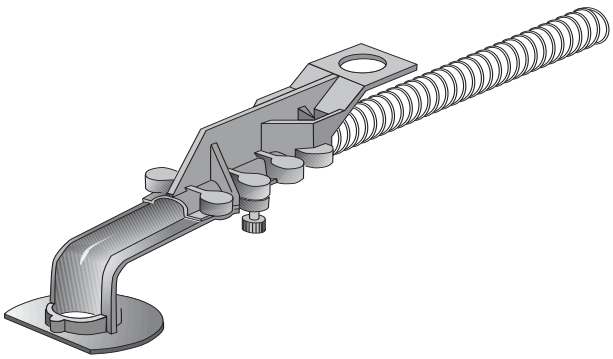
When sampling with multiple bottles, both the compact and standard 6712 Samplers use a distributor arm. It is adjustable so that you can position the discharge tube over the bottles of each kit. Each bottle kit also uses a discharge tube of a specific length. Table 2-1 lists the correct discharge tube lengths for each bottle kit. After installing the distributor arm and discharge tube, run the distributor to each bottle position to ensure proper installation.

If using bulk tubing to cut your own tubes, cut the ends of the tube square, not at an angle, and cut the length accurately.

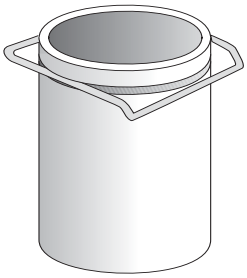
2.2 Installing the Distributor Arm and Discharge Tube

The two-piece distributor arm has four positions, marked on the underside with the letters A, B, C, and D. Adjust the arm to the correct position for the bottle kit being used. Table 2-1 shows the correct position for each kit. Thread the discharge tube through the spring and arm so that the tube protrudes from the arm $^{1}/_{16}$ to $^{1}/_{8}$ inch. If too much tube protrudes from the arm it can catch on bottles and jam the distributor arm.

Attach the arm to the distributor shaft. Secure the arm with the black plastic nut. Slide the free end of the discharge tube onto the bulkhead fitting.



Distributor Arm



Composite Tube Guide

Step 1

The two-piece arm has four positions, marked on the underside with the letters A, B, C, and D. Adjust the arm to the correct position for the bottle kit. Table 2-1 shows you the correct position for each kit.

Thread the discharge through the spring and arm so that the tube protrudes from the arm 1/16 to 1/8 inch.

Step 2

Attach the arm to the distributor shaft. The arm and shaft are keyed so that you can align them correctly. Secure the arm to the shaft with the black plastic nut.

Step 3

Slide the end of the discharge tube onto the bulkhead fitting.

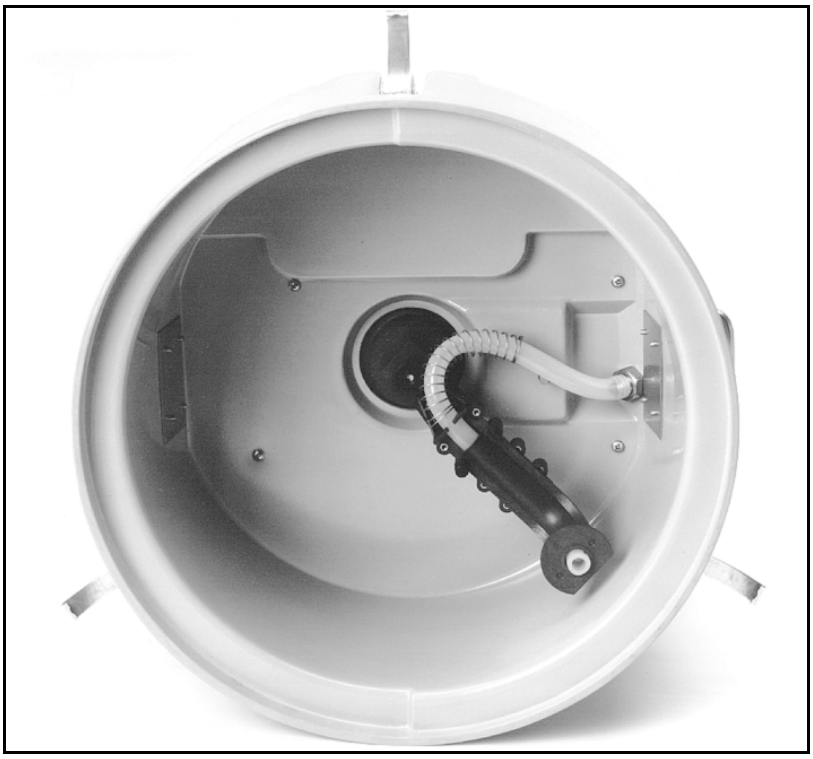


Figure 2-1 Installing the Distributor Arm

Table 2-1 Distributor Arm Adjustments and Discharge Tube Lengths for Bottle Kits

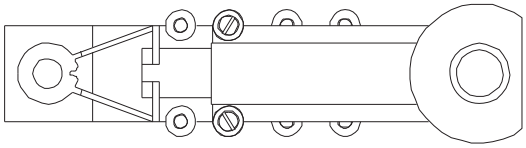
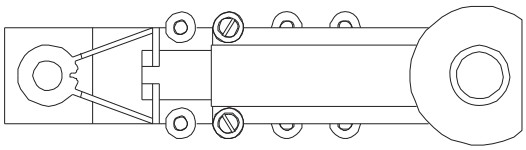
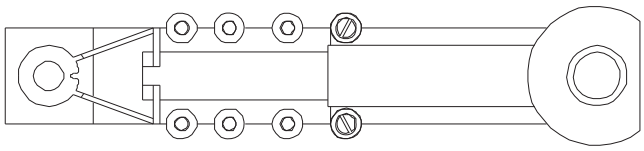
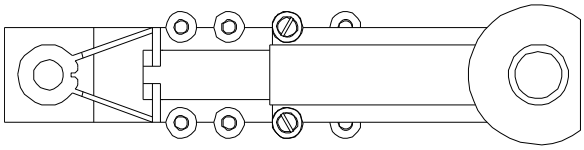
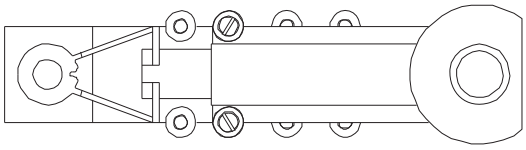
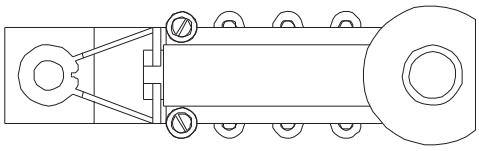
Compact 24-Bottle Kit • 500-milliliter polyethylene bottle Distributor Arm Position: B Discharge Tube: 60-9003-257 Discharge Tube Length: 14 1/4 inches (36.2 cm)	
Compact 12-Bottle Kit • 375-milliliter glass bottles • 500-milliliter polyethylene bottles Distributor Arm Position: B Discharge Tube: 60-9003-257 Discharge Tube Length: 14 1/4 inches (36.2 cm)	

Table 2-1 Distributor Arm Adjustments and Discharge Tube Lengths for Bottle Kits

Standard 24-Bottle Kit • 350-milliliter glass bottles • 1,000-milliliter polypropylene bottles Distributor Arm Position: D Discharge Tube: 60-9003-260 Discharge Tube Length: 17 1/4 inches (43.8 cm)	
Standard 12-Bottle Kit • 950-milliliter glass bottles • 1,000-milliliter polypropylene bottles Distributor Arm Position: C Discharge Tube: 60-9003-262 Discharge Tube Length: 16 1/2 inches (41.9 cm)	
Standard 8-Bottle Kit • 1.8-liter glass bottles • 2.0-liter polyethylene bottles Distributor Arm Position: B Discharge Tube: 60-9003-264 Discharge Tube Length: 15 3/4 inches (40.0 cm)	
Standard 4-Bottle Kit • 3.7-liter (1-gallon) glass bottles • 3.7-liter (1-gallon) polyethylene bottles Distributor Arm Position: A Discharge Tube: 60-9003-266 Discharge Tube Length: 15 inches (38.1 cm)	

2.3 Installing Bottle Kits for Multiplex Sampling

The samplers are shipped from the factory with sample bottles in place. When using the sampler for the first time, you will only need to remove the bottle lids. When installing cleaned bottles or a new kit, keep these guidelines in mind:

- **Never** mix glass and plastic bottles together.
- Install all bottles to insure that they remain in place.
- Align the bottles correctly. If the bottles are misaligned, the sampler may miss the bottle mouth, or the sampler will deposit samples in the “wrong” bottle.

- Each time you change from one size bottle to another, you must adjust the length of the distributor arm and install a discharge tube of the correct length.
- Each time you install a bottle kit, check the program settings for the number of bottles and bottle volume.

You must adjust the distributor arm and use a different discharge tube for each bottle kit. See *Installing Distributor Arm and Discharge Tube*, and Table 2-1 for more information.

2.3.1 Aligning Bottle Kits in the Standard Tub

Figures 2-2 through 2-5 show each kit being installed in the standard tub. Refer to Table 2-1 to adjust the distributor arm to the correct length and use the correct length of discharge tube.

1. Install the bottles then secure the plastic retaining ring with the three draw cords. (For glass bottles use the stainless steel retaining ring).
2. Adjust the distributor arm to the correct position, insert the discharge tube, and attach the distributor arm.

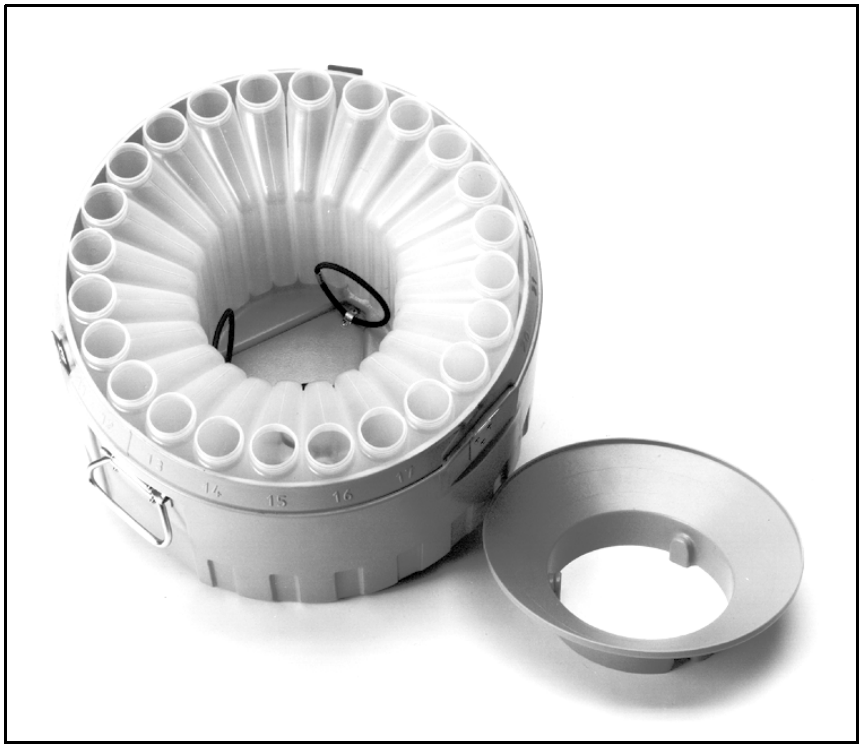


Figure 2-2 Placing the 24-Bottle Kit in a Standard Tub

1. Slide the 12-bottle insert into the tub, aligning the label with the corresponding numbers on the outside of the tub.
2. Place the bottles in the insert. Secure the bottles against the wall with the stainless steel retaining ring.
3. Adjust the distributor arm to the correct position, insert the discharge tube, and attach the distributor arm.

Figure 2-3 Placing the 12-Bottle Kit in a Standard Tub

1. Position the 8-bottle insert in the tub, aligning the label with the corresponding numbers on the outside of the tub.
2. Place the bottles in the insert then secure the plastic bottle insert with the three draw cords.
3. Adjust the distributor arm to the correct position, insert the discharge tube, and attach the distributor arm.

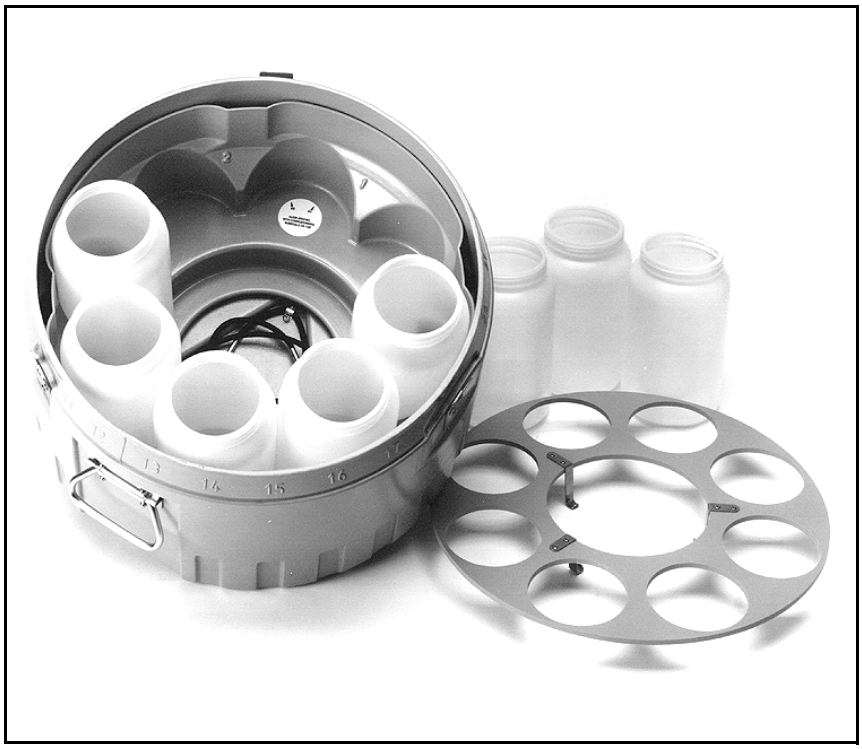


Figure 2-4 Placing the 8-Bottle Kit in a Standard Tub

1. Place the rack in the tub, aligning the label with the corresponding numbers molded on the outside of the tub.
2. Place bottles in the rack and secure the hold down over the bottles with the three draw cords.
3. Adjust the distributor arm to the correct position, insert the discharge tube, and attach the distributor arm.

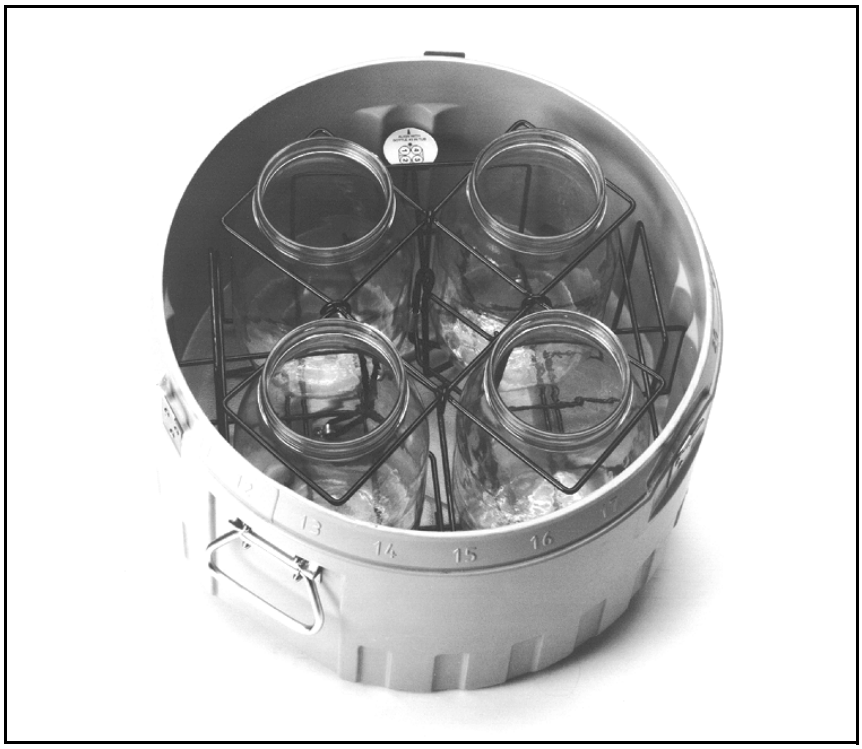


Figure 2-5 Placing the 4-Bottle Kit in a Standard Tub

Compact Sampler Tub Alignment Notches

Aligning the carrier

Figure 2-6 Placing the carrier in the compact tub

2.3.2 Aligning Bottle Kits in the Compact Tub

To align the bottles:

1. Place the bottles in the carrier, and secure them with the appropriate retaining ring.
2. Place the carrier in the tub, aligning it as shown in Figure 2-6. The carrier will drop into the notches when properly aligned.

2.4 Installing Bottle Kits for Composite Sampling

You can install a single $2^1/2$ gallon bottle in either the standard or compact sampler tub for composite sampling. Single bottle sampling uses a composite tube guide instead of a distributor arm to position the discharge tube over the bottle. Install the composite tube guide and discharge tube as shown in Figure 2-7. Discharge tube part numbers and lengths are listed in Table 2-2.

The compact and standard sampler bottle bases accept a $2^1/2$ gallon glass or plastic bottle. Place the bottle in the recess formed in the bottle base.

2.4.1 Optional Jumbo Bottle Base

You can install an optional bottle base on the standard sampler to collect larger composite volumes. The optional base replaces the standard tub and holds a 4 gallon (15 liter) polyethylene bottle, 5 gallon (19 liter) glass bottle or 5.5 gallon (20.8 liter) polyethylene bottle. Prepare the sampler as shown in Table 2-2 and Figure 2-7, and place the bottle in the recess formed in the bottle base.

Step 1

Both the compact and standard samplers use the same composite tube guide to hold the discharge tube in place over the composite bottle.

Attach the composite tube guide by firmly sliding it onto the distributor-shaft housing. It will snap in place. The guide has a slot that fits over a key on the housing to align it.

Step 2

Thread the discharge tube through the guide as shown. Attach the tube to the bulkhead fitting.

Removal

To remove the composite tube guide, rotate the metal clip to one side while pulling the guide away from the center section.

Figure 2-7 Installing the Composite Tube Guide

Table 2-2 Discharge Tubes for Composite Sampling

Configuration	Discharge Tube	Discharge Tube Length
Compact 1 Bottle • 9.4-liter ($2^1/2$ gallon) glass bottle • 9.4-liter ($2^1/2$ gallon) polyethylene bottle	60-9003-258	10 inches (25.4 cm)
Standard 1 Bottle • 9.4-liter ($2^1/2$ gallon) glass bottle • 9.4-liter ($2^1/2$ gallon) polyethylene bottle	60-9003-271	12 inches (30.5 cm)
Jumbo Bottle Option • 15 liter (4 gallon) polyethylene bottle • 19 liter (5 gallon) glass bottle • 20.8 liter (5.5 gallon) polyethylene bottle *Standard samplers only. Requires the Jumbo Bottle Base*	60-9003-271	12 inches (30.5 cm)

5 Gallon Glass Composite Bottle | **2.5 Gallon Plastic Composite Bottle** | **2.5 Gallon Glass Composite Bottle**

Figure 2-8 Composite Bottles

2.5 Installing a Power Source

The 6712 Sampler requires 12-volt DC power. Power sources available from Teledyne Isco are listed below.

946 Lead Acid Battery

934 Nickel Cadmium Battery

913 High Capacity Power Pack (120 volts AC, 50/60 Hz)

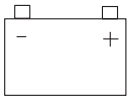
923 High Capacity Power Pack (240 volts AC, 50/60 Hz)

914 Battery Backed Power Pack (120 volts AC, 50/60 Hz)

924 Battery Backed Power Pack (240 volts AC, 50/60 Hz)

(the 924 is not certified for use in Europe)

948 45 Amp Hr Battery



Power Source Connector Icon

Connect the power source to the sampler connector that is labeled with this icon.

To install the smaller batteries or power packs on the sampler:

1. Place the power source in the sampler's battery recess.
2. Secure the power source with the black rubber draw-catches.
3. Attach the power-source cable to the power-source connector on the controller.

⚠ CAUTION

Use only Teledyne Isco-made power packs. If using a power pack with the 6712, Teledyne Isco recommends you use the new 913 or 923 power pack. Older model power packs may not provide sufficient power.

Refer to the *Teledyne Isco Power Products Guide* shipped with your sampler for more information on Teledyne Isco's power sources.

If you use a 120 or 240 volt AC-connected power pack, the AC line cord is the "Disconnect Device." Always install the sampler with the line cord and plug visible and readily accessible, so that power can be disconnected easily.

2.5.1 Connecting an External 12-Volt DC Source

You can also power the sampler with an external 12-volt DC source, such as an automotive battery. Connect the sampler to the battery with the External 12-Volt DC Power Cable.

⚠ CAUTION

Be sure to attach the positive and negative clips to the correct battery terminals. If polarity is reversed, the sampler may be permanently damaged.

2.6 Suction Line

The suction line is the tubing from the sampling point to the pump intake. The 6712 uses a 3/8-inch ID suction line of lengths 3 to 99 feet. Teledyne Isco offers vinyl or PTFE suction lines. The PTFE tubing has a polyethylene jacket to protect it from kinks and abrasions.

Guidelines for Measuring and Cutting the Suction Line:

- Cut the line to the desired length but use the shortest length feasible for the installation.
- Cut the line in 1 foot increments. For instance, 4 feet, not 3 1/2. If using metric units of measure, cut the line in increments of 0.1 meter. Do not include the length of the strainer in the measurement.

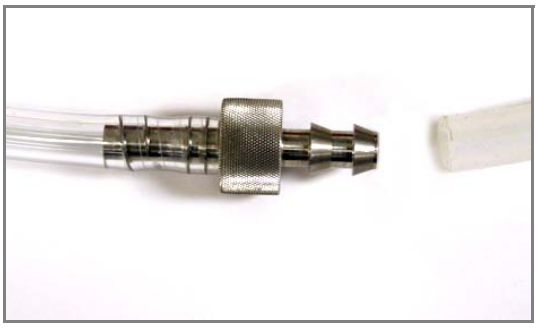
The vinyl line contains a very low parts-per-million level of phenols. If phenol content affects your sample analysis, use the PTFE suction line.

When installing the sampler, be sure the vertical distance between the liquid level and the pump is as small as possible.

2.6.1 Attaching Suction Line to Pump Tube

Attach the vinyl suction line to the pump tube with the 3/8-inch tubing coupler. First, screw the threaded end into the suction line until the flat surface is flush against the suction line (Figure 2-9). Then, push the other end of the coupler into the end of the pump tube until the other flat surface is flush against the tubing.

1.



2.

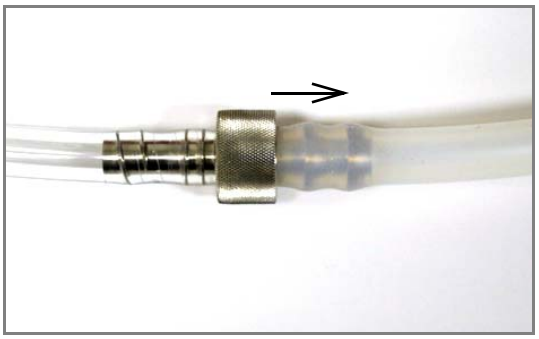


Figure 2-9 Attaching the suction line to the pump tubing

Once the coupler is attached to the pump tube, removal is difficult, and may require cutting the tube.

2.7 Strainers

Teledyne Isco offers three styles of strainer that help prevent solids from clogging the suction line:

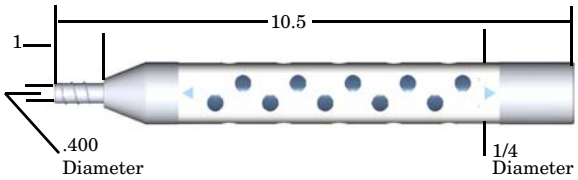
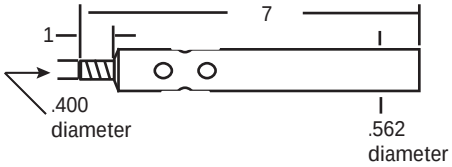
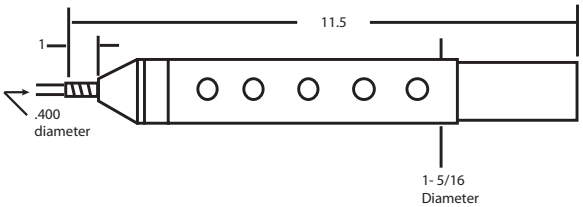
- 3/8-inch standard weighted polypropylene strainer for routine and priority pollutant sampling
- 3/8-inch stainless steel low flow strainer
- 3/8-inch CPVC-coated strainer for acidic liquid sources

To select the right strainer for your application, see Table 2-3. To install the optional stainless strainer in PTFE suction line, heat the end of the suction line to make it more pliable, then carefully screw the strainer's threaded connector into the suction line.

2.7.1 Alternative to Strainers

When sampling from high velocity streams with heavy suspended solids, some field investigations suggest that more representative samples are obtained without the strainer. Consider attaching a short piece of thin walled aluminum tubing to the end of the suction line; anchor the tubing so that the inlet opens upstream. The aluminum tubing's thin wall will not disturb the flow stream, and most sample analyses disregard aluminum ions. Under most conditions, the pre-sample purge removes any debris over the tubing entrance.

Table 2-3 Selecting the Right Strainer

Strainer	Dimensions	Application	Maximum Depth
3/8 Stainless Steel Ends, Polypropylene Center		Routine applications.	Vinyl Line: 22 feet (6.7m). PTFE Line: 15 feet (4.5m).
3/8 Stainless Steel Low Flow		Low flow applications	Vinyl Line: 22 feet (6.7m). Teflon Line: 15 feet (4.5m).
3/8 CPVC		Highly acidic liquids.	Vinyl Line: 4 feet (1.2m).

Note

- The suction lines will float when filled with air during the purge cycles and when depths exceed the listed ratings. Secure the suction lines when sampling at depths exceeding the maximum ratings.
- All strainer dimensions are in inches.
- PTFE suction line is compatible only with the 3/8 stainless steel strainer.

2.8 How Does the Sampler Work?

When the sampler takes a sample, it draws liquid through the strainer and suction line to the pump tube. The liquid flows through the pump tube and past the liquid detector, which senses the liquid. From the detector, the liquid follows the pump tube through the pump to the bulkhead fitting and then through the discharge tube to the sample bottle.

2.8.1 A Typical Sampling Cycle

1. The sampler moves the distributor arm over the bottle that is to receive the sample.
2. The pump reverses for the pre-sample purge.
3. The pump direction changes, filling the suction line.
4. When the detector senses liquid, the sampler begins measuring the sample.
5. After depositing the sample, the pump again reverses for the post-sample purge.

Sampling cycles vary somewhat according to program settings for distribution. The sampler can move the distributor arm clockwise and counterclockwise, making a number of distribution methods possible. (In this manual, the words “sample event” refer to a full sampling cycle for any distribution.)

Other variations include extended-program settings for suction-line rinses and sampling retries. A sampler running a program with line rinses completes the pre-sample purge and then rinses the line. The suction line is purged after each rinse. When programmed for sampling retries, the sampler will attempt to pump a sample again if it fails on previous attempts.

a. Controller.
b. Peristaltic pump.
c. Liquid Detector.
d. Strainer
e. Suction line
f. Stainless Steel Coupling
g. A pump tube routed from the liquid detector’s intake port through the pump, out the detector’s discharge port, and over the side of the controller to a bulkhead fitting at the top of the center section.
h. Bulkhead fitting.
i. Discharge tube running from the bulkhead fitting on the inside of the center section through the spring and distributor arm.
j. Distributor arm and spring.

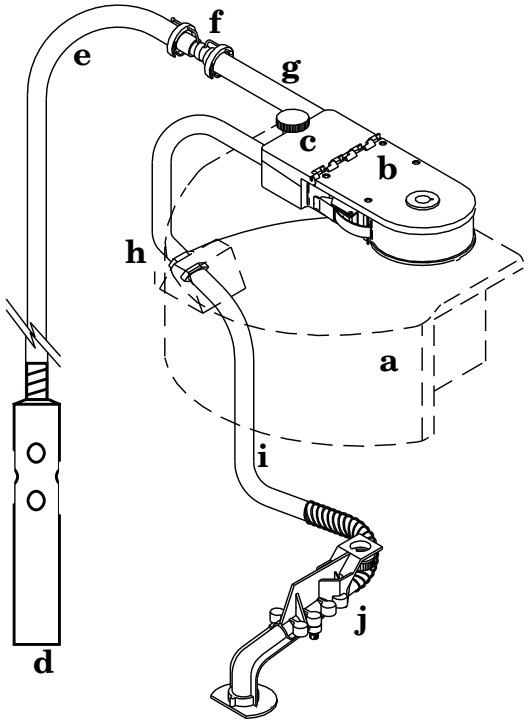


Figure 2-10 Identifying the Sampler Components

2.8.2 Measuring Sample Volume

"Sample volume" refers to the amount of liquid delivered into a bottle. The volume is determined by the programmed value. The volume is dependent on the volume per revolution of the pump, which is dependent on the suction head. The 6712 delivers the sample by counting the pump revolutions and automatically compensating for the suction head.

2.9 Installing the Sampler

The following paragraphs briefly describe initial sampler installation.

⚠ CAUTION

Tests indicate that the pump produces sound levels in excess of 85db at one meter. Prolonged exposure to this sound could result in hearing loss and requires the use of protective ear plugs.

2.9.1 Icing the Samples

Ice is placed in the center of the bottle kit or around the composite bottle. The ice capacity varies according to the bottle kit. To increase cooling for the multiple-bottle kits use an ice-water bath. Place as much ice as possible in the center of the bottle kit and slowly add cold water. Continually add ice, as the water will melt some ice.

Always use the retaining rings or hold downs. They hold the bottles in position and keep the bottles from floating.

2.9.2 Tips for Routing Suction Line

Route the line so that it runs continuously downhill from the sampler to the liquid source. This helps drain the line during pre-sample and post-sample purges. When the sampler is used in below freezing temperatures, there is a risk of the suction line being frozen. A suitably warm sampling source can usually prevent this, provided there are no loops in the suction line. Some situations may require more protective measures, such as insulation of the suction line, or heat tape. Thoroughly draining the suction line minimizes the possibility of frozen liquid clogging the line.

2.9.3 Intake Placement

For representative samples, place the intake in the main current of the flow stream, not in an eddy or at the edge of flow. Placing an intake at the bottom may produce samples with excess heavy solids and no floating materials, while placement at the top may produce the opposite conditions.

2.9.4 Positioning a Sampler

Place the sampler on a relatively flat, horizontal surface. Placing the sampler on a steep incline may cause the sample to miss the bottle mouth.

When installing the sampler, be sure the vertical distance between the level of the liquid and the pump is as small as possible.

⚠ CAUTION

When using the 6712 sampler with a 750 or 710 module, transmitters such as cell phones or walkie talkies must not be operated within 3 meters of the sampler. If water level readings are fluctuating due to TV/radio station transmitter towers in the area, the sampler must be relocated.

⚠ WARNING

The 6712 samplers have not been approved for use in hazardous locations as defined by the National Electrical Code.

⚠ WARNING

If you must enter a manhole or other dangerous location to install the sampler, observe standard safety precautions. Refer to Appendix C for a discussion of safety considerations.

2.9.5 Using the Suspension Harness or ProHanger

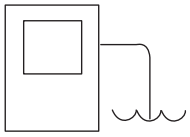
Teledyne Isco has a stainless steel suspension harness to lower or raise the sampler through a manhole or suspend the sampler during operation. You can suspend the harness from any suitable support. Prohanger is an X-shaped bracket that fits inside the lip of a manhole and lets you suspend the sampler using a cable harness.

2.10 Connecting External Instruments

The 6712 sampler can be used in conjunction with several types of external instruments.

2.10.1 Flow Meter

To connect the sampler to a Teledyne Isco open-channel flow meter, 4100 series flow logger, 2100 series flow module, or 1640 Liquid Level Actuator, attach the sampler-to-flow meter cable to the Flow Meter Connector. To connect the sampler to a closed-pipe flow meter, attach a Teledyne Isco 4-20 mA Input Interface device to the sampler's Flow Meter connector. When using the sampler with an external instrument, remember these guidelines:



Flow Meter Connector Icon

- Both the sampler and the flow instrument must be on and running a program.
- If using a flow meter, logger, or module for flow pacing, the sampler and the flow instrument must both run programs with flow pacing settings.
- If using a flow meter or flow logger for trigger pacing, the sampler must run a program with flow pacing settings, and the flow instrument must run a program with trigger pacing settings.
- When the sampler runs an event-paced program, it disregards pacing pulses from a flow meter or flow logger. However, the sampler continues to monitor for enable signals.

2.10.2 Rain Gauge Connector

Connect the rain gauge, SDI-12 Sonde, or Refrigerator Temperature Sensor connect cables to the nine-pin Rain Gauge Connector. When connecting a rain gauge and an SDI-12 Sonde, or rain gauge and a Refrigerator Temperature Sensor, use the appropriate Y-connect cable. See the Accessories appendix at the end of this manual.

Rain Gauge Connector Icon

⚠ WARNING

Most Teledyne Isco flow meters are not certified for use in hazardous locations as defined by the National Electrical Code. Contact your Teledyne Isco representative for your equipment's status. Never operate equipment in hazardous locations that has not been certified as safe for such use. Refer to Appendix C in the back of this manual for more safety information

☑ *Note*

Select Extended Programming to use the SDI-12 sonde. (See Switching Between Standard and Extended Modes on page 4-1.)

☑ *Note*

Update the Hardware Setup whenever you add or remove an SDI-12 sonde. (See Section 6.) In Extended Programming, rain gauge and SDI-12 sonde readings are only available if they are selected in the Hardware Setup.

Table 2-4 Connecting Teledyne Isco Instruments to the Sampler

Connector Icon	Connect These Instruments:
Power Source	12 volt power source
Rain Gauge	674 Rain Gauge Programmable I/O Pins (pins C, H, and I) SDI-12 Sonde Refrigerator Temperature Sensor
Interrogator	581 RTD (Rapid Transfer Device) IBM PC or compatible computer running FLOWLINK or SAMPLINK External Modem External Data Logger/Controller
Flow Meter	1640 Liquid Level Actuator 3000 Series Flow Transmitters 2100 Series Flow Modules 4100 Series Flow Loggers 4200 Series Flow Meters Master/Slave Sampler Pulse Duration Input Interface 4-20 mA Input Interface Closed-Pipe Flow Meters (using 4-20 mA Input Interface)

2.11 Locking the Sampler

Teledyne Isco offers stainless steel cables to lock the sampler (standard size – use P/N 68-6700-134; compact – use 68-6710-111). To lock the sampler, place the hook through the center section latch. Repeat this for the other two latches, and then pull the ends of the cables together over the top of the sampler. Lock the loops with the padlock. You can also lock each latch individually, using three padlocks, one for each of the latches.

2.12 Servicing the Sampler

Servicing the sampler includes:

- Recovering the sampler from the monitoring site
- Collecting the filled sample bottles and replacing them with clean bottles
- Replacing a battery, if required
- Collecting the data recorded by the sampler during the program.

Samplers are usually serviced after they complete a sampling program. When working up a service schedule, you will need to estimate the program completion time. You should also be familiar with the program's settings for the start time or if the sampler is programmed for continuous sampling.

Continuous sampling is controlled by the distribution setting entered at the "RUN CONTINUOUSLY?" screen. A "YES" response directs the sampler to reset the distribution sequence and continue the countdown to the next sample event. Appropriate service intervals will prevent overfilled bottles.

2.13 Recovering the Sampler

When recovering the sampler, keep it level to prevent spilling the collected samples.

If the battery's charge is questionable, replace it with a fully-charged battery.

The 6712 has a "fuel gauge" that gives an indication of power usage. The controller keeps track of how much power has been consumed since the last time it lost power. The current power consumption, as well as the previous power consumption, can be accessed by pressing the STOP key while in the main menu.

Keep in mind that the sampler has no idea as to how much charge was originally stored in the battery (or even if a battery is being used), and therefore has no idea as to the remaining capacity of its power source.

2.14 Collecting Sample Bottles

If you return the entire sampler back to the office, place caps on the bottles and drain any water from the carrier or tub. If you leave the sampler at the site and only need to collect the bottles, follow these guidelines for bottle collection.

2.14.1 Compact Sampler Bottle Collection

To collect the bottles from a compact sampler:

1. Open the latches, and lift the center section from the tub. Place caps on the bottles.
2. Remove the bottles by lifting the bottle carrier from the tub. Attach a label to the carrier detailing the location, date, etc.

Removing Bottles From the Compact Sampler

3. Pour any ice water out of the tub.

4. Slide a new bottle carrier filled with clean bottles into the tub.
5. Pour more ice into the carrier or tub.

2.14.2 Standard Sampler Bottle Collection

To collect the bottles from a standard sampler:

1. Open the latches, and lift the center section from the tub. Place caps on the bottles.
2. Drain any ice water from the standard tub by opening tub's drain plug. Remember to replace the plug's cap when done.
3. Attach a label to the tub or on each bottle detailing the location, time, date, etc.
4. Replace the standard tub and/or bottles with a clean set.
5. Pour more ice into the tub.

Drain Plug Location on the Tub

6712 Portable Sampler

Section 3 Programming Introduction

Before programming the 6712, you should become familiar with its keys and how to use the screens.

The 6712 Sampler has two sets of programming modes. The first mode, **Standard Programming**, lets you set up typical sampling programs easily and efficiently. The second mode, **Extended Programming**, lets you create sophisticated programs for complex sampling applications.

All of the sampling features available in standard programming mode are available in extended programming mode. However, extended programming provides many additional features.

Standard and extended programming features are explained in separate sections. This section focuses on some basic features that are common to both programming modes, such as using the menus and setting the clock.

⚠ CAUTION

This sampler has a high performance pump. As with all such pumps, it relies upon liquid to cool working components. If the sampler is programmed to pump in the absence of liquid in excess of 5 minutes, excessive heat buildup may damage the paddles, rollers, and housing. Ensure that the liquid inlet is completely immersed.

3.1 Initial Operation

Turn the sampler on by pressing the Standby key. It is labeled with this icon: ⏻. The start-up screen appears first.

```
6712 SAMPLER
STANDARD PROGRAMMING
For HELP at any
screen press ? key.
```

It remains on the display for about eight seconds or until you press a key. It tells you the type of programming screens the sampler is currently using — standard or extended — and gives you a tip about the on-line help. The main menu screen, shown below, appears next.

```
RUN
PROGRAM
VIEW REPORT
OTHER FUNCTIONS
```

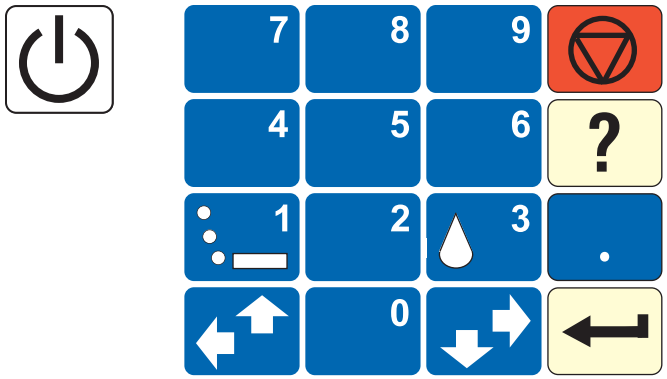
(If a module is attached, a different screen may appear first. See the module manual for more information.)

The sampler will continue to use the program mode you selected, even if the sampler is turned off and on again, until you manually switch to the other programming mode.

With the display backlight activated, the screen will glow for several seconds following your last keystroke.

If you press a key and the screen text does not change, it is probably because the keystroke turned the backlight on, instead of performing its function. Simply press the same key again.

Table 3-1 About the Keypad



Key	Name	Function
	Standby	Turns sampler on or off.
	Stop	Stops the pump or distributor. Pauses a running sampling program. In programming screens, returns to a previous screen.
	Enter	Accepts a menu choice or number entry and goes to next screen.
?	Help	In programming screens, displays a brief help message.
	Down-Right Arrow	Selects the menu option right or below the current choice.
	Up-Left Arrow	Selects the menu option left or above the current choice.
0	Numbers	Types a number.
.	Decimal Point	Types a decimal point.
1	Pump Reverse	Press when at the main menu to run the pump in reverse.
3	Pump Forward	Press when at the main menu to run the pump forward.

The sampler is programmed at the factory so that the standard programming screens appear when you first turn the sampler on. You can switch between programming modes by typing in a numerical command at the main menu:

- At the main menu type **6712.2** to show the extended programming screens.
- At the main menu type **6712.1** to show the standard programming screens.

3.1.1 Selecting a Language

You have the option of having screens display in English or another language. The default is English. At the main menu, type **6712.8:**

```
ENGLISH
SPANISH
```

Use the arrow keys to move between the choices (languages other than those shown above could appear on your unit). When the language choice you want is blinking, press ↵(Enter). The ↵ (Enter) key always accepts the blinking option.

3.2 Using Menus and Entering Numbers

A menu is a list of options. The main menu has four options:

The Main Menu

```
RUN
PROGRAM
VIEW REPORT
OTHER FUNCTIONS
```

- RUN
- PROGRAM
- VIEW REPORT
- OTHER FUNCTIONS

The options identify the operations that can be performed from the menu. For example, to run the sampling program, select RUN; to modify the program, select PROGRAM.

3.2.1 Selecting Menu Options

In menu screens, one menu option always blinks.

- Press ↵ when the blinking option is the one you want; it will accept your choice and go to the next screen.
- Select a different option by pressing an arrow key until the option you want blinks. Then press ↵.

3.2.2 Entering Numbers

Number-entry screens prompt you to enter a value. An example is shown to the left.

To enter a number:

```
SUCTION LINE LENGTH
IS __ ft
(3-99)
```

- Type the length of the suction line. Acceptable values are shown between the parentheses. Press ↵ to accept the number.

Press the number keys to type the number. Then, press ↵. As soon as you press ↵, the sampler saves your number and moves to the next screen. In some screens, you can use the . (Decimal Point) key in a number.

Some screens display the range of acceptable numbers between parentheses. If an entry is too low or high, the controller beeps and erases the entry. Type a new number and continue.

3.3 Quick View Screens

Quick view screens are a special type of menu screen. They show the current program settings and let you move quickly through the program. You must change the programming style to QUICK VIEW/CHANGE to see the quick view screens, as shown below:

1	RUN PROGRAM VIEW REPORT **OTHER FUNCTIONS**	Select OTHER FUNCTIONS.
2	MAINTENANCE MANUAL FUNCTIONS **PROGRAMMING STYLE**	Select PROGRAMMING STYLE.
3	PROGRAMMING STYLE NORMAL **QUICK VIEW/CHANGE**	Select QUICK VIEW/CHANGE.

3.3.1 Paging Through Quick View Screens

The arrows in the corners of each quick view screen are menu options that let you move from one quick view screen to another.

Select the up arrow (↑) to go to the previous screen.

Select the down arrow (↓) to go to the next screen.

Press Stop to return to the main menu.

Because the forward arrow is always blinking when the screen appears, you can simply press ↵ to go to the next quick view screen, making it easy to page through the screens.

3.3.2 Changing Settings in a Quick View Screen

Although the quick view screens offer you a quick way to see the program settings, they also provide you with a way to change settings. Using quick view screens to change settings is sometimes a faster way to change a program because you can go quickly to the setting or settings that needs updating.

To change the program settings in a quick view screen:

Press an arrow until the setting blinks. Press ↵. The 6712 then displays the screen used to change the setting.

The Quick View screens below shows you how to change the sample volume. Begin by paging through the quick view screens until you see the screen containing the sample volume setting **200 ml SAMPLES.**

When you change a setting, the sampler stores the new settings and returns to the updated quick view screen. You can repeat this process until all settings shown in the quick view screens have been changed. When you are done, select the screen's forward arrow to move to the next quick view screen, or press Stop to return to the main menu.

Quick View Screens in Standard Programming

```
RUN
PROGRAM
VIEW REPORT
OTHER FUNCTIONS
```

- To see the Quick View screens, select PROGRAM.

```
↑
SITE DESCRIPTION:
"SITE 29  "
                ↓
```

- Use the keypad's arrow key to select ↓ for the next quick view screen. When ↓ is blinking, press ↵.
- Use the keypad's arrow key to select ↑ for the previous quick view screen. When ↑ is blinking, press ↵.
- Use the keypad's arrow key to select the program setting. When the setting is blinking, press ↵ to display the screen used to change the setting.
- Press Stop for the main menu.
- All quick view screens work the same way.

```
↑
200 ml SAMPLES
                ↓
```

- Press the arrow key until 200 ml SAMPLES blinks. Then press ↵.

```
SAMPLE VOLUME:
250 ml (10-1000)
```

- Type the new sample volume and press ↵.

```
↑
250 ml SAMPLES
                ↓
```

3.4 Clock and Calendar

You may have to set the internal clock or calendar. The samplers are shipped with their clocks set to U.S. Central Standard time. If your sampler operates in a different time zone, you will have to reset the clock. The example to the left shows you how to find the time and date screen.

Entering Times and Dates

```
ENTER TIME AND DATE:
HH:MM   DD-MON-YY
__:__   __-__-__
```

- Move from one field to another by pressing the arrow keys.
- Change a setting in a field by typing a number. Press ↵ to accept the new setting.

When setting the clock and calendar, use a 24-hour clock for times and the day-month-year format for dates. The illustration at the left shows blanks for each position that accepts an entry. The positions are called fields. When this screen appears on your sampler, the fields will contain the sampler's current settings for the time and date.

- To move from one field to another without changing the setting, press the arrow keys. Use this technique when you want to change only one or two settings.
- Change the setting by typing a new number. Press ↵ to accept the new setting.

For example, to enter 2:00 p.m. (2:00 p.m is 14:00 on a 24-hour clock), type 14. Press ↵. Next, type 0 (zero) for the minutes, and press ↵. To enter a date, such as January 22, 2001, type: 22 ↵ 01 ↵ 01 ↵ .

3.4.1 Setting the Clock and Calendar

1	RUN PROGRAM VIEW REPORT **OTHER FUNCTIONS**	Select OTHER FUNCTIONS.
2	**MAINTENANCE** MANUAL FUNCTIONS PROGRAMMING STYLE	Select MAINTENANCE.
3	**SET CLOCK** PUMP TUBE ALARM INTERNAL BATTERY DIAGNOSTICS	Select SET CLOCK.
4	ENTER TIME AND DATE: HH:MM DD-MON-YY **14:00 22-JAN-01**	Enter the time and date.
5	SET CLOCK PUMP TUBE ALARM INTERNAL BATTERY DIAGNOSTICS	Press Stop to return to the main menu.

3.4.2 Menu Screens: Clock Start Times

There are four start time settings you can use in a sampling program. This section discusses only one of these settings, the clock start time. A clock start time lets you set up a sampling program that starts at the same time on one or more days of the week. For example, you may want to begin sampling at 6:00 a.m. on Monday through Friday (refer to the screen below).

To select a day or days from the menu:

1. Press an arrow key until the cursor is on the correct day. Then, press ↵.
2. Repeat these steps until each day you want is blinking.
3. Press an arrow until DONE blinks. Press ↵.

To remove days from the list:

1. Press an arrow key until the cursor is on the day you want to remove. Press ↵ to deselect it.
2. When finished, select DONE and press ↵

Using the Clock Start Time Menu

```
NO DELAY TO START
DELAYED START
CLOCK TIME
WAIT FOR PHONE CALL
```

- Select CLOCK TIME.

```
FIRST SAMPLE AT:
06:00
```

- Type the time of day and press ↵.

```
SELECT DAYS:
SU MO TU WE TH FR SA

DONE
```

- Press an arrow key until the cursor is on the correct day. Then, press ↵. To remove a day, move the cursor to it and press ↵ to deselect it.
- Repeat these steps until each day you want is blinking.
- Press an arrow until DONE blinks. Press ↵.

3.5 Menu Screens: Site Descriptions and Program Names

The sampler has two text-entry menus, one for site description and another for an extended-program name. They work in the same way. A site description is commonly a number, address, or other short note that helps identify the monitoring site. Extended programming has a similar screen that lets you enter program names for stored programs.

The example on the next page shows how to change the site description from FACTORY01 to SITE 29. Line 1 contains text between two quotation marks. Lines 2 and 3 contain the menu options — numbers, letters, and punctuation marks — used to spell out the description. In line 3, the space between the ampersand (&) and the double quotes (") is a space character. Line 4 contains two additional options:

- BACK-UP, an option that moves the cursor on the text line to the left one character.
- DONE, an option that tells the sampler to save the text.

The cursor is the blinking rectangle that identifies the current field. When the screen first appears, the cursor blinks on the first character of the text in line 1. The matching character in line 2 or 3 also blinks.

When you press ↵, the cursor on line 1 moves to the right one position, and, at the same time, the sampler blinks on the matching character on lines 2 or 3.

To change any character in the text line:

1. Press the left or right arrow until the replacement character on lines 2 or 3 blinks.
2. Press ↵. The replacement character will appear on the first line, and the cursor will move to the next character.
3. *Repeat steps 1 and 2 until the text in the top line is complete.*
4. Finish the entry by selecting DONE. Then, press ↵.

Some additional tips for using the text-entry menus:

- Hold an arrow key down for faster movement.
- If your description uses all ten spaces in the text line, the sampler automatically moves to the next screen as soon as you add the tenth character.
- You can enter numbers by pressing the number keys.
- Erase characters by replacing them with a space character.
- Select the BACK-UP option to move the cursor to the left.
- To leave the menu before completing the entry, press Stop. The sampler will display this menu:

```
SAVE CHANGES?
YES   NO
```

Select YES to save any changes made. Select NO to leave the original description (or program name) unchanged.

Changing the Site Name

```
SITE: "FACTORY01"
ABCDEFGHIJKLMNOPQRST
UVWXYZ-&  "0123456789
BACK-UP   DONE
```

```
SITE: "SACTORY01"
ABCDEFGHIJKLMNOPQRST
UVWXYZ-&  "0123456789
BACK-UP   DONE
```

- Press the Down-Right arrow until the **S** on line 2 blinks. Then, press ↵.

```
SITE: "SICTORY051"
ABCDEFGHIJKLMNOPQRST
UVWXYZ-&  "0123456789
BACK-UP   DONE
```

- Press the Up-Left arrow until the I blinks. Press ↵.
- Continue pressing arrow keys to select T, E, and space. Press ↵ after selecting each character.

```
SITE: "SITE_29_   "
ABCDEFGHIJKLMNOPQRST
UVWXYZ-&_"0123456789
BACK-UP   DONE
```

- Press 29 on the keypad, then Up-Left until space blinks. Press ↵.

```
SITE: "SITE_29_   "
ABCDEFGHIJKLMNOPQRST
UVWXYZ-&_"0123456789
BACK-UP   DONE
```

- Press the Down-Right arrow until DONE blinks. Press ↵.

3.6 Messages

The sampler has four sets of messages that supplement the programming screens. **Information messages** tell you about programming status. **Help Notes** are brief comments associated with programming screens describing the setting or offering assistance. **Warning messages** tell you something is different than Teledyne Isco's standard. **Operation messages** report the sampler's status as it runs a program.

3.6.1 Information Messages

These are brief messages about the programming status, such as " 'ROM' PASSED TEST" or the status message that displays when you first start up the sampler. Information messages are displayed for four seconds, unless they are terminated by pressing any key on the keypad.

3.6.2 Help Notes

To see a Help note:

1. Press the ? (Help) key.

2. When the note requires several screens, the word "more" appears in the lower-right corner. Press ↵ for the next note.

3. Move back and forth between screens by pressing the arrow keys.

4. Press Stop at any time to return to the programming screen.

Most help notes refer to a related section in this manual. Screens that require extensive explanation have notes that contain only a reference to the manual. Sections mentioned in the notes appear in the index and the table of contents.

```
SUCTION LINE LENGTH
IS 7 ft
(3-99)
```

- Press ? (Help).

```
Enter the length of
suction line only,
excluding strainer
and pump tube.      <more>
```

- Press ↵ or Down-Right to see the next screen.
- Press Stop to return to the programming screen.

```
See "Installing
Suction Line" in
your manual.
                    <more>
```

- Press ↵ or Down-Right to see the next screen.
- Press Up-Left to see the previous screen.
- Press Stop to return to the programming screen.

```
Press the red STOP
key to exit HELP.
```

- Press Up-Right to see the previous notes.
- Press Stop to return to the programming screen.

Using Help Notes

Although this example shows the help notes that are associated with the suction-line length screen, you can use the same technique to see help notes for other screens.

3.6.3 Warning Messages

Warning messages appear when the sampler determines something is out of the ordinary. For example, the following warning appears when you type a number that is larger than the standard bottle volume:

```
BOTTLE VOLUME IS
3500 ml   (300-30000)
```

```
WARNING!
STANDARD BOTTLE
VOLUME EXCEEDED!
```

The 6712 does accept nonstandard volumes because you might use a nonstandard container occasionally. For a list of recommended volumes for Teledyne Isco bottles press the ? (Help) key at the "Bottle Volume Is" screen, or refer to the Technical Specifications.

The 6712 uses the bottle and sample-volume settings to determine the maximum number of samples that can be deposited without overfilling the bottles. Entering a volume that exceeds the standard volume may cause the sampler to overfill the bottle.

3.6.4 Operation Messages

An operation message reports the sampler's status as it runs a program. An example is shown below.

```
PROGRAM WILL START
AT 06:00   TU   20-FEB

05:56:22   TU   20-FEB
```

3.7 Menu Trees

Selecting a menu option will take you to a number-entry screen or another menu screen. The screens are organized in a branching structure that resembles a tree. Refer to Figure 3-1 for a simple chart of the menu tree for standard programming. The standard programming structure is different — much simpler — than the extended programming structure. Charts that show you most of the sampler's screens appear in *Appendix A, Flowcharts*.

The entire structure changes a little when a module is attached because the sampler adds a set of screens for a module as soon as it detects the module's presence. The manuals for each module contain menu trees for its programming screens.

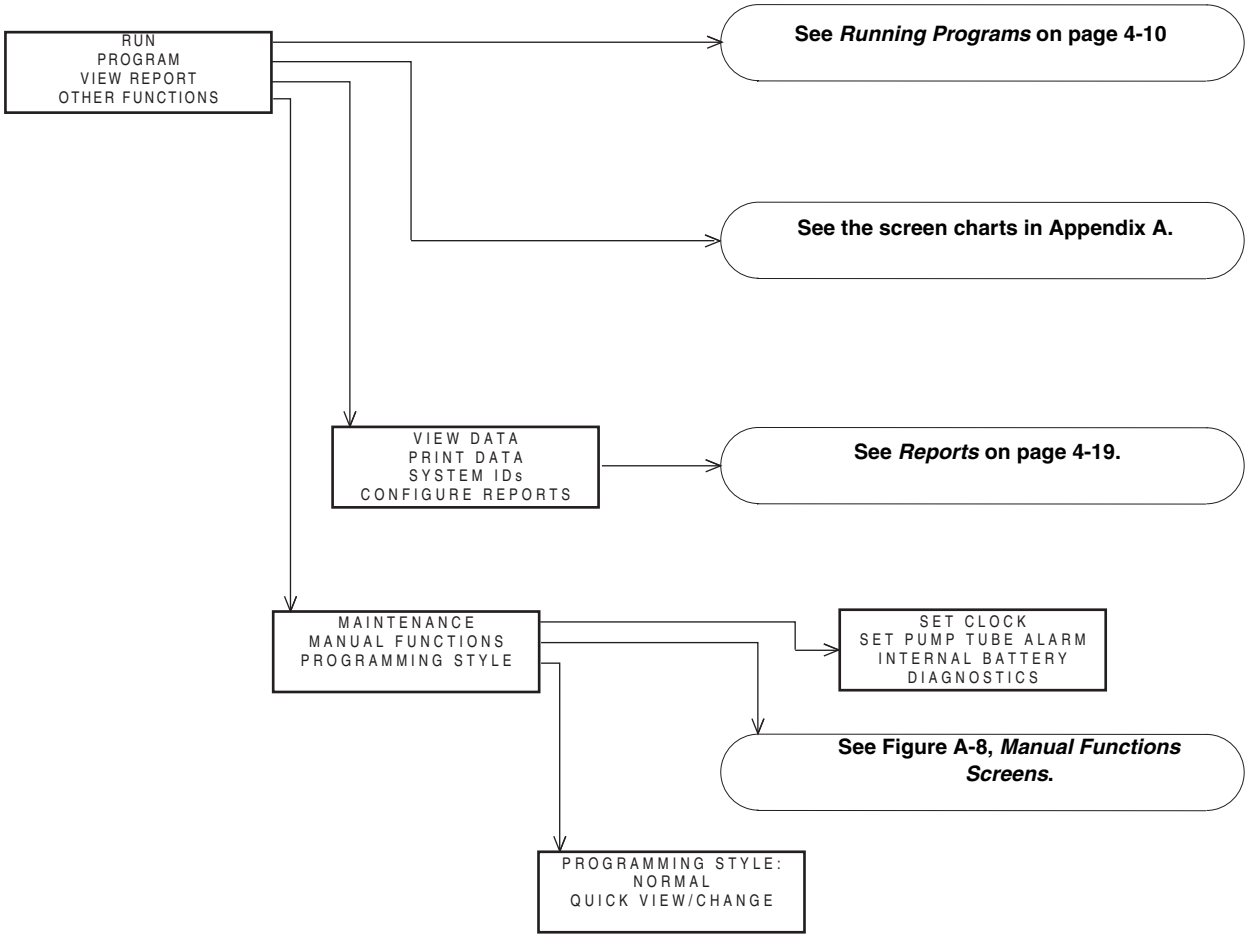


Figure 3-1 Menu Tree for Standard Programming

6712 Portable Sampler

Section 4 Standard Programming

The 6712 Sampler has two sets of programming screens. The first set, called standard programming screens, lets you set up typical sampling programs easily and efficiently. The second set, extended programming screens, lets you create sophisticated programs for complex sampling applications.

All of the sampling features available within the standard programming screens are available in extended programming. However, extended programming provides several additional features which are discussed in the next section. Menu flowcharts for both sets of programming screens are in Appendix A.

4.1 Switching Between Standard and Extended Modes

Factory default settings cause the sampler to begin in standard programming mode the first time you turn it on. The start-up screen tells you which programming mode the sampler is currently using. You can switch between programming modes by entering a numerical command at the main menu:

- At the main menu, type **6712.1** to enter standard programming mode.
- At the main menu, type **6712.2** to enter extended programming mode.

```
RUN
PROGRAM
VIEW REPORT
OTHER FUNCTIONS
```

Main Menu

4.2 Language Selection, Units of Length

You have the option of displaying screens in English or Spanish (or possibly another language). The default is English. At the main menu, type **6712.8** to display:

```
ENGLISH
SPANISH
```

Use the arrow key to move between the two choices. When the desired choice is blinking, press ↵.

If you select the English option, you will advance to a second screen that asks you to select your units of length:

```
SELECT UNITS FOR
LENGTH:
ft    m
```

Use the arrow key to move between the two choices, feet or meters. When the desired choice is blinking, press ↵. The default unit of length for the Spanish option is meters.

4.3 Programming Examples

The following table is an example of time-paced sampling. Further details about some of the menu items are provided in later sections.

Table 4-1 Standard Program: Sample Every 15 Minutes, One Sample Per Bottle

1	6712 SAMPLER STANDARD PROGRAMMING For HELP at any screen press ? key.	Turn the sampler on by pressing the On/Off key. Press ↵. This screen disappears on its own after 8 seconds.
2	RUN **PROGRAM** VIEW REPORT OTHER FUNCTIONS	The option PROGRAM will be blinking. Press ↵.
3	SITE DESCRIPTION: “FACTORY051“ CHANGE? YES **NO**	The option NO will be blinking. Press ↵. For the purposes of this example, it isn’t necessary to change the description.
4	NUMBER OF BOTTLES: 1 2 4 8 12 **24**	Select the number of bottles in your bottle kit by pressing either arrow key until the correct number blinks. Press ↵. For this example, select 24.
5	BOTTLE VOLUME IS 1000 ml (300-30000)	Type the volume for the bottles in your kit. For this example, 1000 is correct, so simply press ↵.
6	SUCTION LINE LENGTH IS 10 ft (3-99)	Type the length of the suction line, then press ↵. If you change the length, the sampler will display a message, “PLEASE WAIT!. . . GENERATING PUMP TABLES.”
7	**TIME PACED** FLOW PACED	Because this example requires samples every 15 minutes, select TIME PACED by pressing an arrow until the option TIME PACED blinks. Then, press ↵.
8	TIME BETWEEN SAMPLE EVENTS 0 HOURS, 15 MINUTES	Type 0 for hours and press ↵. Type 15 for minutes and press ↵. Tip: Move back and forth between hours and minutes by pressing an arrow key.
9	**SEQUENTIAL** BOTTLES/SAMPLE SAMPLES/BOTTLE	Because this program requires one sample in each bottle, select SEQUENTIAL by pressing an arrow until the option SEQUENTIAL blinks. Then, press ↵.
10	RUN CONTINUOUSLY? YES **NO**	For this example, select NO by pressing an arrow until the option blinks. Then, press ↵. Selecting YES allows the program to run indefinitely by repeating the sample distribution. Continuous sampling assumes that filled bottles are replaced with empty bottles at regular service intervals.

Table 4-1 Standard Program: Sample Every 15 Minutes, One Sample Per Bottle (Continued)

11	SAMPLE VOLUME: 200 ml (10-1000)	Type the volume of the sample you want deposited in each bottle. Then, press ↵.
12	NO DELAY TO START **DELAYED START** CLOCK TIME WAIT FOR PHONE CALL	For this example, select DELAYED START by pressing an arrow until the option blinks. Then, press ↵.
13	FIRST SAMPLE AFTER A 5 MINUTE DELAY (1-999)	Type the delay period you want between the time you run the program and the time the sampler takes the first sample. Then, press ↵.
14	PROGRAMMING COMPLETE RUN THIS PROGRAM NOW? YES **NO**	Run the program immediately by selecting YES. Select NO if you want to run the program later by selecting RUN from the main menu. Press ↵ after making your choice. In this example, NO is selected.
15	**RUN** PROGRAM VIEW REPORT OTHER FUNCTIONS	Run the program by selecting RUN and pressing ↵.

The following table is an example of flow-paced sampling.

- Program type: Standard
- Site description: SITE 29
- Bottle kit: 24, 1000 milliliter bottles
- Suction line length: 7 feet
- Pacing: Flow pacing, every two pulses
- Distribution: 2 bottles per sample
- Sample Volume: 250 milliliters
- Start time: Clock Time, 6:00 a.m. on Monday, Wednesday, Friday
- Module: No module installed

Table 4-2 Standard Program: Flow-Paced Sampling, Two Bottles Per Sample

1	6712 SAMPLER STANDARD PROGRAMMING For HELP at any screen press ? key.	
2	RUN **PROGRAM** VIEW REPORT OTHER FUNCTIONS	Select PROGRAM.
3	SITE DESCRIPTION: “FACTORY051“ CHANGE? YES **NO**	Select NO.

Table 4-2 Standard Program: Flow-Paced Sampling, Two Bottles Per Sample (Continued)

4	NUMBER OF BOTTLES: 1 2 4 8 12 **24**	Select 24.
5	BOTTLE VOLUME IS 1000 ml (300-30000)	Enter 1000.
6	SUCTION LINE LENGTH IS 10 ft (3-99)	Enter 7.
7	TIME PACED **FLOW PACED**	Select FLOW PACED.
8	FLOW BETWEEN SAMPLE EVENTS: 2 PULSES (1-9999)	Enter the number of pulses between sample events.
9	SEQUENTIAL **BOTTLES/SAMPLE** SAMPLES/BOTTLE	Select BOTTLES/SAMPLE.
10	RUN CONTINUOUSLY? YES **NO**	For this example, select NO by pressing an arrow until the option blinks. Then, press ↵. Selecting YES allows the program to run indefinitely by repeating the sample distribution. Continuous sampling assumes that filled bottles are replaced with empty bottles at regular service intervals.
11	1 BOTTLES PER SAMPLE EVENT (1-24)	Enter 2.
12	NO DELAY TO START DELAYED START **CLOCK TIME** WAIT FOR PHONE CALL	Select CLOCK TIME.
13	START FLOW COUNT AT: 00:00	Enter 6, then enter 0. This is the time at which the sampler will start the pacing countdown.
14	SELECT DAYS: SU **MO** TU **WE** TH **FR** SA DONE	Select MO, WE, and FR. Use the arrow keys and ↵ to select the days. When the correct days are blinking, select DONE and press ↵.
15	PROGRAMMING COMPLETE RUN THIS PROGRAM NOW? YES **NO**	Select NO.

4.4 Pacing

Sample pacing is the rate at which the sampler takes samples. Depending on the type of pacing you select, the rate is controlled by the sampler's internal clock or by inputs received from connected instruments.

Standard Time Pacing and Flow Pacing Screens for Samplers without Flow Modules

```
TIME PACED
FLOW PACED
```

- When programming, you will be asked to select time or flow paced sampling. Depending upon your choice, you will see one of the following screens:

```
TIME BETWEEN
SAMPLE EVENTS:
__ HOURS, __ MINUTES
```

```
FLOW BETWEEN
SAMPLE EVENTS:
____ PULSES (1-9999)
```

Standard programming provides time pacing and flow pacing (refer to Step 7 in the previous two programming examples). In time-paced sampling, the interval between samples is a constant time interval. When you program the sampler for time pacing, the sampler prompts you to enter the time between sample events in hours and minutes. Time paced programs always take a sample at the start time.

Flow paced sampling requires a flow meter, flow logger, or a module. A flow meter or flow logger paces a sampler by sending an electronic signal to the sampler after measuring a specified volume of liquid. Because each pulse represents a volume interval, flow pacing rates are proportional to the volume of water flowing through the channel.

When you program the sampler for flow pacing and are using a flow meter or flow logger, the sampler prompts you to enter the interval between sample events in pulses. The sampler initiates a sample event when the set number of pulses is received. Programs that are flow paced do not take a sample at the start time.

After setting the program start time, you will be prompted to enter a maximum run time of zero to 999 hours. If you would like the program to run indefinitely, enter 0 (zero) for maximum run time.

Flow Pacing Screen for Samplers with Flow Modules

```
FLOW BETWEEN
SAMPLE EVENTS:
____ Mgal
(0.001 -99999)
```

The flow pacing screens change when you attach a flow module (see example to the left). Because the sampler is more closely integrated with the modules, the standard flow pacing screen prompts you for the flow volume between sample events instead of pulses between events. The flow volume units displayed are what you had previously programmed.

4.4.1 Trigger Pacing

Teledyne Isco 4200 Series Flow Meters and 4100 Series Flow Loggers send pulses for trigger pacing. The flow meter or flow logger sends pulses at two different time intervals when trigger pacing a sampler. Trigger pacing, for example, lets you sample less frequently when the trigger condition — a condition based on level, flow, or rainfall — remains below a set point. The intervals are determined by the flow instrument's program settings for trigger pacing.

When conditions change and readings pass the set point, triggering the new rate, you can sample more frequently. Or, when the trigger condition is a clock setting, the instrument changes the pacing interval according to the time of day. Using a clock trigger condition, for instance, the flow meter or flow logger can pace the sampler slowly at night and more frequently during the day. (For more information about trigger pacing, see your flow meter or FLOWLINK manual.)

The flow meter or flow logger sends the same pulse for both flow and trigger pacing, and the sampler cannot distinguish between them. Therefore, to program a sampler for trigger pacing, simply program it for flow pacing.

4.5 Distribution

Distribution describes how the sampler is to deposit samples. A sample is the volume of liquid deposited in a bottle. A sample event includes the full sampling cycle and may deposit a sample into more than one bottle.

In standard programming, you can program the sampler for these different distribution methods:

- Sequential
- Bottles Per Sample
- Samples Per Bottle
- Composite

4.5.1 Sequential

In sequential distribution, the sampler deposits one sample in each bottle. A sequential sample represents a “snapshot” of the flow stream at a point in time.

4.5.2 Bottles Per Sample

In bottles per sample distribution, the sampler deposits a sample in each of a set of bottles. A bottle set includes at least two bottles but may include all bottles. Use bottles per sample when the volume to be collected is larger than the amount one bottle can hold or when you need identical samples.

4.5.3 Samples Per Bottle

In samples per bottle distribution, the sampler deposits samples from several sample events in a single bottle before moving to the next bottle. Use samples per bottle distribution to collect a series of small composite samples.

4.5.4 Composite

For single bottle configurations, samples per bottle distribution is known as composite sampling. A composite sample represents an average of the flow stream’s characteristics during the sampling period.

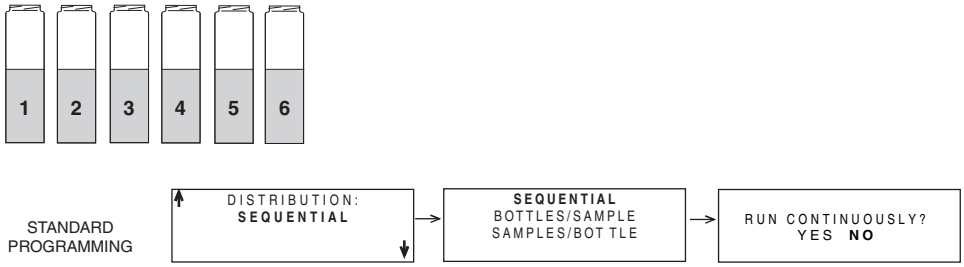
4.5.5 Continuous Sampling

Sample programs can be run indefinitely by selecting “YES” at the “RUN CONTINUOUSLY?” screen. Continuous sampling resets the distribution when the distribution sequence is complete. That is, when the last bottle/set is reached, the next bottle/set is the first bottle/set. All pacing modes except RANDOM are supported.

When running a program continuously, the bottles must be serviced at regular intervals to prevent overfilling the bottles. The sampler assumes that the next bottle/set is empty and ready to receive samples.

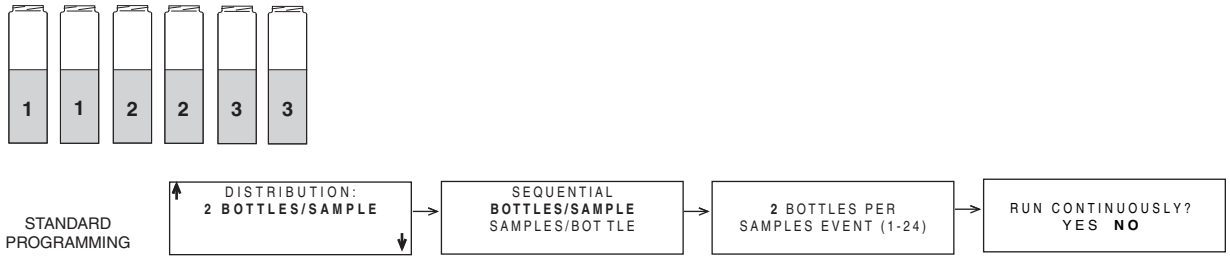
The figure on the next page steps through the programming screens for sequential, bottles per sample, and samples per bottle distribution.

Sequential



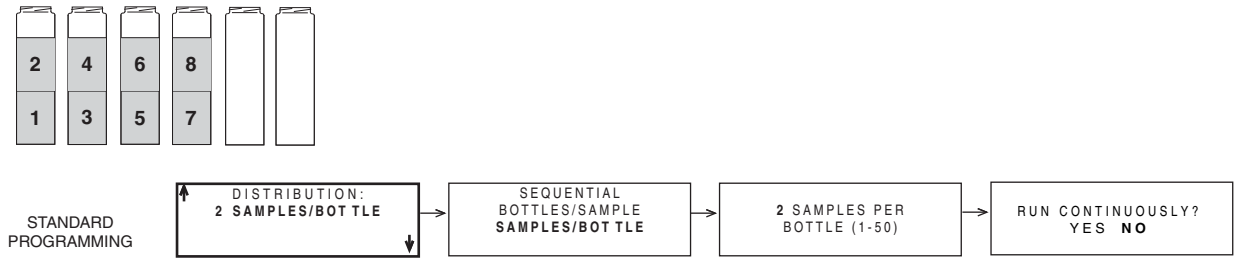
Each bottle receives one sample from one sample event.

Bottles-per-Sample



Multiple bottles receive a sample from one sample event.

Samples-per-Bottle



Each bottle receives a sample from multiple sample events.

Figure 4-1 Sample Distribution

4.6 Start Times

It is important to understand the difference between the time at which you run a program and the program's start time. Running a program simply means selecting RUN from the sampler's main menu. The start time is the time at which the sampler begins the program's first sample interval countdown. The start time is controlled by your selections from the start time screens.

Each program contains start-time settings that tell the sampler when to begin the program. When programming the sampler, you can select one of four start time options: NO DELAY TO START, DELAYED START, CLOCK TIME, or WAIT FOR PHONE CALL.

- Select NO DELAY TO START when you want the sampler to start as soon as you select RUN.
- Select DELAYED START when you want the sampler to delay from 1 to 999 minutes before starting the program.
- Select CLOCK TIME when you want the sampler to begin the program at a specific time on at least one day of the week.
- Select WAIT FOR PHONE CALL when you want the sampler to begin the program after receiving a remote command to start (optional modem required).

4.6.1 How Do Start Times Work?

As soon as you select RUN from the main menu, the sampler checks the program's start time settings. With a "DELAYED START" setting, the sampler starts a countdown to the start time. The period between the time you select RUN and the start time you've specified in the program is called the "delay to start time."

When you run a program with "CLOCK TIME" settings, the sampler also starts a countdown to start time until the day of week and clock times are met.

The sampler may not collect a sample at the start time. The sampler must be enabled, and the pacing selected must call for a sample at start. In any event, the sampler checks the pacing settings and begins the pacing-interval countdown.

Delayed Start Screen

1
```
NO DELAY TO START
DELAYED START
CLOCK TIME
WAIT FOR PHONE CALL
```

• Select DELAYED START.

2
```
FIRST SAMPLE
AFTER A
___MINUTE DELAY
(1-999)
```

- Enter the number of minutes to delay the countdown to the first sample.

3
```
START FLOW COUNT
AFTER A
__MINUTE DELAY
(1-999)
```

- The sampler uses this screen for flow paced programs.

Clock Start Time Menu

1
```
NO DELAY TO START
DELAYED START
CLOCK TIME
WAIT FOR PHONE CALL
```

• Select CLOCK TIME.

2
```
FIRST SAMPLE AT
06:00
```

• Enter the time of day.

3
```
SELECT DAYS:
SU MO TU WE TH FR SA

DONE
```

- Press an arrow key until the cursor is on the correct day. Press↵.
- Repeat until each day you want is blinking.
- Press an arrow until DONE blinks. Press ↵.

4.6.2 Sampler Enable/Disable

Teledyne Isco flow meters and flow loggers have a programmable sampler-enable feature that lets them enable (start) or disable (stop) a program according to certain monitored conditions. For example these conditions can be level, flow rate, pH, temperature, percent, rainfall, I/O; or a combination of two conditions.

The 1640 Liquid Level Actuator can also be used, as well as any other instrument that can ground the input to pin F. Grounding the input disables the sampler.

The sampler disregards disable signals during the delay to start time. However, when the sampler detects a disable signal at the start time, it suspends the program until it is enabled. The diagram in Figure 4-2 shows the sampler's responses.

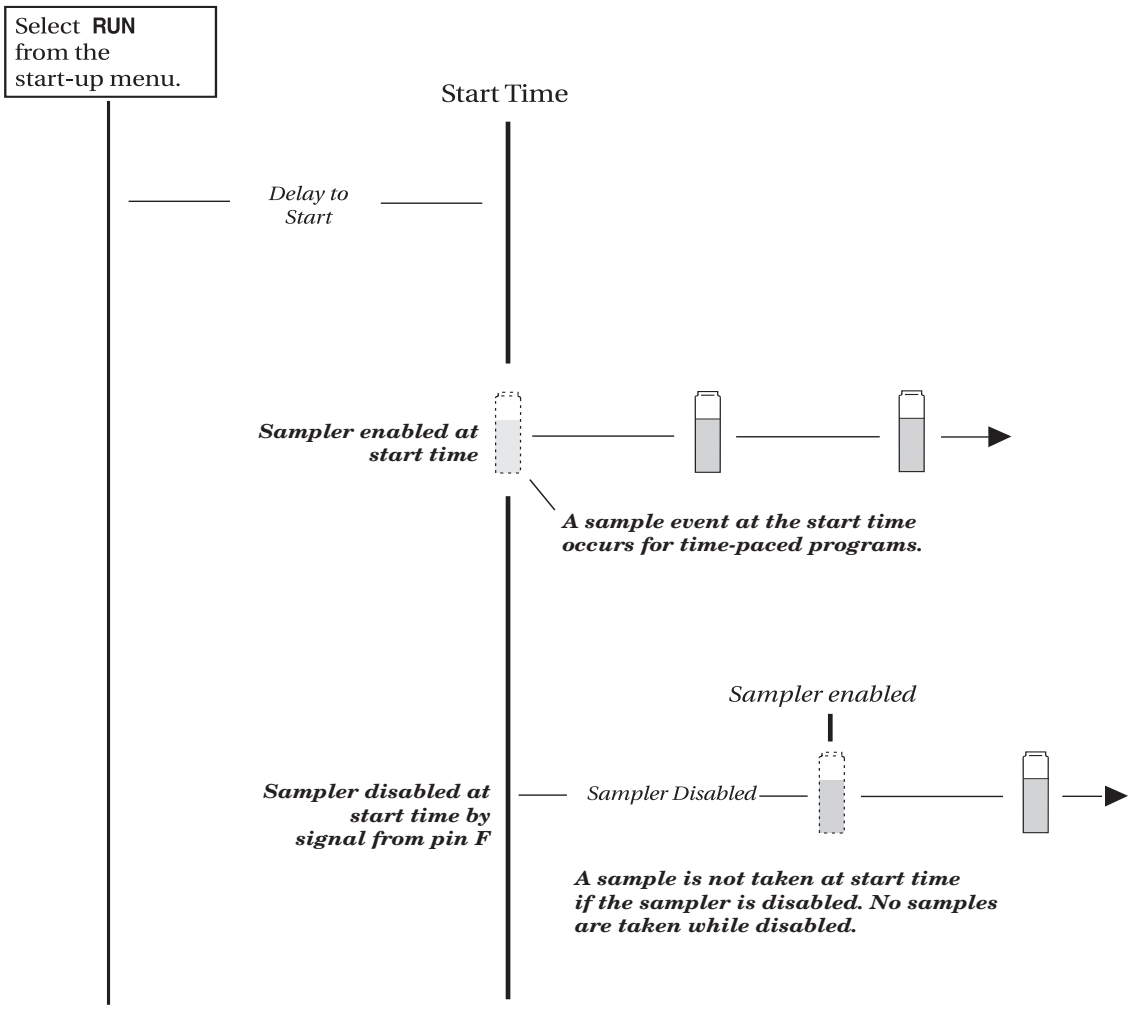


Figure 4-2 Start Time Diagram

4.7 Running Programs

To run a program, select RUN from the main menu. You may also select YES at the RUN THIS PROGRAM NOW? screen at the end of the programming screens.

4.7.1 Run Time Screens

While running a sampling program the sampler displays a variety of messages that report the program's status. For example, if the sampler has not yet reached the programmed start time, it displays the scheduled start time as well as the current time.

Once the program reaches the start time, you can determine the time of the next sample, the next bottle to receive a sample, sample distribution, and other information. Other messages appear while the sampler runs through a sampling cycle and takes a sample. When the sampler needs to report multiple messages, it alternates them, displaying each for one to three seconds.

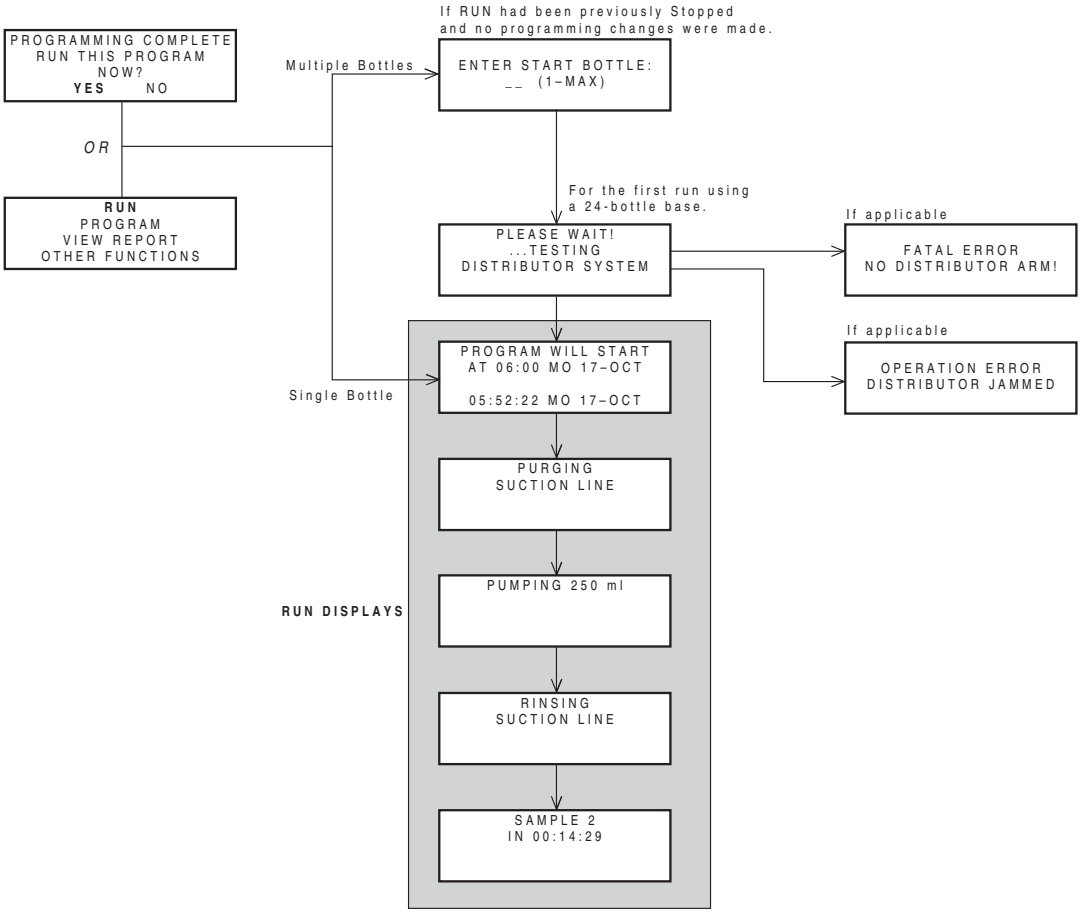


Figure 4-3 Running a Program

4.7.2 Module Readings

Samplers with an attached module display the module's readings: pH and temperature for the pH module; level, percentage, or flow rate for the 4-20 mA module; level, flow rate, and flow volume readings for the flow modules; level, velocity, flow rate, and positive flow volume readings for the area velocity module. Some module screens will alternate with the sampler screens.

```
BOTTLE 2
IN 00:14:39
150 gpm      0.82 ft
00001438200 gal
```

The Module readings are updated:

- Every second when displaying the reading during programming.
- Every minute otherwise.

An * (asterisk) appears next to the reading if the module was unable to take a reading. If an asterisk appears, the reading displayed is the last available reading. Flow rates will be reported as zero flow if the error persists for more than five minutes (for a level or velocity reading that flow is calculated from).

```
BOTTLE 2
IN 00:12:00
***** gpm      5.73 ft
00001457600 gal
```

If an entire reading is filled with asterisks, the value exceeds the number of characters that can be displayed. The sampler stores the actual reading in memory, so it may be collected later.

For those programs that have delayed or scheduled start times, the readings will be displayed while waiting for the start time. Keep in mind that any totalizer values will be reset at the start time. Module and sonde readings are also displayed after a program is complete, until a key is pressed.

It is not necessary to run a program to view module or sonde readings. Real time data can be viewed on the display by selecting “VIEW REPORT” from the main menu.

4.8 Interrupting a Running Program

You can interrupt a sampling program by pressing the Stop key while the sampler is waiting for the next sample event. Pressing Stop places the sampler into *Manual Paused* operation and records a manual pause in the sample event log.

In this state, the sampler allows you to access several functions. You can modify the program, reset alarms, take a grab sample, etc., without adversely affecting the running program. Modifying the program is limited to adjusting the pacing intervals, enable conditions and sample volume. The basic program structure, such as the type of pacing, can not be changed.

While in the manual paused state, the sampling program continues to operate as normal, with the exception of taking samples. If a sample was to be taken, it is skipped. The sampler records “sample skipped” in the sample event log and continues to operate as normal.

The manual paused state displays a scrolling menu with several options (see example below). Use the Arrow keys to scroll through the manual paused options and the ↵ key to make a selection. Return to the running program by selecting resume program or pressing the Stop key. If you do not make a selection, the sampler automatically resumes the original sampling program five minutes after the last key was pressed.

```
← STOP PROGRAM
RESUME PROGRAM
VIEW DATA
GRAB SAMPLE →
```

Manual Paused Screen

4.8.1 Stop Program

This option terminates the running program and records program stopped in the sample event log. The program cannot be resumed.

4.8.2 Resume Program

Selecting this option will cause the sampler to exit the manual paused state and return to normal program operation. A manual resume event will be logged.

4.8.3 View Data

This option allows you to view the data recorded by the sampler. See *Reports* on page 4-19 for more information.

4.8.4 Grab Sample

When selected, you will be asked to enter the volume to be pumped. A sample will then be taken as if it is to be *placed into a container outside the sampler base*. Do this by removing the pump tubing from the bulkhead fitting. See *Grab Samples* on page 4-15. A grab sample event will be logged.

4.8.5 Pump Tube Alarm

If the pump tube is changed, this option should be selected to reset the pump counts on the counter. This will remove the "WARNING: REPLACE PUMP TUBING" message that may appear while the program is running. A pump tube replaced message is logged. See Replacing The Pump Tube in Section 7, Maintenance.

4.8.6 Calibrate Volume

When selected, you will be asked to enter the volume to be pumped. A sample will then be taken as if it is to be *placed into a container outside the sampler base*. Do this by removing the pump tubing from the bulkhead fitting.

After the sample has been pumped, you will then be asked to enter the amount actually delivered. Once you have entered the delivered volume and accepted the calibration, a volume delivered event will be logged.

4.8.7 Cal/Adj Parameters

When the sampler is configured for operation with a module, this option becomes available. Selecting this option will display the appropriate level adjustment screens and/or the calibration screens. If the level is adjusted, an adjusted level event is logged. If a parameter is calibrated, an appropriate event is logged.

Calibrating a parameter probe will temporarily "turn off" the partition data storage and the sample enable/disable functions. These functions are disabled during the calibration and for five minutes after the program is resumed. During this time, parameter data normally collected at the data storage interval will be logged as a 252 error message.

4.8.8 Adjust Pacing

This option is available when the running program is paced by Time, Flow Pulses or Flow Volume. If you select this option, you are asked to enter a new pacing interval. The sampler logs an interval changed event.

The original pacing interval continues to count down until you return the sampler to the running program (select resume program). If the new pacing interval is less than the original count remaining, the new interval is used.

If the original count remaining is less than the new pacing interval, the original count will continue to count down to the next sample event. Subsequent samples are then paced by the new interval.

4.8.9 Adjust Volume

Select this option to change the sample volume within the limits of the currently programmed sample distribution. If you change a sample volume, a volume changed event is logged.

4.8.10 Power Used

The 6712 has a "fuel gauge" that gives an indication of power usage. The controller keeps track of how much power has been consumed since the last time it lost power. If the controller is powered by an external battery, this fuel gauge can help you estimate the condition of the battery.

Keep in mind that the sampler has no idea as to how much charge was originally stored in the battery (or even if a battery is being used), and therefore has no idea as to the *remaining capacity* of its power source.

4.9 Other Functions

Other Functions Menu

```
RUN PROGRAM
VIEW REPORT
OTHER FUNCTIONS
```

• Select OTHER FUNCTIONS.

```
MAINTENANCE
MANUAL FUNCTIONS
PROGRAMMING STYLE
```

In Standard Programming, the "Other Functions" menu screen includes options for:

- Maintenance (see Section 8).
- Manual Functions (see below).
- Programming Style (see Section 3).

4.10 Manual Functions

The manual functions programming screens let you:

- Take grab samples.
- Calibrate sample volumes.
- Operate the pump manually.
- Move the distributor arm.

4.11 Grab Samples

Taking a Grab Sample

1 | **GRAB SAMPLE**
CALIBRATE VOLUME
OPERATE PUMP
MOVE DISTRIBUTOR

• Select GRAB SAMPLE

2 | SAMPLE VOLUME:
___ ml (10-9990)

• Enter the desired volume

3 | GRAB SAMPLE
PRESS ↵ WHEN READY!

4 | PURGING
SUCTION LINE

5 | PUMPING 200 ml

6 | PURGING
SUCTION LINE

7 | GRAB SAMPLE
CALIBRATE VOLUME
OPERATE PUMP
MOVE DISTRIBUTOR

• Press STOP to return to main menu.

Grab samples let you take a single sample on demand, collecting the sample in an external container (Figure 4-4). Keep in mind:

When the sampler delivers a grab sample, it runs through a complete sampling cycle, using the current settings for volume and for line rinses or retries. If it is a two-part program, the sampler uses the settings for part A.

To take a grab sample while the sampler is running a program, you must interrupt the program by pressing the Stop key. Restart the program by running it again.

To take a grab sample:

1. Disconnect the pump tube from the bulkhead fitting.
2. Place the end of the tube over a collection container.
3. Follow the steps in *Taking a Grab Sample* at left.
4. Reconnect the pump tube to the bulkhead fitting.

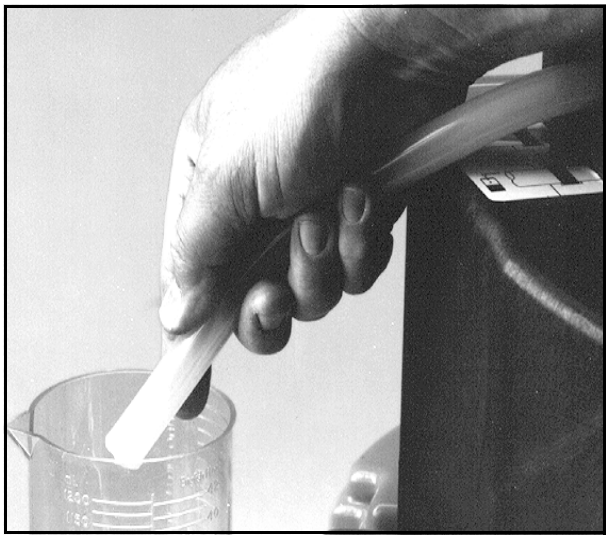


Figure 4-4 Taking a Grab Sample

4.12 Calibrate Volume

The sampler delivers accurate sample volumes without calibration. If you find that sample volumes vary significantly from the programmed values, first check the suction line for proper installation. Be sure it slopes continuously downhill to the liquid source and drains completely after each sampling cycle. Then, compare the actual length of the suction line to the suction line length settings in the program to see that they match. Also check the pump tube for excessive wear and replace it if necessary.

You may want to calibrate when:

- A new pump tube is installed. Run the pump for five minutes before calibrating.
- The sample source is above the sampler.
- Sampling from pressurized lines (15 PSI Maximum).

4.12.1 Calibration Tips

- For the best results, calibrate the sampler after it's installed on site.
- Use a graduated cylinder for volume measurement.
- The sampler clears the previous calibration setting when you reinitialize the sampler.
- You cannot calibrate while the sampler is running a program.
- When the sampler delivers the sample, it runs through a complete sampling cycle, using the current settings for volume line rinses and retries. If it is a two part program, the sampler uses the volume setting for part A.

To calibrate:

1. Disconnect the pump tube from the bulkhead fitting.
2. Place the end of the tube over a collection container.
3. Follow the steps in Calibrating Sample Volumes in the margin.
4. Reconnect the pump tube to the bulkhead fitting.

Calibrating Sample Volumes

1
```
RUN
PROGRAM
VIEW REPORT
OTHER FUNCTIONS
```
- Select OTHER FUNCTIONS

2
```
MAINTENANCE
MANUAL FUNCTIONS
MODULE
HARDWARE
```
- Select MANUAL FUNCTIONS

3
```
GRAB SAMPLE
CALIBRATE VOLUME
OPERATE PUMP
MOVE DISTRIBUTOR
```
- Select CALIBRATE VOLUME

4
```
SAMPLE VOLUME:
___ ml (100-9990)
```
- Enter the desired volume

5
```
CALIBRATE VOLUME

PRESS ↵ WHEN READY!
```

6
```
PURGING
SUCTION LINE
```

7
```
PUMPING 200 ml
```

8
```
PURGING
SUCTION LINE
```

9
```
VOLUME DELIVERED:
____ml
```
- Measure the volume delivered and enter the amount here.

10
```
200 ml
ARE YOU SURE?
YES  NO
```
This screen appears when the amount you entered in step 9 was more than twice, or less than half, the programmed volume.

- Select YES when the volume delivered matches the volume displayed on this screen.
- Select NO to enter the volume delivered.

4.13 Operating the Pump

You can manually operate the sampler's pump in the forward or reverse direction. You can do this to test the pump, draw a large sample, or purge the suction line.

When you run the pump manually, the sampler reports the number of pump counts during the pump's operation. Use this feature to obtain an estimate of the pump counts required to purge a nonstandard suction line.

You can also manually run the pump from the main menu. Press the "1" key and then ↵ to run the pump in reverse. Press the "3" key and then ↵ to run the pump forward.

Operating the Pump

GRAB SAMPLE
CALIBRATE VOLUME
OPERATE PUMP
MOVE DISTRIBUTOR

SELECT DIRECTION
PUMP FORWARD
PUMP REVERSE

PURGING. . .
PRESS THE RED 'STOP'
KEY WHEN DONE

PURGED _____COUNTS

⚠ CAUTION

Tests indicate that the pump produces sound levels in excess of 85db at one meter. PROLONGED EXPOSURE TO THIS SOUND LEVEL COULD RESULT IN HEARING LOSS AND REQUIRES THE USE OF PROTECTIVE EAR PLUGS.

4.14 Moving the Distributor Arm

The sampler lets you reposition the distributor arm. Use this feature to verify a bottle location when installing a bottle kit. You cannot move the distributor arm while the sampler is running a program.

⚠ CAUTION

DO NOT rotate the distributor arm manually; this will severely damage the distributor drive gears.

Moving the Distributor Arm

GRAB SAMPLE
CALIBRATE VOLUME
OPERATE PUMP
MOVE DISTRIBUTOR

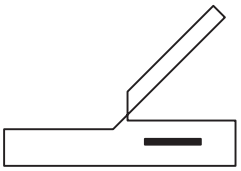
- Select MOVE DISTRIBUTOR

GO TO BOTTLE ____
(1-MAX)

- Enter the bottle number to which you want to move the distributor

NOW AT BOTTLE ____

4.15 Reports



Interrogator

The 6712 records a variety of data while running a sampling program. It uses the data to produce four reports:

- The Program Settings report, listing the program settings.
- The Sampling Results report, listing the program settings, time of samples and other program events.
- The Combined Results report, combining the sample event times with rainfall or module data.
- The Summary report, listing daily summaries of data collected. The Summary report may be rainfall and/or module data.

The sampler stores the data for each report in memory where they remain until you select RUN. Selecting RUN clears the memory so that it can store the data from the next program.

4.15.1 Collecting Reports

There are a number of ways to collect the reports:

View reports (program settings, sampling results, and abbreviated summary reports) on the sampler's display.

Collect the reports (except for summary reports) with a Teledyne Isco 581 RTD and use a computer running flowlink or samplink to transfer the reports from the RTD to a file on the computer.

Collect the reports (except for summary reports) with an IBM PC or compatible computer running flowlink.

Collect the reports with and IBM PC or compatible computer running samplink.

581 RTD

4.15.2 Viewing the Data

Because the display area is small, the data on the reports will be displayed a little differently from the data that is transferred to and viewed on your computer.

- For the Sampling Report, the sampler displays each program event, one at a time.
- For the Module and Rainfall Data reports, it displays daily summaries, instead of the full reports available with the rtd, Flowlink, or Samplink.

If you select Sampling Report or Rainfall (step 3 in *Viewing Data*, shown in the margin), the sampler begins displaying the report data. The sampler advances automatically through the report items, displaying each item briefly. While the sampler advances automatically through the displays:

- Stop the automatic displays by pressing Stop once. Then, use the arrow keys to move manually through the report.
- Return to the main menu by pressing Stop twice.

At the end of the report, the sampler leaves the last item displayed until you press:

- the arrow keys to move forward or backward manually through the report.
- Stop to return to the main menu.

- ↵ to start the automatic displays again.

Viewing Data

1
```
RUN
PROGRAM
VIEW REPORT
OTHER FUNCTIONS
```
• Select VIEW REPORT.

2
```
VIEW DATA
SYSTEM IDs
CONFIGURE REPORTS
```
• Select VIEW DATA.

3
```
SELECT DATA TO VIEW:
SAMPLING REPORT
MODULE DATA
RAINFALL DATA
```
• Select a report or data type.

4
```
VIEW:
DAILY SUMMARY
CURRENT READINGS
```
• Select DAILY SUMMARY to view the stored data, or CURRENT READINGS to view real-time data.

If you select Module Data in step 3, the sampler displays the screen shown in step 4. Select the Daily Summary option and the sampler displays the stored data just as the Sampling Report was described above. Selecting the Current Readings option causes the sampler to display real-time readings. When there are multiple screens, they will be displayed alternately. You can quickly advance through the screens by pressing an arrow key or ↵. Pressing Stop exits the Current Readings mode.

4.15.3 Configuring Reports

Configuring Reports

1
```
RUN
PROGRAM
VIEW REPORT
OTHER FUNCTIONS
```
• Select VIEW REPORT.

2
```
VIEW DATA
SYSTEM IDs
CONFIGURE REPORTS
```
• Select CONFIGURE REPORTS

3
```
SAMPLINK REPORT
FLOWLINK REPORT
CUSTOM REPORT
ALL REPORTS
```
• Select the option that matches your data collection software, or tailor the output according to the reports needed.

The Configure Reports option lets you specify which of the Sampling Reports will be included in any output request. Each sampler is shipped with the option Flowlink Report selected.

The Samplink Report and Flowlink Report options allow you to tailor the output to the Teledyne Isco software used to collect the reports. The Samplink Report option provides the Sampling Reports, but disables the output of the detailed partition data.

Flowlink Report provides the Sampling Reports and the detailed partition data. Selecting the Flowlink Report option enables the output of the detailed partition data so Flowlink can add the data to the site's database file.

When you are familiar with the available Sampling Reports, you may want to specify an output containing only the specific data you require. The Custom Report option will allow selection of detailed data. Data collection time and storage space may be optimized using this option.

4.15.4 Sampling Results Report

As the sampler runs a program, it records the program's events. Program events include such items as sample events, program enables and disables, power losses, and so on. Table 4-3 lists each event with a short description. You can view the report by following the steps in *Viewing the Data* on page 4-19 or print the log as the Sampling Results report.

In the text file version of the report, sample-event entries include the time of the event as well as the sample and bottle numbers.

The sample column contains the sample number deposited into the bottle. This information reflects the distribution selected for the program.

The letters in the Source columns are codes for the cause of the event. The letters in the Error column are codes for the causes of missed samples. The source and error codes appear with explanations at the end of the report. A list of codes appears in Table 4-3.

The last column in the Sampling Results report records the pump counts for the sample event. Large variations in pump counts from event to event indicate fluctuating heads, a relocated suction line, or a temporarily clogged strainer.

4.15.5 Combined Results Report

At the time of each sample event, the sampler records the readings from each connected module, rain gauge, or SDI-12 sonde. The Combined Results Report presents the event time, sample and bottle number, and the respective readings from the device.

For flow modules, the readings are level and flow rate. For the pH module, the readings are temperature and pH. For the rain gauge and SDI-12 Sonde, the readings vary according to the selections enabled during the hardware setup in extended programming. When recording four or more sonde parameters, the Combined Results report will exceed the standard 40 character width. To read the additional columns, the data must be collected with Flowlink 4 for Windows software.

4.15.6 Summary Report

This report summarizes the rain gauge or module data. The types of readings are the same as those available to the Combined reports. The sampler compiles the data to present a daily total, the day's average, maximum, and minimum reading, and a listing of hourly averages. The sampler then graphs the day's readings.

Table 4-3 Reports: Program Events, Source Codes, and Error Codes	
* Indicates events and codes that occur in Standard Programming	
Program Events (listed in the order that they most likely would occur)	
*Program Run	The sampler ran the sampling program.
*Program Started	The sampler started the sampling program.
*Program Enabled (Disabled)	The sampler was enabled or disabled according to program settings or an external instrument.
'A'/'B' Enabled (Disabled)	Program part 'A' or 'B' was enabled or disabled according to the program's settings.
Sample	A sample was taken as programmed. (See Source Codes and Error Codes in this table.)
*Sample Switch Time	A sample was taken at programmed switch time.
*Program Done	The sampler finished the sampling program.
'A'/'B' Done	The sampler finished program part 'A' or 'B'.
*Manual Pause	Stop was pressed during the program to enter the Manual Paused state.
*Program Stopped	You selected Stop from the manual paused options, terminating the program.
*Grab Sample	A grab sample was taken while in the Manual Paused state.
Pump Tube Replaced	The pump tube alarm was reset while in the Manual Paused state.
Calibrate Volume	The volume was calibrated.
Calibrate SDI Parameter	An SDI-12 sonde or module parameter was calibrated.
*Adjusted Pacing	The pacing interval was changed while in the Manual Paused state.
*Volume Changed	Sample volume was changed while in the Manual Paused state.
Adjust Enable	Sampler enable thresholds were changed while in the Manual Paused state.
Reset Rain History	The rain history was reset.
Adjust Suction Head	The suction head was changed while in the Manual Paused state.
*Manual Resume	The resume program option was selected from the Manual Paused state.
Program Paused (Resumed)	The program reached a programmed pause or resume time.
'A'/'B' Paused (Resumed)	Program part 'A' or 'B' reached a programmed pause or resume time.
*Power Failed	The power source was disconnected.
*Power Restored	The power source was reconnected.
Alarm Occurred	An alarm occurred.
Alarm Acknowledged	An alarm was acknowledged.
*Missed Password	The password was missed.

Table 4-3 Reports: Program Events, Source Codes, and Error Codes (Continued)

(The Source and Error Codes Listed below refer to why a sample was taken and what happened while it was being taken.)

Source Codes		
*C	Calibrate sample	Sample volume delivered during calibration.
*D	Disable	Sample event at disable time.
*E	Enable	Sample event at enable time.
Ev	Event	Event-paced sample event.
*F	Flow	Flow-paced sample event.
*G	Grab sample	Sample volume delivered as a grab sample.
M	Command driven sample	A command driven sample.
PH	Phone command	Phone command sample.
R	Resume	Sample event at resume time.
*S	Start	Sample event at start time.
Sw	Switch time	Sample event at switch time.
TO	Time Override	Sample event at bottle-switch time.
*T	time	Time-paced sample event.
Error Codes		
*DJ	Distributor Jammed	The distributor jammed.
*IP	sample in progress	Sample in progress when report was printing.
*L	pump latch open	Unable to take sample because the pump band was opened.
*ND	no distributor arm	There is no distributor arm or the stop is damaged.
*NL	No Liquid Detected	The sampler was unable to detect liquid.
LF	Not enough flow	Not enough flow for the minimum sample volume entered for samples with volumes proportional to flow.
*NM	No More Liquid	After the sampler detected liquid and while the sample was being taken, the liquid detector stopped detecting liquid.
M	Bottle Full	The composite bottle is full.
*O	Sampler Shut Off	The sampler was turned off with the On-Off key during the sample event.
Ov	Probable Overflow	The sampler was directed to take a sample that would not fit into the bottle. Occurs for flow paced, time override programs only.
*P	Power Failed	The power supply failed during the sample event. Note: Power failures during five consecutive sample events results in a LOW BATTERY shut-down.
*PJ	Pump Jammed	The pump jammed.
*Sk	Sample Skipped	Sample not taken.
*US	User Stopped	You pressed the Stop key during the sample event.

Figures 4-5, 4-6, 4-7, 4-8, and 4-9 show examples of reports configured to show program settings, sampling results, combined results, and a summary report.

```
SAMPLER ID# 3687447734  06:32 19-DEC-02
  Hardware: A0      Software: 1.02
*********** PROGRAM SETTINGS ***********
     ----------

 SITE DESCRIPTION:
    "FACTORY051"

     ----------
   UNITS SELECTED:
   FLOW RATE: cfs
 FLOW VOLUME: Mgal

     ----------
   BUBBLER MODULE:
        WEIR
        90
      V-NOTCH
     ----------
  24,  1000 ml BTLS

 10 ft SUCTION LINE

     ----------
      PACING:
    TIME, EVERY
 0 HOURS, 15 MINUTES

     ----------
    DISTRIBUTION:
     SEQUENTIAL


     ----------

   200 ml SAMPLES


     ----------

  5 MINUTE DELAY TO
    FIRST SAMPLE

----------------------------------------
```

Figure 4-5 Report: Program Settings

```
SAMPLER ID# 3687447734  06:32 19-DEC-02
  Hardware: A0      Software: 1.02
*********** SAMPLING RESULTS ***********
   SITE: FACTORY051
Program Started at 15:03 WE 18-DEC-02
Nominal Sample Volume =  200 ml
                                    COUNT
                                       TO
SAMPLE  BOTTLE TIME  SOURCE ERROR LIQUID
------- ------ ----      -- --    ------
              15:03  PGM ENABLED
  1,1     1   15:03      S           250
  1,1     2   15:18      T           247
  1,1     3   15:33      T           247
  1,1     4   15:48      T           249
  1,1     5   16:03      T           247
  1,1     6   16:18      T           247
  1,1     7   16:33      T           247
  1,1     8   16:48      T           248
  1,1     9   17:03      T           237
  1,1    10   17:18      T           236
  1,1    11   17:33      T           237
  1,1    12   17:48      T           241
  1,1    13   18:03      T           238
  1,1    14   18:18      T           236
  1,1    15   18:33      T           237
  1,1    16   18:48      T           236
  1,1    17   19:03      T           242
  1,1    18   19:18      T           237
  1,1    19   19:33      T           235
  1,1    20   19:48      T           238
  1,1    21   20:03      T           237
  1,1    22   20:18      T           237
  1,1    23   20:33      T           236
  1,1    24   20:48      T           230
              20:48  PGM DONE 19-DEC

   SOURCE S  ==> START
   SOURCE T  ==> TIME
   ----------------------------------------
```

Figure 4-6 Report: Sampling Results

```
SAMPLER ID# 3687447734  06:32 19-DEC-02
  Hardware: A0      Software: 1.02
 BUBBLER MODULE: 2215419583
  Hardware: A00000  Software: 1.07
*********** COMBINED RESULTS ***********
   SITE: FACTORY051
Program Started at 15:03 WE 18-DEC-02
Nominal Sample Volume =  200 ml
```

SAMPLE	BOTTLE	TIME	LEVEL ft	FLOW RATE cfs	TOTAL FLOW Mgal
1,1	1	15:03	0.009	2.495	000000.000
1,1	2	15:18	0.012	2.576	000000.017
1,1	3	15:33	0.012	2.666	000000.035
1,1	4	15:48	0.012	2.773	000000.053
1,1	5	16:03	0.012	2.773	000000.072
1,1	6	16:18	0.012	2.798	000000.091
1,1	7	16:33	0.012	2.798	000000.109
1,1	8	16:48	0.012	2.798	000000.128
1,1	9	17:03	0.012	2.751	000000.147
1,1	10	17:18	0.012	2.773	000000.166
1,1	11	17:33	0.009	2.798	000000.185
1,1	12	17:48	0.012	3.728	000000.207
1,1	13	18:03	0.012	3.728	000000.232
1,1	14	18:18	0.012	3.728	000000.257
1,1	15	18:33	0.009	3.728	000000.282
1,1	16	18:48	0.012	5.273	000000.317
1,1	17	19:03	0.012	5.239	000000.353
1,1	18	19:18	0.012	6.651	000000.397
1,1	19	19:33	0.009	6.651	000000.442
1,1	20	19:48	0.009	6.651	000000.486
1,1	21	20:03	0.012	6.651	000000.531
1,1	22	20:18	0.012	6.651	000000.576
1,1	23	20:33	0.009	3.404	000000.612
1,1	24	20:48	0.012	3.425	000000.634

Figure 4-7 Report: Combined Results

```
SAMPLER ID# 3687447734  06:32 19-DEC-02
  Hardware: A0      Software: 1.02
*********** COMBINED RESULTS ***********
   SITE: FACTORY051
Program Started at 15:03 WE 18-DEC-02
Nominal Sample Volume =  200 ml
                        FR-TEMP
SAMPLE  BOTTLE TIME           C
------- ------ ----        ----
                    NO FR-TEMPERATURE
----------------------------------------


SAMPLER ID# 3687447734  06:32 19-DEC-02
  Hardware: A0      Software: 0.01.0127
*********** COMBINED RESULTS ***********
   SITE: FACTORY051
Program Started at 15:03 WE 18-DEC-02
Nominal Sample Volume =  200 ml
SAMPLE  BOTTLE TIME
------- ------ ----------- ------ ----
                    NO RAIN GAUGE
----------------------------------------


SAMPLER ID# 3687447734  06:32 19-DEC-02
  Hardware: A0      Software: 0.01.0127
SDI-12 DATA
*********** COMBINED RESULTS ***********
   SITE: FACTORY051
Program Started at 15:03 WE 18-DEC-02
Nominal Sample Volume =  200 ml


                    NO SDI-12 SONDE
----------------------------------------
```

Figure 4-8 Report: Combined Results (continued)

```
SAMPLER ID# 3687447734   16:41 20-DEC-02
   Hardware: A0      Software: 1.02
  BUBBLER MODULE: 2215419583
   Hardware: A00000  Software: 1.07
    SITE: FACTORY051

   Summary Report for 19-DEC-02 (TH)
         Day's Flow:     000000.054 Mgal
       Average Flow Rate:     0.4437 cfs
 07:20 Minimum Flow Rate:     0.0237 cfs
 13:25 Maximum Flow Rate:     7.0207 cfs
        Hourly Average Flow Rate:
       00:00-01:00:       NO DATA
       01:00-02:00:       NO DATA
       02:00-03:00:       NO DATA
       03:00-04:00:       NO DATA
       04:00-05:00:       NO DATA
       05:00-06:00:       NO DATA
       06:00-07:00:       NO DATA
       07:00-08:00:       NO DATA
       08:00-09:00:     2.519 cfs
       09:00-10:00:     2.747 cfs
       10:00-11:00:     2.791 cfs
       11:00-12:00:     3.456 cfs
       12:00-13:00:     5.385 cfs
       13:00-14:00:     6.651 cfs
       14:00-15:00:     2.591 cfs
       15:00-16:00:     1.593 cfs
       16:00-17:00:       NO DATA
       17:00-18:00:       NO DATA
       18:00-19:00:       NO DATA
       19:00-20:00:       NO DATA
       20:00-21:00:       NO DATA
       21:00-22:00:       NO DATA
       22:00-23:00:       NO DATA
       23:00-24:00:       NO DATA

             *---+---+---+---+---+---+*
       8.00  +                        +
             I                        I
             I                        I
             I            #           I
             I            #           I
       6.00  +            #           +
             I            #           I
             I           ##           I
             I           ##           I
             I           ##           I
       4.00  +           ##           +
             I          ###           I
             I          ###           I
             I        #####           I
             I       #######          I
       2.00  +       #######          +
             I       #######          I
             I       ########         I
             I       ########         I
             I       ########         I
       0.00  +       ########         +
             *---+---+---+---+---+---+*
 Hour Ending:       08:     16:     24:
             Units are 'cfs'
```

Figure 4-9 Report: Summary

4.16 System IDs

System IDs

```
RUN
PROGRAM
VIEW REPORT
OTHER FUNCTIONS
```

• Select VIEW REPORT.

```
VIEW DATA
SYSTEM IDs
CONFIGURE REPORTS
```

• Select SYSTEM IDs.

```
SAMPLER
6712 ID _____
HARDWARE: __
SOFTWARE: __
```

• Displayed briefly

```
[MODULE TYPE]
[MODEL #] ID: _____
HARDWARE: __
SOFTWARE: __
```

• Displayed briefly

```
SOFTWARE OPTIONS

[Options List]
```

• Press STOP to return to the main menu.

In addition to viewing report data and configuring reports, the View Report option on the main menu lets you view system identification information.

The sampler reports the sampler model number, ID (identification number), and software version number as system identification notes. The sampler also reports the same information for an attached module.

The model and ID numbers remain unchanged through the life of the sampler. The ID numbers appear on the sampler's reports and in files created by flowlink and samplink when they interrogate the sampler. The software packages use the ID number to make sure that data from different samplers is not combined in the same file.

The software version number changes when your sampler's software is updated.

The system will also list any software options that you have activated on your unit. These software options are discussed in Section 5.

4.17 Programming for 700 Series Modules

The bay on the controller's side accepts any of Teledyne Isco's 700 Series Modules. These modules are optional accessories that are not required for operation of the 6712. However, the modules offer an economical way to combine flow-rate or parameter monitoring with sampling.

The programming of these modules is integrated with the programming of the sampler, so attachment of a module will cause different screens to be displayed, depending on the type of module and the selections you make while programming.

Two modules that are commonly used are the 730 Bubbler Module, which monitors a flow stream's level and flow rate, and the 750 Area Velocity Module for monitoring a flow stream's level, velocity, and flow rate. The following sets of screens give you an example of what screens you might see while programming the sampler and module. Refer to Table 4-1 (which does not have a module attached) at the beginning of this section to compare the sequence of screen displays.

⚠ CAUTION

Most Teledyne Isco accessories and interfacing equipment are not certified for us in hazardous locations as defined by the National Electrical Code. Check applicable guidelines, codes, and regulations of federal, state, city, and county agencies. Refer to Appendix C in the back of this manual for more safety information.

Table 4-4 Programming Example With 730 Module Installed

1	MODULE INSERTED--- DOWNLOAD DATA NOW OR LOSE ALL DATA! DONE	With the sampler off, insert the module in the bay on the controller. Turn the sampler on by pressing the On/Off key. Press ↵. Download stored data, if you want to keep it. Pressing DONE erases it and advances to the next screen.
2	6712 SAMPLER STANDARD PROGRAMMING For HELP at any screen press ? key.	This screen will now appear for 8 seconds.
3	RUN **PROGRAM** VIEW REPORT OTHER FUNCTIONS	The option PROGRAM will be blinking. Press ↵.
4	SITE DESCRIPTION: "FACTORY051" CHANGE? YES **NO**	The option NO will be blinking. Press ↵. For the purposes of this example, it isn't necessary to change the description.
5	SELECT UNITS FOR FLOW RATE: **cfs** gps gpm Mgd lps m3s m3h m3d	Select the desired units for the flow rate. For this example, choose cfs. Press ↵.
6	SELECT UNITS FOR FLOW VOLUME: cf gal **Mgal** m3 lit	Select the desired units for the flow volume. For this example, choose Mgal. Press ↵.
7	PROGRAM MODULE? **YES** NO	Select YES to program the module.

Table 4-4 Programming Example With 730 Module Installed (Continued)

8	MODE OF OPERATION: FLOWMETER LEVEL ONLY	If you choose Flowmeter, proceed to screen #9 below. If you choose LEVEL ONLY, proceed to screen #12.
9	**WEIR** FLUME DATA POINTS EQUATION MANNING FLOW-INSERT	When you select Flowmeter, you will have several options for performing the flow conversion. For this example, choose Weir. Press ↵.
10	**V-NOTCH** RECTANGULAR CIPOLLETTI	For this example, choose V-Notch. Press ↵.
11	V-NOTCH WEIR ANGLE: 120 **90** 60 45 30 22.5	For this example, choose a Weir angle of 90. Press ↵.
12	CURRENT LEVEL IS __.__ ft ADJUST LEVEL TO __.__ ft	The current level will be displayed. Enter an adjustment if needed. If the adjustment is different by more than 0.50 ft, you will be prompted "ARE YOU SURE? YES NO" Choose NO to re-enter; select YES if correct. Press ↵.
13	NUMBER OF BOTTLES: 1 2 4 8 12 **24**	Select the number of bottles in your bottle kit by pressing either arrow key until the correct number blinks. Press ↵. For this example, select 24.
14	BOTTLE VOLUME IS 1000 ml (300-30000)	Type the volume for the bottles in your kit. For this example, 1000 is correct, so simply press ↵.
15	SUCTION LINE LENGTH IS 10 ft (3-99)	Type the length of the suction line, then press ↵. If you change the length, the sampler will display a message, "PLEASE WAIT!. . . GENERATING PUMP TABLES."
16	TIME PACED **FLOW PACED**	Select FLOW PACED. If the module is being used as a flowmeter, you will see screen #17a. If the module is being used for level only, you will see screen #17b.
17a	FLOW BETWEEN SAMPLE EVENTS: **0.075 Mgal** (0.001 - 99999)	If the module is being used as a flowmeter, choose the amount of flow between sample events.

Table 4-4 Programming Example With 730 Module Installed (Continued)

17	FLOW BETWEEN SAMPLE EVENTS: **2** PULSES (1-9999)	If the module is being used for level only, enter the number of pulses between sample events.
18	SEQUENTIAL **BOTTLES/SAMPLE** SAMPLES/BOTTLE	Select BOTTLES/SAMPLE.
19	**2** BOTTLES PER SAMPLE EVENT (1-24)	Enter 2.
20	RUN CONTINUOUSLY? YES **NO**	Select NO.
21	SAMPLE VOLUME: **250** ml (10-1000)	Enter 250.
22	NO DELAY TO START DELAYED START **CLOCK TIME** WAIT FOR PHONE CALL	Select CLOCK TIME.
23	START FLOW COUNT AT: 06:00	Enter 6, then enter 0. This is the time at which the sampler will start the pacing countdown.
24	SELECT DAYS: SU **MO** TU **WE** TH **FR** SA DONE	Select MO, WE, and FR. Use the arrow keys and ↵ to select MO, WE, and FR. When the correct days are blinking, select DONE and press ↵.
25	PROGRAMMING COMPLETE RUN THIS PROGRAM NOW? YES **NO**	Select NO.

Table 4-5 Programming Example With 750 Module Installed

1	MODULE INSERTED--- DOWNLOAD DATA NOW OR LOSE ALL DATA! DONE	With the sampler off, insert the module in the bay on the controller. Turn the sampler on by pressing the On/Off key. Press ↵. Download stored data, if you want to keep it. Pressing DONE erases it and advances to the next screen.
2	6712 SAMPLER STANDARD PROGRAMMING For HELP at any screen press ? key.	This screen will now appear for 8 seconds.
3	RUN **PROGRAM** VIEW REPORT OTHER FUNCTIONS	The option PROGRAM will be blinking. Press ↵.
4	SITE DESCRIPTION: "FACTORY051" CHANGE? YES **NO**	The option NO will be blinking. Press ↵. For the purposes of this example, it isn't necessary to change the description.
5	SELECT UNITS FOR FLOW RATE: **cfs** gps gpm Mgd lps m3s m3h m3d	Select the desired units for the flow rate. For this example, choose cfs. Press ↵.
6	SELECT UNITS FOR FLOW VOLUME: cf gal **Mgal** m3 lit	Select the desired units for the flow volume. For this example, choose Mgal. Press ↵.
7	SELECT UNITS FOR VELOCITY: **fps** mps	Select the desired units for the flow velocity. For this example, choose fps. Press ↵.
8	PROGRAM MODULE? **YES** NO	Select YES to program the module.
9	MODE OF OPERATION: **FLOWMETER** LEVEL AND VELOCITY	The 750 can have two different modes of operation: Flowmeter or Level and Velocity. For this example, choose Flowmeter. Press ↵.
10	FLOW CALCULATION: **AREA * VELOCITY** LEVEL TO FLOW RATE	When you select Flowmeter, you will have two options for performing the flow conversion: Area * Velocity or Level to Flow Rate. For this example, choose Area * Velocity. Press ↵.
11	LEVEL TO AREA: **CHANNEL SHAPE** DATA POINTS	For this example, choose Channel Shape. Press ↵.
12	**ROUND PIPE** U-CHANNEL RECTANGULAR CHANNEL TRAPEZOIDAL CHANNEL	For the channel shape, select Round Pipe. Press ↵.

Table 4-5 Programming Example With 750 Module Installed (Continued)

13	ROUND PIPE DIAMETER = 2.00 ft	Enter the diameter of the round pipe. Press ↵.
14	CURRENT LEVEL IS __.__ ft ADJUST LEVEL TO __.__ ft	The current level will be displayed. Enter an adjustment if needed. If the adjustment is different by more than 0.50 ft, you will be prompted "ARE YOU SURE? YES NO" Choose NO to re-enter; select YES if correct. Press ↵.
15	ZERO LEVEL OFFSET: _.___ ft	Enter the amount of zero level offset. Press ↵.
16	MAXIMUM DEPTH FOR VELOCITY MEASUREMENT 2" 3" 4"	(This screen is applicable for standard-sized probes only.) Select the maximum depth for the velocity measurement. Press ↵.
17	NUMBER OF BOTTLES: 1 2 4 8 12 **24**	Select the number of bottles in your bottle kit by pressing either arrow key until the correct number blinks. Press ↵.

From this point forward, the screens will be the same as in Table 4-2.

6712 Portable Sampler

Section 5 Extended Programming

The 6712 Sampler has two sets of programming screens. The first set, called standard programming screens, lets you set up typical sampling programs easily and efficiently. The second set, extended programming screens, lets you create sophisticated programs for complex sampling applications.

All of the sampling features available with standard programming screens, discussed in Section 4, are available with extended programming screens. However, the extended screens provide several additional features and some screen display differences which are discussed in this section. The menu flowcharts for both sets of programming screens are in *Appendix A, Menu Flowcharts*.

> ☑ ***Note***
>
> This section assumes that you have read, and are familiar with, the instructions in Section 4, Standard Programming!

5.1 Extended and Standard Mode

The sampler is shipped with factory default settings in standard programming mode when you first turn the sampler on. The start-up screen tells you which programming mode the sampler is currently using. You can switch between programming modes by entering a numerical command at the main menu:

At the main menu type **6712.2** to enter extended programming mode.

At the main menu type **6712.1** to enter standard programming mode.

RUN "EXTENDED 1"
PROGRAM
VIEW REPORT
OTHER FUNCTIONS

Main Menu for Extended Mode

5.2 One-Part and Two-Part Programs

Extended programming lets you set up a "one-part" program or a "two-part" program. One-part programs let you fill all bottles of the tub with one set of pacing, distribution, and enable settings. Two-part programs add an additional set of extended pacing, distribution, and enable screens to the sampling program. Each set of screens is called a program part. The program parts are simply called part 'A' and part 'B'. Both parts share the program settings for suction-line length, suction head, and rinses and retries. They also share one start-time setting.

Each part has its own group of bottles. Because settings for each part are independent of each other, the sampler, when running a two-part program, fills each bottle group as if they were being filled by two different programs. Two-part programs finish when both parts are done.

Two-part programming is ideal for sampling storm events. Many storm-water run-off monitoring permits require a first-flush grab sample within the first 30 minutes of the storm event and flow-paced samples during the remainder of the event. With a two-part program, you can set up part 'A' for the first-flush sample and part 'B' for the remainder. Table 5-2 shows a storm-water sampling program.

5.3 Storage for Extended Programs

The sampler stores five sampling programs: one standard and four extended. Program storage eliminates the need to reprogram the sampler with frequently used settings. This feature is especially useful for complex extended programs such as two-part programs or programs with many nonuniform-time settings.

Teledyne Isco ships the sampler to you with factory programs that you can modify to suit your own needs. All four extended programs are identical to each other.

The stored programs will also save your 700 Series Module program settings and any sampler enable conditions using rain gauge data or SDI-12 sonde parameters. These program settings remain as long as you do not change the type of module, or change the rain gauge or SDI-12 Hardware Setup.

5.3.1 Selecting a Stored Program

When the sampler is in extended programming mode, it always has one current and three noncurrent programs, each occupying a permanent location in memory. The first time you access the extended mode, the current program is "EXTENDED 1," one of the factory extended programs. The name of the current extended program appears in quotations on the first line of the main menu.

The factory programs are named "EXTENDED 1," "EXTENDED 2," "EXTENDED 3," and "EXTENDED 4." You can rename them with more descriptive names, making them easier to identify. The program name is one of the extended program's settings.

After selecting a stored program, review the settings with the quick view screens. Each sampling program stores all the settings required by the sampler to run a program. These settings include the bottle-kit information (number of bottles and the bottle volume), the suction-line length, the site description, start times, and so on.

If you use the same program at two sites — each requiring different bottle configurations, suction line lengths, or other details — always check these settings before running a program. You may need to make minor changes to the program to make sure the settings match your equipment.

The current program is the program you see when you select PROGRAM from the main menu and page through the programming screens. It is the program the sampler uses when you select RUN from the main menu.

You cannot delete programs, but you can modify them as often as necessary. To run a program with different settings without losing the settings in your current program, select a stored program and modify its settings.

For example, assume you have been running the current program, named “EXTENDED 1,” at site A for several weeks. This program contains all the settings you need for site A, and you don’t want to lose those settings.

Nevertheless, you need another program because you want to move the sampler to site B, so you select “EXTENDED 2” and modify it for site B. The settings in “EXTENDED 1” are preserved automatically. When you return the sampler to site A, you won’t need to reprogram the sampler. Merely select “EXTENDED 1” again, double-check the program settings, and run the program. To select an extended program, follow the steps in Table 5-1.

Table 5-1 Selecting a Stored Extended Program

1	6712 SAMPLER, EXTENDED PROGRAMMING For HELP at any screen, press ? key.	Press the On/Off key to turn the sampler on. Press ↵ to clear the start-up message. If the words “STANDARD PROGRAMMING” appear on the second line of the start-up message, the sampler is using the standard programming screens. To see the extended screens, type **6712.2** at the main menu shown in step 2.
2	RUN “EXTENDED 1” **PROGRAM** VIEW REPORT OTHER FUNCTIONS	Select PROGRAM from the main menu.
3	PROGRAM NAME: **"EXTENDED 1"** SITE DESCRIPTION: "_____"	Select PROGRAM NAME: "EXTENDED 1" from the quick view menu.
4	**SELECT NEW PROGRAM** CHANGE PROGRAM NAME	Select SELECT NEW PROGRAM to change the program. You can go through QUICK VIEW screens quickly by pressing ↵ at each screen. You can also change settings in quick view screens; see *Changing Settings in a Quick View Screen* on page 3-4.
5	“EXTENDED 1” **“EXTENDED 2”** “EXTENDED 3” “EXTENDED 4”	Select the name of the extended program you want to use. Each program’s name appears on the same line. If you inadvertently give two programs identical names, you can still identify them by their location on the screen.
6	PROGRAMMING COMPLETE RUN THIS PROGRAM NOW? YES **NO**	To run the program immediately, select YES. To run the program later, select NO.
7	**RUN “EXTENDED 2”** PROGRAM VIEW REPORT OTHER FUNCTIONS	

5.4 Programming for 700 series Modules

The bay on the controller's side accepts any of Teledyne Isco's 700 Series Modules. These optional accessories are not required to operate the 6712. However, the modules offer an economical way to combine flow-rate or parameter monitoring with sampling.

The programming of these modules is integrated with the programming of the sampler, so attachment of a module will cause different screens to be displayed, depending on the type of module and the selections you make while programming.

Two modules that are commonly used are the 730 Bubbler Module, which monitors a flow stream's level and flow rate, and the 750 Area Velocity Module for monitoring a flow stream's level, velocity, and flow rate. Section 4 contains two examples of programming for modules. Module programming is the same in Extended as it was in Standard programming.

5.5 Programming SDI-12 Sondes

As an option, the 6712 accepts up to 16 parameters from up to ten sensors with SDI-12 addresses from 0 - 9. The data parameters used by the sonde and sampler must match. Certain vendors' sondes, such as Hydrolab and YSI, have enhanced commands that facilitate "plug and play" setup. These Teledyne Isco Ready sondes can tell the 6712 what values they have, their order, and units of measure. Other sondes can be used, but require manual setup to identify proper data types for each data value reported.

For more information about programming SDI-12 sondes, refer to Section 6.

5.6 Programming Examples

In addition to the features available with standard programming, and discussed in Section 4, extended programming offers:

- Nonuniform time pacing
- Random interval pacing
- Event pacing
- Multiple bottle compositing
- Time switched bottles or bottle sets
- Programmable sampler enable
- Pauses and resumes
- Two-part programming
- Automatic or user-defined suction head
- Suction line rinses
- Sampling retries

This manual provides several programming examples. Some, demonstrating simple tasks, appear in the margins. Others, demonstrating more complex tasks, appear as examples. Table 5-2 on the following pages steps you through a storm water runoff sampling using extended programming.

5.6.1 Storm Water Runoff Sampling

Storm water runoff sampling is an ideal application for two-part programming. Typical monitoring permits require that a series of timed samples be taken during the initial portion of the storm event, followed by flow paced samples during the remainder of the event.

This example assumes that a Rain Gauge and a Bubbler Flow Module are connected to the sampler.

> ☑ ***Note***
>
> To enable the Bubbler Module programming screens, insert the module before turning on the sampler

Using a 24-bottle kit, it divides the bottles into two groups, with six bottles assigned to part 'A' and 18 to part 'B.' The sampler will begin taking samples after being enabled according to programmable enable controls; that is, when the rain gauge detects 0.15 inches of rainfall in 30 minutes, and the module detects a flow stream level of more than 0.25 feet. Because both program parts use the same enable settings, the sampler will enable both parts at the same time. A list of settings for the program follow:

- Program type: Extended.
- Program name: STORM.
- Site description: SITE 54.
- Units: Length – Ft, Flow Rate – gpm, Flow Volume – gal
- Mode of Operation: Flowmeter, Flow-Insert, Round, 12"
- Bottle kit: 24, 1000-milliliter bottles.
- Suction-line length: 5 feet.
- Suction head: Auto suction head.
- Line rinses: None.
- Sampling retries: None.
- Part 'A' and 'B' bottle assignments: Bottles 1 - 6 to part 'A', bottles 7 - 24 to part 'B'.
- Part 'A' pacing: Time pacing, sampling every 5 minutes.
- Part 'A' distribution: Sequential, 1 sample per bottle.
- Part 'A' sample volume: 800 milliliters.
- Part 'A' enable: At least 0.15 inches of rainfall in 30 minutes and a flow stream level of more than 0.25 feet; once enabled, stay enabled, sample taken when the sampler is enabled.
- Part 'A' pause and resumes: None.
- Part 'B' pacing: Flow pacing, sampling every 2,500 gallons.
- Part 'B' distribution: Sequential, 1 sample per bottle.
- Part 'B' sample volume: 500 milliliters.
- Part 'B' enable: At least 0.15 inches of rainfall in 30 minutes and a flow stream level of more than 0.25 feet;

once enabled, stay enabled, no sample taken when the sampler is enabled; first sample taken 20 minutes after the sampler is enabled.

- Part 'B' pause and resumes: None.
- Start time: Delayed start of 1 minute.
- 730 Bubbler Module: Installed

Table 5-2 Storm Water Runoff Sampling

1	6712 SAMPLER EXTENDED PROGRAMMING For HELP at any screen press ? key.	This screen will appear briefly.
2	RUN "EXTENDED 1" **PROGRAM** VIEW REPORT OTHER FUNCTIONS	Select PROGRAM. Note: If the start-up screen displayed "STANDARD PROGRAMMING", type **6712.2** at this menu before selecting PROGRAM.
3	PROGRAM NAME: "EXTENDED 1 " CHANGE? **YES** NO	Select YES. Note: If the quick view screen shows up, press STOP then select OTHER FUNCTIONS, SOFTWARE OPTIONS, QUICKVIEW/CHANGE, NORMAL. Then press STOP and go back to step 2.
4	SELECT NEW PROGRAM **CHANGE PROGRAM NAME**	Select CHANGE PROGRAM NAME.
5	NAME: "**STORM** " ABCDEFGHIJKLMNOPQRST UVWXYZ-& 0123456789 BACK-UP DONE	Enter the word "STORM" for the program name.
6	SITE: DESCRIPTION "FACTORY051" CHANGE? **YES** NO	Select YES.
7	SITE: "**SITE 54** " ABCDEFGHIJKLMNOPQRST UVWXYZ-& 0123456789 BACK-UP DONE	Enter "SITE 54" for the site description.
8	SELECT UNITS FOR LENGTH: **ft** m	Select ft.
9	SELECT UNITS FOR FLOW RATE cfs gps **gpm** Mgd lps m3s m3h m3d	Select gpm.
10	SELECT UNITS FOR FLOW VOLUME cf **gal** Mgal m3 lit	Select gal.

Table 5-2 Storm Water Runoff Sampling (Continued)

11	PROGRAM MODULE? **YES** NO	Select YES
12	MODE OF OPERATION **FLOWMETER** LEVEL ONLY	Select FLOWMETER
13	WEIR FLUME DATA POINTS EQUATION MANNING **FLOW-INSERT**	Select FLOW-INSERT.
14	WEIR/ORIFICE TYPE V-NOTCH **ROUND**	Select ROUND.
15	FLOW INSERT SIZE: 6" 8" 10" **12"**	Select 12.
16	NEW MODULE SETUP-- DOWNLOAD DATA NOW OR LOSE ALL DATA! DONE	Select DONE. Note: Partition memory status message will be displayed briefly.
17	CURRENT LEVEL IS ___.___ ft. ADJUST LEVEL TO ___.___ ft.	Press ENTER.
18	DATA STORAGE INTERVAL IN MINUTES 1 2 **5** 10 15 30	Select 5. (If the data storage interval is different from the current program, you will be informed that the storage interval has changed, and that the stored data will be lost. Download stored data (if desired) and select DONE.
19	NUMBER OF BOTTLES: 1 2 4 8 12 **24**	Select 24.
20	BOTTLE VOLUME IS 1000 ml (300-30000)	Enter 1000.
21	SUCTION LINE LENGTH IS 5 ft (3-99)	Enter 5. The 6712 calculates new pump tables.
22	**AUTO SUCTION HEAD** ENTER HEAD	Select AUTO SUCTION HEAD.

Table 5-2 Storm Water Runoff Sampling (Continued)

23	0 RINSE CYCLES (0-3)	Enter 0.
24	RETRY UP TO 0 TIMES WHEN SAMPLING (0-3)	Enter 0.
25	ONE-PART PROGRAM **TWO-PART PROGRAM**	Select TWO-PART PROGRAM.
26	24 BOTTLES AVAILABLE ASSIGN BOTTLES 1 THRU **6** TO PART 'A' (1-23)	Enter 6. Screen will say "Beginning Part A" before proceeding with screen 27.
27	**UNIFORM TIME PACED** FLOW PACED EVENT PACED NONUNIFORM TIME	Select UNIFORM TIME PACED.
28	TIME BETWEEN SAMPLE EVENTS: 0 HOURS, **5** MINUTES	Enter 0 for hours, 5 for minutes.
29	**1** BOTTLES PER SAMPLE EVENT (1- 6)	Enter 1.
30	SWITCH BOTTLES ON: **NUMBER OF SAMPLES** TIME	Select NUMBER OF SAMPLES.
31	SWITCH BOTTLES EVERY **1** SAMPLES (1-50)	Enter 1.
32	RUN CONTINUOUSLY? YES **NO**	Select NO.
33	DO YOU WANT SAMPLE VOLUMES DEPENDENT ON FLOW? YES **NO**	Select NO.
34	SAMPLE VOLUME **200** ml (10-1000)	Enter 800.

Table 5-2 Storm Water Runoff Sampling (Continued)

35	ENABLE: **RAIN** LEVEL FLOW NONE	Select RAIN. Note: All valid enable options will appear here, so your screen may differ.
36	ENABLE: RAIN **AND** OR DONE	Select AND.
37	ENABLE: RAIN AND **LEVEL** FLOW NONE	Select LEVEL.
38	"RAIN" SET POINT: **0.15** INCHES PER __HOURS, __MINUTES	Enter 0.15 for inches, then enter 30 minutes.
39	ENABLED WHEN: **ABOVE SET POINT** BELOW SET POINT	Select ABOVE SET POINT.
40	RESET RAIN HISTORY? **YES** NO	Select YES.
41	"LEVEL" CONDITION: **SET POINT** RANGE RATE OF CHANGE	Select SET POINT.
42	"LEVEL" SET POINT **0.25** ft (0.001-30.000)	Enter 0.25.
43	ENABLED WHEN: **ABOVE SET POINT** BELOW SET POINT	Select ABOVE SET POINT.
44	ONCE ENABLED, STAY ENABLED? **YES** NO	Select YES.
45	SAMPLE AT ENABLE? **YES** NO	Select YES.
46	PAUSE RESUME 1. HH:MM DD HH:MM DD 2. HH:MM DD HH:MM DD CLEAR **DONE**	Select DONE. Screen will say "End of Part A" then "Beginning Part B."
47	UNIFORM TIME PACED **FLOW PACED** EVENT PACED NONUNIFORM TIME	Select FLOW PACED.

Table 5-2 Storm Water Runoff Sampling (Continued)

48	PACED BY: FLOW PULSES **FLOW MODULE VOLUME**	Select FLOW MODULE VOLUME.
49	FLOW BETWEEN SAMPLE EVENTS: 2500 gal (0.001-99999)	Enter 2500.
50	SAMPLE AT START? **YES** NO	Select YES. This will cause the first sample to be taken 20 minutes (the delay to start of sampling specified in Step 67) after the enable for Part B.
51	1 BOTTLES PER SAMPLE EVENT (1- 18)	Enter 1.
52	SWITCH BOTTLES ON: **NUMBER OF SAMPLES** TIME	Select NUMBER OF SAMPLES.
53	SWITCH BOTTLES EVERY **1** SAMPLES (1- 50)	Enter 1.
54	RUN CONTINUOUSLY? YES **NO**	Select NO.
55	SAMPLE VOLUME: **200** ml (10-1000)	Enter 500.
56	ENABLE: **RAIN** LEVEL FLOW 'A' DONE NONE	Select RAIN.
57	ENABLE: RAIN **AND** OR DONE	Select AND.
58	ENABLE: RAIN AND **LEVEL** FLOW 'A' DONE DONE	Select LEVEL.
59	"RAIN" SET POINT: **0.15** INCHES PER __HOURS, __MINUTES	Enter 0.15 for inches, then enter 30 minutes.
60	ENABLED WHEN: **ABOVE SET POINT** BELOW SET POINT	Select ABOVE SET POINT.

Table 5-2 Storm Water Runoff Sampling (Continued)

61	RESET RAIN HISTORY? **YES** NO	Select YES.
62	"LEVEL" CONDITION: **SET POINT** RANGE RATE OF CHANGE	Select SET POINT.
63	"LEVEL" SET POINT **0.25** ft (0.100-30.000)	Enter 0.25.
64	ONCE ENABLED, STAY ENABLED? **YES** NO	Select YES.
65	SAMPLE AT ENABLE? YES **NO**	Select NO.
66	START OF SAMPLING AFTER A 15 MINUTE DELAY (1-999)	Enter 20.
67	PAUSE RESUME 1. HH:MM DD HH:MM DD 2. HH:MM DD HH:MM DD CLEAR **DONE**	Select DONE. Screen will say "End of Part B."
68	NO DELAY TO START **DELAYED START** CLOCK TIME WAIT FOR PHONE CALL	Select DELAYED START.
69	START "STORM" AFTER A 72 HOUR "DRY" PERIOD? YES **NO**	Select NO. (Option for samplers using a 0.01 inch tip rain gauge. See Dry Period Option, described on page 5-26.)
70	START "STORM" AFTER A 1 MINUTE DELAY (1-999)	Enter 1.
71	PROGRAMMING COMPLETE RUN THIS PROGRAM NOW? YES **NO**	Select NO.

The above example presented several screens that are not available in standard programming. Descriptions of features available in extended programming follow.

5.7 Suction Head

Extended Screen for Suction Head Settings

```
AUTO SUCTION HEAD
ENTER HEAD
```

If you choose AUTO SUCTION HEAD, the head will be determined for you. If you select ENTER HEAD, the screen below will be displayed so you can enter the suction head.

```
SUCTION HEAD OF
___ ft
(min - max)
```

Suction head is the vertical distance between the surface of the liquid source and the sampler's pump. At each sample event, the sampler determines the suction head automatically.

In extended programming, you can manually enter the suction head if you want. Select ENTER HEAD only when the head remains stable and you can measure it accurately.

5.8 Rinses and Retries

Screens for Line Rinses and Sampling Retries

```
__RINSE CYCLES
(0-3)
```

```
RETRY UP TO __ TIMES
WHEN SAMPLING
(0-3)
```

Rinses and retries are extended programming features. You can program the sampler to rinse the suction line automatically. During a line rinse cycle, the sampler draws liquid through the line to the liquid detector. As soon as it detects liquid, the sampler reverses the pump to purge the line.

The sampling retries feature lets you set the number of times, from 0 to 3, that the sampler tries to detect liquid in the line before skipping the sample.

5.9 Pacing

Extended Pacing Screen

```
UNIFORM TIME PACE
FLOW PACED
EVENT PACED
NONUNIFORM TIME
```

Sample pacing is the rate at which the sampler takes samples. Depending on the type of pacing you select, the rate is controlled by the sampler's internal clock or by inputs received from connected instruments.

Standard programming provides time pacing and flow pacing, which are described in Section 4. Extended programming provides additional pacing types, so its pacing screen (see example in margin) has four items listed instead of two.

"Uniform time" pacing is identical to "time" pacing in standard programming. "Flow paced" is the same for both types of programming. Event paced and nonuniform time pacing are described below.

5.9.1 Event Pacing

To program the sampler for event pacing, select event paced. Refer to Table 5-3 for an example of event paced sampling that uses three event conditions.

Up to fourteen event conditions can be defined (for two-part programs, up to fourteen event conditions can be defined for each part). An event will occur when any of the programmed event

conditions becomes true. The default distribution setting for event-paced sampling is sequential (each time an event occurs, the sampler takes one sample, placing it in one bottle). However, any distribution setting may be used.

If you have programmed multiple conditions, and more than one condition comes true at the same time (within your measurement interval), one sample will be taken and all conditions that caused the event will be noted on reports.

Table 5-3 uses **rate of change** for the event condition (see step 7). This feature enables the event condition under specific circumstances.

In the example below, a rate of change is set so that if the level rises more than one foot in a two hour time period, the event condition would be enabled and a sample taken.

In determining if the rise occurs in this example, the sampler looks back at the previous two hour time period to see if there is a rise of more than one foot between any valley (low point) or peak (high point) within that time period.

Once the condition becomes true (a rise of more than one foot is noted), the event condition is enabled. It will not be enabled again unless the condition becomes false, and then true again, within the two hour time window.

In event pacing, up to three different rate of change event conditions can be programmed (for two-part programs, a total of six rate of change event conditions can be defined, three for each part).

5.9.2 Event Paced Sampling

This example uses a sampler with an attached 730 Bubbler Flow Module, Rain Gauge, and an SDI-12 sonde at address 5 with four parameters.

Table 5-3 Event Paced Sampling

1	UNIFORM TIME PACED FLOW PACED **EVENT PACED** NONUNIFORM TIME	Select EVENT PACED.
2	EVENT01: RAIN **LEVEL** FLOW TEMP5 pH5 SP_CO5 DO5 DONE	Select the parameters that will trigger the event. Use the arrow keys to move through the parameters. To define the first event for this example, select LEVEL.
3	"LEVEL" CONDITION: **SET POINT** RANGE RATE OF CHANGE	Choose SET POINT.
4	"LEVEL" SET POINT: **1.000** ft (0.001 - 30.00)	Enter a set point of 1 foot.

Table 5-3 Event Paced Sampling (Continued)

5	ENABLED WHEN: **ABOVE SET POINT** BELOW SET POINT	Select ABOVE SET POINT.
6	EVENT02: RAIN **LEVEL** FLOW TEMP5 pH5 SP_CO5 DO5 DONE	Select LEVEL again.
7	"LEVEL" CONDITION: SET POINT RANGE **RATE OF CHANGE**	Choose RATE OF CHANGE.
8	CONDITION IS TRUE WHEN "LEVEL" **RISES** FALLS	Choose RISES. This will enable the event condition if a rise occurs within the time frame and above the amount specified in screen #9.
9	"LEVEL" RISES **1.000** ft __HOURS, __MINUTES	Enter 1 ft and press ↵. Then enter 2 hours.
10	EVENT03: RAIN LEVEL FLOW TEMP5 **pH5** SP_CO5 DO5 DONE	Select pH.
11	"pH5" CONDITION: SET POINT **RANGE** RATE OF CHANGE	Select RANGE.
12	"pHx" RANGE: LOWER: **4.00** UPPER: **10.00** (0.00 - 14.00)	Enter 4 for the lower range and 10 for the upper range.
13	ENABLED WHEN: **INSIDE RANGE** OUTSIDE RANGE	Choose INSIDE RANGE.
14	EVENT04: RAIN LEVEL FLOW TEMP5 pH5 SP_CO5 DO5 DONE	You will not be entering a fourth event condition, so use the arrow keys to scroll down, and then select DONE.
15	PACING: EVENT PACED 3 EVENT CONDITIONS	Proceed with the rest of the programming steps.

5.9.3 Nonuniform Time Pacing

The extended time pacing options are uniform time and nonuniform time. “Uniform time” pacing is identical to “time” pacing in standard programming. Nonuniform time pacing uses an irregular interval between sample events; each interval is individually programmable. There are three types of nonuniform time pacing:

- Nonuniform clock time pacing.
- Nonuniform interval pacing.
- Random interval pacing.

5.9.4 Nonuniform Clock Time Pacing

For clock time pacing, enter specific times for each sample event (see screen 2). You can enter as many as 99 clock times, but the interval between times cannot be greater than 24 hours. (Remember to use a 24-hour clock when entering times.) The sampler takes a sample at the start time.

5.9.5 Nonuniform Interval Pacing

For nonuniform interval pacing, enter the number of sample events spaced at intervals of minutes: 12 samples at 5 minute intervals, 6 samples at 10 minute intervals, and so on. The sampler accepts as many as 99 nonuniform interval entries. The sampler takes a sample at start time.

5.9.6 Random Interval Pacing

Time Pacing Screens

1
```
NONUNIFORM TIME:
CLOCK TIMES
INTERVALS IN MINUTES
RANDOM INTERVALS
```

CLOCK TIMES

2
```
TAKE SAMPLES AT:
1. START TIME
2. HH:MM
3. HH:MM
```

INTERVALS IN MINUTES

3
```
FIRST SAMPLE AT
START TIME,
THEN . . .
```

4
```
QUANTITY AT INTERVAL
1. __ AT ___ MIN
2. __ AT ___ MIN
3. __ AT ___ MIN
```

RANDOM INTERVALS

5
```
PROGRAM RUN TIME:
__ HOURS, __ MINUTES
```

To program the sampler for random interval pacing, enter the length of time you want to sample. The run time is the only random programming setting you’ll need to enter because the sampler derives the number of sample events required for the program from the distribution settings. (You can combine random pacing with any distribution.) Each time you run the program, the sampler generates a new set of random intervals. This makes each sample event unpredictable from run to run.

In both nonuniform clock time pacing and nonuniform interval pacing, the sampler takes a sample at the start time. For random pacing, however, it takes the first sample at the end of the first interval, not at the start time.

5.10 Distribution

Distribution describes how the sampler is to deposit samples. A sample is the volume of liquid deposited in a bottle. A sample event includes the full sampling cycle and may deposit a sample into more than one bottle. You can program the sampler for five distribution methods:

- Sequential
- Bottles per sample
- Samples per bottle
- Composite
- Multiple Bottle Compositing

5.10.1 Sequential

In sequential distribution, the sampler deposits one sample in each bottle. A sequential sample represents a "snapshot" of the flow stream at a point in time.

5.10.2 Bottles Per Sample

In bottles per sample distribution, the sampler deposits a sample in each of a set of bottles. A bottle set includes at least two bottles but may include all bottles. Use bottles per sample when the volume to be collected is larger than the amount one bottle can hold or when you need identical samples.

5.10.3 Samples Per Bottle

In samples per bottle distribution, the sampler deposits samples from several sample events in a single bottle before moving to the next bottle. Use samples per bottle distribution to collect a series of small composite samples.

5.10.4 Composite

For single bottle configurations, samples per bottle distribution is known as composite sampling. A composite sample represents an average of the flow stream's characteristics during the sampling period.

5.10.5 Multiple Bottle Compositing

Multiple bottle compositing is a combination of bottles-per-sample and samples-per-bottle. At each sample event, the sampler deposits a sample into a set of bottles. It moves to a new bottle set only after each bottle of the first set contains the programmed number of samples. Use multiple-bottle compositing to collect identical sets of composite samples or a composite sample that is larger than the capacity of a single bottle. Multiple bottle compositing is available only in extended programming.

5.10.6 Time Switching

In extended programming, the sampler offers an additional distribution feature, time switching. This feature determines when the sampler fills the next bottle or bottle set, and may be used with time-paced or flow-paced sample programs. Time switching distribution occurs at regular intervals (as programmed in screen 3 in the margin). The switch times are relative to the programmed "FIRST SWITCH TIME" (screen 4).

Switch times occur regardless of the state of the sampler. Be aware that the sampler may leave empty bottles if it becomes disabled. Pause and resumes are an exception; the sampler will not switch bottles during a pause if the current bottle is empty.

Time Switched Distribution

1 2 BOTTLES PER SAMPLE EVENT (1-max)

- Enter the number of bottles that should receive samples at each sample event.

2 SWITCH BOTTLES ON: NUMBER OF SAMPLES **TIME**

- Select TIME.

3 SWITCH BOTTLES EVERY __ HOURS, __ MINUTES

- Enter the time between bottle switches.

4 FIRST SWITCH TIME AT: __:__

- Enter the first bottle switch time.

If the program settings instruct the sampler to take a sample at the start time, the sampler also draws a sample at the switch time. When this occurs, the pacing will also be reset at the switch time.

Time switching is normally used with flow-paced programs that do not take a sample at start. These programs will place a sample in the current bottle if it is empty at the switch time, and then move to the next bottle/set. Pacing intervals are reset at every switch time.

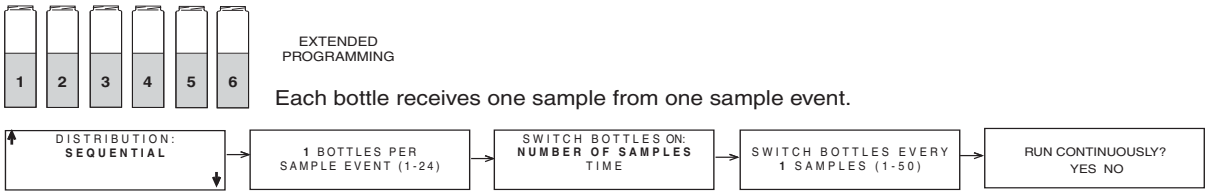
When you use the time switching feature, the volume in each bottle or bottle set may vary. Sample volumes that would exceed the bottle capacity are not taken and a “PROBABLE OVERFILL” message is logged.

5.10.7 Continuous Sampling

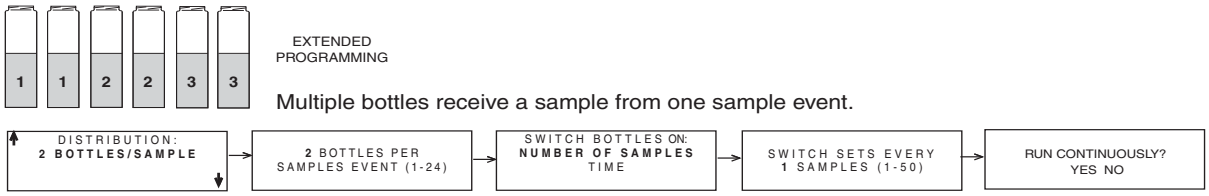
Sample programs can be run indefinitely by selecting “YES” at the “RUN CONTINUOUSLY?” screen. Continuous sampling resets the distribution when the distribution sequence is complete. That is, when the last bottle/set is reached, the next bottle/set is the first bottle/set. All pacing modes except RANDOM are supported.

When running a program continuously, the bottles must be serviced at regular intervals to prevent overfilling the bottles. The sampler assumes that the next bottle/set is empty and ready to receive samples. If you are using this feature with two-part programming, keep in mind that the parts will most likely reset at different intervals.

Sequential

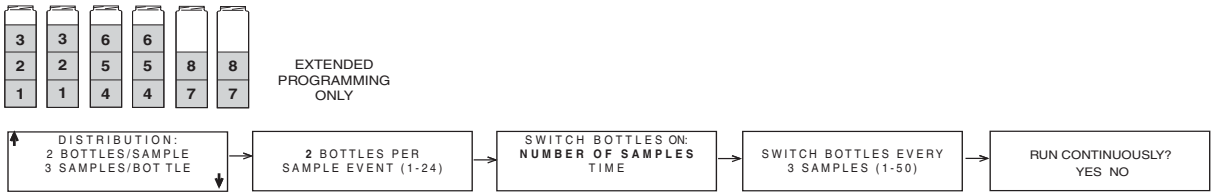


Bottles-per-Sample



Samples-per-Bottle

Multiple Bottle Compositing



Time Switched (Flow-paced, No sample at start)

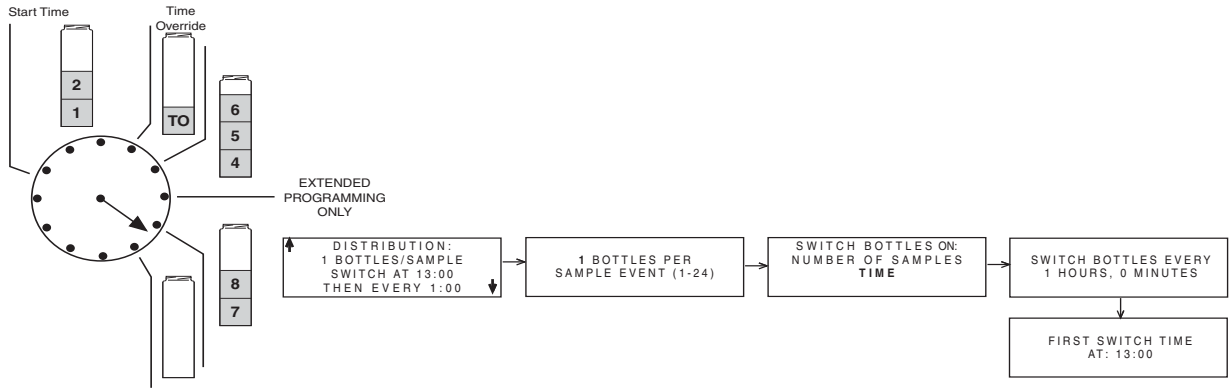


Figure 5-1 Sample Distribution

5.11 Flow Proportional Sample Volumes

The 6712 can collect flow proportional sample volumes. For some sampling protocols, these flow-weighted, variable-volume samples can be more representative of the stream. This is because stream characteristics often change as the flow fluctuates.

Variable-volume sampling is possible when the sampler is programmed for Uniform Time pacing. To enable this feature, select YES at the display asking "DO YOU WANT SAMPLE VOLUMES DEPENDENT ON FLOW?"

```
DO YOU WANT
SAMPLE VOLUMES
DEPENDENT ON FLOW?
YES    NO
```

After answering YES, the sampler displays screens to program the flow proportional volumes. If the sampler has a 700 Series Flow Module inserted, you will be asked which flow measurement should be used to determine the volumes.

```
FLOW PULSES
FLOW MODULE VOLUME
```

To base the volumes on an external flow measurement device attached to the Flow Meter connector, select FLOW PULSES. To base the volumes on the 700 Series Flow Module readings, select FLOW MODULE VOLUME.

Next, the sampler asks for the SAMPLE VOLUME to collect at each time interval. This volume is expressed as 10 ml for every *X* number of pulses, or if using a flow module, for every volume unit.

```
SAMPLE VOLUME:
10 ml FOR EVERY
___ PULSES
```

Refer to section 5.11.1, *Calculating Variable Sample Volume Settings*, for a more detailed discussion on this setting.

The final screen used to program variable-volume sampling is the MINIMUM SAMPLE VOLUME. If the number of flow pulses or flow module volume is not sufficient enough to collect this minimum volume, the sample is skipped and the flow count carries over to the next sample time. This setting ranges from 10 ml to a maximum determined by the bottle volume.

```
MINIMUM
SAMPLE VOLUME
___ ml
(10 - maximum)
```

5.11.1 Calculating Variable Sample Volume Settings

The entry for the SAMPLE VOLUME display can be calculated based on expected flow rates and collection volume requirements.

The number of pulses or flow module volume that you enter should ensure that the minimum volume of liquid required for analysis is collected without exceeding the bottle volume capacity of the sampler. You may find it helpful to determine a range of values by calculating both possibilities. The number you enter would be selected from this range. This range is illustrated in Figure 5-2.

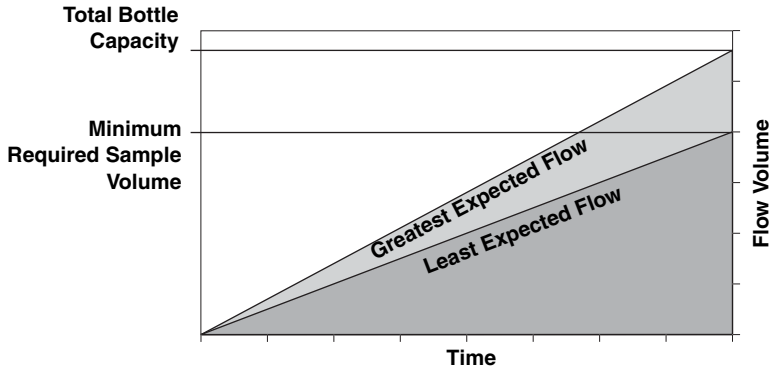


Figure 5-2 Factors Affecting Flow-Weighted Variable-Volume Samples

In other words, at the greatest expected flow, this SAMPLE VOLUME value should be set to prevent filling the bottle before the end of the program. An early full-bottle condition would result in a composite sample that is not representative of the flow stream.

At the lowest expected flow, the SAMPLE VOLUME value should be set to ensure that enough sample is collected. If too little sample liquid is collected, there may not be enough for analysis although it is a representative composite sample.

For example, consider an NPDES sampling program used to collect a flow-proportional composite sample for BOD, TSS, and NH_3-N analysis. The laboratory requires at least 1,000 ml for BOD, 100 ml for TSS, and 400 ml for NH_3-N tests. The minimum composite volume needed for analysis is then 1,500 ml, but to allow for duplicates and spillage, this volume is doubled to 3,000 ml. The samples are to be collected over an eight hour period at 15 minute intervals into a 9,400 ml composite bottle. Flow rates at the site range from 1.5 to 2.0 mgd, the equivalent volume of 500,000 and 666,667 gallons respectively over the eight hour period. This flow is measured by an external flow meter that sends a flow pulse every 100 gallons. Figure 5-3 depicts this scenario.

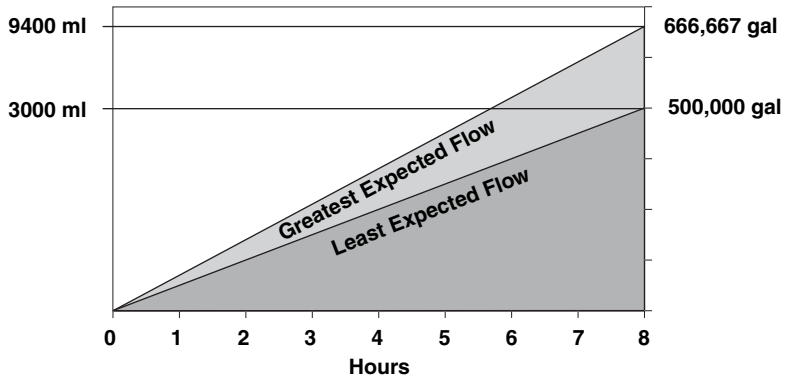


Figure 5-3 Variable-Volume Scenario

5.11.2 Calculations when Using an External Flow Meter

```
SAMPLE VOLUME:
10 ml FOR EVERY
___ PULSES
```

The highest possible SAMPLE VOLUME value is determined by the minimum volume required for analysis and the least expected flow rate over the sampling duration. To calculate the number of pulses at this high end of the range, you should know:

- the least expected flow volume that will pass the flow measurement point
- the flow volume interval between each flow pulse from the external flow meter
- the minimum composite sample volume required for analysis. Allow for duplicates and spillage.

These factors would be applied to the following equation.

$$\text{10 ml for every __ pulses} = \frac{\text{(Least Total Flow Vol) / (Flow Pulse Vol)}}{\text{(Minimum Required Vol) / (10 ml per unit)}}$$

From the scenario we can apply the factors for the equation.

$$\text{10 ml for every 16.7 pulses} = \frac{\text{(500,000 gallons) / (100 gallons per pulse)}}{\text{(3,000 ml / 10 ml)}}$$

Because the SAMPLE VOLUME entry must be in whole numbers, 16.7 is rounded down to 16. It is important to note that this number is inversely proportional to the amount of volume collected. Rounding up would result in less volume collected.

The lowest possible SAMPLE VOLUME value is dependent upon the highest expected flow and the available bottle volume. To calculate the number of pulses or volume at this low end, you should know:

- the greatest expected flow volume that will pass the flow measurement point
- the flow volume interval between each flow pulse from an external flow meter
- the available bottle volume for sample collection.

These factors would be applied to the following equation.

$$\text{10 ml for every __ pulses} = \frac{\text{(Greatest Total Flow Vol) / (Flow Pulse Vol)}}{\text{(Total Bottle Vol) / (10 ml per unit)}}$$

From the scenario we can apply the factors to the equation.

$$\text{10 ml for every 7.0 pulses} = \frac{\text{(666,667 gallons / 100 gallons)}}{\text{(9,400 ml / 10 ml)}}$$

At high flow rates, a number below 7 would overfill the bottle. At low flow rates, a number greater than 16 would collect too little sample. Therefore, a value should be selected between 7 and 16 pulses.

5.11.3 Calculations when Using a 700 Series Flow Module

The same principles discussed in Section 5.11.2 apply. However, the equations differ slightly because the flow module directly measures the stream's flow volumes. The equation for the high end of the range is:

$$\text{10 ml for every __ units} = \frac{\text{(Least Total Flow Vol)}}{\text{(Minimum Required Vol) / (10 ml per unit)}}$$

Using the same scenario the calculations would be:

```
SAMPLE VOLUME:
10 ml FOR EVERY
___ Gallons
```

$$\text{10 ml for every 1667 gallons} = \frac{\text{500,000 gallons}}{\text{(3,000 ml) / (10 ml per gallon)}}$$

The equation for the low end of the range is:

$$\text{10 ml for every __ units} = \frac{\text{(Greatest Total Flow Vol)}}{\text{(Total Bottle Vol) / (10 ml per unit)}}$$

The scenario would be applied as:

$$\text{10 ml for every 709 gallons} = \frac{\text{666,667 gallons}}{\text{(9400 ml) / (10 ml per unit)}}$$

Therefore, a value should be selected between 709 and 1667 gallons for the given scenario.

5.12 Sampler Enable

Certain external instruments can enable (start) or disable (stop) a sampler by sending a signal to pin F of the sampler's flow meter connector. Teledyne Isco flow meters, flow loggers, and the Model 1640 Liquid Level Actuator have a programmable sampler-enable feature that lets them enable or disable the sampler. You can define the condition (such as level, flow rate, pH, temperature, percent, rainfall, and I/O) or combination of conditions that need to be true in order to enable the sampler. Refer to Figure A-12 in Appendix A for details on programming sampler enables.

When the sampler detects that it is disabled at start time, it suspends the program until it is enabled. Once enabled, the sampler collects a sample only when programmed to take a sample at the enable time. The diagram in Figure 5-4 shows the sampler's response when enabled or disabled at the start time.

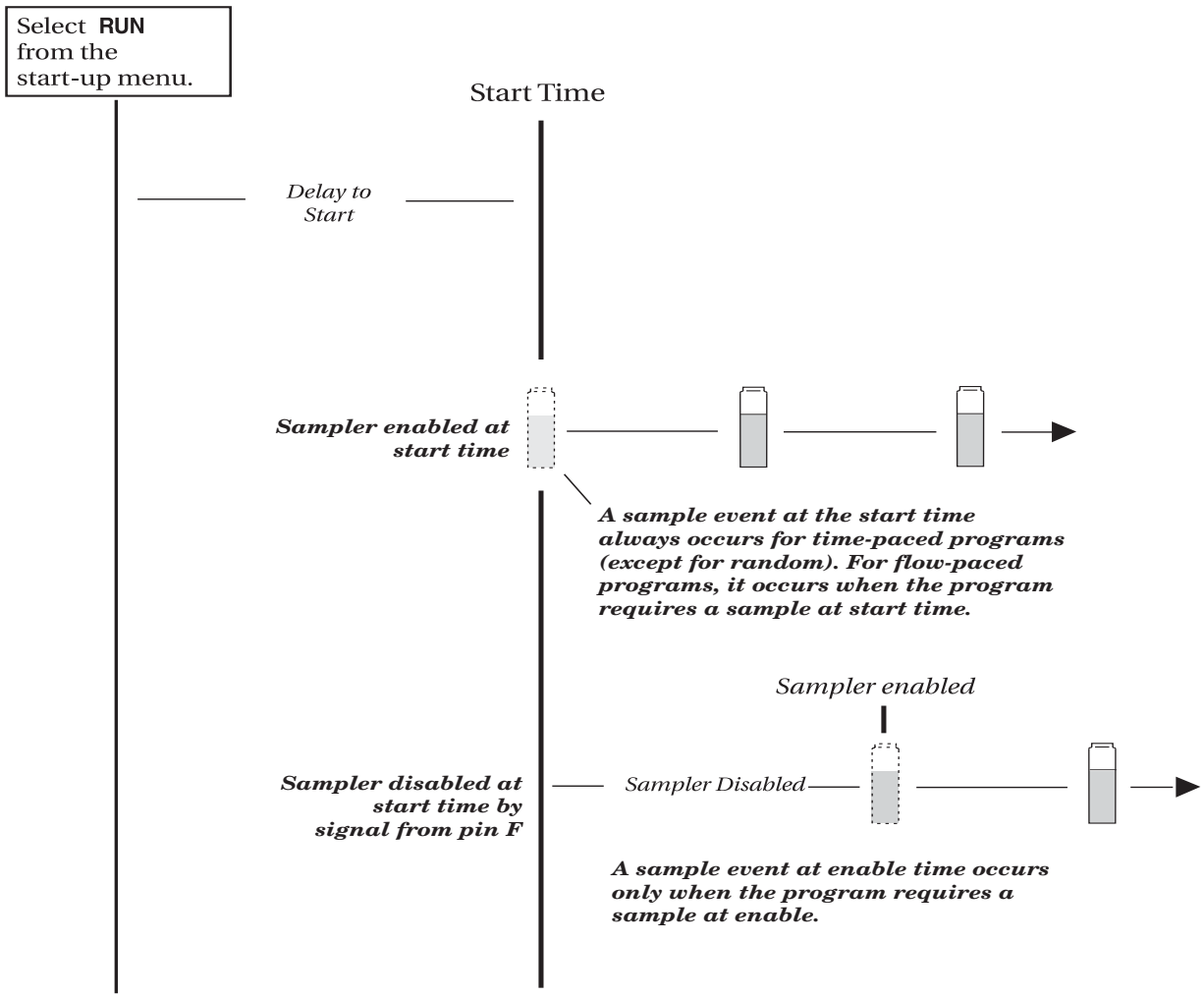


Figure 5-4 Start Time Diagram for Sampler Enable Settings

5.12.1 Sampler Enable

This example uses a sampler with an attached 730 Bubbler Flow Module, Rain Gauge, and an SDI-12 sonde at address 5 with four parameters.

Table 5-4 Sampler Enable

1	ENABLE: NONE PROGRAMMED	In this example, you will be enabling the sampler if it rains .5” in 2 hours and the level goes above 1 foot.
2	ENABLE: **RAIN** LEVEL FLOW TEMP5 pH5 SP_CO5 DO5 NONE	Select RAIN.
3	ENABLE: RAIN **AND** OR DONE	Choose AND.
4	ENABLE: RAIN AND **LEVEL** FLOW TEMP5 pH5 SP_CO5 DO5 DONE	Select LEVEL.
5	“RAIN” SET POINT: **.5** INCHES PER __HOURS, __MINUTES	Enter .5 for the inches of rain. Press ↵ . Enter 2 HOURS.
6	ENABLED WHEN: **ABOVE SET POINT** BELOW SET POINT	Select ABOVE SET POINT.
7	RESET RAIN HISTORY? **YES** NO	Select YES.
8	“LEVEL” CONDITION **SET POINT** RANGE RATE OF CHANGE	Select SET POINT.
9	“LEVEL” SET POINT: **+1** ft (0.001 - 30.00)	Enter 1 foot.
10	ENABLED WHEN: **ABOVE SET POINT** BELOW SET POINT	Select ABOVE SET POINT.
11	ENABLE: RAIN >0.50” / 2:00 AND LEVEL >1.000 ft	Your enable conditions will be summarized on the display. If correct, press ↵ to continue. If necessary, make changes to the enable conditions.

5.13 Sampler Enable Responses

In addition to programming enable conditions, extended programming lets you control the sampler's response to its enable state. You can:

- Stay enabled after the first enable.
- Set up a repeatable enable.
- Take a sample at enable or disable.
- Delay the start of sampling after the enable.
- Reset the sampling interval countdown each time the sampler is enabled.
- Control the sampling interval countdown while disabled.
- Enable Part B of a two-part program when Part A is done.

5.13.1 Once Enabled Stay Enabled

For certain monitoring programs, you may want the sampler to continue to sample, even though the conditions that enabled the sampler no longer exist. When you use the ONCE ENABLED, STAY ENABLED feature, after becoming enabled the sampler takes samples until it reaches the end of its program.

```
ONCE ENABLED,
STAY ENABLED?
YES   NO
```

Note

The STAY ENABLED feature works only when the sampler becomes enabled following program start. If you need this feature with enable *prior* to program start, contact Teledyne Isco for details.

5.13.2 Repeatable Enable

After enabling the sampler, the enabling instrument (or instruments) continues to monitor the conditions and disables the sampler when the conditions are no longer satisfied. If re-enabled, the sampler resumes the sampling program.

Note

Repeatable enable is called "sampler latching" in flow meters, flow loggers, and FLOWLINK. Latching a sampler produces the same results as selecting YES; the difference is that the external instrument controls the latching.

5.13.3 Sample at Enable or Disable

You have the option of directing the sampler to take a sample as soon as it receives the enable and/or disable signal. If you program the sampler to stay enabled and choose to take a sample at enable, the sample interval will be reset at the enable time. Samples at disable do not affect the sample intervals. Standard programs do not take a sample at the enable time.

```
SAMPLE AT ENABLE?
YES   NO
```

5.13.4 Delay To Start Of Sampling

If you have selected ONCE ENABLED STAY ENABLED and have chosen to not sample at the enable, you have the opportunity to suspend the start of sampling. This choice is useful for storm programs that require a flow-paced sample taken after the initial grab sample.

```
START SAMPLING
AFTER A
___ MINUTE DELAY
(1-999)
```

5.13.5 "Dry Period" Option

For samplers used with a 0.01 inch tip rain gauge, you can cause the sampler to wait for a "dry" period of under 0.10 inches of rain over a 72-hour period before running the program. At RUN time, the sampler asks if you want to restart the 72-hour period. Select this choice if you want the sampler to disregard any "dry" period that took place prior to the program start. The sampler will wait for up to one year for the "dry" period to occur.

```
START "EXTENDED 1"
AFTER A 72 HOUR
"DRY" PERIOD?
YES   NO
```

5.13.6 Resetting the Sample Interval at Enable

```
RESET SAMPLE
INTERVAL AT ENABLE?
YES   NO
```

If you answer "NO" to the above screen, you will see:

```
CONTINUE COUNTDOWN
WHILE DISABLED?
YES   NO
```

You may want the pacing countdown to start over each time the sampler becomes enabled. To accomplish this, select "YES" when asked if you want to reset the sample interval at enable. The next sample event will occur at the end of a full interval. Furthermore, if the sampler is enabled several times during the program, it resets the countdown each time.

Use the reset-interval feature carefully. For example, avoid resetting the interval when you sample with uniform-time pacing and want to take samples at specific times.

The effects of resetting the interval can be seen in this example: A sampler has been programmed to sample every 15 minutes and to reset the interval when enabled. It receives an enable signal at 10:03 and takes a sample. After resetting the interval, the sampler takes subsequent samples at 10:18 (not 10:15), 10:33 (not 10:30), and so on.

If you select "NO" when asked if you want to reset the sample interval at enable, you will be asked if you want to continue the countdown while disabled. You can have the sampler continue the countdown, repeating it as often as necessary while the sampler is disabled, or you may suspend the countdown while disabled, resuming the countdown as the sampler is enabled. The standard program allows the countdown to continue while disabled.

5.14 Pauses/Resumes

Pause and Resume Screens

Flowcharts containing the pause and resume screen appear in Appendix A.

```
PAUSE      RESUME
1. 17:00 MO  08:00 TU
2. 17:00 TU  08:00 WE
CLEAR      DONE
```

```
SAMPLE AT RESUME?
YES   NO
```

Pause and resume settings, available in extended programming, create an intermittent sampling schedule. A program with pauses and resumes begins sampling at its programmed start time, continuing until the first pause time and day of the week. It then suspends sampling until the first resume time, when it begins sampling again. If the start time falls within a pause period, the sampler will not begin sampling until the next resume time. Pauses and resumes repeat weekly.

You can enter up to nine pairs of pause and resume times. The pause and resume times shown as examples to the left suspend the program between 5:00 p.m. Monday and 8:00 a.m. on Tuesday and between 5:00 p.m. Tuesday and 8:00 a.m. on Wednesday. If the start time is Monday at 8:00 a.m., the sampler takes samples between 8:00 a.m. and 5:00 p.m. Monday; between 8:00 a.m. and 5:00 p.m. Tuesday; and, continues after 8:00 a.m. Wednesday. To remove pause and resume settings from a program, select CLEAR.

A sampler running a pause/resume program resets the pacing interval at each resume time. You can program the sampler to take a sample at resume times (see screen at left).

5.15 Running Programs

To run an extended program, select run from the main menu. You may also select YES at the RUN THIS PROGRAM NOW? screen at the end of the programming screens.

Extended programs scheduled to start at a clock time will not start until the programmed clock time on or after the *first valid date*.

Note that if you have recently calibrated a parameter probe, the sampler may delay the start and display “PLEASE WAIT” until valid readings are expected from the probe. The delay accounts for the time typically required to install the probe, and lasts for five minutes after you complete the calibration.

5.15.1 Run Time Screens

Run time screens, which report the program’s status while running a program, are explained in Section 4.

5.15.2 Interrupting a Running Program

Interrupting a running program is also explained in Section 4. The scrolling menu that appears during the manual paused state can have two extra options when using extended programming:

Adjust Enable – This option is available for extended sampling programs that have programmed enable conditions. Selecting this option allows you to change the set-points or ranges for the enable conditions. The sampler displays all of the programming screens that define the thresholds of the programmed enables. You cannot change the type of enables used or the way they are combined.

If rain is an enabling condition, you also have the option of resetting the rain history.

Adjust Suction Head – If you have chosen to manually enter the suction head, and are in the manual paused state, the scrolling menu will have an option to adjust the suction head. If you make changes to the suction head value, the sampler logs a changed suction head event.

5.16 Sampling Reports

The 6712 records a variety of data while running a sampling program. Sample reports can be found in Section 4.

Section 4, Table 4-3 contains a list of source codes and program events that may be recorded when using either standard or extended programming.

5.17 Other Functions

Other Functions Menu

```
RUN "PROGRAM NAME"
PROGRAM
VIEW REPORT
OTHER FUNCTIONS
```

• Select OTHER FUNCTIONS.

```
MAINTENANCE
MANUAL FUNCTIONS
SOFTWARE OPTIONS
HARDWARE
```

In extended programming, the "Other Functions" menu screen includes options for:

- Maintenance (see Section 7)
- Manual Functions (see Section 4)
- Software Options
- Hardware

5.18 Software Options

The software option screens allow you to set up a number of different software options:

- Liquid Detector Enable
- Normal/Quick View Screens
- Measurement Interval
- Dual Sampler Mode
- Full Bottle Detection
- Display Backlighting
- Event Marks
- Pump Purge Counts
- Serial Output
- Remote Access
- Interrogator Connect Power

5.18.1 Liquid Detector Enable/Disable

```
USE LIQUID DETECTOR?
YES   NO
```

Under some conditions (pressurized lines, sampling foam), a more repeatable sample volume may be delivered by disabling the liquid detector. Selecting NO will turn the Liquid Detector off.

If the Liquid Detector is off:

- you must enter the SUCTION HEAD
- no RINSES or RETRIES will be available
- you will not be able to CALIBRATE SAMPLE volumes
- the RESULTS report will read a COUNT TO LIQUID of 0
- A complete purge will occur between samples when using multiple bottles-per-sample distribution.

5.18.2 Programming Style

The sampler has two different styles of programming screens: normal and quick view. These are both explained in Section 3.

When you are in extended programming, the default style is Quick View, which allows you to move more quickly through the screens.

If you prefer a step-by-step display for the screens, switch to the Normal setting.

5.18.3 Measurement Interval

```
MEASUREMENT INTERVAL
 5  15  30  SECONDS
 1   2   5   MINUTES
STORAGE INTERVAL
```

If using a 700 Series module or SDI-12 Sonde parameter for enabling, the sampler will request a Measurement Interval. The Measurement Interval allows the sampler to compare the parameter to the enabling conditions at a rate faster than the Data Storage interval. If the Measurement Interval is equal to or greater than the Data Storage interval, the parameter will be checked at the rate of Data Storage interval.

Normally, there are two considerations when selecting the Measurement Interval: power consumption and duration of the enabling event. This setting for battery powered samplers will require some degree of balance between the need to conserve power yet detect the enabling event before it has passed.

5.18.4 Dual Sampler Mode

Dual Sampler Mode

```
DUAL SAMPLER MODE?
 YES  NO
```

- Select YES to put the sampler in the dual sampler mode. When you no longer need dual samplers, return to this screen to turn the feature off.

Dual Sampler Mode lets you operate two samplers as a pair. The primary sampler disables the secondary one until the primary sampler completes its sampling program. The samplers then reverse roles with the second sampler becoming the primary one.

Setting Up Dual Samplers –

1. Turn on the dual sampler mode in both samplers.
2. Install the samplers.
3. Connect the samplers with the Dual Sampler Mode Interconnect Cable by attaching the cable to the sampler's flow-meter connectors. If your installation includes a flow meter or flow logger, use the Dual Sampler Mode to Flow Meter Cable instead.
4. Decide which sampler is to be the primary sampler; the primary sampler should be the sampler with the program you want to run first.
5. Turn the primary sampler on and run its sampling program by selecting RUN. After at least 5 seconds, turn the secondary sampler on and select RUN from its main menu.

How Does It Work? – The primary sampler sends a disable signal out its flow meter connector. The secondary sampler receiving the signal is held disabled until the primary sampler completes its program.

When using a flow meter or flow logger a Dual Sampler Mode to Flow Meter cable must be used. This cable is constructed so that the pacing instrument receives only the event marks. Therefore, a connected flow meter will not receive a bottle number signal, nor will it be able to control the sampler inhibit.

Bottle Full Detect

```
BOTTLE FULL DETECT?
YES      NO
```

Bottle Full Detection – The sampler can detect a full bottle condition when collecting samples in a single bottle (composite sampling). When the sampler detects a full bottle, it stops the sampling routine.
A BOTTLE FULL condition will also stop a sampling routine that is set to RUN CONTINUOUSLY.

The Bottle Full Detect screen allows you to enable or disable this feature. Selecting "YES" enables the sampler to detect a full bottle and stop the sampling routine. Selecting "NO" disables this feature. The Bottle Full Detect setting is part of the sampling program. Because it is a program setting, full bottle detection can be enabled or disabled for each of the four extended programs. If the Bottle Full Detect setting is critical to your sampling program, always check this Software setting after you select a different Extended Program.

This feature relies on a post-purge after each sample. When using the Bottle Full Detect, make sure that post-sample purges greater than 100 are used.

Bottle Full Detect is always disabled in the Standard Programming mode.

Adjusting the Display Backlighting

```
BACKLIGHT ALWAYS OFF
TIMED BACKLIGHT
CONTINUOUS BACKLIGHT
```

Display Backlighting – The display has a backlight that is adjustable so that the backlight is always off, timed or always on.

In the timed backlight mode the sampler turns the backlight off after detecting no key strokes within 60 seconds. Any keystroke (except ON-OFF) turns the backlighting on again. In this mode the backlight must be on before the sampler accepts a menu choice or number entry. If you press a key and a screen does not respond, it is because the keystroke turned the backlight on.

It is recommended that you use either BACKLIGHT ALWAYS OFF or TIMED BACKLIGHT when using a battery.

Event Marks

```
EVENT MARK SENT FOR:
EVERY SAMPLE
COMPLETE SAMPLES
```

Event Marks – The sampler generates an event mark at each sample event, sending it through the flow meter connector to a connected instrument. The event mark may also control an external device; a connected solenoid relay, for example. When using the event mark for a data logger or to control external devices, you may need to adjust the mark by changing the factory settings.

The event mark is adjustable through the software setup screens. You can set up the sampler to generate an event mark for EVERY SAMPLE or for COMPLETE SAMPLES.

If you select COMPLETE SAMPLES, the sampler sends a three-second pulse only after it successfully collects a sample. The sampler will not send an event mark if an error occurs, such as "No Liquid Detected."

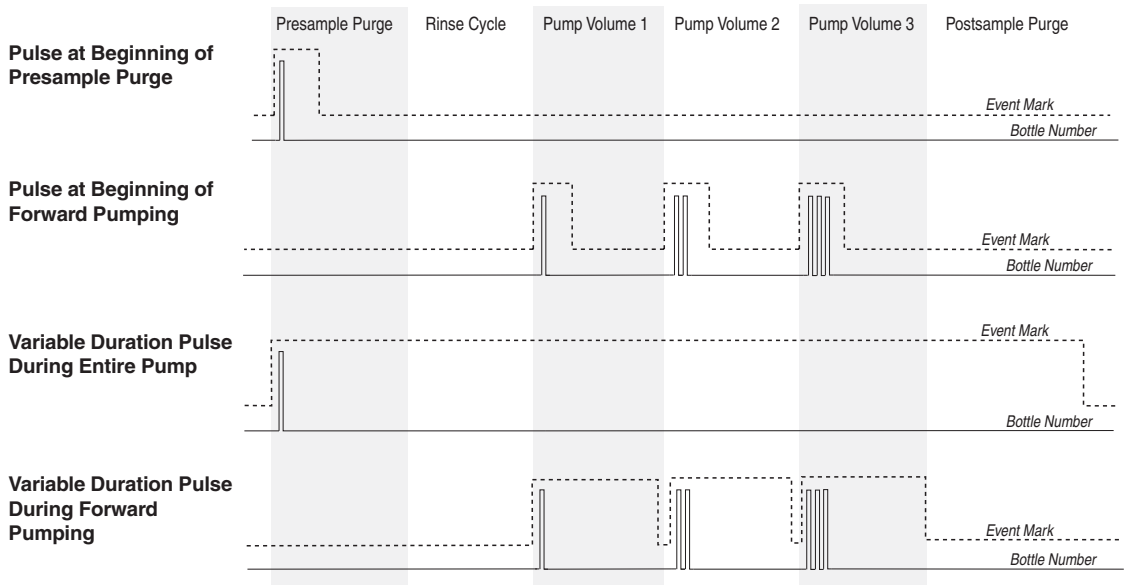
If you select EVERY SAMPLE, the sampler will send an event mark every time a sample is initiated. The event mark signal can be a:

- 3-second pulse at the beginning of the pre-sample purge.

- 3-second pulse at the beginning of forward pumping only, marking the time the sampler deposited the sample.
- Variable duration pulse generated during the pump cycle, from the beginning of the pre-sample purge to the end of the postsample purge.
- Variable duration pulse generated only during forward pumping.

Figure 5-5 shows event mark timing diagrams.

Bottle Number – Concurrent with the event mark, the sampler also sends a bottle number signal. The bottle number signal is a series of pulses. The number of pulses sent represents the bottle currently accepting a sample (see Figure 5-5).



This diagram shows the pulses sent for a bottles-per-sample distribution scheme

Figure 5-5 Event Mark Timing Diagram

5.18.5 Pre-sample and Post-sample Purge Counts

PRE-SAMPLE PURGE:
____COUNTS
(10-9999)

POST-SAMPLE PURGE:
DEPENDENT ON HEAD
FIXED COUNT

POST-SAMPLE PURGE:
____COUNTS
(10-9999)

The pre-sample purge is when the pump runs in reverse clearing the strainer of any debris before taking a sample. The pre-sample purge is set at 200 pump counts. After the sample is taken a post-sample purge occurs to clear the liquid from the suction line. The duration of the post-sample purge is determined by the length of the suction line to maximize the battery life. The pre- and post-sample purge can also be manually set.

5.18.6 Serial Output

Programming the serial output

```
PERIODIC
SERIAL OUTPUT?
YES   NO
```

```
PORT SETTINGS:
9600N81   4800N81
2400N81   1200N81
```

```
SERIAL OUTPUT EVERY:
15 SEC   1 MIN
5 MIN   15 MIN
```

Serial ASCII data can be output through the controller's interrogator port. The output frequency is user-selectable: every 15 seconds, every minute, every 5 minutes, every 15 minutes, or by command.

To receive serial data as a *periodic output*:

1. Select YES at screen asking if you want periodic serial output.
2. Select the appropriate baud rate setting in screen . Note that at all baud rates the data is sent with no parity, eight data bits, and one stop bit. If you have difficulty with the connection, try a slower baud rate.
3. Select the desired output interval in screen.
4. Connect to the 6712 controller's interrogator connector using a standard interrogator cable.

To receive serial data by *command*:

1. Select NO at the screen asking for periodic serial output .
2. Connect your computer to the 6712 controller's interrogator connector with a standard interrogator cable, P/N 60-2544-040 (25 pin) or 60-2544-044 (9 pin).
3. Configure your communications software for a baud rate no higher than 19,200 kb, no parity, 8 data bits, and 1 stop bit.
4. From the computer's keyboard, type "?" repeatedly until the 6712 controller determines the baud rate. Once the baud rate is known, the 6712 returns an identification banner. This banner indicates that the connection is working properly.
5. Type DATA<CR> each time the data string is desired.

The serial data is in comma-separated-value format. Only the values that the sampler is set up to measure will be output in the data string. The string is terminated with a <CR><LF>. To read the data in the string, refer to Table 5-5. This serial data can also be accessed from a remote location using the optional dialout modem (see Section 7).

☑ *Note*

The internal modem is disabled when an interrogator cable is connected to the sampler's Interrogator port. It cannot receive incoming calls, and the alarm dialout is rendered inoperative, while this cable is connected. **Disconnect the interrogator cable in order to use the 4200T modem.**

Table 5-5 Serial Data Codes

Identifier	Parameter	Units
B?[1]	Bottle number and time	days since 1-Jan 1900
CR	Current day's rain	tips (rolls over every 256 tips)
CS[2]	Checksum	unsigned long
DE	Description	6712 Sampler
FL	Flow	cubic meters per second
ID	Unit specific identifier	10 digit unsigned long
LE	Level	meters
MO	Model	6712
PE	Percent	percent of full scale
PH	pH	none
PR	Previous day's rain	tips (rolls over every 256 tips)
RA	Rain	tips (rolls over every 256 tips)
RTE	Refrigerator Temperature	degrees celsius
SS	Sampler enable state	logical
TE	Temperature	degrees celsius
TI	Current time	days since 1-Jan-1900
VE	Velocity	meters per second
VO	Volume	cubic meters
VSI	Velocity signal strength	percent
VSP	Velocity spectrum strength	percent
CO_a[3]	Conductivity	milliseimens per centimeter
DO_a	Dissolved oxygen	milligrams per liter
PH_a	pH	none
SA_a	Salinity	parts per thousand
SP_a	Specific Conductance	milliseimens per centimeter
TD_a	Total Dissolved Solids	grams per liter
TE_a	Temperature	degrees Celsius
OR_a	Oxidation reduction potential	millivolts
LE_a	Level	meters
MM_a	Ammonium-nitrogen	milligrams nitrogen per liter
MA_a	Ammonia-nitrogen	milligrams nitrogen per liter
NI_a	Nitrate-Nitrogen	milligrams nitrogen per liter
TB_a	Turbidity	nephelometric turbidity units

Table 5-5 Serial Data Codes (Continued)

Identifier	Parameter	Units
CL_a	Chloride	milligrams per liter
CP_a	Chlorophyll	micrograms per liter
FL_a	Flow rate	cubic meters per second
VO_a	Flow volume	cubic meters
xxD_a[4]	Other data not listed above	

- The three most recent samples will have entries as B?. The "?" will be the first bottle number in the set. If the sample is a grab sample, it will be shown as B0.
- An "a" in the identifier indicates an SDI-12 address.
- "xx" matches the data label for the SDI-12 parameter.
- The checksum does not include the checksum, carriage return, and linefeed.
- The string is terminated with <CR><LF>.

5.18.7 Program Lock

The specialized software option Program Lock (P/N 60-9003-532) may be purchased from Teledyne Isco.

Once activated, the purchased option is always available, even if the software is upgraded at a later time. **The option must be installed at the factory. Consult the factory for further details.**

To view which software options have been activated, select VIEW REPORT>SYSTEM IDs. A Software Options screen will list a code for each active option. The code for Program Lock is **1108**.

PROGRAM LOCK DISABLED

ENABLE PROGRAM LOCK?
YES NO

CHANGE PASSWORD TO

REENTER NEW PASSWORD

The Program Lock adds password security to the 6712 sampling programs. With this option activated, a user-selected password (up to five digits) must be entered before any program changes or run time modifications can be made. Run time modifications include accessing the Manual Pause menu options and shutting off the sampler. You will still be able to run the current program, view reports, and interrogate the sampler without the knowledge of the password.

If three consecutive attempts to enter the password fail, a five minute "time-out" will follow in which most keys are deactivated.

The user-selected password defaults to "6712" and may be changed in the Software options that are available in the Extended Program mode (see example at left). While the password may only be changed in the Extended Program mode, the program lock works for both Standard and Extended programs.

Should you forget your password, a key code can be obtained from Teledyne Isco's Customer Support department for a nominal fee.

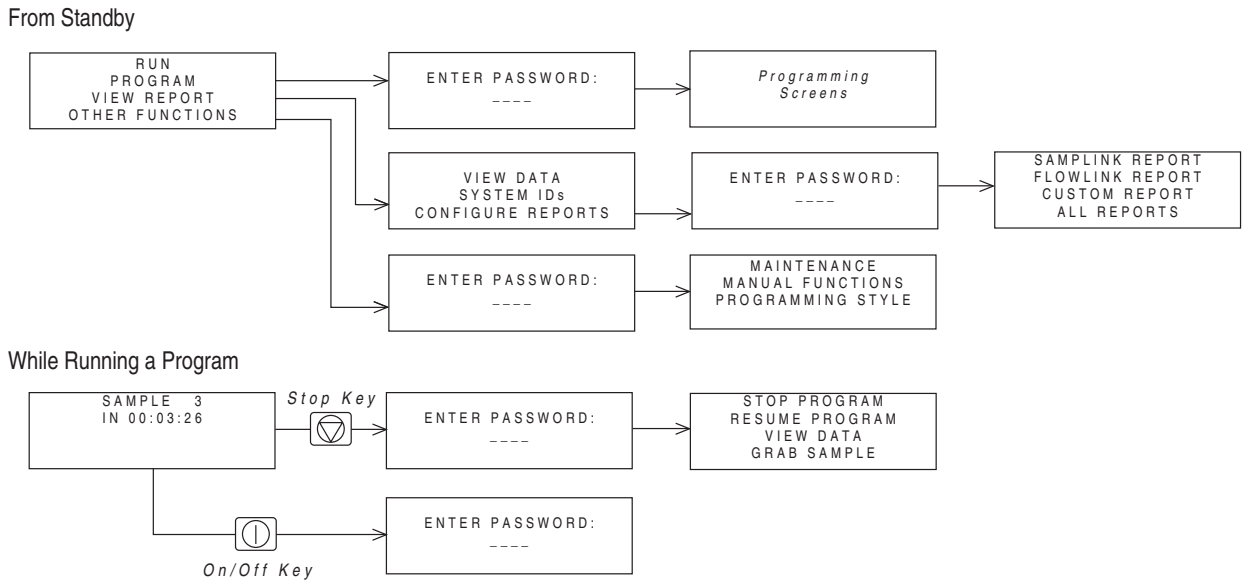


Figure 5-6 Password Protected Functions

5.19 Hardware Setup

The hardware setup screens make adjustments to the sampler's hardware-based features:

RUN "*PROGRAM NAME*"
PROGRAM
VIEW REPORT
OTHER FUNCTIONS

• Select Other Functions

MAINTENANCE
MANUAL FUNCTIONS
PROGRAMMING STYLE
HARDWARE

• Select Hardware

- SDI-12 Sonde Setup
- Rain Gauge Setup
- I/O Pin Programming
- Dialout Alarms
- Pager Numbers
- Text Messaging
- Refrigerator Temperature
- Analog Outputs

5.19.1 SDI-12 Sonde Setup

The 6712 supports SDI-12 sondes. For more information on setting up sondes, refer to Section 6.

5.19.2 Rain Gauge Setup

With standard programming, the sampler does not record rain gauge readings. However, with extended programming, recording the rain gauge readings and the rain enable option can be turned on or off. Enter the hardware setup and follow the screens to the left in the margin.

DO YOU HAVE A
RAIN GAUGE CONNECTED?
YES NO

• Select YES.

RAIN GAUGE:
0.01 inch TIP
0.1 mm TIP

• The rain gauges are set up to tip on either .01 inch or .1 mm. Select the desired tip.

When asked if you have a rain gauge connected, select YES to record the rain gauge readings and add RAIN as a sampler enable option. Select the appropriate tip for the rain gauge. The sampler will then create a rain memory partition and update the available sampler enable conditions.

Select NO to disable the readings and the sampler enable option. When you select NO, the sampler removes the rain memory partition, leaving the memory space available for other reading types.

5.19.3 I/O Pin Programming

Pins C, H, and I on the Rain Gauge Connector are user-configured as I/O1, I/O2, and I/O3 (Input/Output pins) respectively. Each pin can be either an input for sampler enabling, or an output for alarms.

Note

The state of the I/O lines is not defined when the sampler is OFF.

Enable

The enable input requires a pulse signal of 5 to 15 volts. Teledyne Isco offers optional interface modules for converting from a 4-20 mA analog or pulse duration signal.

Alarms

The alarm output can be set for any RUNNING PROGRAM or RUN ERROR state. In addition, the CONDITIONS output can report alarm conditions using the parameters the 6712 is configured to measure. You can set thresholds for one or two conditions and the CONDITIONS output can then trigger alarms when the measured parameters exceed the threshold.

Alarm function requires an alarm interface module, factory-installed talking modem, or external digital cellular modem (see Section 5.19.4 *Dialout Alarms*).

Teledyne Isco offers a module designed to provide one, two, or three contact closures. The alarm module can interface the sampler with many types of non-Isco devices. For more information about the alarm module, contact your Teledyne Isco sales representative.

Example: I/O Pin Programming

Although the screens displayed may vary depending on your site setup, the programming sequence will be the same or similar to the following example.

1. Select OTHER FUNCTIONS to enable the dialout alarm.

```
RUN "EXTENDED 1"
     PROGRAM
   VIEW REPORT
OTHER FUNCTIONS
```

2. Select hardware and use the down arrow to scroll to the I/O screen.

```
   MAINTENANCE
MANUAL FUNCTIONS
SOFTWARE OPTIONS
   HARDWARE
```

```
↑ I/O1 = NONE
  I/O2 = NONE
  I/O3 = NONE  ↓
```

3. Select the first pin to program.

```
SET I/O1:
```

From this screen, your choices are viewed by scrolling with the arrow buttons:

PGM RUNNING
PGM ENABLED
'A' ENABLED
'B' ENABLED
PROGRAM DONE
'A' DONE
'B' DONE
RUN ERROR
FLOW-THRU
CONDITIONS
NONE
I/O ENABLE

Note: All choices listed are alarm output settings, except for I/O ENABLE. This is the input function to enable the sampler via an external device.

4. If you select CONDITIONS, the sampler will display:

```
I/O1:
RAIN  NONE
```

Depending on what equipment is connected to your sampler, you may see other parameters in addition to RAIN, such as LEVEL, FLOW, VELOCITY, etc. Under CONDITIONS, you can program limits for a condition to trigger the alarm when the measured parameter exceeds its limit. You can use one or two conditions to trigger one alarm, using AND or OR operators.

5. When you select a parameter with the arrow keys and Enter, you can then program the limits for alarm triggering. For example, if you select rain, the sampler will display:

```
"RAIN" SET POINT:
 1.00 INCHES PER
1 HOURS,    0 MINUTES
```

```
I/O IS HIGH WHEN:
 ABOVE SET POINT
 BELOW SET POINT
```

"I/O IS HIGH" means "Alarm is triggered." Select ABOVE or BELOW, then select whether or not to reset rainfall history when the alarm is triggered:

```
RESET RAIN HISTORY?
     YES   NO
```

Continue with programming I/O2 and I/O3 in the same manner, or if additional alarms are not needed, select NONE.

5.19.4 Dialout Alarms

Dialout alarms require the sampler to be equipped with the factory-installed 2400 baud talking modem, or the external digital cellular CDMA or GSM modem. The dialout alarm allows the sampler to notify a contact list when an "alarm" condition exists (is true).

At the transition to the true state, any programmed I/O output can cause the sampler to warn of the alarm condition. As many as three telephone numbers can be entered. The sampler tries each telephone number in succession until the alarm is acknowledged. For each alarm condition, the sampler will attempt each telephone number entered a maximum of five times, at user specified intervals.

Alarms are set up through the I/O programming menu, shown in Section 5.19.3. "I/O1", "I/O2", and "I/O3" represent the three alarms.

Example: Dialout Alarms

If the controller is equipped with a dialout modem, it can be programmed to notify a telephone or pager contact list when an alarm condition is true.

Before proceeding the I/O conditions must be defined. Refer to section 5.19.4. These steps program a dialout alarm when the condition defined for I/O1 is true.

1. Select YES to enable the dialout alarm.

```
DIALOUT WHEN IO1
 BECOMES TRUE?
   YES    NO
```

The controller asks the same question for IO2 and IO3. Select NO.

```
DIALOUT WHEN IO2
 BECOMES TRUE?
   YES    NO
```

```
DIALOUT WHEN IO3
 BECOMES TRUE?
   YES    NO
```

2. Using the number entry keys, enter as many as 3 telephone numbers to the contact list.

```
DIALOUT NUMBERS:
1. 9,55555550001
2. 9,55555550002
3. P5550003
```

If the phone number requires extended characters, or if you need to designate a number as a pager, press the decimal key. The controller displays:

```
SELECT CODE
,   #   *   PAGER
```

Use an arrow key to select a code and press Enter to insert it in the number on the DIALOUT NUMBERS screen.

3. Enter the delay time between each attempt. A delay will allow time between attempts so you can return a call to the controller to acknowledge the alarm condition.

```
__ MINUTE
DELAY BETWEEN CALLS

(0-99)
```

Note: Numbers may be removed from the list by advancing the cursor to the very end of the number with the right arrow key, then pressing the left arrow key to erase the number.

When the call is answered, the sampler's modem announces the alarm condition (analog talking modem) or sends a digital text message (external cellular modem), and the sampler's three-digit ID number. To acknowledge the call, press the ⊠ (star) key, and the three-digit ID number on your phone. The sampler will reply with an acknowledgment when the keyed entry is correct.

A record of alarms and acknowledgements is available in the Sampling Report. When the sampler detects the alarm condition, it records the type of alarm and the time it occurred. Acknowledgements are a separate Sampling Report entry, recording the time and telephone number that responded to the call.

As mentioned previously, as many as three telephone numbers may be entered. The modem can dial up to 25 digits. Enter numbers using the numeric keys on the sampler keypad. When entering telephone numbers longer than 17 digits, the display will scroll.

Extended characters, the Comma (,), Pound (#), and Star (*), also may be included in the 25 digits. To enter an extended character, press the Decimal Point key on the sampler keypad. The sampler displays a screen used to select and enter the extended characters. Each comma entered will cause the modem to pause for two seconds before proceeding with the remaining digits.

Phone numbers that are no longer needed can be removed. Advance the cursor to the end of the telephone number and then press the Left Arrow key to erase the preceding character. If the cursor is not at the end of the telephone number, the Left Arrow key will only shift the cursor without erasing any characters.

Dialout telephone and pager numbers are included in the Program Settings Report.

☑ Note

Connecting either the serial output or the standard interrogator cable to the sampler disables the internal dial-out modem. The interrogator or serial output cable must be disconnected before you can use the modem.

5.19.5 Pager Numbers

The extended character screen contains a pager option that designates the phone number as a pager. When programmed as a pager number, an identification string will be sent seven times after the pager number is dialed, with a three second delay between strings.

An example identification string would be "828-1", meaning "Alarm condition #1 exists at sampler 828". If more than one alarm condition exists, the string would read similar to "828-1-3.

5.19.6 Digital Modem Text Messaging

The sampler can send alarms in the form of text messages containing the same information as that found in voice messages.

To use this option, you must have:

- a cellular phone with text messaging capabilities

- an external digital modem
  recommended: Teledyne Isco's CDMA cellular modem part # 60-5314-489
  or GSM cellular modem part # 60-5314-563

Note

If an internal voice modem is installed, the sampler will use that modem, and text messaging will be disabled.

When you enter each of the (up to three) phone numbers for the sampler to call, if text messaging is active, a request for the TAP (Telocator Alphanumeric Protocol) server number and communications parameters will be made.

As with voice messaging, the sampler will dial each telephone number up to five times per alarm condition, until the message is acknowledged.

5.19.7 Refrigerator Temperature

Teledyne Isco offers a temperature sensor intended for use with the 6712FR Refrigerated Sampler. The optional sensor connects to the Rain Gauge port and uses I/O3 to transmit its temperature readings to the 6712.

Note

If alarms are being used, the temperature sensor is simply plugged into the panel mount on the one- or two-alarm output module. Because the temperature sensor uses I/O3, it cannot be used with a three-alarm output module.

To configure an attached temperature sensor, select "FR-TEMP" as the input for I/O3. The 6712 will display the NEW HARDWARE SETUP screen. Select DONE and the 6712 reconfigures its memory partitions to record the temperature readings.

Temperature readings are updated approximately every 2.5 seconds. The readings are stored as FR-TEMP readings at the data storage interval. You can retrieve a history of temperature readings through the 6712's reports. The temperature data also can be used as a sampler enable condition.

5.19.8 Analog Output

Teledyne Isco offers three analog outputs as a factory installed option. The option is installed inside the controller and includes a six-pin connector to interface with external devices.

The analog outputs can be programmed for either 0-to-20 mA or 4-to-20 mA operation. With the exception of rain, any parameter that the 6712 sampler is currently measuring can be used to control any (or all) of the analog output channels. Programming the outputs requires parameter levels at each end of the analog range and then assumes a linear relationship between those points. MANUAL CONTROL of each output is also available.

Note

The internal analog output can not be installed in a controller that has the internal voice modem also installed. Contact the factory for information regarding external cellular modem options.

Flowcharts for analog output screens appear in Appendix A.

5.20 Memory

The 6712 Sampler contains 512 kilobytes of battery backed RAM (Random Access Memory) that stores:

- Five sampling programs
- The sampling results from the most recent program
- The rainfall data collected from rain gauges
- The data from a refrigerator temperature sensor
- The data collected from a 700 Series module
- Parameter data collected from an SDI-12 Sonde
- Calculated flow information from the current flow module

The sampling results memory stores up to approximately 1004 events (the actual number is dependent on the number of SDI-12 parameters). The program run and start time information is logged as four events. These four entries are held for the duration of the program. The remaining 1000 are for logging sample events, program events, and errors from the currently running program. If the running program exceeds 1000 events, the data will "roll over." That is, the sampler will replace the oldest stored event with the newest event. When using an SDI-12 sonde, the sampler logs additional entries at each sample event.

Module, sonde, refrigerator temperature, and rain gauge readings are stored in memory partitions. The storage capacity depends on the reading types, the number of bytes per reading, and the data storage interval.

The sampler clears the sampling results memory when the site description changes. It is important to collect the sampling results before changing the site description – the data can not be retrieved afterwards. Keep in mind that the description may change when selecting an extended program.

The partition data is cleared when the sampler automatically creates and sizes the memory partitions. This occurs when you:

- Select a new program with a different storage interval
- Change the Data Storage Interval in the current program
- Change the programming mode
- Install a new 700 Series Module
- Change 700 Series Module mode of operation
- Add or remove a rain gauge with the Hardware Setup

- Add or remove a refrigerator temperature sensor as I/O3
- Add or remove a SDI-12 sonde parameter with the Hardware Setup
- Reinitialize the sampler

The stored data is lost as the sampler reformats its memory. As a precaution, before clearing the memory, the sampler display will show the following message:

```
INTERVAL CHANGED --
DOWNLOAD DATA NOW
OR LOSE ALL DATA!
DONE
```

If you want to keep the stored data, download it before proceeding. When DONE is selected, the sampler clears the stored data and reformats the memory partitions. The sampler then displays the new capacity of the partition memory.

```
PARTITION MEMORY
WILL LAST 13 DAYS
```

If the duration is too short, try changing the data storage interval or eliminating unnecessary reading types in the Hardware or Module Setup. For example, a sampler configured with a 730 Bubbler Module and a rain gauge storing data at a one-minute interval, creates level and rainfall partitions that hold 100 days of readings. Changing the storage interval to two minutes extends the storage capacity to 201 days.

The sampler does not have to be running a program to store readings. When the sampler is on, it stores readings at the selected data storage interval. Once the partition is filled, the readings roll over.

When the sampler is running a program, the partitions become “triggered” by the programmed start time or the first enable time, whichever is later. A triggered partition continues to log readings at the selected interval, but will not replace any readings taken after the trigger event. The sampler fills the partition and then stops recording to preserve the data. The first reading preserved in a full partition is one hour before the trigger event. A full partition can be reset by starting another program or changing storage parameters.

If you need continuous readings for analysis, be sure to collect the readings before the partition fills or rolls over to avoid gaps in the data.

5.21 Pressurized Lines

The sampler can obtain samples from pressurized lines, as long as the line pressure remains below 15 PSI (pounds per square inch). Pressures greater than 15 PSI may prevent the sampler from purging the suction line; moreover, extreme pressures can force liquid past the pump, even when the pump is not running.

For more consistent sample volumes from lines under constant pressure, calibrate the samples.

For information about sampling with line pressures greater than 15 PSI, contact Teledyne Isco.

5.22 Command Driven Operation

The 6712 controller can be used as a slave to an external controller. The external controller is responsible for determining when to take a sample, how much volume to pump, and where to put the sample. The external controller directly interfaces to the sampler via an RS-232 communications port at 2,400-19,200 baud, 8 data bits, no parity, and 1 stop bit. A comma-separated-value protocol is used by the external controller to make requests, and by the sampler to report results. Use a standard computer connect cable (see Appendix E) to connect the sampler's interrogator port and the external controller.

For information on serial data codes and their meanings, refer to Table 5-5 Serial Data Codes in this section.

The 6712 Sampler will respond to three commands: Turn Sampler On, GET STATUS, and TAKE SAMPLE. All commands must include the instruction set. The checksum value is optional.

The available commands are:

1. Turn Sampler On: STS,2,CS,582<CR>

- "582" is the byte-by-byte sum of the ASCII values in the string "STS, 1,CS".
- "<CR>" is a carriage return signifying the end of the command.
- If the sampler is OFF, this command will turn it ON before returning status info.

2. Get Status: STS,1,CS,581<CR>

"STS,1" instructs the sampler to return the current status.

- "CS,581" is the optional checksum value. The byte-by-byte sum of the ASCII values in the string "STS,1,CS" is 581.
- "<CR>" is a carriage return signifying the end of the command.

3. Take Sample: BTL,2,SVO,100,CS,1039<CR>

The TAKE SAMPLE command is only valid if the sampler is WAITING TO SAMPLE.

- "BTL,2" instructs the sampler to place the sample in bottle 2.
- "SVO,100" instructs the sampler to take a 100 ml sample.

- "CS,1039" is the optional checksum value. The byte-by-byte sum of the ASCII values in the string "BTL,2,SVO,100,CS," is 1039.
- "<CR>" is a carriage return signifying the end of the command.

5.22.1 Command Driven Sampler Responses

The 6712 Sampler's response string is the same for each of the three commands. A sample response string is shown below:

MO,6712,ID,2424741493,TI,35523.50000,STS,1,STI,35523.41875,BTL,2,SVO,100,SOR,0,CS,xxxx<CR>

Note that the sampler's response is a series of alphabetical and numerical pairs. The alphabetical characters are headings that describe the following numerical value or code. A complete description of each pair is listed below.

MO,6712, is the model number of the sampler.

ID,2424741493, is the sampler's unique identification number.

TI,35523.50000, is the sampler's current time.

STS,1, is the sampler's current status. The possible states are:

1 = WAITING TO SAMPLE.

4 = POWER FAILED (for short time after power is restored).

5 = PUMP JAMMED (must be resolved before continuing).

6 = DISTRIBUTOR JAMMED (must be resolved before continuing).

9 = SAMPLER OFF.

12 = SAMPLE IN PROGRESS.

20 = INVALID COMMAND.

- identifier code is not supported.
- bottle requested is not in current configuration
- sample volume requested is outside its range (10 - 9990 ml)
- day (Set_Time) must be 5 digits and more recent than 1977

21 = CHECKSUM MISMATCH.

22 = INVALID BOTTLE. (bottle requested is not in the current configuration)

23 = VOLUME OUT OF RANGE. (the sample volume requested is outside its range (10-9990 ml)

STI,35523.41875, is the most recent sample time.

BTL,2, is the bottle receiving the most recent sample.

SVO,100, is the most recent sample's volume.

SOR,0, is the results of attempting the most recent sample. The possible results are:

0 = SAMPLE OK.

1 = NO LIQUID FOUND.

2 = LIQUID LOST (not enough liquid to satisfy requirements.)

3 = USER STOPPED (using the Stop Key).

4 = POWER FAILED.

5 = PUMP JAMMED.

6 = DISTRIBUTOR JAMMED.

8 = PUMP LATCH OPEN.

9 = SAMPLER SHUT OFF (while sampling).

11 = NO DISTRIBUTOR.

12 = SAMPLE IN PROGRESS.

CS,xxxx is the byte-by-byte sum of the entire string “MO,...,CS,”

For commands that are not understood (INVALID COMMAND or CHECKSUM MISMATCH) or when no samples have been taken, the most recent bottle information is left off the response string.

6712 Portable Sampler

Section 6 SDI-12 Sondes

In order to provide you with the flexibility to use the water parameter sensors that best meet your needs, Teledyne Isco has implemented support for SDI-12 protocol. Support of this standard allows you to use SDI-12 compatible devices in conjunction with your 6712 sampler in Extended Programming mode.

6.1 SDI-12 Data Parameters

The 6712 Sampler can accept up to 16 parameters from up to ten sensors with SDI-12 addresses from 0 - 9 (refer to chart in Figure 6-1). This data can be used in different ways. Data can be logged at user selectable time intervals for later download and processing by Teledyne Isco's Flowlink™ program. You can set up sampling programs that will be enabled to run only if conditions based on parameters monitored by the connected SDI-12 devices are met. The sampler can also be programmed to take samples each time certain parameter limits are exceeded.

The data parameters used by the sensing device (sonde) and recording device (sampler) must match. Otherwise, the equipment could record the data values for one parameter as another's, such as reporting a pH value as being temperature.

Certain vendors' sondes (such as Hydrolab and YSI) have enhanced commands that facilitate "plug and play" setup. These Teledyne Isco Ready sondes can tell the 6712 what values they have, their order, and units of measure.

Other SDI-12 compatible sondes can be used, but require manual setup to identify proper data types for each data value reported.

This section shows you how to set up both Teledyne Isco Ready and other SDI-12 sondes for use with the 6712.

⚠ WARNING

SDI-12 Sondes have not been approved for use in hazardous locations as defined by the National Electrical Code.

⚠ CAUTION

Before you install any sonde, you must take the proper safety precautions. Refer to Appendix C in the back of this manual. Additional safety considerations may be required. Check applicable guidelines, codes, and regulations of federal, state, city, and county agencies.

SDI-12 Sonde Data Units:	Parameter	Range	Resolution	Storage Bytes
	Temperature	-40 - 100 °C	0.1 °C	2
	Conductivity	0 - 100 mS/cm	0.01 mS/cm	2
	Specific Conductance	0 - 100 mS/cm	0.01 mS/cm	2
	Total Dissolved Solids	0 - 90 g/l	0.01 g/l	2
	Salinity	0 - 70 ppt	0.1 ppt	2
	Dissolved Oxygen	0 - 20 mg/l	0.1 mg/l	1
	pH	0 - 14	0.1	1
	ORP	-999 - 999 mv	0.1 mv	2
	Level	0 - 6.5279 m	0.0001 m	2
	Ammonium-Nitrogen	0 - 200 mgN/l	0.1 mgN/l	2
	Ammonia-Nitrogen	0 - 200 mgN/l	0.1 mgN/l	2
	Nitrate-Nitrogen	0 - 200mgN/l	0.1 mgN/l	2
	Turbidity	0 - 5000 NTU	0.1 NTU	2
	Chloride	0 - 1000 mg/l	0.1 mg/l	2
	Chlorophyll	0-400 ug/l	0.1 ug/l	2
	Other	-99999.0-99999.0	0.0001	4

Figure 6-1 SDI-12 Sonde Parameters

6.2 Scanning For Sondes

You must be in Extended Programming to use a sonde with the 6712. The sampler can automatically scan for the presence of sondes if you enable that option:

- From the main menu, select OTHER FUNCTIONS.
- Select HARDWARE.
- As you press ↵ to move through the hardware screens, you will see one that looks like the following:

```
↑   NO SDI-12 SONDE
    AUTO SDI-12 SCAN OFF
                         ↓
```

Select “NO SDI-12 SONDE” to scan for sondes. If one is found, you can set it up, and the “AUTO SDI-12 SCAN” option will be switched to yes.

Select the “AUTO SDI-12 SCAN” option to manually turn on (or off) automatic scanning for sondes when the sampler is turned on.

If a sonde has already been connected and set up, the hardware screen will instead display a screen similar to the following:

```
↑   SDI-12 DATA:
    TEMP0 pH0 SD_CO0
    SAL0 05DATA0 DO0
    ORP0 LEVEL0 09DATA0  ↓
```

Press the arrow keys until "SDI-12 DATA" is blinking, then press ↵. You will see the screen below:

```
↑   NO SDI-12 SONDE
    SETUP KNOWN SONDES
    SCAN SDI-12 SONDES
                      ↓
```

Select "SCAN SDI-12 SONDES" and press ↵. The system will scan to see what sondes are connected. If it detects a different sonde, it will indicate so, and advance to the setup screens.

6.3 Teledyne Isco Ready Sondes

Connecting a Teledyne Isco Ready Sonde

1
```
SELECT ADDRESS OF
SONDE TO SETUP:
__ __ DONE
```

- Select the address you want to set up.

2
```
Company Model
Optional Information
SONDE AT ADDRESS __
HAS __ DATA VALUES
```

- Wait a few seconds for the above display to disappear, or press ↵.
- You will then be asked if you want to store the parameter data. Refer to "SONDE SETUP - STORING PARAMETER DATA" on page 6-4.

If the 6712 scans for sondes and finds one that is Teledyne Isco Ready, it will automatically recognize the sonde's data types and units. You can then use Hardware options to setup the definitions for data storage and calibrate the sonde.

Even with a Teledyne Isco Ready sonde, the 6712 may find a parameter that is not on its list of supported parameters (Figure 6-1). It can still work with such a parameter. Such a parameter will be identified as something like "05DATA1" and you will have to mentally associate the appropriate data type with that label. However, once such data is brought into Flowlink™, data sets can be manually changed so that reports show the appropriate labels.

6.4 Other SDI-12 Sondes

If you have connected an SDI-12 sonde that is not Teledyne Isco Ready, you will need to define the sonde's data values.

When you select the address of the sonde you want to set up (see screens in the margin), the company model and other information will be displayed along with the number of data values the sonde has.

When you advance to the next screen (see #3 below), the data types will be listed as "OTHER" because you have not defined them yet. Move between the data types using the arrow keys. Select one to change by pressing ↵.

A list of possible parameters will be displayed (see #4 below). Use the arrow keys to move through the options. When the one you want is blinking, press ↵. Repeat the process until you have defined all of the data parameters for your sonde.

Use the arrow key to move to "DONE" and press ↵. You will then be asked if you want to store the parameter data.

Connecting Other SDI-12 Sondes

3
```
SELECT ADDRESS OF
SONDE TO SETUP:
__ __ DONE
```

- Select the address of the sonde you want to set up.

4
```
Company Model
Optional Information
SONDE AT ADDRESS __
HAS __ DATA VALUES
```

- You can wait a few seconds, or press ↵ to advance to the next screen:

5
```
DATA FROM SONDE __
 1 = OTHER
 2 = OTHER
 3 = OTHER          --->
```

- Press an arrow key until the cursor is on the data you want to identify. Then, press ↵. A scrolling screen listing possible parameters will appear.

6
```
   SONDE ___ ,   DATA 1:
<--  pH
   TEMPERATURE (ºC)
   TEMPERATURE (ºF)   --->
```

- Make your selection and press ↵.

3
```
   DATA FROM SONDE __
<--  1 = TEMPERATURE(ºC)
     2 = OTHER
     3 = OTHER          --->
```

- Repeat the process until you have defined all the data. Press "DONE" when finished.

4
```
   DATA FROM SONDE __
<---  4 = pH
      5 = LEVEL
          DONE
```

- You will then be asked if you want to store the parameter data. Refer to "SONDE SETUP - STORING PARAMETER DATA" in the following paragraphs.

6.5 Sonde Setup - Storing Parameter Data

Whether you are using a Teledyne Isco Ready sonde or other SDI-12 compatible sonde, you will need to tell the 6712 if you want to store all of the parameter data or data from selected parameters.

Data is stored in memory partitions. A fixed amount of memory is available to store data. If you are using some parameters to simply trigger an event or enable condition, it is not necessary to store the data.

If **all** of the parameters' data will fit in memory, you will be asked if you want to store all of the parameter data. Answering "NO" will still allow you to selectively store parameter data; otherwise, all data will be stored.

You will be asked to store parameter data during the setup process. You can also manually change the setup using options in the Hardware menu.

To access the setup option in the Hardware menu, select Other Function from the main menu, then choose Hardware. Advance through the screens until you see one that displays SDI-12 DATA.

Select this screen to display the following:

```
NO SDI-12 SONDE
SETUP KNOWN SONDES
SCAN SDI-12 SONDES
```

Select "SETUP KNOWN SONDES" and then indicate the address of the sonde you want to setup. A screen containing the sonde model and number of data values will appear briefly. Then you will be asked to verify, parameter by parameter, what data you want to store. The screens will look similar to the one below:

```
SONDE 5, STORE
TEMPERATURE DATA?
YES NO
LABEL IS: TEMP5
```

Indicate if you want to store the data for that particular parameter and then advance through the rest of the parameter screens. Once you have defined your data storage options, select "DONE."

You will be prompted that you have entered a new hardware setup and asked if you want to erase the stored data. Indicate "YES" or "NO." A partition memory status message will be displayed and (if a parameter exists that can be calibrated) you will then advance to the calibration screen (refer to "SONDE CALIBRATION AND VALIDATION" on this page). If you do not want to calibrate or validate, select "DONE" to return to the Hardware Options screens.

6.6 Sonde Calibration and Validation

It is recommended that calibration of your sonde be done in the lab, according to manufacturer's recommendations. However, for your convenience, the 6712 allows for field calibration of pH, Dissolved Oxygen (DO), and Oxidation Reduction Potential (ORP).

Field calibrations are stored in the sampler, NOT the sonde, and are used to modify readings from the sonde until a new sonde is connected. When a sonde is moved to another sampler, it will retain calibration constants set in the lab, but will not retain any that were set in the field.

Although field calibration is limited to three parameters, you can validate any of the available parameters. Validation allows you to immerse the sonde in a known solution, note the readings, and see if the sonde is functioning properly. The validation process does not modify any readings like calibration does; it merely alerts you to inaccurate ones.

No data will be stored, nor will enable conditions be updated, while calibrations or validations are being performed.

6.6.1 The Calibration Screens

To access the calibration screens from the main menu, select Other Functions, Hardware. Advance through the screens until you see one that displays "SDI-12 DATA." Select this screen to display the following:

```
NO SDI-12 SONDE
SETUP KNOWN SONDES
SCAN SDI-12 SONDES
```

Select "SETUP KNOWN SONDES" and then select "DONE." You will see a screen similar to the following that will list the parameters you can calibrate.

```
SELECT PARAMETER
TO CALIBRATE:
pH5 DO5 ORP5 DONE
```

The sonde's address will appear after the parameter (such as pH0 and pH5). If you have multiple sondes attached, use the arrow key to select the correct one to calibrate.

Depending upon the parameter you selected, a series of screens will be displayed to step you through the calibration process.

- pH - You will be given the choice of three different pH solutions: 4.00, 7.00, and 10.00. After making your selection, rinse the probe and place in the pH buffer. If the reading is off by more than 0.5 pH units, you will asked to verify if the reading is correct.
- DO - For dissolved oxygen, you can choose between two methods: DO Standard and Saturation. The saturation method requires a temperature reading between 0.0° and 47.0° C. You will also need to enter your altitude and barometric pressure.
- ORP - You will asked to enter the value of your calibration standard.

When calibration is complete, select "DONE" to proceed to the validation screen. If you do not want to validate any parameters, select "DONE" again to return to the Hardware options screens.

6.6.2 The Validation Screen

The validation screen appears after you select "DONE" on the calibration screen. It will be similar to the screen shown below.

```
SELECT PARAMETER
TO VALIDATE:
<--     SAL5    05DATA5   DO5
  ORP5    LEVEL5          -->
```

Use the arrow keys to select the desired parameter to validate. Any parameter can be validated. You will be prompted to place the probe in your validation standard. When stable, press ↵. The reading will be displayed at the bottom of the screen.

When you are done validating, select "DONE" to return to the Hardware options screens.

6.7 Disconnecting Sondes

When you have disconnected all sondes, and have interrogated the sampler for all its data, you can indicate that there is no SDI-12 sonde.

From the main menu, select Other Functions, Hardware. Advance through the screens until you see one that displays "SDI-12 DATA." Select this screen to display the following:

NO SDI-12 SONDE
SETUP KNOWN SONDES
SCAN SDI-12 SONDES

Select "NO SDI-12 SONDE." You will advised that you have a new hardware setup:

NEW HARDWARE SETUP--
DOWNLOAD DATA NOW
OR LOSE ALL DATA!
DONE

If you have collected all the data, select "DONE." A partition memory message will be displayed briefly, and you will be returned to the Hardware options screens.

If you do not have a sonde attached, you may want to turn off automatic scanning for sondes. This will eliminate the time taken to scan for sondes whenever the sampler is turned on.

6712 Portable Sampler

Section 7 Remote Operation

The 6712 controller can be operated remotely from external devices. External controlling devices may be a computer via RS-232 serial communications or a telephone via touch-tone commands. Remote telephone operation requires the factory-installed 2400 baud talking modem.

> ☑ ***Note***
>
> The internal modem cannot be installed in a controller with the analog output option also installed.

7.1 Computer Operation

The 6712 controller can be operated from a remote location using a computer. There are two different levels of computer control:

Menu control is used to start and stop the current sampler program (or programs if in Extended programming mode) and to access other menu commands. This level of remote operation relies on the sampler program for much of its capabilities.

External program control ignores the sampler's program and current state. Using external control, you can turn on the sampler, take a sample, and request sampler status data. The pump, distributor, and serial data output simply respond to the external commands.

To operate the sampler remotely on either level, you must first establish RS-232 serial communication between the computer and the 6712 controller. To do so:

1. Connect your computer to the 6712 controller's interrogator port with a standard interrogator cable, P/N 60-2544-044 (for 9-pin serial ports).
2. On your computer, open a terminal emulator program such as HyperTerminal, and configure it for:
   - baud rate of 19,200 or less
   - no parity
   - 8 data bits
   - 1 stop bit
   - VT100 terminal emulation
3. Using your communications software, connect to the sampler. Press and hold the question mark (?) on the computer keyboard until the sampler returns its banner string. A caret (>) prompt will appear on the screen when the sampler is ready to accept commands.

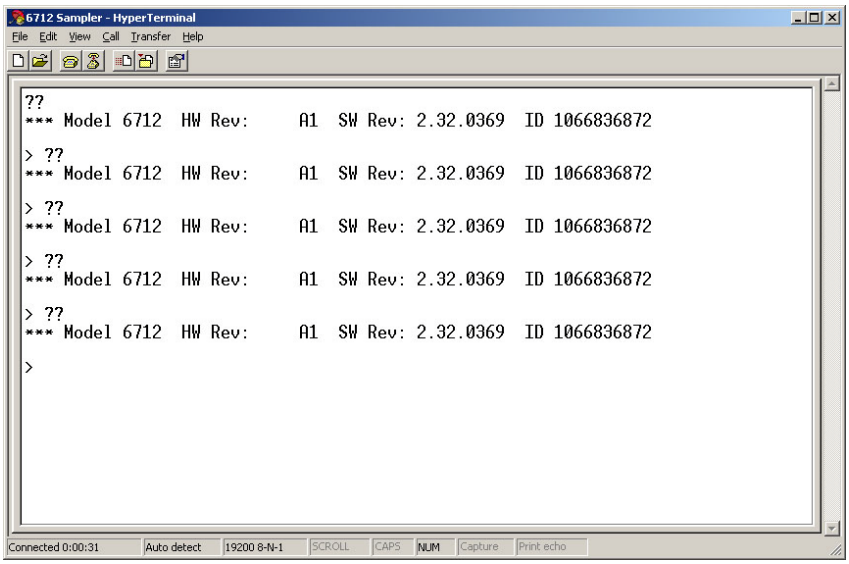


Figure 7-1 Press and hold ?? to connect to the sampler

7.1.1 Menu Control

Once you have remotely connected to the sampler, menu commands can be entered from your computer. These menu commands are listed in Table 7-1.

To access the menu commands, type MENU at the “>” prompt and press ENTER. The screen will return a list of the available options. Note that the current state of the controller will determine the available menu options. Then, type the desired command(s), confirming with ENTER.

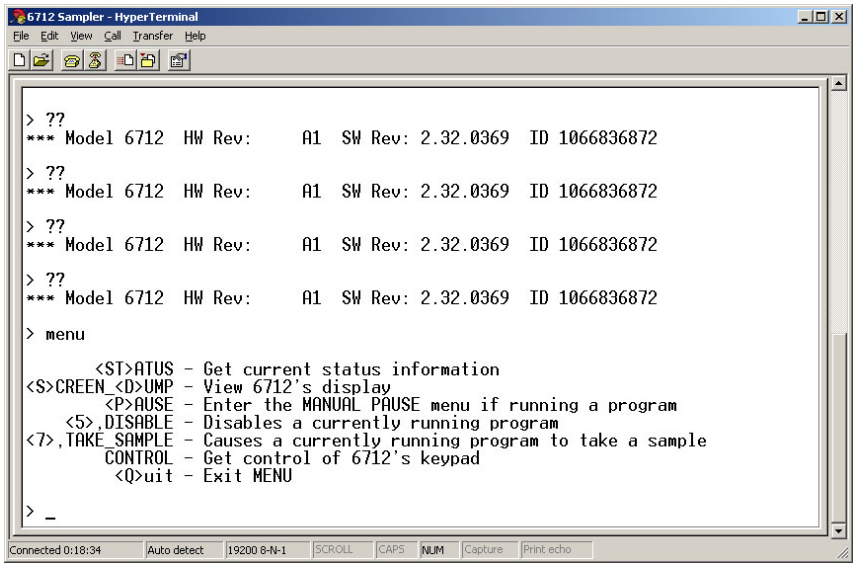


Figure 7-2 Example list of remote menu commands

Table 7-1 6712 Remote Menu Commands

Menu Command	Description
0 or START	This command will immediately start any program set to WAIT FOR PHONE CALL and currently waiting for the remote start command (see Section 4.6).
1 or RUN1	This command will load Program 1 as the sampler's current Extended program, reset partition if the storage interval has been changed, and run the program. RUN1 is valid when the sampler is in standby, or when it is waiting for a start command. RUN1 will also run the current program while in Standard programming.
2 or RUN2 3 or RUN3 4 or RUN4	These commands will load the selected program number as the sampler's current Extended program, reset partition data if the storage interval has changed, and run the program. They are valid when the sampler is in standby, or when it is waiting for a start command. The commands are available for Extended programming only.
5 or DISABLE	This command is similar in functionality to a pin F low signal (a signal typically used to enable or disable the sampler from a flow meter). At run time, the sampler starts with the sampler in the enabled state. DISABLE is valid while a program is running. If successful, a display of REMOTE ENABLE IS FALSE will be returned. A Remote Disable is the highest priority disable. If the sampler is disabled with this command, no condition other than menu command 6, ENABLE, will allow the program to become enabled again.
6 or ENABLE	This command is used to re-enable a disabled sampler. ENABLE is valid while a program is running. If successful, a display of REMOTE ENABLE IS TRUE will be returned.
7 or TAKE_SAMPLE	This command causes the sampler currently running a program to take a sample. The sample will count as one of the program's samples and is placed in the current bottle (Part A's current bottle when using two-part programming). TAKE_SAMPLE is valid while the program is running, after the start time, but not while in the MANUAL PAUSE screens. If successful, a response similar to PUMPING XXML SAMPLE INTO BOTTLE ## will be returned. If not, a response similar to NO SAMPLE, PROGRAM WAITING START will be returned.
ST or STATUS	This command causes the sampler to return its status information and current parameter data.
SD or SCREEN_DUMP	This command causes the sampler to return the information currently displayed on the sampler's screen. The remote screen follows the sampler's display as the information is updated. This mode can be used to observe from a remote location while the sampler is programmed on-site.
P or PAUSE	This command causes a sampler currently running a program to enter the MANUAL PAUSE menu. While you are connected in this mode, the sampler keypad becomes disabled, and your computer's keypad will be redirected to simulate the sampler keypad. The following keys will be activated: <Enter>, decimal point, and number keys. <Esc>, S, or s = STOP. <Backspace>, L or l, and U or u = Left/Up arrows. R or r, and D or d = Right/Down arrows.

Sampling reports

You can retrieve the sampling reports at any time using the same serial connection. Type "Q" to exit the menu. Then at the > prompt, type "REPORT" and press Enter. The sampler controller will send reports as configured.

7.1.2 External Program Control

Under external program control, the sampler operates according to received commands. An external program can be as simple as manually entered commands to collect a sample when needed, or as complex as a user-developed process control program (for SCADA or other systems) that directs sample collection according a system's needs.

The 6712 controller will respond to four commands:

- Turn on the sampler
- Take a sample
- Send status
- Send data

Note that commands and responses are comma-separated pairs. The first set of alpha-characters is an identifier; the second set of numeric characters indicates the value. The 6712 controller will not receive and process the command unless it is followed by a carriage return.

Turn on the sampler – If the sampler is OFF, the sampler responds by placing itself in the ON state and returning a status string to report the new status. (See *Send Status* for a description of this string.)

The command to turn the sampler ON and return status is:

STS,2<CR>

Take a Sample – This directs the sampler to take a sample. The command specifies how much volume to take, and which bottle to place the sample in. The sampler responds by taking a sample and returning a status string that reports the new status.

An example of a command to take a sample is shown below:

BTL,2,SVO,100<CR>

This example instructs the sampler to place the distributor arm over bottle 2 (BTL,2) and take a 100 ml sample (SVO,100).

While most settings of the sampler program (start times, enables, distribution schemes, etc.) are ignored when responding to external commands, the sampler does rely on two program settings that "configure" the sampler. These settings are:

- Number of Bottles–is used to determine the distributor arm position and the acceptable range for the BTL values.
- Suction Line Length–Used with liquid detection to deliver correct sample volumes according to the SVO value.

Send Status – This command causes the sampler to return a data string that identifies the controller and lists its current status.

The command to send current status is:

STS,1<CR>

The status is received as pairs of comma-separated identifiers and values. A complete description of each pair is listed below.

MO,6712, is the model number of the sampler.

ID,2424741493, is the sampler's unique ID number.

TI,35523.50000, is the sampler's current time, shown in a date-time format based on the number of days since 00:00:00 1-Jan-1900, and the time shown as a fraction.

The possible states returned by the STS,1 command are:

1 = WAITING TO SAMPLE.
4 = POWER FAILED (for short time after power is restored).
5 = PUMP JAMMED (must be resolved before continuing).
6 = DISTRIBUTOR JAMMED (must be resolved before continuing).
9 = SAMPLER OFF.
12 = SAMPLE IN PROGRESS.
20 = INVALID COMMAND. Possible causes may be:

- identifier code is not supported.
- bottle requested is not in current configuration
- sample volume requested is outside its range (10 - 9990 ml)
- day (Set_Time) must be 5 digits and more recent than 1977

21 = CHECKSUM MISMATCH. (see "Optional checksum" on page 7-8)
22 = INVALID BOTTLE. (bottle requested is not in the current configuration)
23 = VOLUME OUT OF RANGE. (the sample volume requested is outside its range (10-9990 ml)

STI,35523.41875, is the most recent sample time.

BTL,2, is the bottle that received the most recent sample.

SVO,100, is the most recent sample's volume.

SOR,0, is the results of attempting the most recent sample. The possible results are:

0 = SAMPLE OK
1 = NO LIQUID FOUND
2 = LIQUID LOST (not enough liquid)
3 = USER STOPPED (using the Stop Key)
4 = POWER FAILED
5 = PUMP JAMMED

6 = DISTRIBUTOR JAMMED
8 = PUMP LATCH OPEN
9 = SAMPLER SHUT OFF (while sampling)
11 = NO DISTRIBUTOR
12 = SAMPLE IN PROGRESS

CS,xxxx is the byte-by-byte sum of the entire string "MO,...,CS," (see "Optional checksum" on page 77-8)

Note

For commands that are not understood (INVALID COMMAND or CHECKSUM MISMATCH) or when no samples have been taken, the most recent bottle information is left off the response string.

Send Data – This command causes the sampler to return the Send Status appended with data from any module, rain gauge, or SDI-12 device. Refer to Table 7-2 to interpret the returned string.

Note

This returns the same data as the programmable software option Serial Output, as described in Section 5.18.6 of this manual.

The command to send data is:

DATA<CR>

Table 7-2 Serial Data Codes

Identifier	Parameter	Units
B?[1]	Bottle number and time	days since 1-Jan-1900
CR	Current day's rain	tips[2]
CS[3]	Checksum	unsigned long
DE	Description	6712 Sampler
FL	Flow	cubic meters per second
ID	Unit specific identifier	10 digit unsigned long
LE	Level	meters
MO	Model	6712
PE	Percent	percent of full scale
PH	pH	none
PR	Previous day's rain	tips[2]
RA	Rain	tips[2]
RTE	Refrigerator Temperature	degrees celsius
SS	Sampler enable state	logical
TE	Temperature	degrees celsius

Table 7-2 Serial Data Codes (Continued)

Identifier	Parameter	Units
TI	Current time	days since 1-Jan-1900
VE	Velocity	meters per second
VO	Volume	cubic meters
VSI	Velocity signal strength	percent
VSP	Velocity spectrum strength	percent
CO_ [4]	Conductivity	milliseimens per centimeter
DO_ [4]	Dissolved oxygen	milligrams per liter
PH_ [4]	pH	none
SA_ [4]	Salinity	parts per thousand
SP_ [4]	Specific Conductance	milliseimens per centimeter
TD_ [4]	Total Dissolved Solids	grams per liter
TE_ [4]	Temperature	degrees Celsius
OR_ [4]	Oxidation reduction potential	millivolts
LE_ [4]	Level	meters
MM_ [4]	Ammonium-nitrogen	milligrams nitrogen per liter
MA_ [4]	Ammonia-nitrogen	milligrams nitrogen per liter
NI_ [4]	Nitrate-Nitrogen	milligrams nitrogen per liter
TB_ [4]	Turbidity	nephelometric turbidity units
CL_ [4]	Chloride	milligrams per liter
CP_ [4]	Chlorophyll	micrograms per liter
FL_ [4]	Flow rate	cubic meters per second
VO_ [4]	Flow volume	cubic meters
xxD_ [4, 5]	Other data not listed above	

[1] The three most recent samples will have entries as B?. The “?” will be the first bottle number in the set. If the sample is a grab sample, it will be shown as B0.

[2] Rainfall tips roll over every 256 counts.

[3] The checksum does not include the checksum, carriage return, and linefeed. The string is terminated with <CR><LF>.

[4] A “_” in the identifier indicates an SDI-12 address.

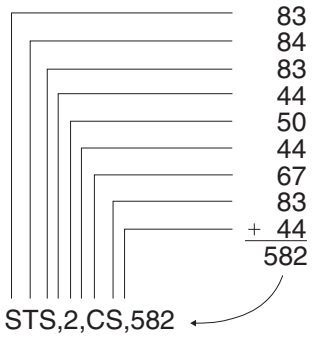
[5] “xx” matches the data label for the SDI-12 parameter.

Optional checksum

Optionally, commands to the sampler can be validated using a checksum. Checksum validation can avoid problems caused by faulty program control or communication lines. When using the checksum, add the CS identifier and a comma at the end of the command, and the checksum value of the string up to the last comma. For example, the command with checksum validation to turn the sampler on would appear as:

STS,2,CS,582<CR>

The numeric value of each character is its ASCII equivalent expressed in decimal format. The checksum of "582" was calculated as shown below.



7.1.3 Remote Control of Sampler Keypad

To control the sampler keypad remotely, type CONTROL at the ">" prompt and press ENTER. The sampler display appears on your computer monitor as you step through the programming screens. While in this mode, the computer keys will be redirected to simulate the sampler's keypad, and the sampler keypad itself will be disabled to avoid any conflict. The active keys and their corresponding functions are given in Table 7-3.

Table 7-3 Remote Control of Sampler Keypad

Computer	Sampler
<Esc>, S, s	STOP
L,l,U,u, <Backspace>	Left / Up
R, r, D, d	Right / Down
O, o	ON
<Enter>, arrows, decimal, numbers	Same as sampler
NOTE: You will not be able to turn the sampler off remotely.	

7.2 Telephone Commands

6712 controllers equipped with an internal voice modem can be operated using telephone commands. This factory-installed option includes a 12 ft (3.6 m) modem cable.

After connecting to the sampler from a touch-tone telephone, command numbers may be entered from the telephone's keypad, followed by the [#] (pound) button. The commands are listed in Table 7-4.

To use telephone commands:

1. Dial the sampler's telephone number. When the sampler connects, it answers with "Teledyne Isco Sampler Site [number]." If the sampler does not receive a touch-tone command in five seconds, it assumes that a computer modem has called and initiates the modem connect sequence. If this occurs you must hang up and try again.
2. Enter the command. For example, to run program 1, press [1] [#].
3. If the command is valid for its current state of operation, the sampler responds with "[command number], please acknowledge." If the command is not valid the sampler responds with the command number followed by three quick beeps. Enter a valid command.
4. Acknowledge the valid command by pressing the number. For the example, press [1].
5. If the number is incorrect, the sampler responds with your entry followed by three quick beeps. You must re-enter the command (step 2).
6. After the command is confirmed, the sampler replies with "[command number] acknowledge" and executes the command.

To enter additional commands, repeat steps 2 through 5. The sampler will hang up after ten seconds of quiet time.

Table 7-4 6712 Remote Phone Commands

Phone Command	Name	Description
[0] [#]	Start	This command will immediately start any program set to WAIT FOR PHONE CALL and currently waiting for the remote start command (see Section 4.6).
[1] [#]	Load and Run Program 1	This command will load Program 1 as the sampler's current Extended program, reset partition if the storage interval has been changed, and run the program. RUN1 is valid when the sampler is in standby, or when it is waiting for a start command. RUN1 will also run the current program while in Standard programming.
[2] [#] [3] [#] [4] [#]	Load and Run Program 2, 3, or 4	These commands will load the selected program number as the sampler's current Extended program, reset partition data if the storage interval has changed, and run the program. They are valid when the sampler is in standby, or when it is waiting for a start command. The commands are available for Extended programming only.

Table 7-4 6712 Remote Phone Commands (Continued)

Phone Command	Name	Description
5 #	Disable	This command is similar in functionality to a pin F low signal (a signal typically used to enable or disable the sampler from a flow meter). At run time, the sampler starts with the phone enable in the enabled state. PHONE DISABLE is valid while a program is running. If successful, a reply of REMOTE ENABLE IS FALSE will be returned. A Remote Disable is the highest priority disable. If the sample is disabled with this command, no condition other than command 6#, ENABLE, will allow the program to become enabled again.
6 #	Enable	This command is used to re-enable a phone-disabled sampler. PHONE ENABLE is valid while a program is running. If successful, a reply of REMOTE ENABLE IS TRUE will be returned.
7 #	Grab Sample	This command causes the sampler currently running a program to take a sample. The sample will count as one of the program's samples and is placed in the current bottle (Part A's current bottle when using two-part programming). TAKE_SAMPLE is valid while the program is running, after the start time, but not while in the MANUAL PAUSE screens. If successful, a response similar to PUMPING XXML SAMPLE INTO BOTTLE ## will be returned. If not, a response similar to NO SAMPLE, PROGRAM WAITING START will be returned.

6712 Portable Sampler

Section 8 Maintenance

This section describes how to maintain and troubleshoot your 6712 sampler. If you think your unit requires repair, or if you have questions concerning its operation or maintenance, contact Teledyne Isco's Technical Service Department:

Phone: (800) 228-4373
(402) 464-0231
FAX: (402) 465-3022

E-mail: IscoService@teledyne.com

8.1 Maintenance Checklist

- Inspect the pump tube for wear. Replace it if necessary.
- Clean the pump tubing housing.
- Change the suction line if necessary.
- Clean the bottles, suction line, strainer and pump tube.
- Check the humidity indicator.
- Check the controller's internal battery status and replace the battery every five years.
- If the keypad label has bubbles under it, the air inside the controller has expanded. To release this pressure, unscrew the flow meter cable or connector cap on the back of the controller. Push down on the label to force the air out, then re-tighten the cable connector or cap.

8.2 Cleaning Guidelines

8.2.1 Controller, Top Cover, Center Section, Retaining Ring, and Tub

Clean the top cover, center section, retaining ring, and tub with warm soapy water or by spraying them with a hose. Avoid using a high-pressure hose to clean the controller, especially around the control panel. Extreme pressures may force water past the control-panel seal.

When cleaning the controller and top cover, cap the connectors at the back of the controller tightly. Keep a power source connected to the power-source connector, or replace the protective cap (shipped with the sampler) over the power source connector, to protect the pins from moisture damage. Make sure the two pump drain holes (located on the bottom right-hand side of the pump, beneath the pump band) are open and free of debris or buildup.

8.2.2 Sample Bottles

The sample bottles have a wide mouth to facilitate cleaning. Wash them with a brush and soapy water, or use a dishwasher. You can autoclave the glass bottles.

8.2.3 Suction Line, Pump Tube, and Discharge Tube

Clean the suction line, pump tube, and discharge tube by placing the end of the suction line in a cleaning solution and pumping it through the delivery system. Rinse with clean water. If these items are severely contaminated, discard them. For critical sampling applications, refer to the following sections.

8.2.4 Strainer

Clean the strainer with a brush and soapy water.

8.3 Cleaning Protocols for Priority Pollutants

Clean sampling equipment is essential for valid laboratory analysis. Teledyne Isco recommends that you develop cleaning protocols in consultation with a laboratory analyst when designing the monitoring program. For example, to clean sample bottles, suction line, and pump tubes, Lair (1974) suggests these protocols used by USEPA Region IV Surveillance and Analysis field personnel engaged in NPDES compliance monitoring. The protocols are based on U.S. Environmental Protection Agency Publications EPA-600/4-77-039 (*Sampling of Water and Wastewater* by Dr. Phillip E. Shelley).

8.3.1 Teledyne Isco Glass Sample Bottles

1. One spectro-grade acetone rinse.
2. Dishwasher cycle (wash and tap water rinse, no detergent).
3. Acid wash with at least 20 percent hydrochloric acid.
4. Dishwasher cycle (wash and tap water rinse, no detergent).
5. Replace in covered Teledyne Isco tubs.

8.3.2 Vinyl Suction Line

- Use new suction line for each new sampling setup, therefore, no cleaning is required.
- Use PTFE suction line when sampling for organic compounds.

8.3.3 Teflon Suction Line

1. Rinse twice with spectro-grade acetone.
2. Rinse thoroughly with hot tap water using a brush, if possible, to remove particulate matter and surface film.
3. Rinse thoroughly three times with tap water.
4. Acid wash with at least 20 percent hydrochloric acid.
5. Rinse thoroughly three times with tap water.
6. Rinse thoroughly three times with distilled water.
7. Rinse thoroughly with petroleum ether and dry by pulling air through the line.
8. Dry overnight in a warm oven (use an oven temperature of lower than 150° F), if possible.
9. Cap ends with aluminum foil.

8.3.4 Teledyne Isco Pump Tube

1. Rinse by pumping hot tap water through the tube for at least 2 minutes.
2. Acid wash the tube by pumping at least a 20 percent solution of hydrochloric acid through the tube for at least 2 minutes.

3. Rinse by pumping hot tap water through the tube for at least 2 minutes.
4. Rinse by pumping distilled water through the tube for at least 2 minutes.

☑ Note

For critical sampling applications, consider replacing the suction line, pump tube, and discharge tube. Replacement eliminates the possibility of any cross contamination from previous sampling sites.

8.4 Maintenance Screens

When you select OTHER FUNCTIONS from the main menu, and then select Maintenance, the following screen will be displayed:

```
SET CLOCK
PUMP TUBE ALARM
INTERNAL BATTERY
DIAGNOSTICS
```

Using these options, you can set the sampler's time and date, set the number of pump counts for the pump tube warning, reset the battery warning for the internal battery, and run a set of diagnostic tests for troubleshooting purposes.

8.4.1 Set Clock

Entering Times and Dates

```
ENTER TIME AND DATE:
HH:MM   DD-MON-YY
__:__   __-__-__
```

- Move from one field to another by pressing the arrow keys.
- Change a setting in a field by typing a number. Press ↵ to accept the new setting.

Teledyne Isco ships samplers from the factory with the clocks set to the correct Central Standard Time. Reset the clock when installing the sampler in a different time zone, for daylight savings time, or when needed.

When setting the clock and calendar, use a 24-hour clock for times and the day-month-year format for dates. The illustration at the left shows blanks for each position that accepts an entry. The positions are called fields. When this screen appears on your sampler, the fields will contain the sampler's current settings for the time and date.

- To move from one field to another without changing the setting, press the arrow keys. Use this technique when you want to change only one or two settings.
- Change the setting by typing a new number. Press ↵ to accept the new setting.

For example, to enter 2:00 p.m. (2:00 p.m is 14:00 on a 24-hour clock), type 14. Press ↵. Next, type 0 (zero) for the minutes, and press ↵. To enter a date, such as January 22, 2001, type: 22 ↵ 01 ↵ 01 ↵ .

Table 8-1 Setting the Clock and Calendar

1	RUN PROGRAM VIEW REPORT **OTHER FUNCTIONS**	Select OTHER FUNCTIONS.
2	**MAINTENANCE** MANUAL FUNCTIONS PROGRAMMING STYLE	Select MAINTENANCE.
3	**SET CLOCK** PUMP TUBE ALARM INTERNAL BATTERY DIAGNOSTICS	Select SET CLOCK.
4	ENTER TIME AND DATE: HH:MM DD-MON-YY **14:00 22-JAN-01**	Enter the time and date.
5	SET CLOCK PUMP TUBE ALARM INTERNAL BATTERY DIAGNOSTICS	Press STOP to return to the main menu.

8.4.2 Pump Tube Alarm

The sampler tracks the pump counts in both the forward and reverse cycles with a resettable counter. When the counter reaches the default count of 1,000,000 or the count you have entered, the sampler displays a message, "WARNING! REPLACE PUMP TUBE." The message appears each time you turn the sampler on or run a program until you reset the counter.

After replacing the pump tube (see page 8-8), reset the count to zero so the sampler can begin tallying the pump counts for the new tube. Replacing the pump tube does not reset the counter.

Experience may suggest a significantly different pump tube life. You can change the alarm count to represent the pump tube life for your application. The example below shows how to set the alarm count and reset the pump counts.

Table 8-2 Resetting the Pump Counter

1	RUN PROGRAM VIEW REPORT **OTHER FUNCTIONS**	Select OTHER FUNCTIONS.
2	**MAINTENANCE** MANUAL FUNCTIONS PROGRAMMING STYLE HARDWARE	Select MAINTENANCE.
3	SET CLOCK **PUMP TUBE ALARM** INTERNAL BATTERY DIAGNOSTICS	Select PUMP TUBE ALARM.
4	1024000 PUMP COUNTS, WARNING AT 1000000	The sampler displays this screen briefly to give you the current pump-count information. The first line shows you the pump counts tallied since the counter was last reset. The second line shows the current alarm setting.
5	1024000 PUMP COUNTS, RESET PUMP COUNTER? **YES** NO	To reset the counter to zero, select YES. Always reset the counter after replacing a pump tube. Select NO when merely checking the current count.
6	WARNING AT **10**00000 PUMP COUNTS (1 - 99)00000)	If necessary, change the pump-count alarm setting by typing the first two digits of the new setting. The sampler accepts entries between 1 and 99. For example, to increase the count to 1,500,000, enter 15.
7	SET CLOCK PUMP TUBE ALARM INTERNAL BATTERY DIAGNOSTICS	Press STOP to return to the main menu.

8.4.3 Internal Battery Warning

The internal lithium battery preserves the sampler's memory when power is removed. For an explanation of how to replace the lithium battery, go to Section 8.8.

Table 8-3 Checking and Replacing the Internal Battery

1	RUN PROGRAM VIEW REPORT **OTHER FUNCTIONS**	Select OTHER FUNCTIONS.
2	**MAINTENANCE** MANUAL FUNCTIONS PROGRAMMING STYLE HARDWARE	Select MAINTENANCE.
3	SET CLOCK PUMP TUBE ALARM **INTERNAL BATTERY** DIAGNOSTICS	Select INTERNAL BATTERY.
4	WARNING! REPLACE INTERNAL BATTERY BEFORE 17-OCT-97	The sampler displays this screen briefly to show you the expiration date.
5	DID YOU REPLACE THE INTERNAL BATTERY? YES NO	After replacing the battery, select YES. Select NO only if checking the expiration date. Resetting the alarm directs the sampler to calculate a new expiration date, five years in the future. If you reset the alarm without replacing the battery, the sampler will not be able to alert you to the battery's impending expiration.
6	SET CLOCK PUMP TUBE ALARM INTERNAL BATTERY DIAGNOSTICS	Press STOP to return to the main menu.

8.4.4 Diagnostics

The sampler has several self-diagnostic tests that check the memory (both the RAM and ROM), pump, and the distributor arm position. It also contains screens that let you reset the sampler's program settings and memory to factory settings.

You do not need to run the diagnostic tests on a routine basis. The diagnostic tests are a troubleshooting tool; Teledyne Isco's Customer Service department staff may ask you to run these tests when they work with you in diagnosing problems with your sampler.

Access the diagnostic screens by selecting Other Functions from the main menu, then Maintenance, and Diagnostics. The unit will automatically test the memory and display; you can choose whether it tests the pump and distributor, and whether it reinitializes the unit to its original factory settings.

PLEASE WAIT!
. . . 'RAM' PASSED TEST

PLEASE WAIT!
. . . 'ROM' PASSED TEST

- If RAM or ROM fails the test, the sampler will report that 'RAM' (or 'ROM') FAILED TEST. Contact Teledyne Isco's Customer Service for assistance.

ABCDEFGHIJKLMNOPQRST
ABCDEFGHIJKLMNOPQRST
ABCDEFGHIJKLMNOPQRST
ABCDEFGHIJKLMNOPQRST

TEST PUMP?
YES NO

PUMPING . . .

PUMPING . . .
ON/OFF RATIO = _.__

PURGING . . .

PURGING . . .
ON/OFF RATIO = _.__

TEST DISTRIBUTOR
YES NO

FINDING ARM FLEXURE

NOW AT BOTTLE __

RE-INITIALIZE?
YES NO

Memory Test – Screens 1 and 2 at left show you the diagnostic tests for the unit's memory. If either screen shows you a message saying that the memory failed the test, contact Teledyne Isco's Customer Service.

Display Test – Screen 3 shows you the display test. You should see the test pattern illustrated in the screen. If the pattern does not match the illustration, the display or its circuitry require repair.

Pump Test – Screen 4 lets you start the pump test by selecting YES. As the sampler runs the test, it first runs the pump forward for a short period. Next, it displays an ON/OFF ratio number. After displaying the forward pumping ratio, the sampler reverses the pump to obtain a purge ratio. The acceptable range is between 0.80 and 1.25. If either ratio is outside the acceptable range, the pump requires repair. You do not need to pump liquid while running the test, and you can run the test with or without a tube in the pump.

⚠ CAUTION

Tests indicate that the pump produces sound levels in excess of 85db at one meter. Prolonged exposure to this sound level could result in hearing loss and requires the use of protective ear plugs.

Distributor Test – The distributor test is provided for factory personnel to verify the distributor's position as it rotates through the 24 positions. (screens 9 through 11). The distributor arm flexes slightly when it contacts the stop, and the sampler measures this flexure. The sampler uses this measurement to position the arm accurately over each bottle.

Reinitialize Controller – The sampler allows you to reset all the program settings to the settings shipped with the sampler (screen 12). Reinitializing also clears the memory that stores the sampler's event log and module data. **Use this option cautiously.**

8.5 Replacing the Pump Tube

Replace the pump tube only with Teledyne Isco's 6712 pump tubing. **Other pump tubes will not work**. The 6712 pump tubing is easily recognized by the blue alignment collars.

Improper pump tubes include those made for Teledyne Isco's other samplers (3700, GLS, etc.) and tubing from non-Teledyne Isco vendors. Also note that the discharge tube is not the same as the pump tube. You could experience several problems if you install the wrong pump tubing:

- The sampler will not pump the liquid.
- Pump jams
- Inaccurate sample volumes
- Faulty liquid detection

Inspect the pump tube periodically. Replace the tube when it cracks or appears worn. Inspect the tube frequently when the sample liquid contains a high percentage of suspended or abrasive solids.

☑ *Note*

The importance of regular tubing replacement cannot be overstated. The key is to replace the tube before failure, not after. When a pump tube ruptures, grit and other abrasive debris can be driven into the pump shaft seal. Over time, this abrasive material will degrade the pump seal, jeopardizing the NEMA 4x 6 rating of the controller.

Failure to maintain the pump tube may result in permanent damage to the sampler. Check the condition of the pump tube regularly and if the tube shows signs of fatigue or wear, replace it immediately. A properly maintained sampler will provide the years of reliable service that is expected of a Teledyne Isco Sampler.

8.5.1 Checklist For Replacing Pump Tube

1. Disconnect power from the sampler.

⚠ WARNING

The pump's safety lock prevents the sampler from running the pump when the pump band is open. DO NOT tamper with the safety mechanism. The pump is extremely powerful. The pump rollers can injure you severely if the sampler activates the pump while you are working on it or inside it. Disconnect power from the sampler before replacing the pump tube.

2. Loosen the liquid detector's cover by unscrewing the black knob on top of the detector. Unlatch the pump band. (The band is the rounded metal band that holds the tube in the pump.)
3. Pull the tube away from the bulkhead fitting. Pull it from the pump and detector.
4. Clean the pump rollers and the inside of the pump band.
5. Thread the new tubing through the pump so that the tube follows its natural curve around the pump rollers. You may need to move the pump rollers to make the installation easier.
6. The blue collars on the tube help align the tube in the detector and pump. Align the tube by placing the collars in the grooves inside the liquid detector.
7. Close the detector's cover and tighten the black knob. Close the pump strap and latch it.
8. Reset the pump-tube counter. (See example in table 8-2.)
9. Take a "dry" grab sample to test the tube installation.

☑ *Note*

To extend the pump tube life:
• Always use Teledyne Isco pump tubes.
• Install the tube properly, aligning the blue collars correctly in the liquid detector's grooves.
• Follow the natural curve of the tube when wrapping the tube around the pump rollers.
• Minimize the line rinses and sampling retries in the sampling programs
• Use the shortest possible suction line.
Conditions that shorten tube life:
• Improper installation.
• Abrasive materials suspended in sample liquid.
• Frequent line rinses.
• Long purge cycles, such as those used with long suction lines.

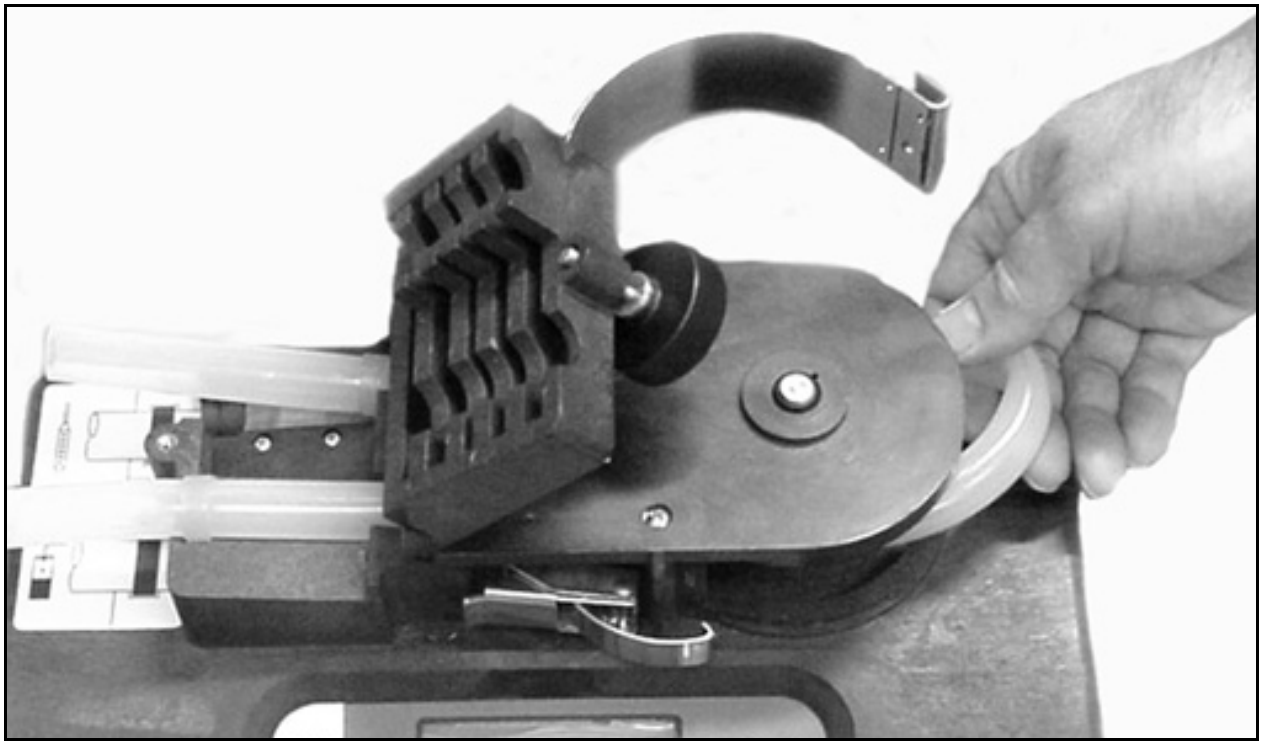


Figure 8-1 Removing and Replacing the Pump Tube

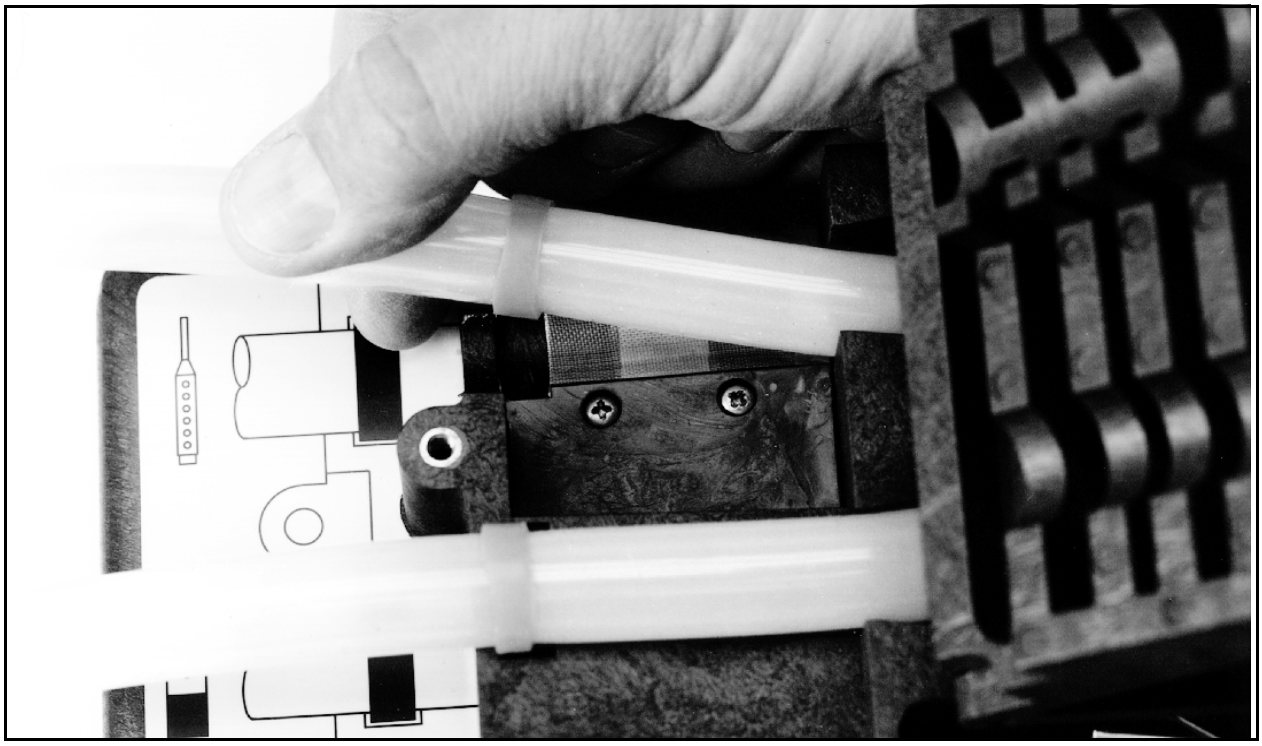


Figure 8-2 Placing the Pump Tube in the Liquid Detector

8.6 Opening the Controller Case

You will need to open the controller case to gain access to:

- The desiccant bag that dries the controller's interior
- The battery that provides backup power to the controller

⚠ CAUTION

The circuit boards can be damaged from a discharge of static electricity. Always use an antistatic mat when opening the controller to protect the circuit boards.

To open the case:

1. Pull the discharge tube and pump tube away from the bulkhead fitting.
2. Remove the distributor arm by unscrewing the nut that attaches the arm to the distributor shaft. DO NOT ROTATE THE DISTRIBUTOR ARM MANUALLY; THIS WILL SEVERELY DAMAGE THE DISTRIBUTOR DRIVE GEARS.
3. Remove the controller from the center section.
4. Open the case by removing the 11 screws that attach the case bottom to the case top.

Note

The case top and bottom fit together with a sealed tongue-and-groove joint. Any damage — nicks or cuts — to the tongue, groove, or sealing gasket prevent the case from sealing completely when you close it. Use extreme care when opening the case to avoid damaging the joining surfaces.

Refer to Figure 8-3 for the location of the desiccant box. To gain access to the main circuit board and battery, remove the two distributor connectors and the EMI shield.

8.7 Replacing the Desiccant

A humidity indicator, labeled "INTERNAL CASE HUMIDITY," is located to the right of the keypad. It indicates the amount of moisture present inside the control box. The paper indicator is **blue** when the control box is dry.

The control box is a completely sealed unit. You do not need to open the control box during normal operation. The 6712 Samplers use a desiccant bag inside the controller case to prevent moisture damage to its electronic components. Thus, the humidity indicator should remain blue under normal conditions. If moisture does accumulate, the numbered areas on the indicator will turn light **pink** or **white**, starting with the area numbered "20." This indicates that the relative humidity inside the control box exceeds 20%. As more moisture accumulates, the areas numbered "30" and "40" will turn light pink or white, indicating relative humidities of 30% and 40% respectively.

If the 30% area of the humidity indicator turns light pink or white, open the control unit, inspect it for leaks, and replace the desiccant bag.

⚠ CAUTION

Do not attempt to reactivate the used desiccant. Reactivation may cause desiccant to leak out of the bag, causing mechanical damage inside the controller.

Follow the instructions in Opening the Controller Case in Section 8.6 to open the controller. Remove the bag from the cardboard box (part #69-9003-518) at the front of the case and replace it with a fresh bag of desiccant (part #099-0002-00).

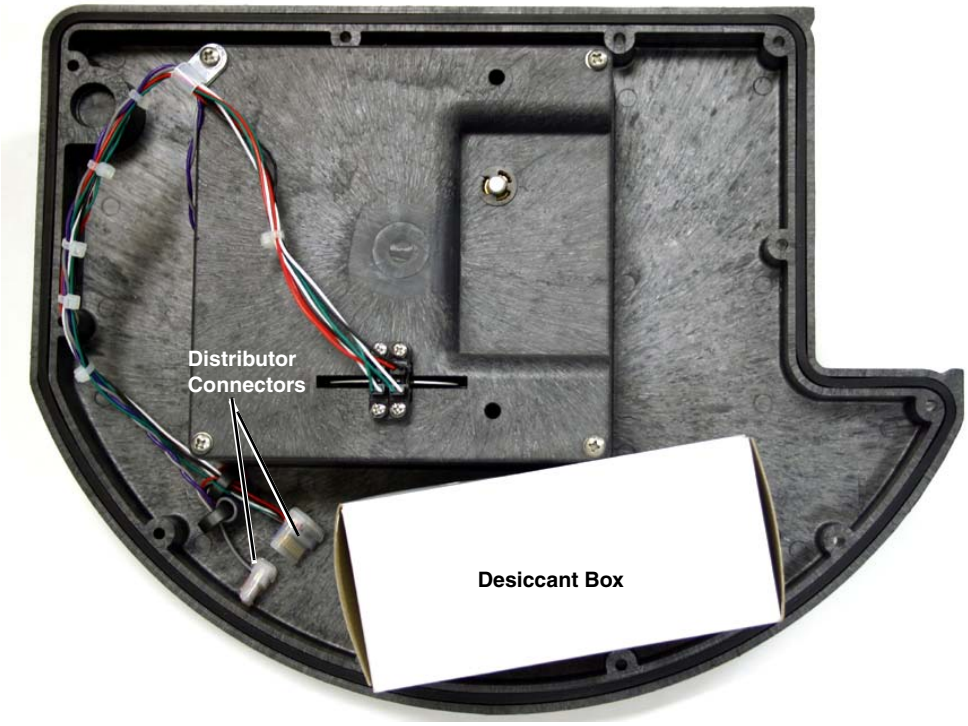


Figure 8-3 Opening the Controller

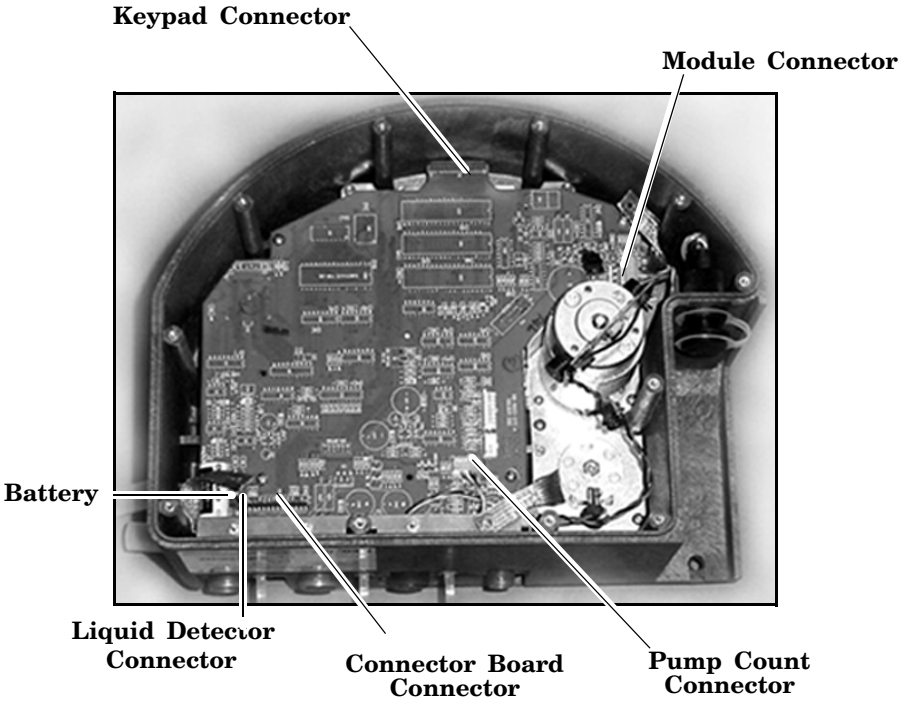


Figure 8-4 Main Circuit Board Connections

8.8 Replacing the Internal Battery

Battery Status Display

```
WARNING!
REPLACE INTERNAL
BATTERY BEFORE
17-OCT-06
```

A lithium battery housed inside the controller maintains power to the sampler's memory when the controller is disconnected from a power source. If it discharges completely, the sampler will lose all program settings and all data stored in memory when the external power source is disconnected. The battery requires replacement every five years. The sampler keeps track of the time that has passed since the battery was installed. To view this information, select INTERNAL BATTERY from the Maintenance screen (see example at left). After 5 seconds, the sampler asks if you have replaced the internal battery (see example at left).

```
DID YOU REPLACE THE
INTERNAL BATTERY?
YES              NO
```

Select YES to reset the countdown to 59 months from the current date.

While replacing the battery, it is likely that the stored readings will be lost and your program will revert to the default program. Before proceeding, retrieve the stored data and record your program settings.

☑ Note

Teledyne Isco recommends you replace the battery every five years, as soon as the battery warning appears. To ensure that the replacement meets Teledyne Isco's specifications, use only Teledyne Isco replacement batteries. (See *Appendix D, Replacement Parts*.)

To replace the internal battery:

1. Open the controller case. Separate the case bottom and top by removing the two distributor connectors.
2. Lift the desiccant box from the case.
3. Remove the EMI shield and grounding straps by loosening the five 1/4-inch stop nuts.
4. Disconnect the module, liquid detector, and pump count connectors from the main circuit board.
5. Remove the three screws and the 1/4-inch stud attaching the main circuit board to the case.
6. Detach the main circuit board from the keypad connector by pulling gently upward on the edges of the board next to the connector. Pull the main board up until the keypad connector is almost even with the edge of the case. Next, detach the main circuit board from the connector board.
7. De-solder the lithium battery, using care to prevent damage to the circuit board. Insert the replacement battery and solder it in place.

☑ *Note*

Poor soldering techniques can easily damage a printed circuit board. The battery should be replaced by a skilled technician.

⚠ WARNING

Danger of explosion if lithium battery is incorrectly replaced. Replace with the same type, ensuring correct polarity. Do not dispose of used lithium battery in fire.

8. Reconnect the main circuit board to the connector board before reconnecting it to the keypad. Replace the 1/4-inch stud and the three screws, and reconnect the module, liquid detector, and pump count connectors.
9. Replace the EMI shield and grounding straps. Reconnect the two distributor connectors.
10. Ensure that all connections and hardware are secure. Replace the desiccant and close the case.
11. Reset the battery alarm.

8.9 Error Messages

If the sampler detects an error that prevents it from taking a sample or continuing the program, it displays an error message.

```
OPERATION ERROR:
PUMP JAMMED
```

There are messages for the following conditions:

- PUMP JAMMED
- DISTRIBUTOR JAMMED
- PROBABLE OVERFLOW
- POWER FAILED
- LOW BATTERY
- USER STOPPED
- NO DISTRIBUTOR ARM
- NO LIQUID DETECTED
- NO MORE LIQUID
- PUMP LATCH OPEN
- SAMPLER SHUT OFF
- BOTTLE FULL
- SAMPLE IN PROGRESS

Error Messages

ERRORS HAVE OCCURED
DURING PROGRAM

Since the sampler may encounter more than one error during a program, it does not display the messages continuously. Instead, it records each error and the time it occurred in the Sampling Results and Combined Results report. It alerts you to the recorded errors by displaying the message, "ERRORS HAVE OCCURRED DURING PROGRAM."

FATAL ERROR
NO DISTRIBUTOR ARM

If the sampler detects a low battery condition, it stops the running program and displays the "LOW BATTERY" error message. A low battery condition exists when five consecutive sample events have resulted in a POWER FAILED error message.

Fatal Error – The Fatal Error message will only show up if you are using a multiple bottle configuration and the distributor system fails. Failing the test can indicate any of the following conditions:

- The distributor arm is not attached to the sampler.
- The distributor-arm stop inside the center section is missing or broken.
- The distributor drive mechanism inside the controller is malfunctioning.

8.10 Pump Tube Warning

WARNING: REPLACE
PUMP TUBE

Occasionally, the sampler displays a warning message to alert you to a potential problem. The warning, REPLACE PUMP TUBE, reminds you to check the condition of the pump tube. Instructions regarding the pump tube can be found elsewhere in this section.

6712 Portable Sampler

Appendix A Menu Flowcharts

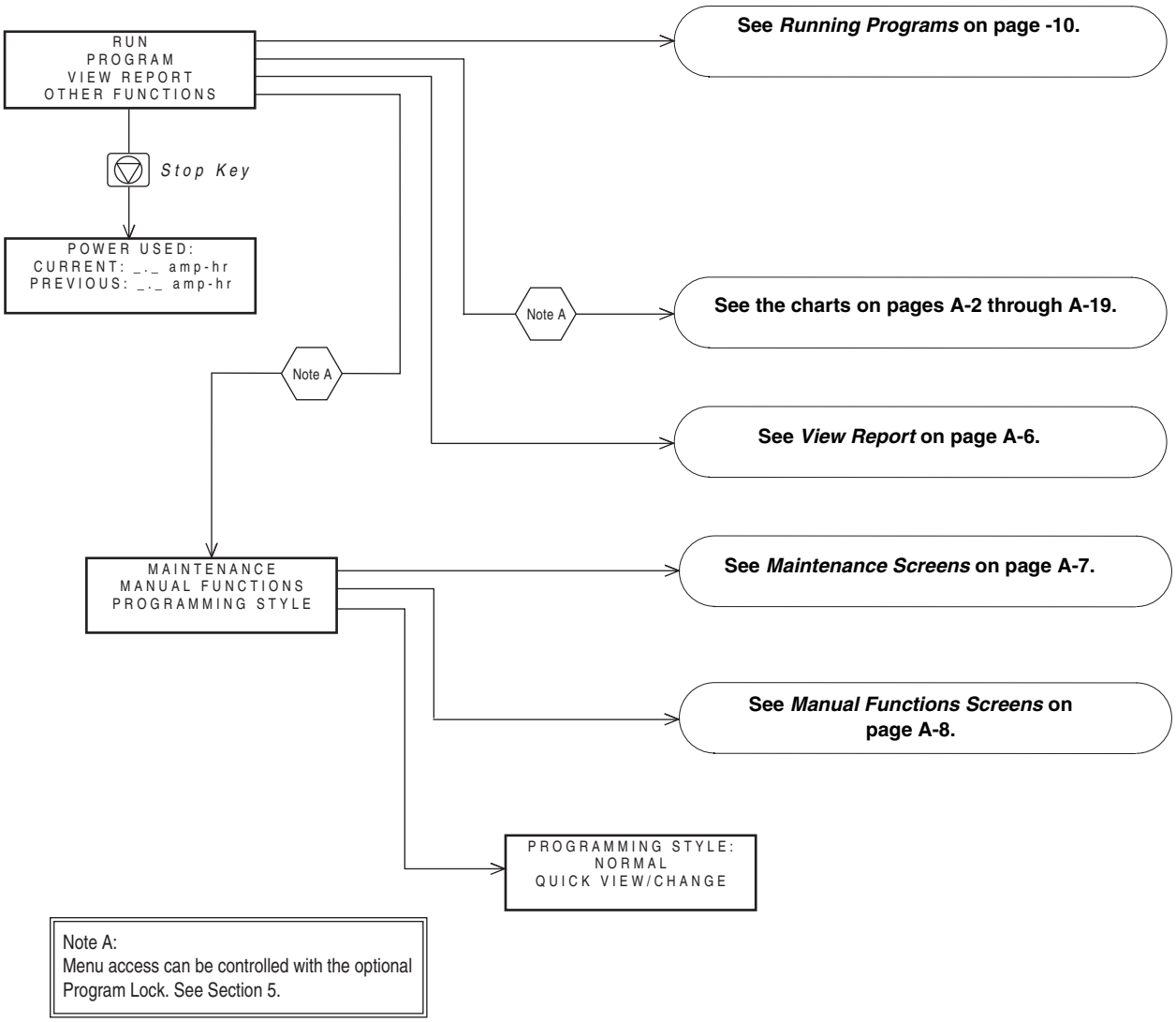


Figure A-1 6712 Menu Tree for Standard Programming

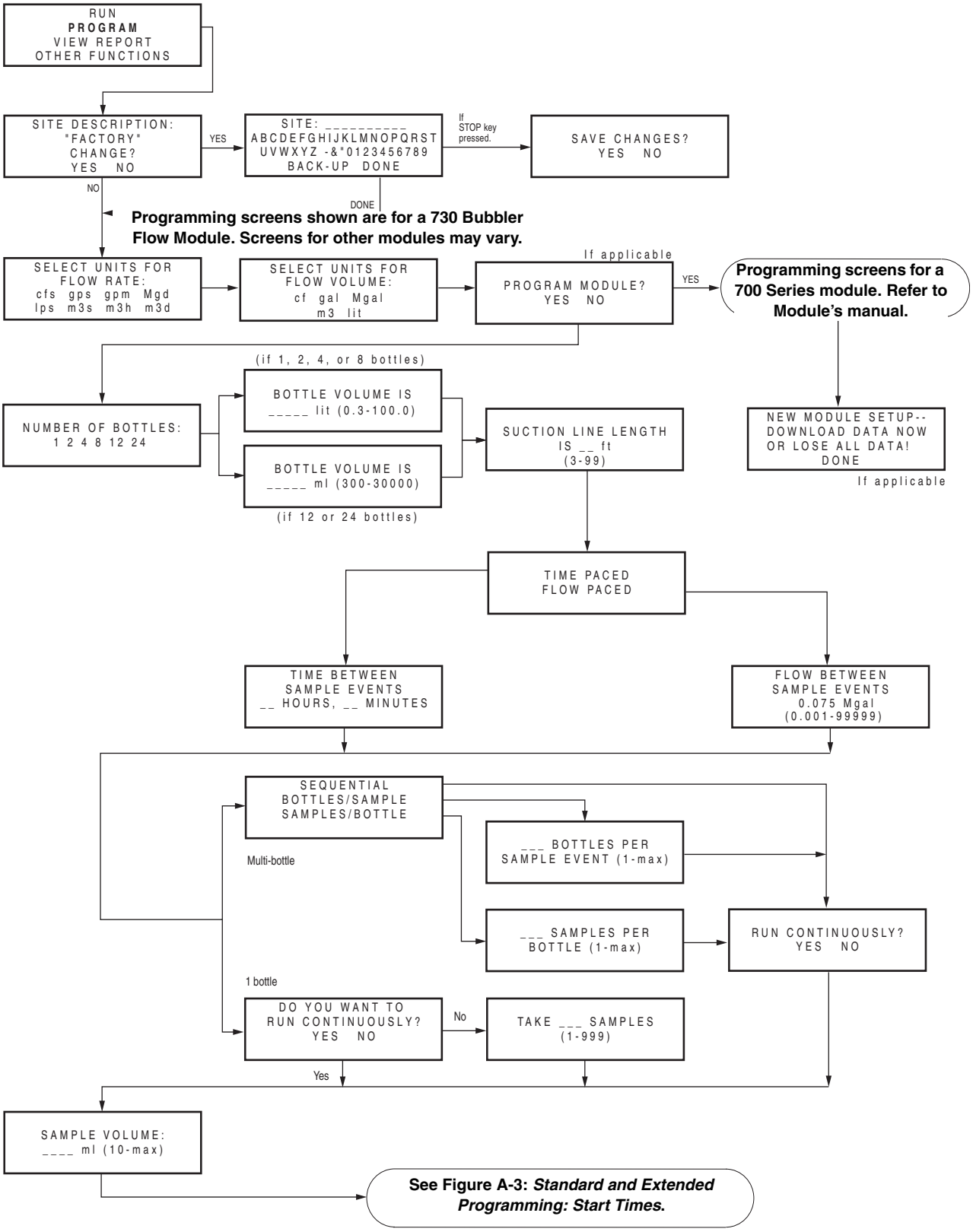
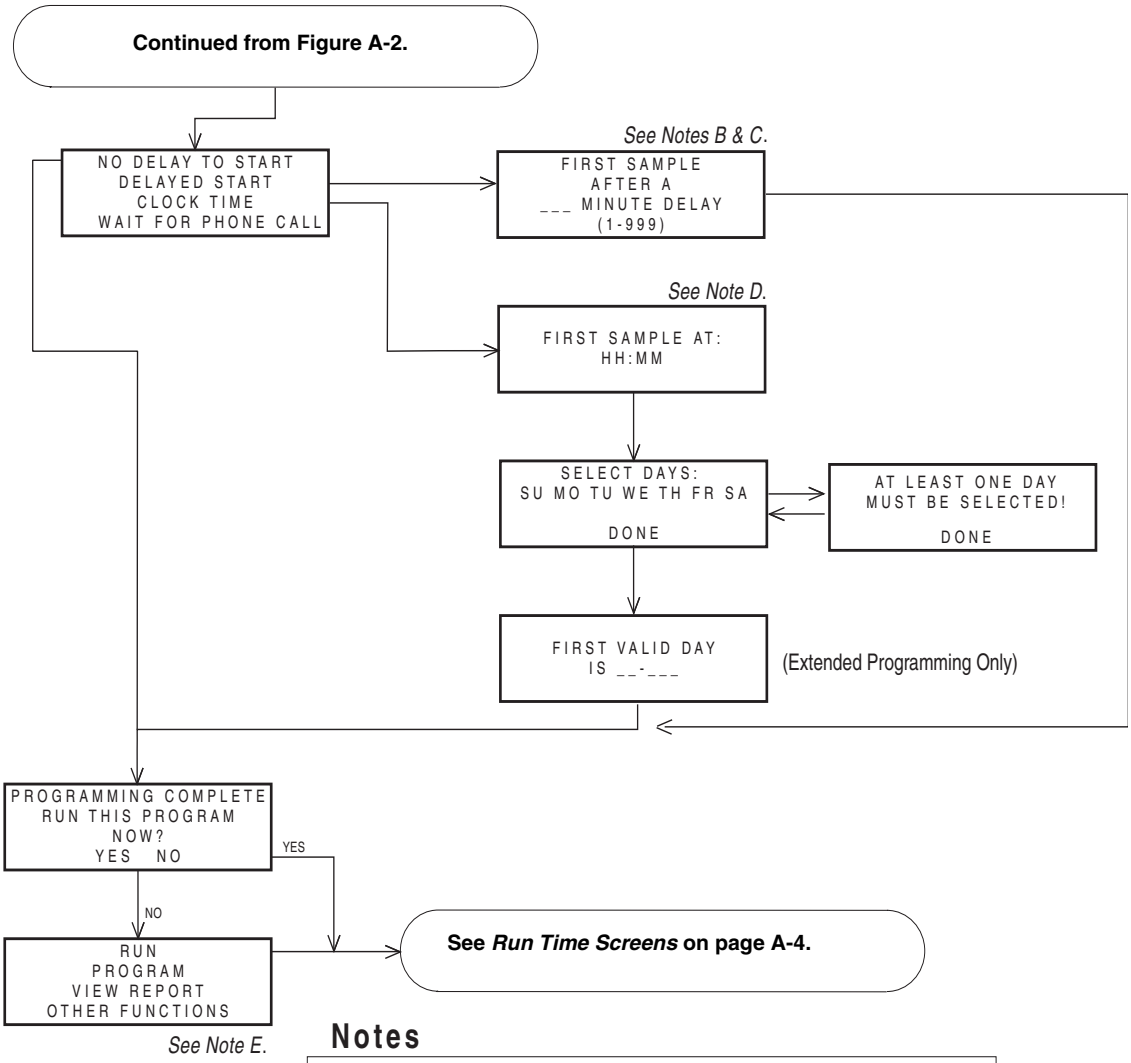


Figure A-2 Standard Programming: Programming Screens



Notes

B. Appears for standard flow-paced programs.

START FLOW COUNT
AFTER A
___ MINUTE DELAY
(1-999)

C. Appears for extended programs.

START "EXTENDED 1"
AFTER A
___ MINUTE DELAY
(1-999)

D. Appears for standard flow-paced programs.

START FLOW COUNT AT
HH:MM

E. Main menu for extended programming.

RUN "EXTENDED 1"
PROGRAM
VIEW REPORT
OTHER FUNCTIONS

Figure A-3 Standard and Extended Programming: Start Times

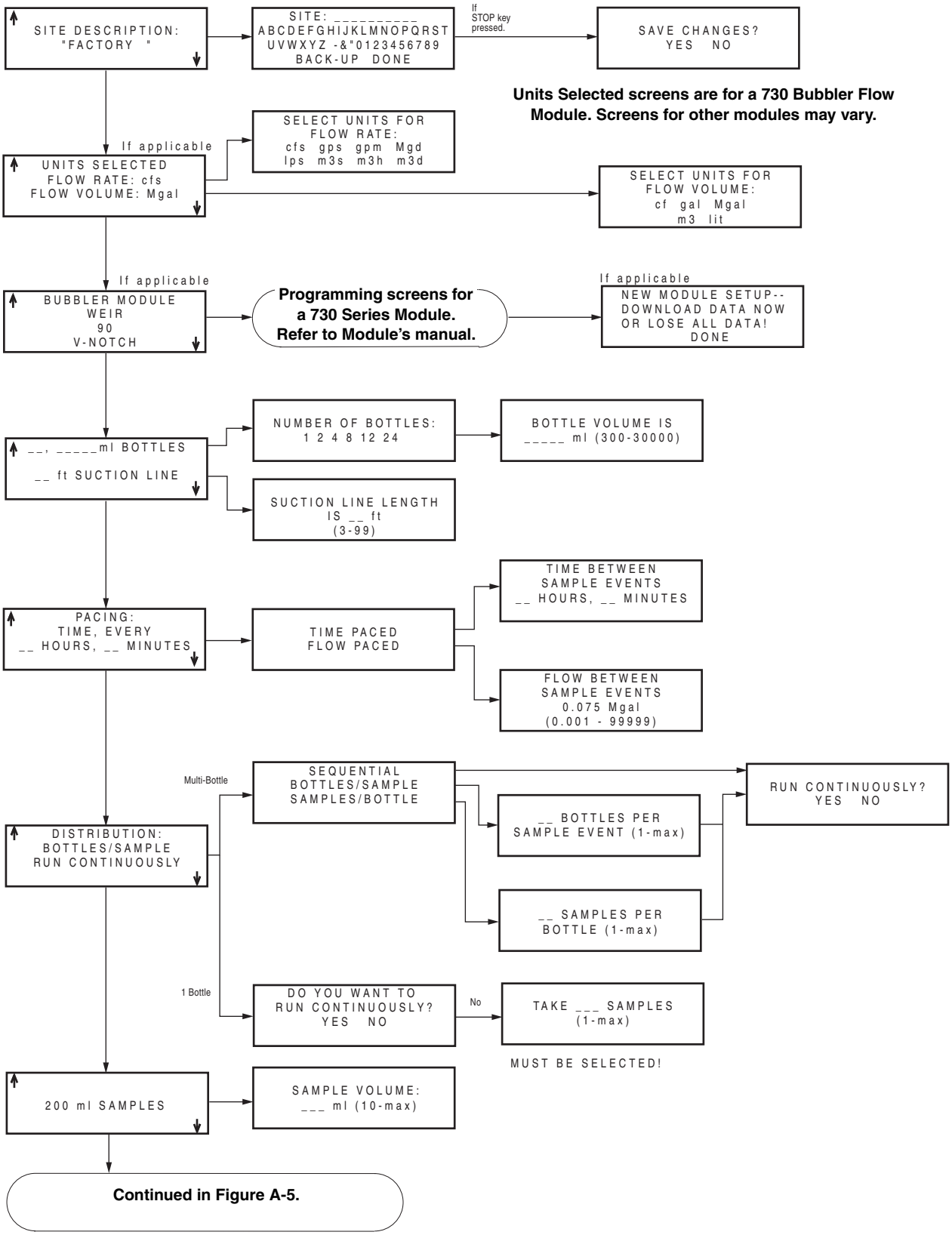


Figure A-4 Standard Programming: Quick View; Programming Screens

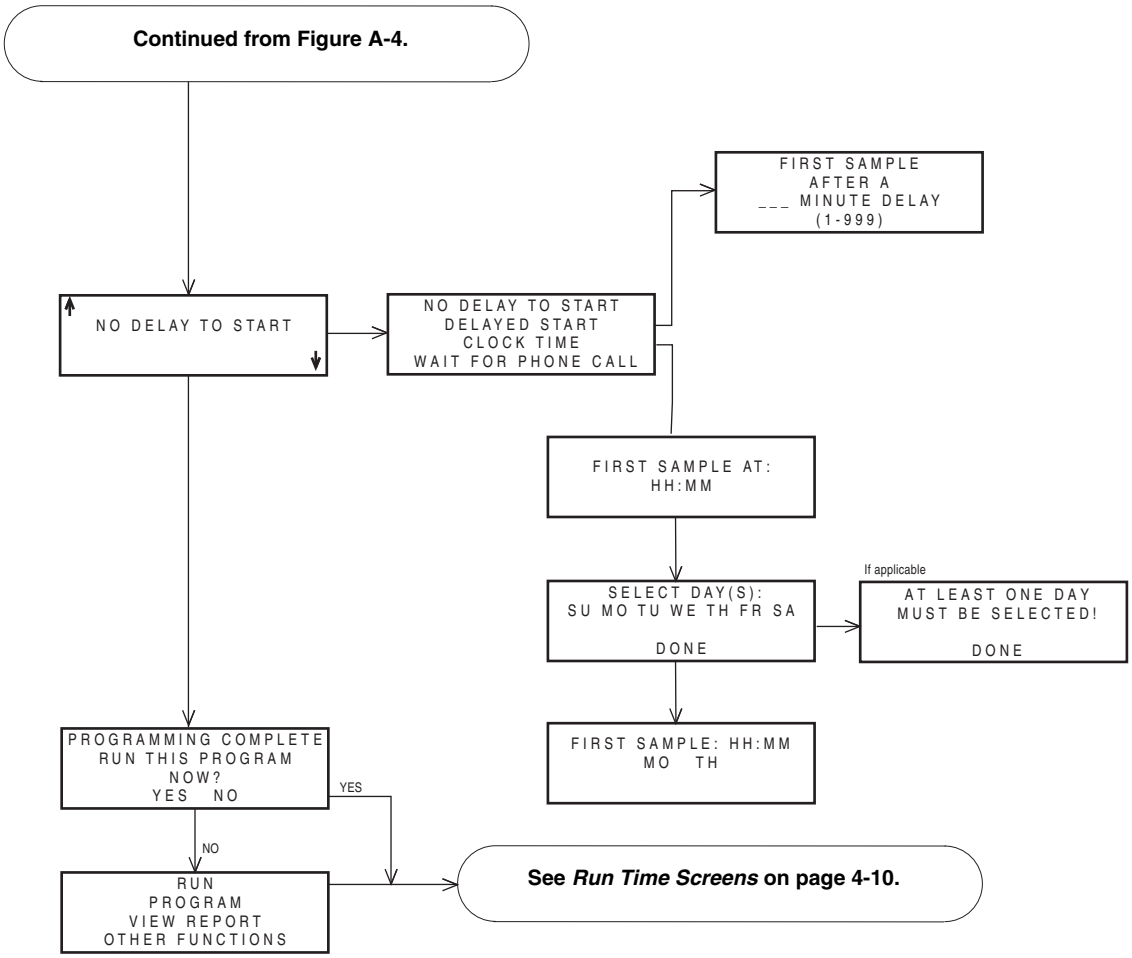


Figure A-5 Standard Programming: Quick View; Start Times

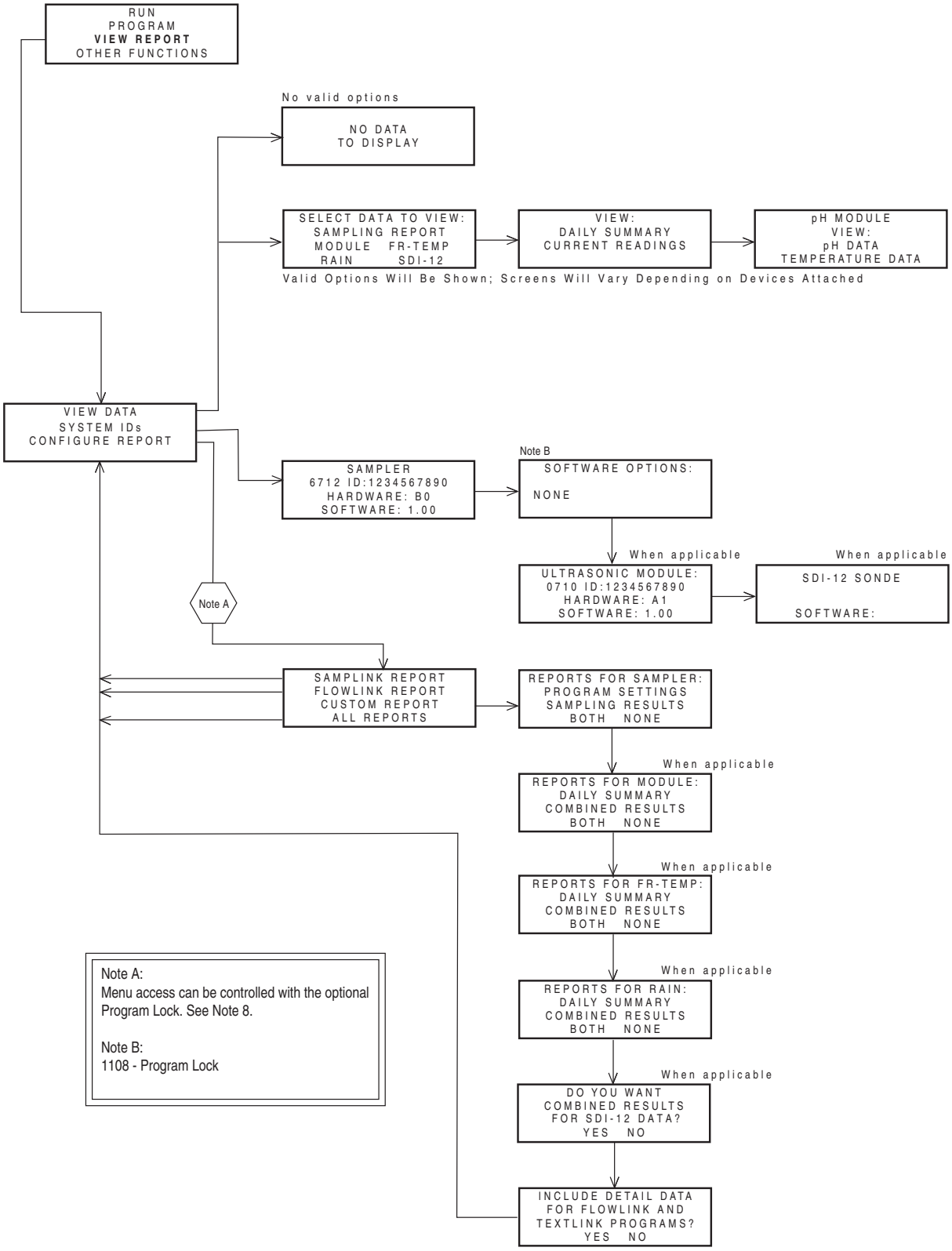


Figure A-6 View Report

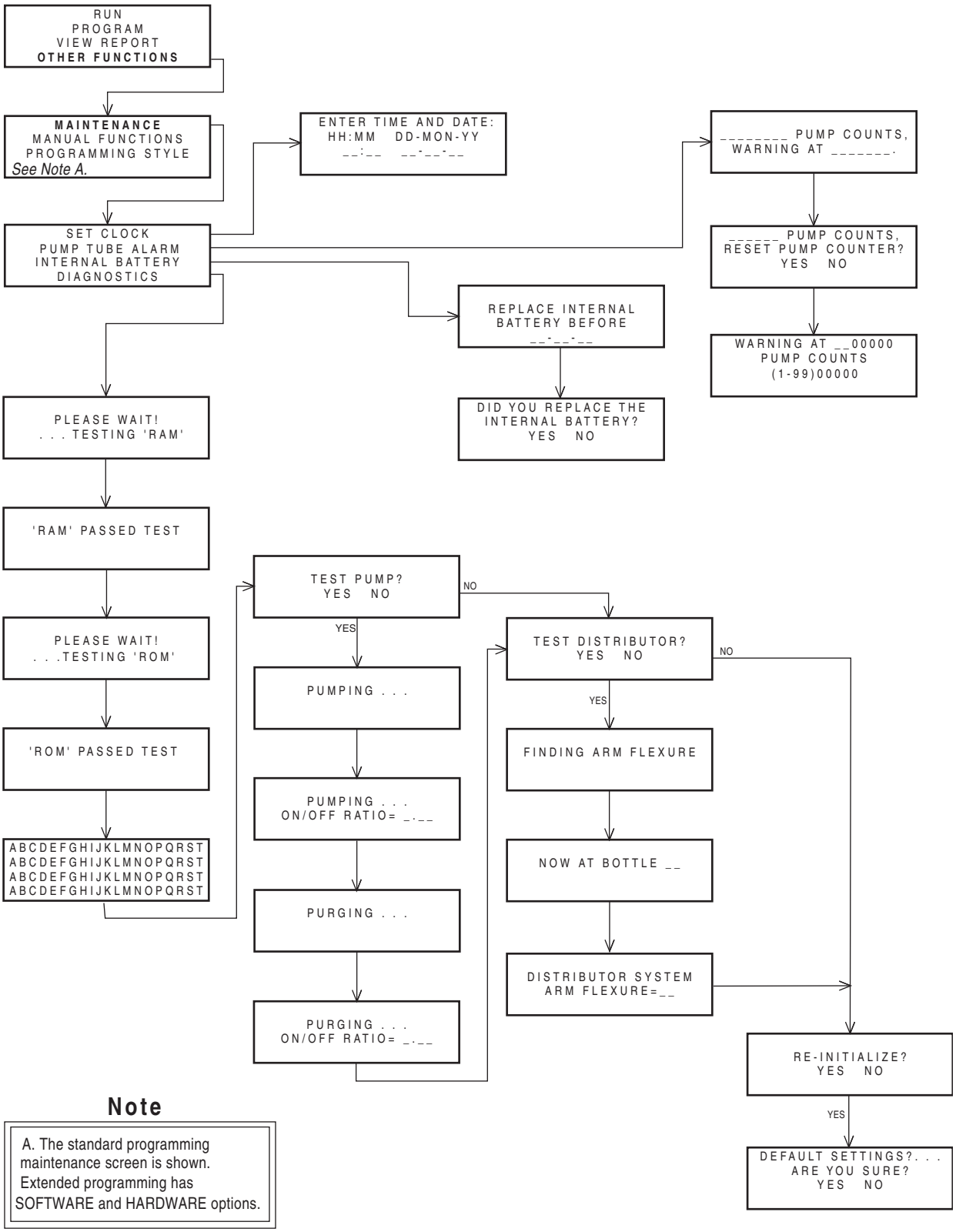


Figure A-7 Maintenance Screens

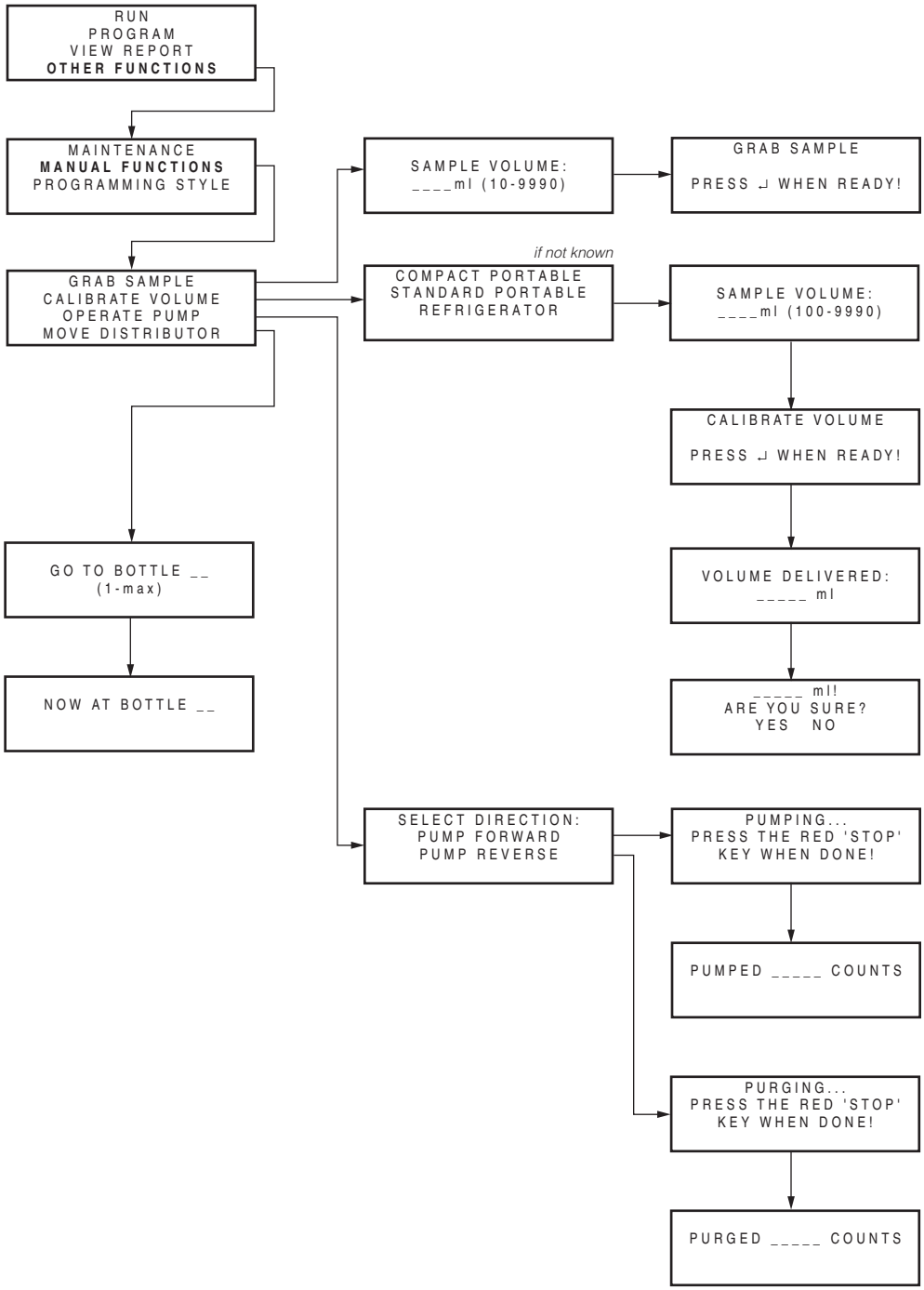


Figure A-8 Manual Functions Screens

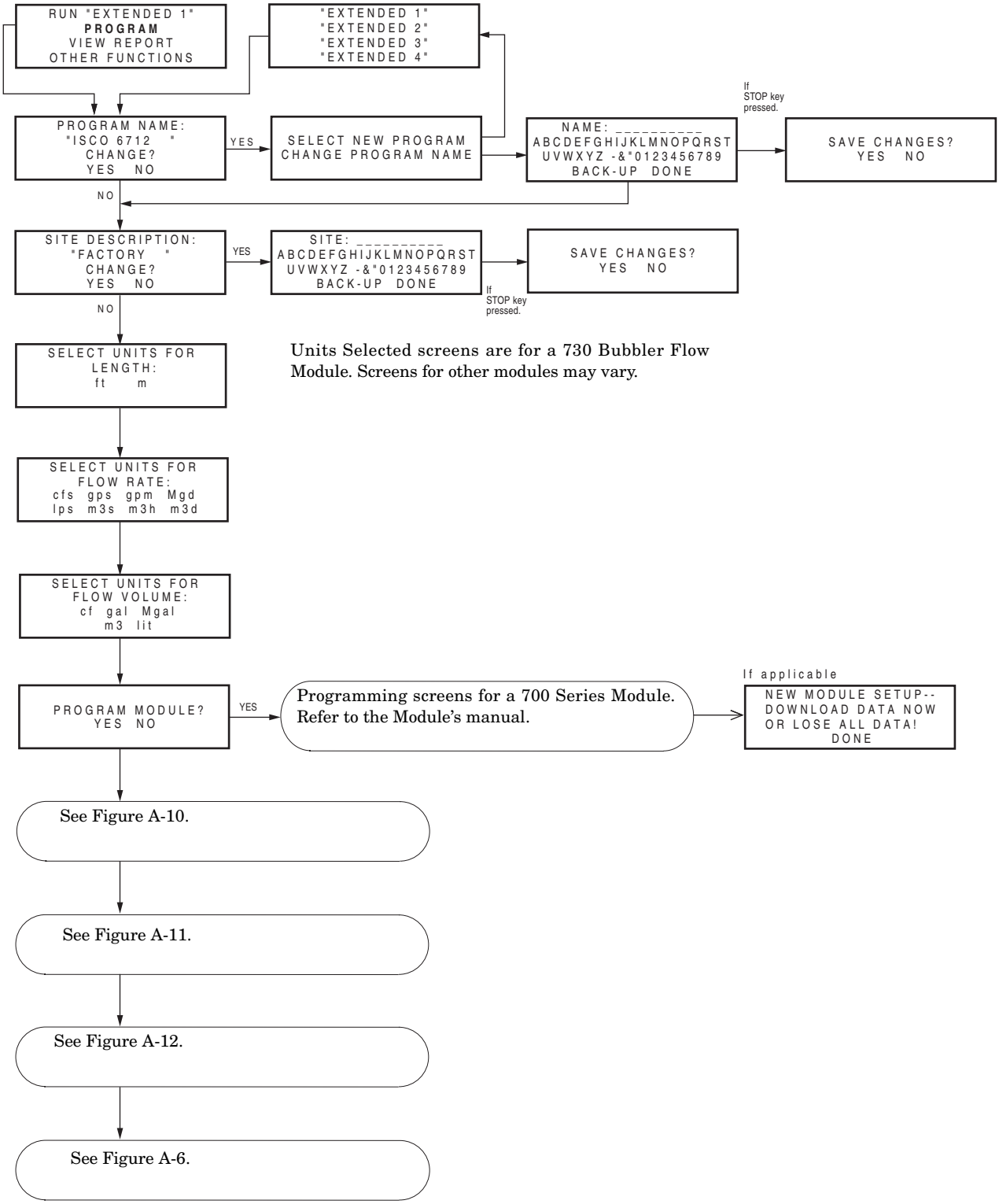


Figure A-9 Extended Programming: Programming Screens

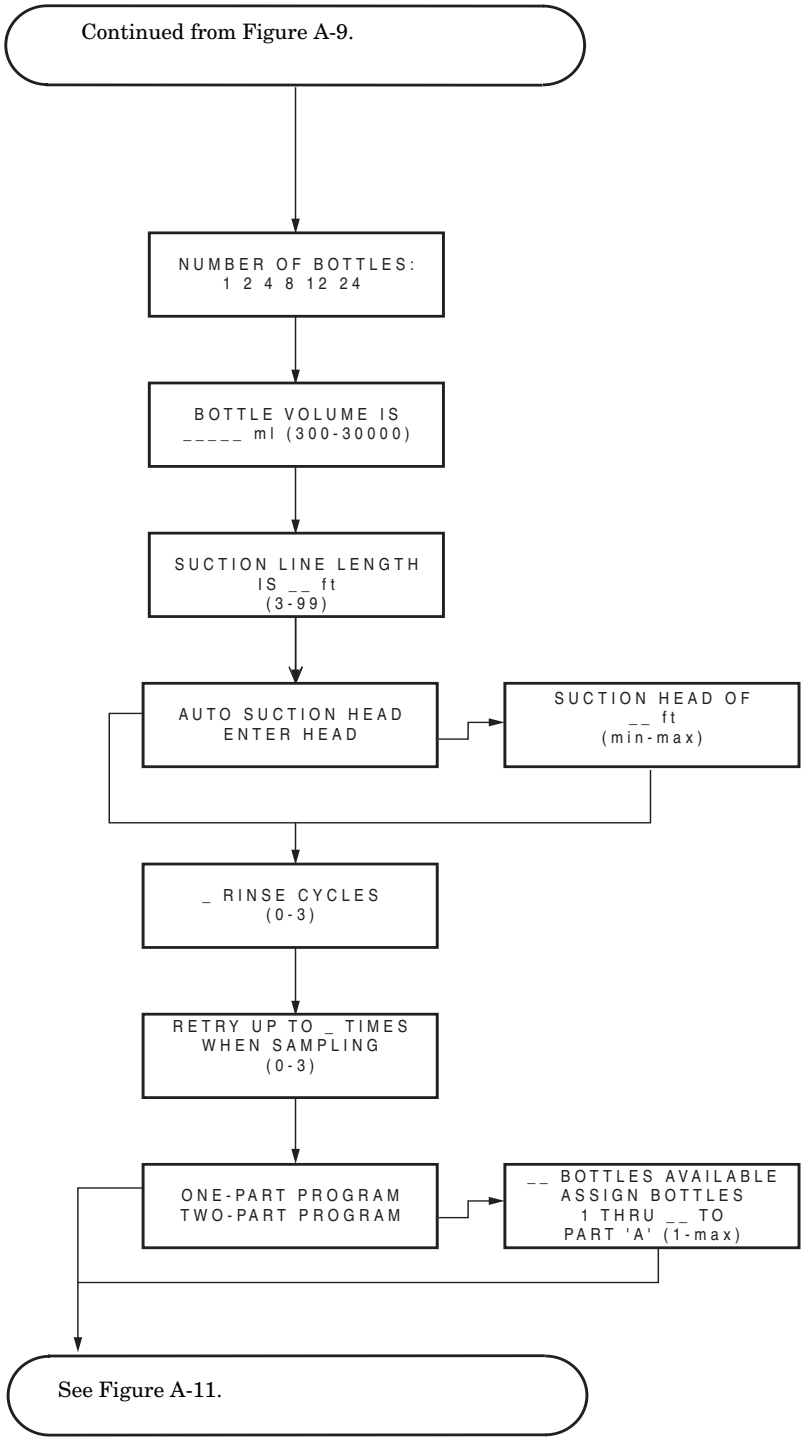


Figure A-10 Extended Programming: Equipment Setup

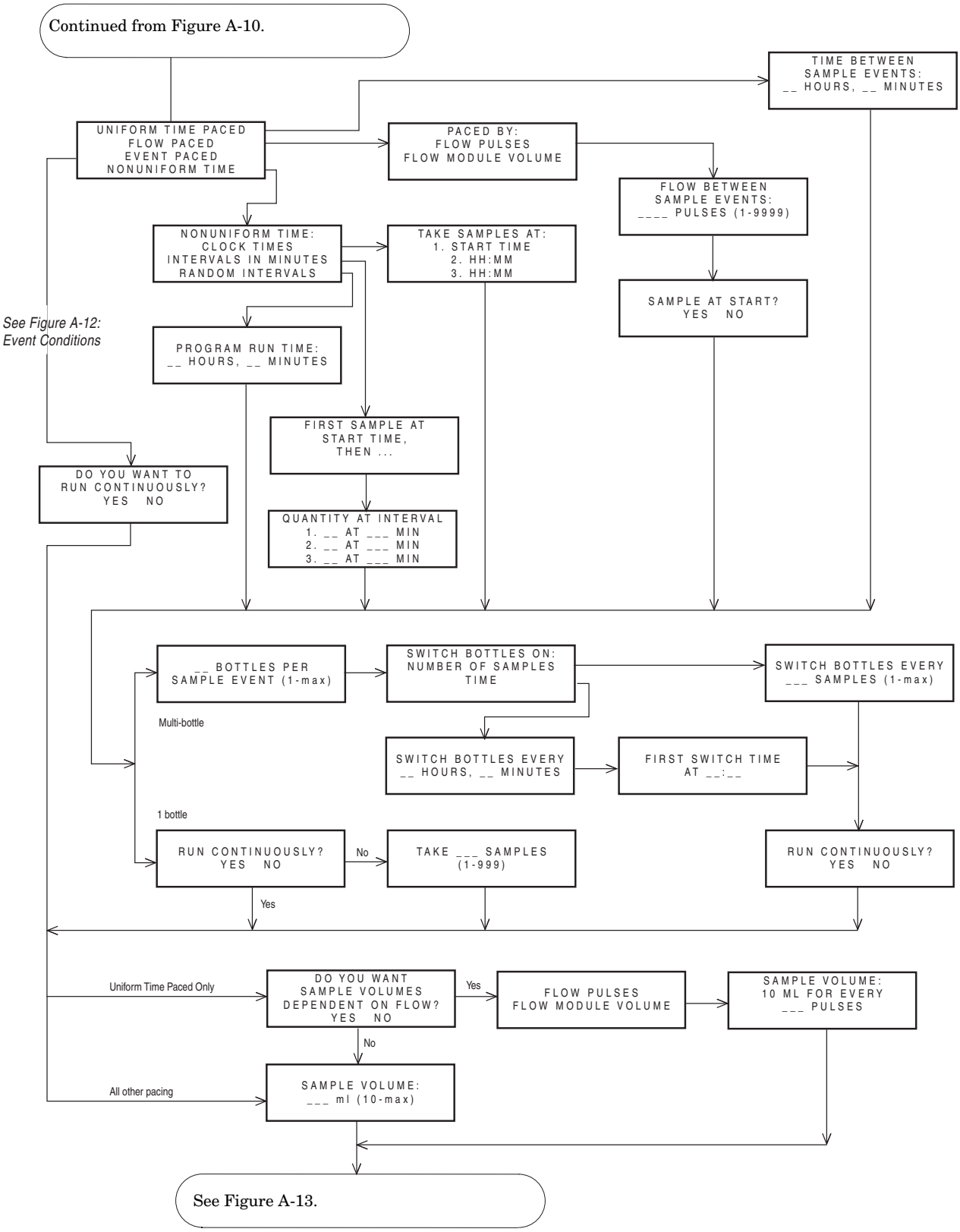


Figure A-11 Extended Programming: Pacing and Distribution

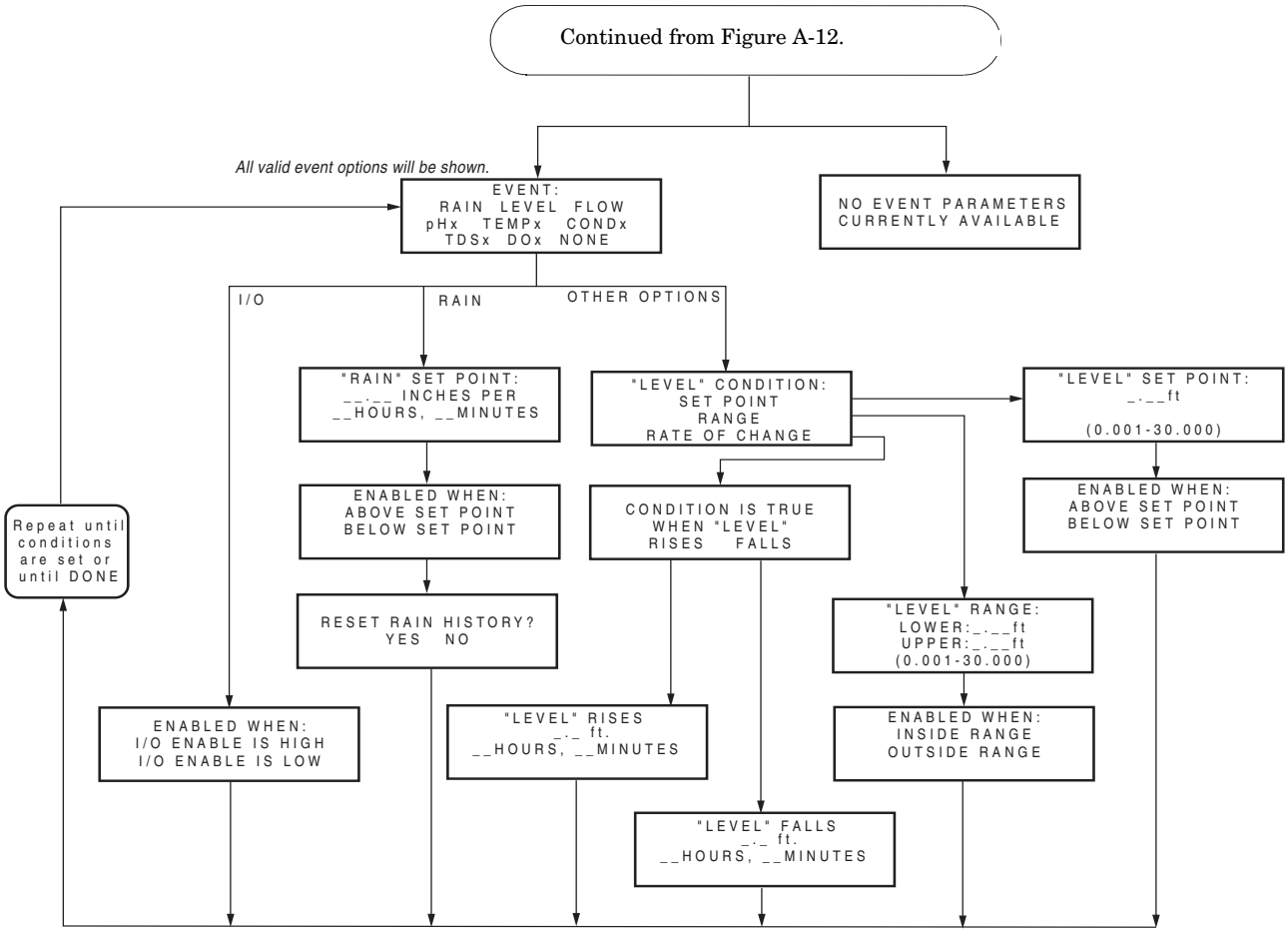


Figure A-12 Extended Programming: Event Conditions

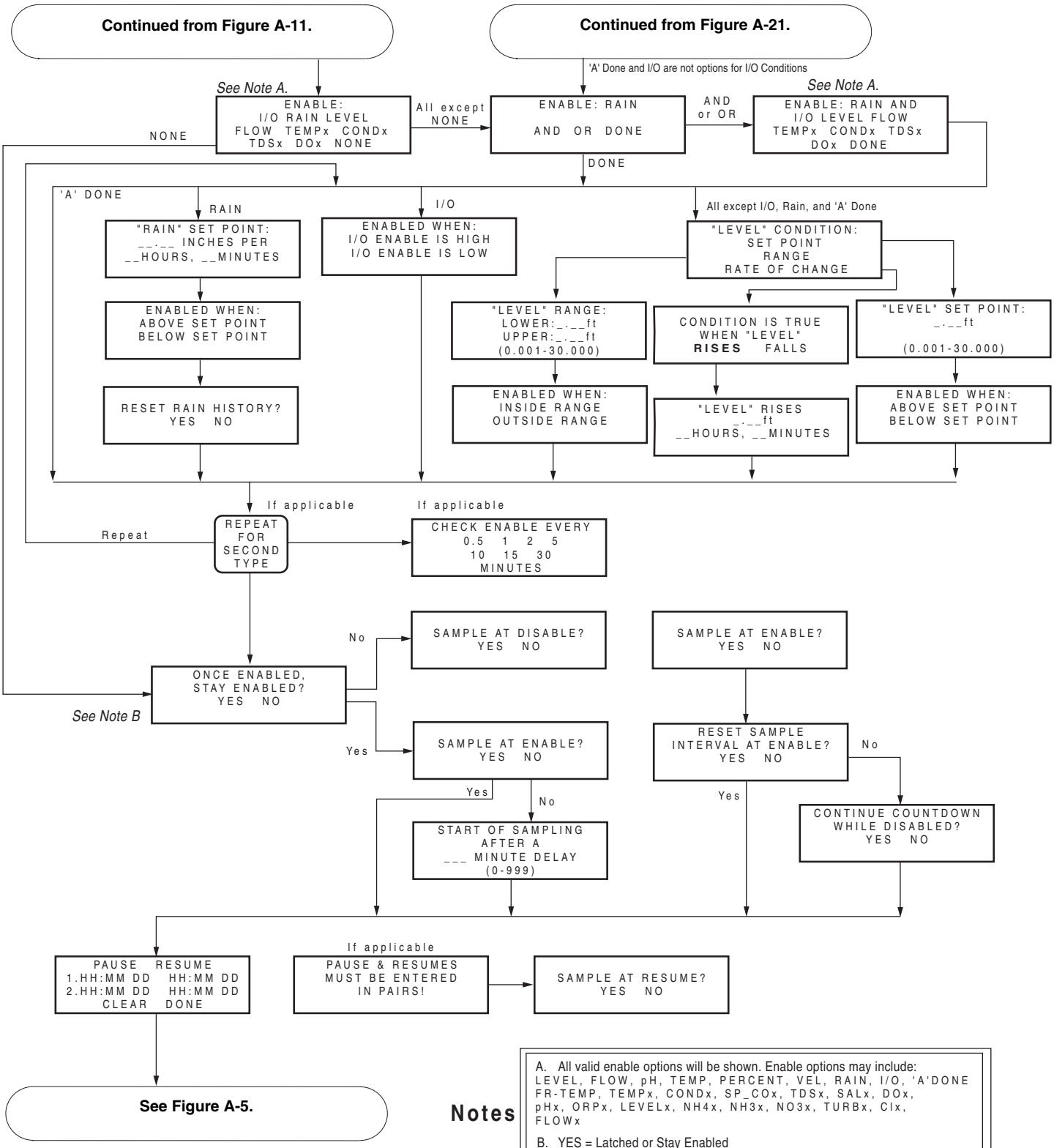


Figure A-13 Extended Programming: Programmed Sampler Enable

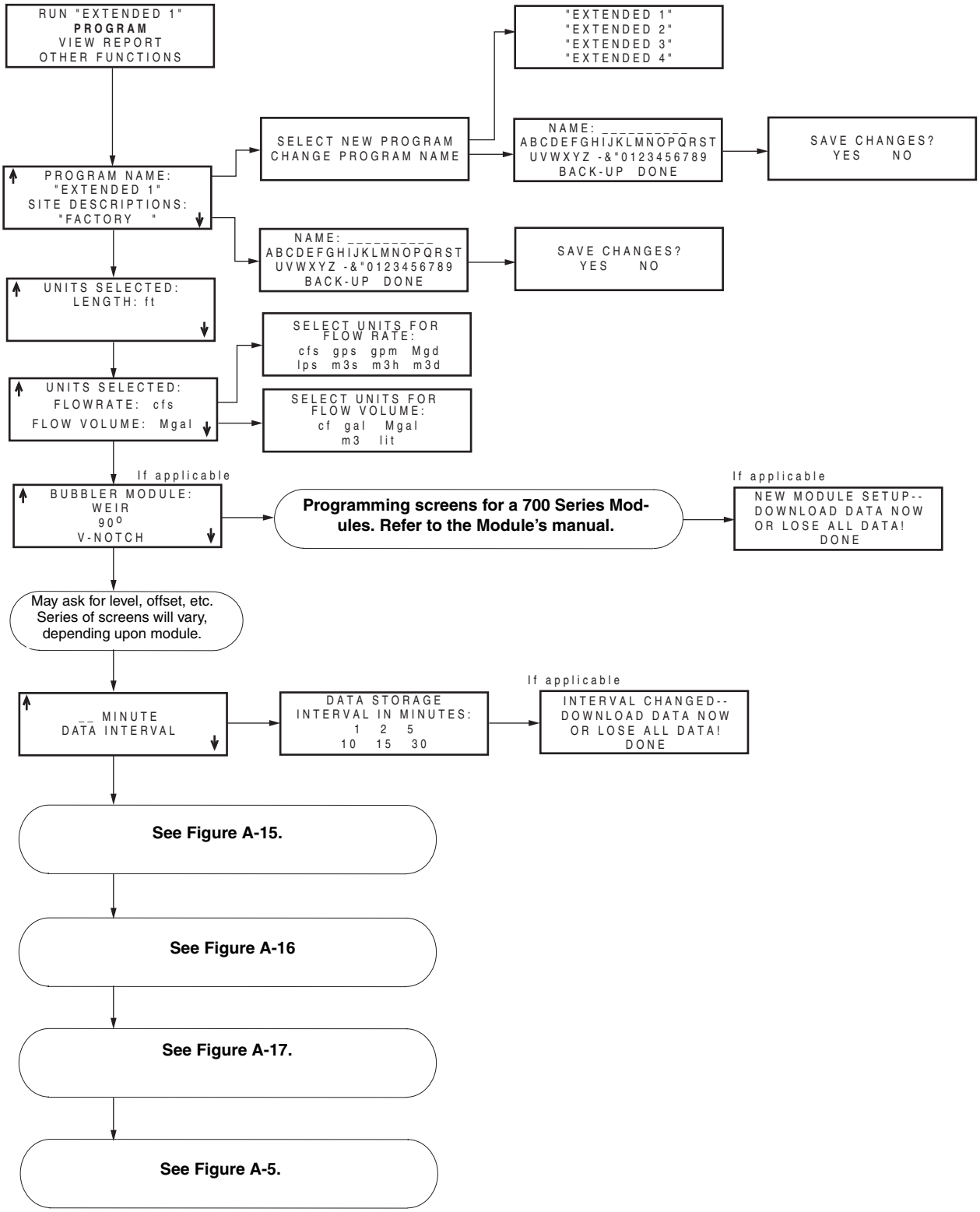


Figure A-14 Extended Programming: Quick View; Programming Screens

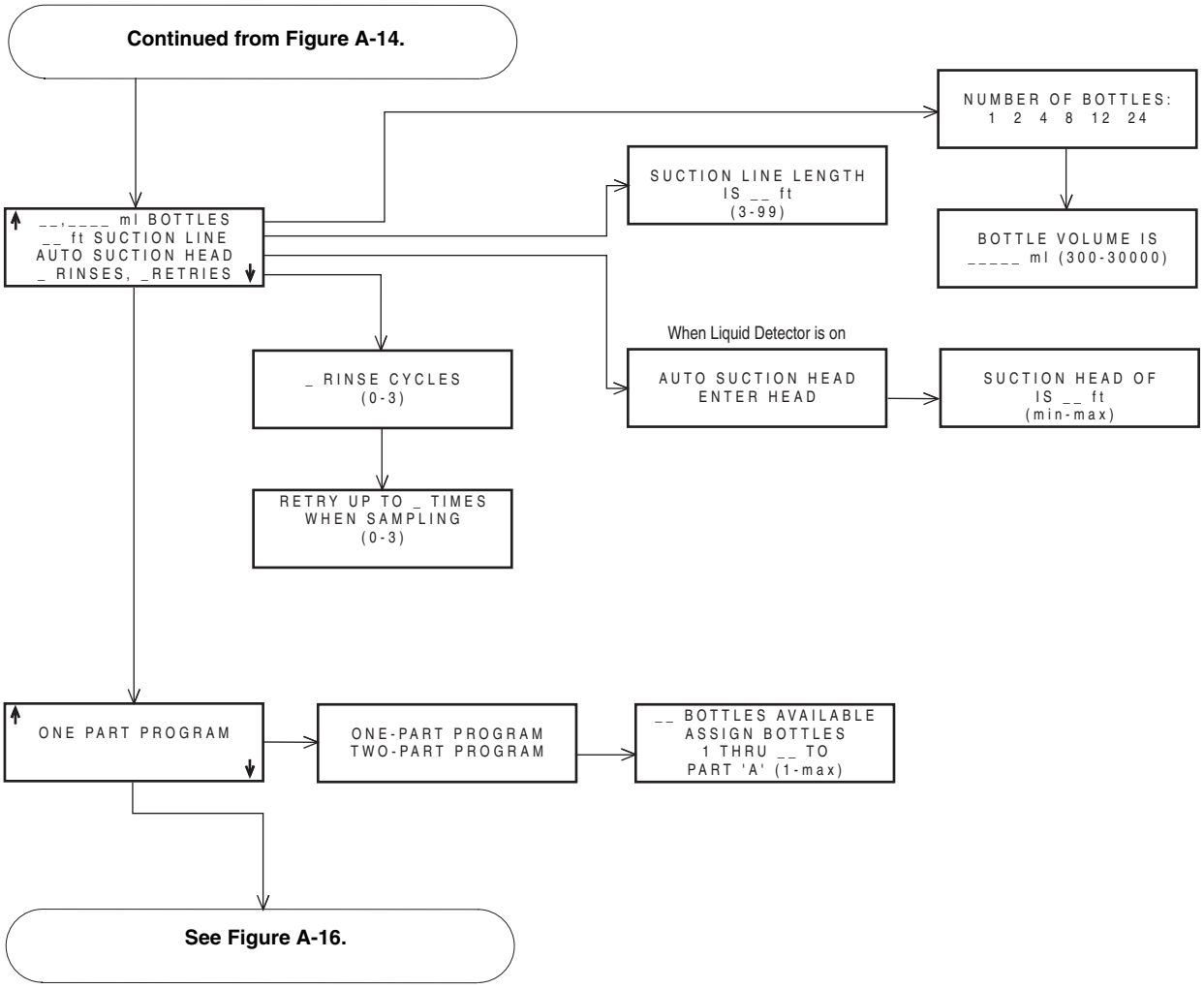


Figure A-15 Extended Programming: Quick View; Equipment Set-Up

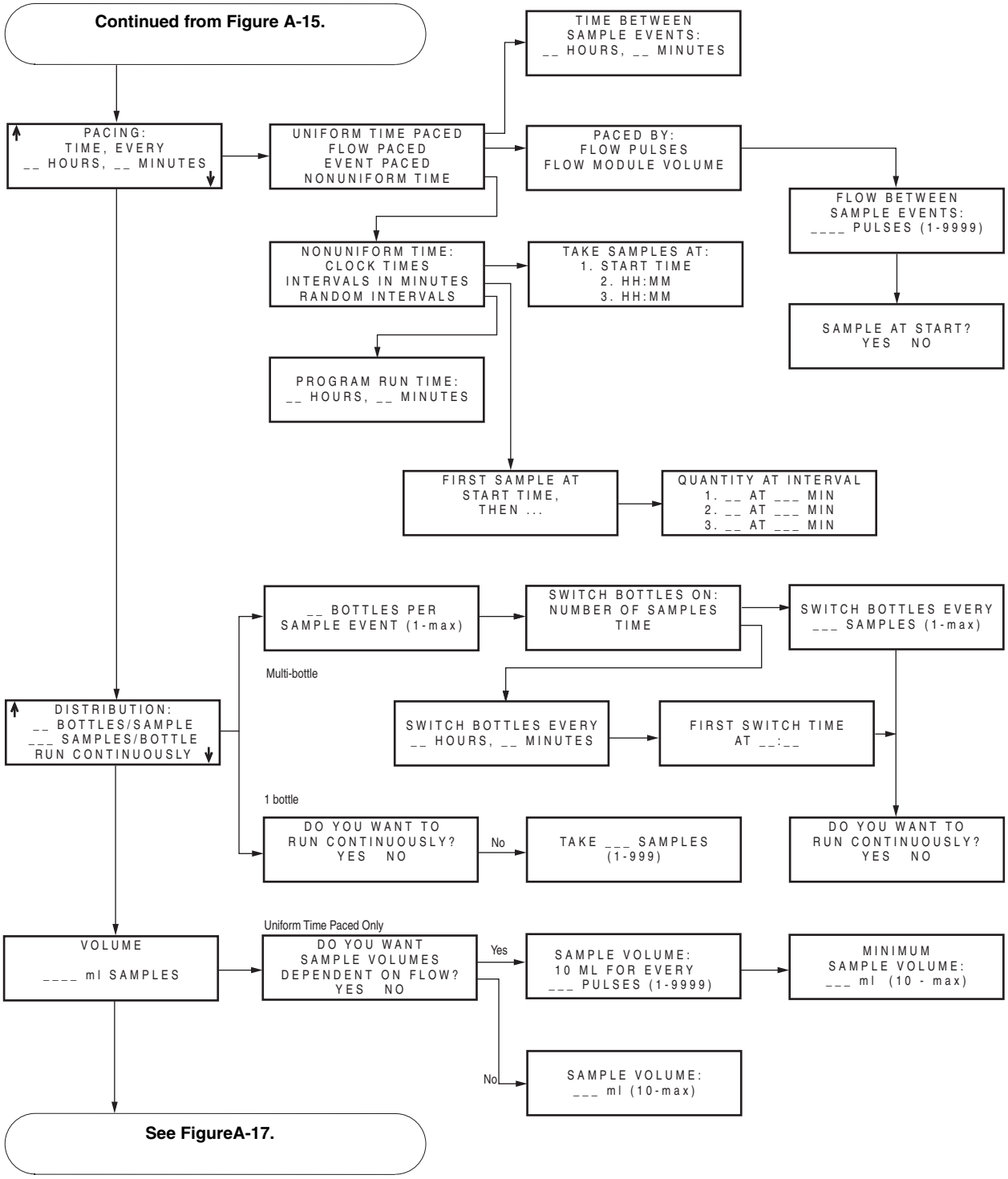


Figure A-16 Extended Programming: Quick View; Pacing and Distribution

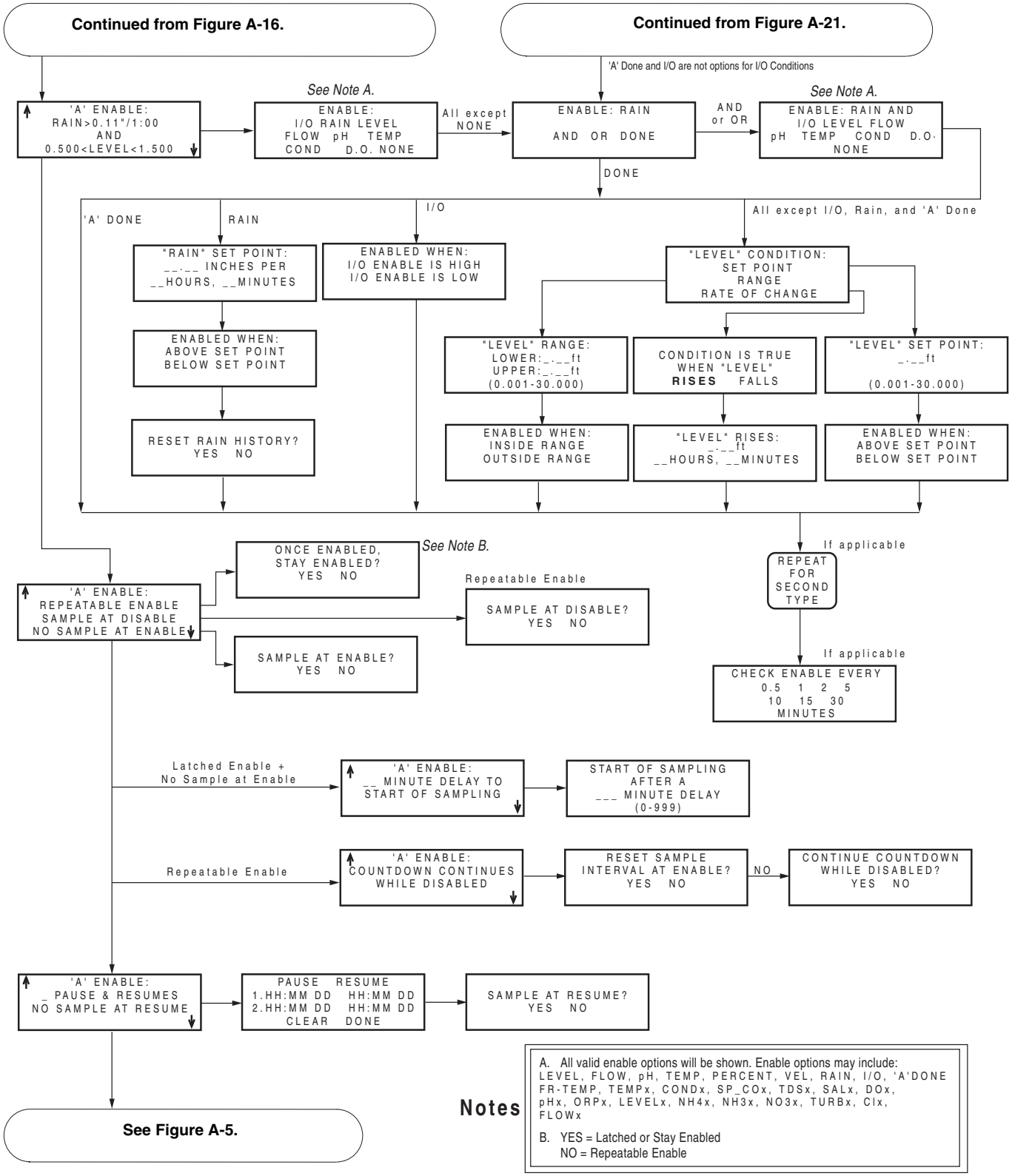


Figure A-17 Extended Programming: Quick View; Programmed Sampler Enable

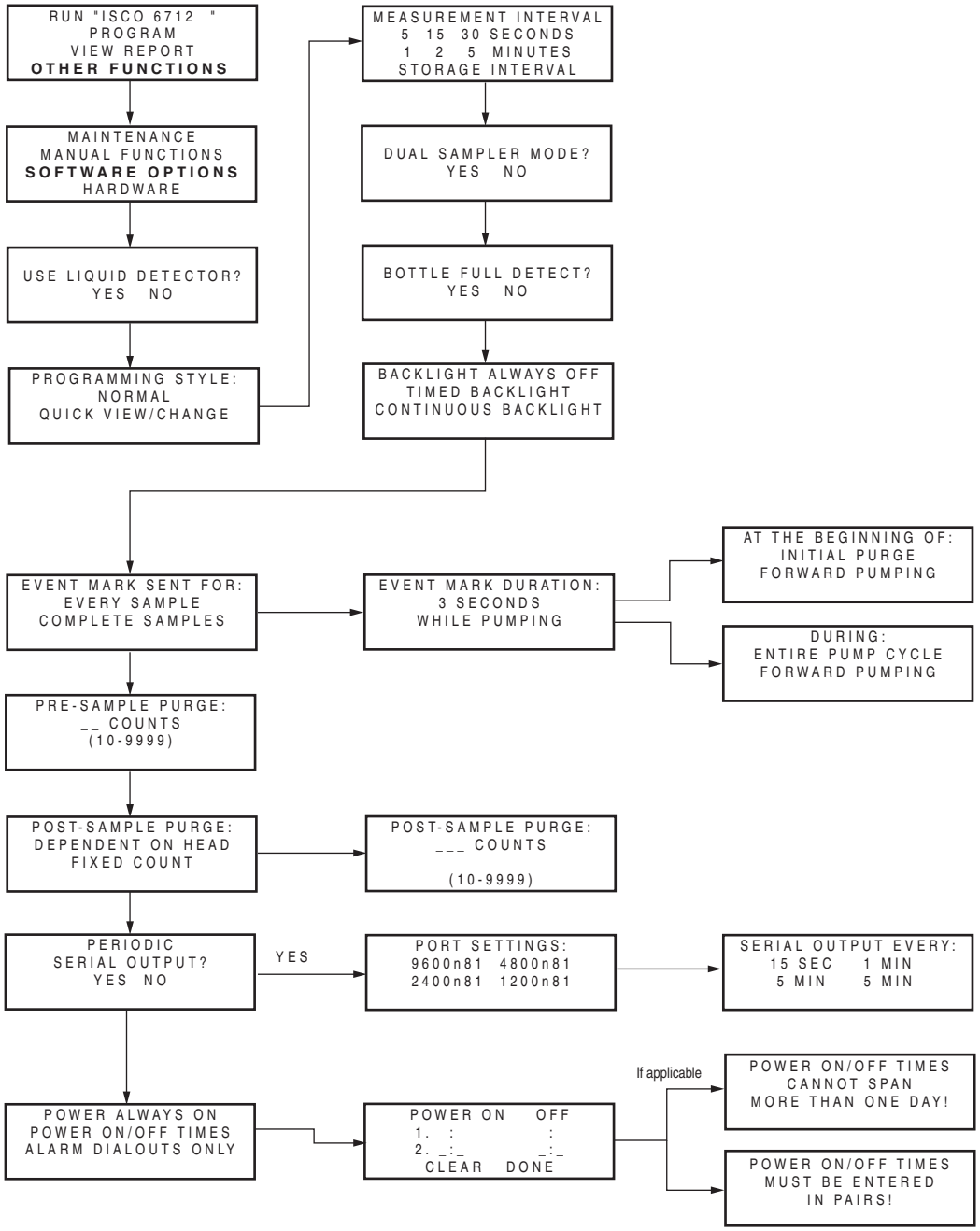


Figure A-18 Extended Programming: Normal View; Software Options

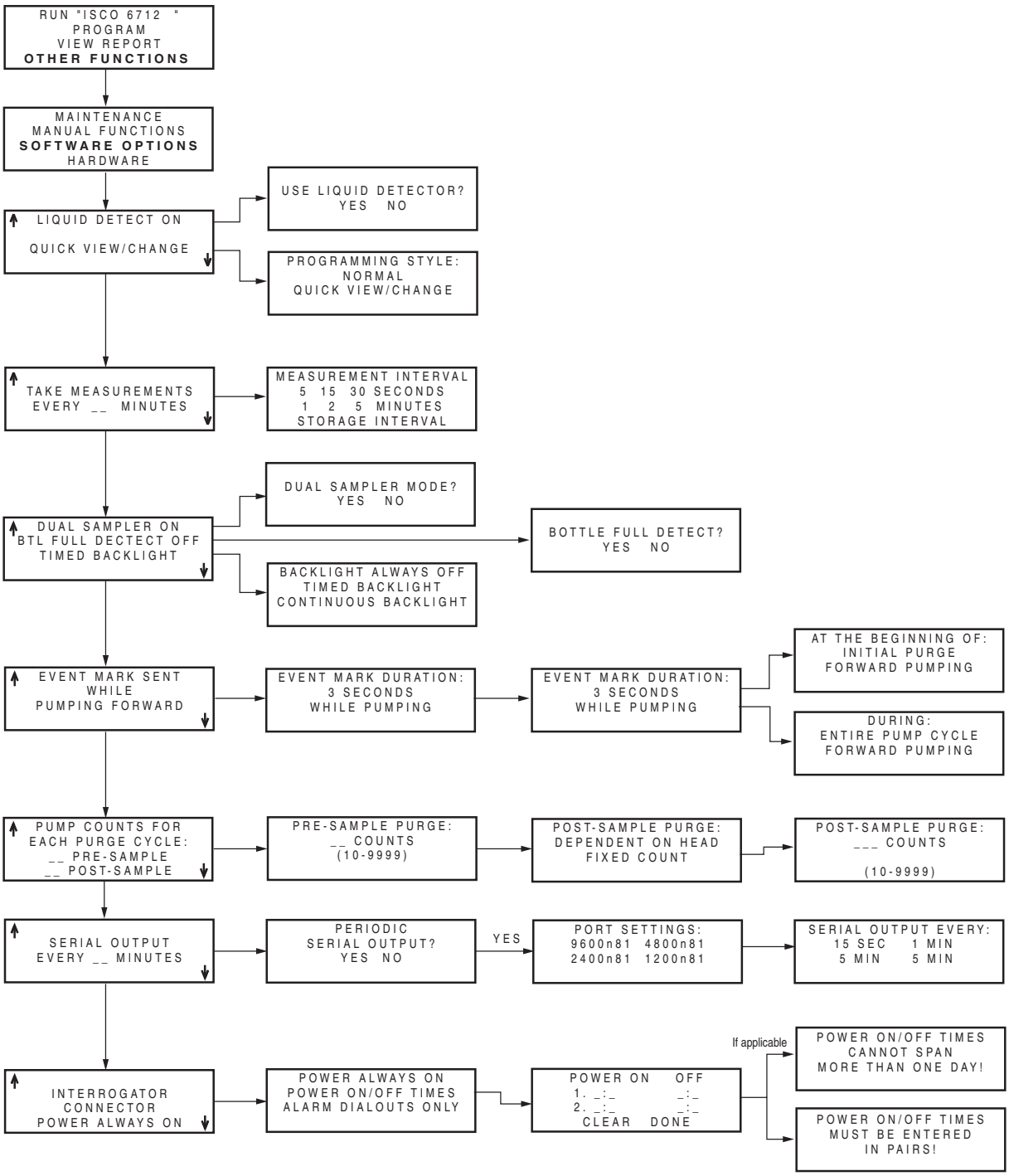


Figure A-19 Extended Programming: Quick View; Software Options

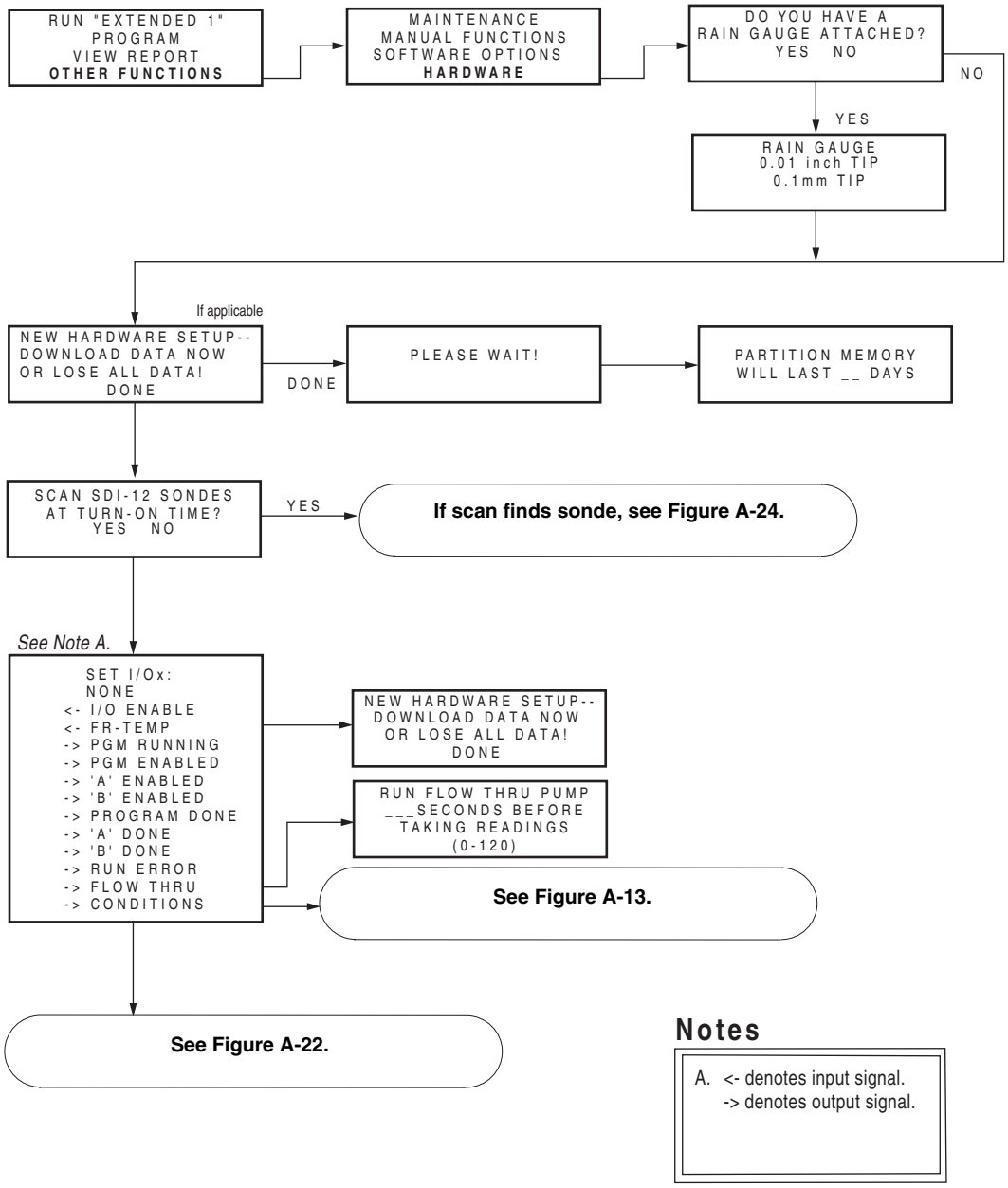


Figure A-20 Extended Programming: Normal View; Hardware

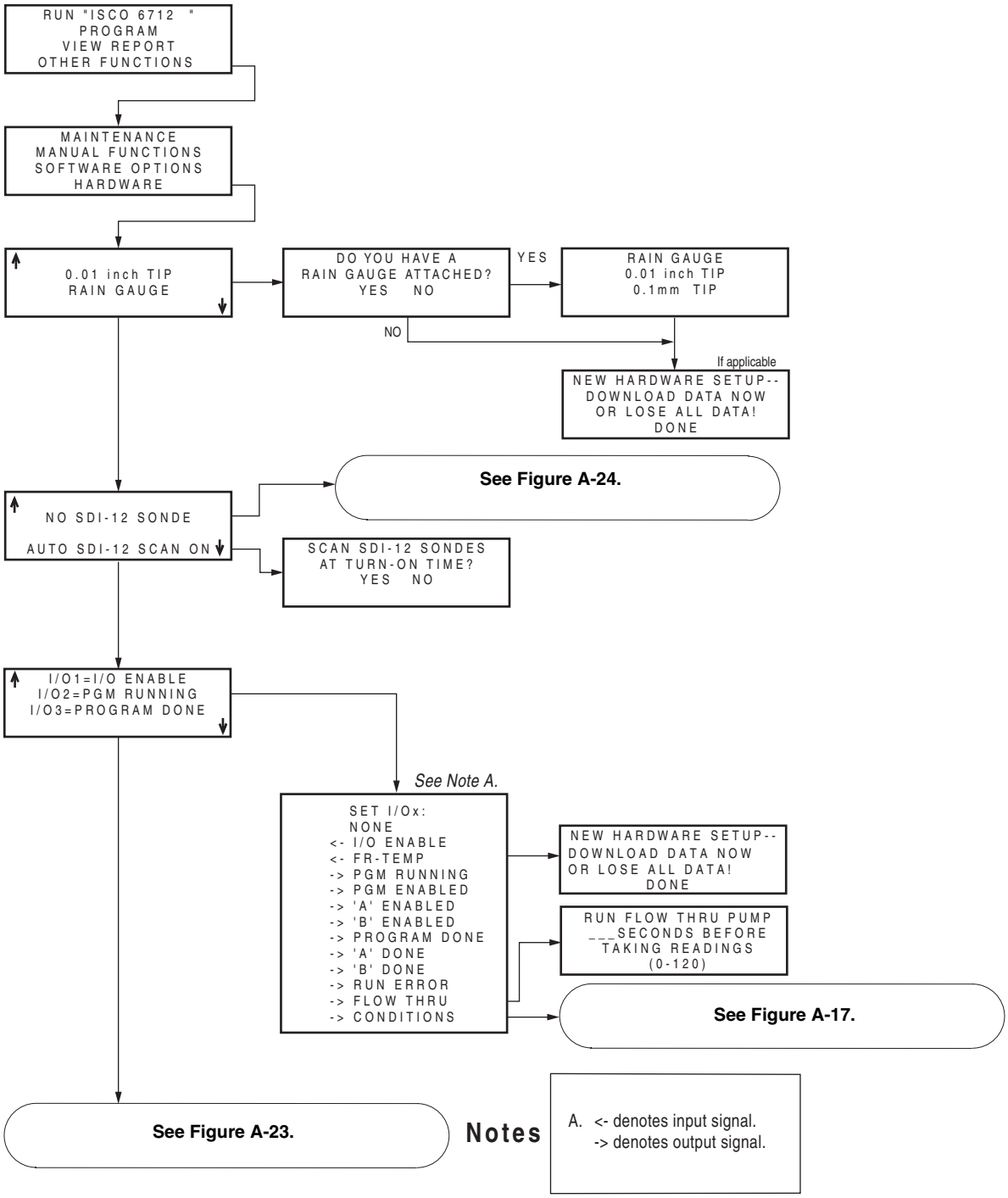


Figure A-21 Extended Programming: Quick View; Hardware

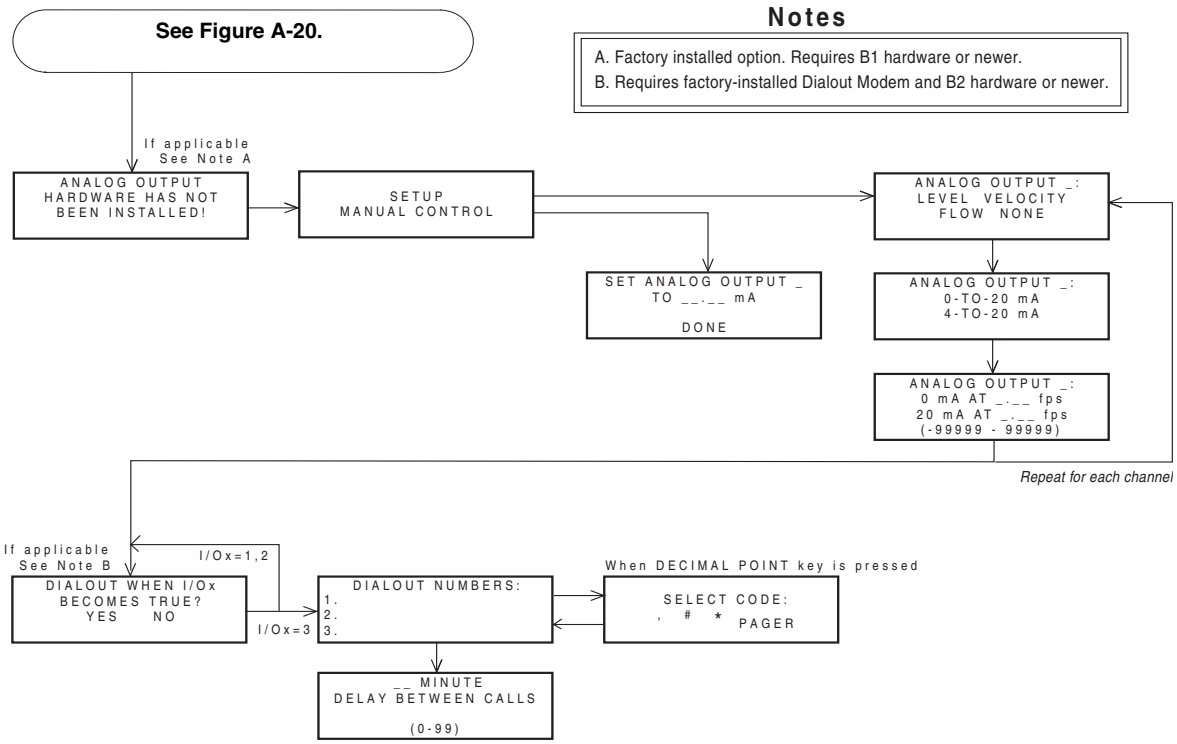


Figure A-22 Analog and Dialout Screens

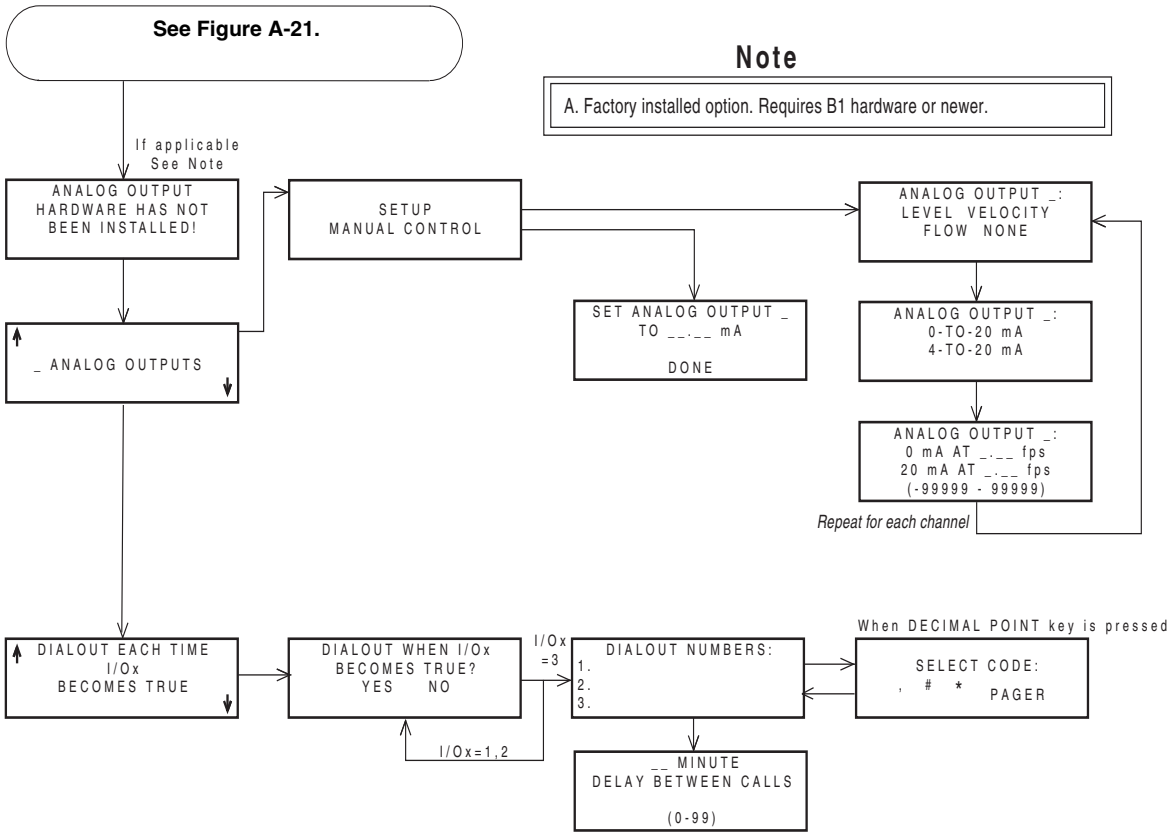


Figure A-23 Analog Output and Dialout Quick View Screens

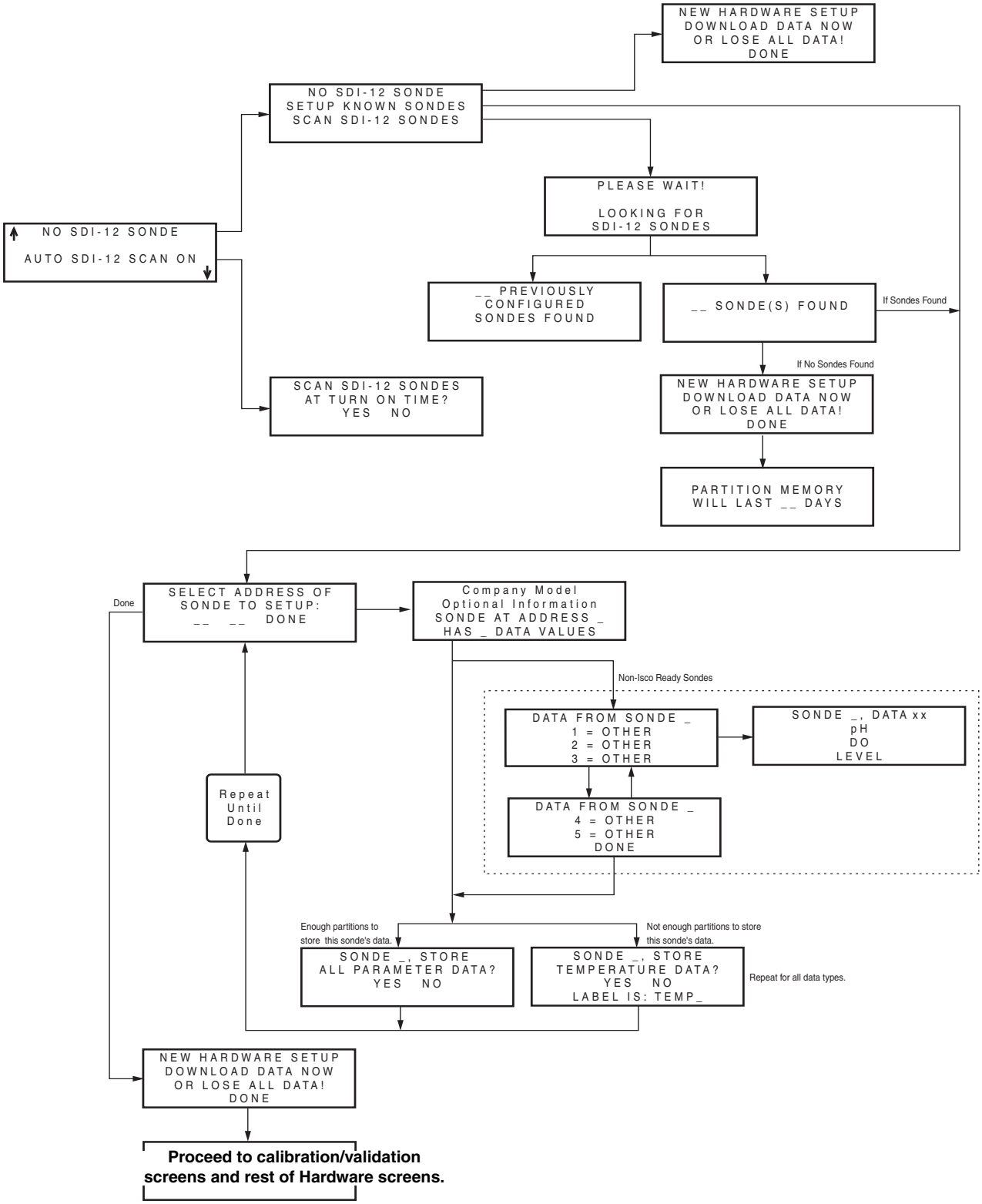


Figure A-24 SDI-12 Sonde Screens

6712 Portable Sampler

Appendix B Material Safety Data Sheets

This appendix provides Material Safety Data sheets for the internal desiccant used in the 6712 sampler.

Specific questions regarding the use and handling of these products should be directed to the manufacturer listed in the MSDS.

101 Christine Drive
Belen, New Mexico 87002
Phone: (505) 864-6691
Fax: (505) 861-2355

SÜD-CHEMIE
Performance Packaging

ISO 9002

MATERIAL SAFETY DATA SHEET -- September 28, 1998
SORB-IT®
Packaged Desiccant

SECTION I -- PRODUCT IDENTIFICATION

Trade Name and Synonyms:	Silica Gel, Synthetic Amorphous Silica, Silicon, Dioxide
Chemical Family:	Synthetic Amorphous Silica
Formula:	$SiO_2.x\ H_2O$

SECTION II -- HAZARDOUS INGREDIENTS

Components in the Solid Mixture

COMPONENT	CAS No	%	ACGIH/TLV (PPM)	OSHA-(PEL)
Amorphous Silica	63231-67-4	>99	PEL - 20 (RESPIRABLE), TLV – 5	LIMIT – NONE, HAZARD - IRRITANT ˝

Synthetic amorphous silica is not to be confused with crystalline silica such as quartz, cristobalite or tridymite or with diatomaceous earth or other naturally occurring forms of amorphous silica that frequently contain crystalline forms.

This product is in granular form and packed in bags for use as a desiccant. Therefore, no exposure to the product is anticipated under normal use of this product. Avoid inhaling desiccant dust.

SECTION III -- PHYSICAL DATA

Appearance and Odor:	White granules; odorless.
Melting Point:	>1600 Deg C; >2900 Deg F
Solubility in Water:	Insoluble.
Bulk Density:	>40 lbs./cu. ft.
Percent Volatile by Weight @ 1750 Deg F:	<10%.

101 Christine Drive
Belen, New Mexico 87002
Phone: (505) 864-6691
Fax: (505) 861-2355

SÜD-CHEMIE
Performance Packaging

ISO 9002

MATERIAL SAFETY DATA SHEET -- September 28, 1998
SORB-IT®
Packaged Desiccant

SECTION IV -- FIRE EXPLOSION DATA

Fire and Explosion Hazard - Negligible fire and explosion hazard when exposed to heat or flame by reaction with incompatible substances.

Flash Point - Nonflammable.

Firefighting Media - Dry chemical, water spray, or foam. For larger fires, use water spray fog or foam.

Firefighting - Nonflammable solids, liquids, or gases: Cool containers that are exposed to flames with water from the side until well after fire is out. For massive fire in enclosed area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn. Withdraw immediately in case of rising sound from venting safety device or any discoloration of the tank due to fire.

SECTION V -- HEALTH HAZARD DATA

Health hazards may arise from inhalation, ingestion, and/or contact with the skin and/or eyes. Ingestion may result in damage to throat and esophagus and/or gastrointestinal disorders. Inhalation may cause burning to the upper respiratory tract and/or temporary or permanent lung damage. Prolonged or repeated contact with the skin, in absence of proper hygiene, may cause dryness, irritation, and/or dermatitis. Contact with eye tissue may result in irritation, burns, or conjunctivitis.

First Aid (Inhalation) - Remove to fresh air immediately. If breathing has stopped, give artificial respiration. Keep affected person warm and at rest. Get medical attention immediately.

First Aid (Ingestion) - If large amounts have been ingested, give emetics to cause vomiting. Stomach siphon may be applied as well. Milk and fatty acids should be avoided. Get medical attention immediately.

First Aid (Eyes) - Wash eyes immediately and carefully for 30 minutes with running water.

101 Christine Drive
Belen, New Mexico 87002
Phone: (505) 864-6691
Fax: (505) 861-2355

SÜD-CHEMIE
Performance Packaging
ISO 9002

MATERIAL SAFETY DATA SHEET -- September 28, 1998
SORB-IT®
Packaged Desiccant

NOTE TO PHYSICIAN: This product is a desiccant and generates heat as it adsorbs water. The used product can contain material of hazardous nature. Identify that material and treat accordingly.

SECTION VI -- REACTIVITY DATA

Reactivity - Silica gel is stable under normal temperatures and pressures in sealed containers. Moisture can cause a rise in temperature which may result in a burn.

SECTION VII --SPILL OR LEAK PROCEDURES

Notify safety personnel of spills or leaks. Clean-up personnel need protection against inhalation of dusts or fumes. Eye protection is required. Vacuuming and/or wet methods of cleanup are preferred. Place in appropriate containers for disposal, keeping airborne particulates at a minimum.

SECTION VIII -- SPECIAL PROTECTION INFORMATION

Respiratory Protection - Provide a NIOSH/MSHA jointly approved respirator in the absence of proper environmental control. Contact your safety equipment supplier for proper mask type.

Ventilation - Provide general and/or local exhaust ventilation to keep exposures below the TLV. Ventilation used must be designed to prevent spots of dust accumulation or recycling of dusts.

Protective Clothing - Wear protective clothing, including long sleeves and gloves, to prevent repeated or prolonged skin contact.

Eye Protection - Chemical splash goggles designed in compliance with OSHA regulations are recommended. Consult your safety equipment supplier.

101 Christine Drive
Belen, New Mexico 87002
Phone: (505) 864-6691
Fax: (505) 861-2355

SÜD-CHEMIE
Performance Packaging
ISO 9002

MATERIAL SAFETY DATA SHEET -- September 28, 1998
SORB-IT®
Packaged Desiccant

SECTION IX -- SPECIAL PRECAUTIONS

Avoid breathing dust and prolonged contact with skin. Silica gel dust causes eye irritation and breathing dust may be harmful.

* No Information Available

HMIS (Hazardous Materials Identification System) for this product is as follows:

Health Hazard	0
Flammability	0
Reactivity	0
Personal Protection	HMIS assigns choice of personal protective equipment to the customer, as the raw material supplier is unfamiliar with the condition of use.

The information contained herein is based upon data considered true and accurate. However, United Desiccants makes no warranties expressed or implied, as to the accuracy or adequacy of the information contained herein or the results to be obtained from the use thereof. This information is offered solely for the user's consideration, investigation and verification. Since the use and conditions of use of this information and the material described herein are not within the control of United Desiccants, United Desiccants assumes no responsibility for injury to the user or third persons. The material described herein is sold only pursuant to United Desiccants' Terms and Conditions of Sale, including those limiting warranties and remedies contained therein. It is the responsibility of the user to determine whether any use of the data and information is in accordance with applicable federal, state or local laws and regulations.

Material Safety Data Sheet

Indicating Silica Gel

Identity (Trade Name as Used on Label)

Manufacturer :	MULTISORB TECHNOLOGIES, INC. (formerly Multiform Desiccants, Inc.)	MSDS Number* :	M75
Address:	325 Harlem Road Buffalo, NY 14224	CAS Number* :	
Phone Number (For Information):	716/824-8900	Date Prepared:	July 6, 2000
Emergency Phone Number:	716/824-8900	Prepared By* :	G.E. McKedy

Section 1 - Material Identification and Information

Components - Chemical Name & Common Names (Hazardous Components 1% or greater; Carcinogens 0.1% or greater)	%*	OSHA PEL	ACGIH TLV	OTHER LIMITS RECOMMENDED
Silica Gel SiO_2	98.0	6mg/m^3 (total dust)	10mg/m^3 (total dust)	
Cobalt Chloride	>2.0	0.05mg/m^3 (TWA cobalt metal dust & fume)	.05mg/m^3 (Cobalt, TWA)	
Non-Hazardous Ingredients				
TOTAL	100			

Section 2 - Physical/Chemical Characteristics

Boiling Point	N/A	Specific Gravity (H_20 = 1)	2.1
Vapor Pressure (mm Hg and Temperature	N/A	Melting Point	N/A
Vapor Density (Air =1)	N/A	Evaporation Rate (_____=1)	N/A
Solubility in Water	Insoluble, but will adsorb moisture.	Water Reactive	Not reactive, but will adsorb moisture.
Appearance and Odor	Purple crystals, no odor.		

Section 3 - Fire and Explosion Hazard Data

Flash Point and Methods Used	N/A	Auto-Ignition Temperature	N/A	Flammability Limits in Air % by Volume	N/A	LEL	UEL
Extinguisher Media	Dry chemical, carbon dioxide and foam can be used.						
Special Fire Fighting Procedures	Water will generate heat due to the silica gel which will adsorb water and liberate heat.						
Unusual Fire and Explosion Hazards	When exposed to water, the silica gel can get hot enough to reach the boiling point of water. Flooding with water will reduce the temperature to safe limits.						

Section 4 - Reactivity Hazard Data

STABILITY ☐**Stable** ☐**Unstable**	Conditions To Avoid	Moisture and high humidity environments.
Incompatibility (Materials to Avoid)	Water.	
Hazardous Decomposition Products	Carbon dioxide, carbon monoxide, water	
HAZARDOUS POLYMERIZATION ☐May Occur	Conditions To Avoid	None.

*Optional

Indicating Silica Gel

Page 2

Section 5 - Health Hazard Data

PRIMARY ROUTES OF ENTRY	☐Inhalation ☐Ingestion ☐Skin Absorption ☐Not Hazardous	**CARCINOGEN LISTED IN**	☐NTP ☐OSHA ☐IARC Monograph ☐Not Listed
HEALTH HAZARDS	Acute: May cause eye, skin and mucous membrane irritation.		
	Chronic: Prolonged inhalation may cause lung damage.		
Signs and Symptoms of Exposure	Drying and irritation.		
Medical Conditions Generally Aggravated by Exposure	Asthma.		
EMERGENCY FIRST AID PROCEDURES - Seek medical assistance for further treatment, observation and support if necessary.			
Eye Contact	Flush with water for at least 15 minutes.		
Skin Contact	Wash affected area with soap and water.		
Inhalation	Remove affected person to fresh air.		
Ingestion	Drink at least 2 glasses of water.		

Section 6 - Control and Protective Measures

Respiratory Protection (Specify Type)	Use NIOSH approved dust mask or respirator.		
Protective Gloves	Light cotton gloves.	Eye Protection	Safety glasses.
VENTILATION TO BE USED	☐ Local Exhaust	☐Mechanical (General)	☐Special
	☐Other (Specify)		
Other Protective Clothing and Equipment	None.		
Hygienic Work Practices	Avoid raising dust. Avoid contact with skin, eyes and clothing.		

Section 7 - Precautions for Safe Handling and Use/Leak Procedures

Steps to be Taken if Material Is Spilled Or Released	Sweep or vacuum up and place the spilled material in a waste disposal container. Avoid raising dust.
Waste Disposal Methods	Dispose in an approved landfill according to federal, state and local regulations.
Precautions to be Taken In Handling and Storage	Cover promptly to avoid blowing dust. Wash after handling.
Other Precautions and/or Special Hazards	Keep in sealed containers away from moisture. The silica gel will readily adsorb moisture.

*Optional

Indicating Silica Gel

6712 Portable Sampler

Appendix C General Safety Procedures

In field installations of Teledyne Isco wastewater samplers and associated equipment, the safety of the personnel involved should be the foremost consideration. The following sections provide safety procedures for working in and around manholes and sewers. the first section offers general safety advice. The second section deals with the special problem of hazardous gases found in sewers.

⚠ WARNING

The 6712 has not been approved for use in hazardous locations as defined by the National Electrical Code.

⚠ CAUTION

Before any sampler is installed, the proper safety precautions must be taken. The following discussions of safety procedures are only general guidelines. Each situation in which you install a flow meter varies. You must take into account the individual circumstances you are in. Additional safety considerations, other than those discussed here, may be required.

C.1 Practical Safety Precautions

The following procedures are those used by Black & Veatch, a respected consulting firm, and are published here by permission.

Field personnel must keep safety uppermost in their minds at all times. When working above ground, rules of common sense and safety prevail. However, when entering manholes, strict safety procedures must be observed. Failure to do so could jeopardize not only your own life, but also the lives of other crew members.

C.1.1 Hazards

There are many hazards connected with entering manholes. Some of the most common hazards are:

Adverse Atmosphere – The manhole may contain flammable or poisonous gases or the atmosphere may be deficient in oxygen. Forced ventilation may be necessary.

Deteriorated Rungs – Manhole steps may be corroded and not strong enough to support a man. It may be difficult to inspect the rungs because of poor lighting.

Traffic – Whenever manholes are located in the traveled way, barricades and warning devices are essential to direct traffic away from an open manhole.

Falling Objects – Items placed near the manhole opening may fall and injure a worker in the manhole.

Sharp Edges – Sharp edges of items in or near a manhole may cause cuts or bruises.

Lifting Injuries – Unless proper tools are used to remove manhole covers, back injuries or injuries to hands or feet may result.

C.1.2 Planning

Advance planning should include arrangements for test equipment, tools, ventilating equipment, protective clothing, traffic warning devices, ladders, safety harness, and adequate number of personnel. Hasty actions may result in serious injuries. Time spent in the manhole should be kept to a minimum.

C.1.3 Adverse Atmospheres

[Refer to Table C-1, Hazardous Gases, at the end of this appendix.] Before workers enter a manhole, tests should be made for explosive atmosphere, presence of hydrogen sulfide, and oxygen deficiency. Combustible or toxic vapors may be heavier than air, so the tests on the atmosphere must be run at least 3/4 of the way down the manhole.

Whenever adverse atmosphere is encountered, forced ventilation must be used to create safe conditions. After the ventilating equipment has been operated for a few minutes, the atmosphere in the manhole should be retested before anyone enters the manhole.

When explosive conditions are encountered, the ventilating blower should be placed upwind to prevent igniting any gas that is emerging from the opening. When a gasoline engine blower is used, it must be located so that exhaust fumes cannot enter the manhole.

If testing equipment is not available, the manhole should be assumed to contain an unsafe atmosphere and forced ventilation must be provided. It should never be assumed that a manhole is safe just because there is no odor or the manhole has been entered previously.

C.1.4 Entering Manholes

Since the top of the manhole is usually flush with the surrounding surface, there may not be anything for the person who is entering the manhole to grab on to steady himself. Persons who are entering manholes should not be permitted to carry anything in their hands as they enter the manhole, to ensure that their hands will be free to hold on or grab if they slip. A good method for entering a manhole is to sit on the surface facing the manhole steps or ladder, with the feet in the hole and the arms straddling the opening for support. As the body slides forward and downward, the feet can engage a rung, and the back can rest against the opposite side of the opening. If there is any doubt about the soundness of the manhole steps, a portable ladder should be used.

A person should never enter a manhole unless he is wearing personal safety equipment, including a safety harness and a hard hat. Two persons should be stationed at the surface continuously while anyone is working inside a manhole, to lift him out if he is

overcome or injured. One man cannot lift an unconscious man out of a manhole. The persons stationed at the surface should also function as guards to keep people and vehicles away from the manhole opening. To avoid a serious injury, a person should not be lifted out of a manhole by his arm unless it is a dire emergency.

When more than one person must enter a manhole, the first person should reach the bottom and step off the ladder before the next one starts down. When two men climb at the same time, the upper one can cause the lower one to fall by slipping or stepping on his fingers.

C.1.5 Traffic Protection

In addition to traffic cones, markers, warning signs, and barricades, a vehicle or a heavy piece of equipment should be placed between the working area and oncoming traffic. Flashing warning signals should be used to alert drivers and pedestrians. Orange safety vests should be worn by personnel stationed at the surface when the manhole is located in a vehicular traffic area.

C.1.6 Falling Objects

All loose items should be kept away from the manhole opening. This applies to hand tools as well as stones, gravel and other objects.

C.1.7 Removing the Covers

Manhole covers should be removed with a properly designed hook. Use of a pick ax, screwdriver, or small pry bar may result in injury. A suitable tool can be made from 3/4-inch round or hex stock. Two inches of one end should be bent at a right angle and the other end should be formed into a D-handle wide enough to accommodate both hands. Even with this tool, care must be exercised to prevent the cover from being dropped on the toes. The 2-inch projection should be inserted into one of the holes in the cover, the handle grasped with both hands, and the cover lifted by straightening the legs which have been slightly bent at the knees.

C.1.8 Other Precautions

Other precautions which should be taken when entering a manhole are:

- Wear a hard hat.
- Wear coveralls or removable outer garment that can be readily removed when the work is completed.
- Wear boots or nonsparking safety shoes.
- Wear rubberized or waterproof gloves.
- Wear a safety harness with a stout rope attached.
- Do not smoke.
- Avoid touching yourself above the collar until you have cleaned your hands.

C.1.9 Emergencies

Every member of the crew should be instructed on procedures to be followed in cases of an emergency. It is the duty of each crew chief to have a list of emergency phone numbers, including the nearest hospital and ambulance service, police precinct, fire station, and rescue or general emergency number.

C.1.10 Field Equipment

The following equipment will be available for use:

Blowers	Gloves	Traffic cones
Breathing apparatus	Hard Hats	Coveralls
Harnesses	First aid kits	Manhole irons
Emergency flashers	Pick axes	Flashlights
Rain slickers	Mirrors	Ropes
Gas detectors	Safety vests	Gas masks
Waders”		

C.2 Lethal Atmospheres in Sewers

The following is an article written by Dr. Richard D. Pomeroy, and published in the October 1980 issue of ***Deeds & Data*** of the WPCF. Dr. Pomeroy is particularly well known for his studies, over a period of nearly 50 years, in the field of the control of hydrogen sulfide and other odors in sewers and treatment plants. He has personally worked in a great many functioning sewers. In the earlier years he did so, he admits, with little knowledge of the grave hazards to which he exposed himself.

It is gratifying that the subject of hazards to people working in sewers is receiving much more attention than in past years, and good safety procedures are prescribed in various publications on this subject. It is essential that people know and use correct procedures.

It is less important to know just what the hazardous components of sewer atmospheres are, as safety precautions should in general be broadly applicable, but there should be a reasonable understanding of this subject. It is disturbing to see statements in print that do not reflect true conditions.

One of the most common errors is the assumption that people have died from a lack of oxygen. The human body is able to function very well with substantially reduced oxygen concentrations. No one worries about going to Santa Fe, New Mexico, (elev. 2,100 meters), where the partial pressure of oxygen is equal to 16.2% (a normal atmosphere is about 21%) oxygen. When first going there, a person may experience a little ‘shortness of breath’ following exercise. People in good health are not afraid to drive over the high passes in the Rocky Mountains. At Loveland Pass, oxygen pressure is 13.2% of a normal atmosphere. At the top of Mt. Whitney, oxygen is equal to 12.2%t. Many hikers go there, and to higher peaks as well. After adequate acclimation, they may climb to the top of Mt. Everest, where oxygen is equal to only 6.7%.

The lowest oxygen concentrations that I have observed in a sewer atmosphere was 13 percent. It was in a sealed chamber, near sea level, upstream from an inverted siphon on a metropolitan trunk. A man would be foolish to enter the chamber. Without ventilation, he might die, but not from lack of oxygen.

It seems unlikely that anyone has ever died in a sewer from suffocation, that is, a lack of oxygen. Deaths have often been attributed to 'asphyxiation.' This is a word which, according to the dictionary, is used to mean death from an atmosphere that does not support life. The word has sometimes been misinterpreted as meaning suffocation, which is only one kind of asphyxiation.

In nearly all cases of death in sewers, the real killer is hydrogen sulfide. It is important that this fact be recognized. Many cities diligently test for explosive gases, which is very important, and they may measure the oxygen concentration which usually is unimportant, but they rarely measure H_2S. Death has occurred where it is unlikely that there was any measurable reduction in the oxygen concentration. Waste water containing 2 mg per liter of dissolved sulfide, and at a pH of 7.0, can produce, in a chamber with high turbulence, a concentration of 300 PPM H_2S, in the air. This is considered to be a lethal concentration. Many people have died from H_2S, not only in sewers and industries, but also from swamps and from hot springs. In one resort area, at least five persons died from H_2S poisoning before the people were ready to admit that H_2S is not a therapeutic agent. Hardly a year passes in the U.S. without a sewer fatality from H_2S as well as deaths elsewhere in the world.

The presence of H_2S in a sewer atmosphere is easily determined. A bellows-and-ampoule type of tester is very satisfactory for the purpose, even though it is only crudely quantitative. When using a tester of this type, do not bring the air to the ampoule by way of a tube, as this may change the H_2S concentration. Hang the ampoule in the air to be tested, with a suction tube to the bulb or bellows.

Lead acetate paper is very useful as a qualitative indicator. It cannot be used to estimate the amount of sulfide, but it will quickly turn black in an atmosphere containing only a tenth of a lethal concentration.

Electrodes or other similar electrical indicating devices for H_2S in air have been marketed. Some of them are known to be unreliable, and we know of none that have proved dependable. Do not use one unless you check it at frequent intervals against air containing known H_2S concentrations. A supposed safety device that is unreliable is worse than none at all.

Remember that the nose fails, too, when it comes to sensing dangerous concentrations of H_2S.

Various other toxic gases have been mentioned in some publications. It is unlikely that any person has been asphyxiated in a sewer by any of those other gases, except possibly chlorine. The vapor of gasoline and other hydrocarbons is sometimes present in

amounts that could cause discomfort and illness, but under that condition, the explosion hazard would be far more serious. The explosimeter tests, as well as the sense of smell, would warn of the danger. Pipelines in chemical plants might contain any number of harmful vapors. They, too, are sensed by smell and explosimeter tests if they get into the public sewer. Such occurrences are rare.

The attempt to instill a sense of urgency about real hazards is diluted if a man is told to give attention to a long list of things that in fact are irrelevant.

Be very careful to avoid high H_2S concentrations, flammable atmospheres, and hazards of physical injuries. Remember that much H_2S may be released by the stirring up of sludge in the bottom of a structure. Obey your senses in respect to irritating gases, such as chlorine (unconsciousness comes suddenly from breathing too much). Be cautious about strange odors. Do not determine percent oxygen in the air. There is a danger that the result will influence a man's thinking about the seriousness of the real hazards. Most important, use ample ventilation, and do not enter a potentially hazardous structure except in a good safety harness with two men at the top who can lift you out."

C.3 Hazardous Gases

The following table contains information on the properties of hazardous gases.

Table C-1 Hazardous Gases

Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air =1	Physiological Effect	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Ammonia	NH_3	Irritant and poisonous. Colorless with characteristic odor.	0.60	Causes throat and eye irritation at 0.05%, coughing at 0.17%. Short exposure at 0.5% to 1% fatal.	300 to 500	85	16 25	Near top. Concentrates in closed upper spaces	Sewers, chemical feed rooms.	Detectable odor at low concentrations
Benzene	C_6H_6	Irritant, colorless anesthetic	2.77	Slight symptoms after several hours exposure at 0.16% to 0.32%. 2% rapidly fatal.	3,000 to 5,000	25	1.3 7.1	At bottom.	Industrial wastes, varnish, solvents.	Combustible gas indicator
Carbon Bisulfide	CS_2	Nearly odorless when pure, colorless, anesthetic. Poisonous.	2.64	Very poisonous, irritating, vomiting, convulsions, psychic disturbance.	—	15	1.3 44.0	At bottom	An insecticide	Combustible gas indicator

Table C-1 Hazardous Gases (Continued)

Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air =1	Physiological Effect	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Carbon Dioxide	CO_2	Asphyxiant, Colorless, odorless. When breathed in large quantities, may cause acid taste. Non-flammable. Not generally present in dangerous amounts unless an oxygen deficiency exists.	1.53	Cannot be endured at 10% more than a few minutes, even if subject is at rest and oxygen content is normal. Acts on respiratory nerves.	40,000 to 60,000	5,000	— —	At bottom; when heated may stratify at points above bottom.	Products of combustion, sewer gas, sludge. Also issues from carbonaceous strata.	Oxygen deficiency indicator
Carbon Monoxide	CO	Chemical asphyxiant. Colorless, odorless, tasteless. Flammable. Poisonous.	0.97	Combines with hemoglobin of blood. Unconsciousness in 30 min. at 0.2% to 0.25%. Fatal in 4 hours at 0.1%. Headache in few hours at 0.02%.	400	50	12.5 74.0	Near top, especially if present with illuminating gas.	Manufactured gas, flue gas, products of combustion, motor exhausts. Fires of almost any kind.	CO ampoules.
Carbon Tetra-Chloride	CCl_4	Heavy, ethereal odor.	5.3	Intestinal upset, loss of consciousness, possible renal damage, respiratory failure.	1,000 to 1,500	100	— —	At bottom.	Industrial wastes, solvent, cleaning	Detectable odor at low concentrations.
Chlorine	Cl_2	Irritant. Yellow-green color. Choking odor detectable in very low concentrations. Non-flammable.	2.49	Irritates respiratory tract. Kills most animals in a very short time at 0.1%.	4	1	— —	At bottom.	Chlorine cylinder and feed line leaks.	Detectable odor at low concentrations.
Formaldehyde	CH_2O	Colorless, pungent suffocating odor.	1.07	Irritating to the nose.	—	10	7.0 73.0	Near bottom.	Incomplete combustion of organics. Common air pollutant, fungicide.	Detectable odor.
Gasoline	C_5H_{12} to C_9H_{20}	Volatile solvent. Colorless. Odor noticeable at 0.03%. Flammable.	3.0 to 4.0	Anesthetic effects when inhaled. Rapidly fatal at 2.4%. Dangerous for short exposure at 1.1 to 2.2%.	4,000 to 7,000	1,000	1.3 6.0	At bottom.	Service stations, garages, storage tanks, houses.	1. Combustible gas indicator. 2. Oxygen deficiency indicator.**
Hydrogen	H_2	Simple asphyxiant. Colorless, odorless, tasteless. Flammable	0.07	Acts mechanically to deprive tissues of oxygen. Does not support life.	—	—	4.0 74.0	At top.	Manufactured gas, sludge digestion tank gas, electrolysis of water. Rarely from rock strata.	Combustible gas indicator.
Hydrogen Cyanide	HCN	Faint odor of bitter almonds. Colorless gas	0.93	Slight symptoms appear upon exposure to 0.002% to 0.004%. 0.3% rapidly fatal.	—	10	6.0 40.0	Near top.	Insecticide and rodenticide.	Detector tube

Table C-1 Hazardous Gases (Continued)

Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air =1	Physiological Effect	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air = 1	Physiological Effect*	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air.) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Hydrogen Sulfide	H_2S	Irritant and poisonous volatile compound. Rotten egg odor in small concentrations. Exposure for 2 to 15 min. at 0.01% impairs sense of smell. Odor not evident at high concentrations. Colorless. Flammable.	1.19	Impairs sense of smell, rapidly as concentration increases. Death in few minutes at 0.2%. Exposure to 0.07 to 0.1% rapidly causes acute poisoning. Paralyzes respiratory center.	200 to 300	20	4.3 45.0	Near bottom, but may be above bottom if air is heated and highly humid.	Coal gas, petroleum, sewer gas. Fumes from blasting under some conditions. Sludge gas.	1. H_2S Ampoule. 2. 5% by weight lead acetate solution.
Methane	CH_4	Simple asphyxiant. Colorless, odorless, tasteless, flammable.	0.55	Acts mechanically to deprive tissues of oxygen. Does not support life.	Probably no limit, provided oxygen percent-age is sufficient for life.	—	5.0 15.0	At top, increasing to certain depth.	Natural gas, sludge gas, manufactured gas, sewer gas. Strata of sedimentary origin. In swamps or marshes.	1. Combustible gas indicator 2. Oxygen deficiency indicator.
Nitrogen	N_2	Simple asphyxiant. Colorless, tasteless. Non-flammable. Principal constituent of air. (about 79%).	0.97	Physiologically inert.	—	—	— —	Near top, but may be found near bottom.	Sewer gas. sludge gas. Also issues from some rock strata.	Oxygen deficiency indicator.
Nitrogen Oxides	NO N_2O NO_2	Colorless Colorless, sweet odor. Reddish-brown. Irritating odor. Deadly poison	1.04 1.53 1.58	60 to 150 ppm cause irritation and coughing. Asphyxiant. 100 ppm dangerous. 200 ppm fatal.	50	10	— —	Near bottom.	Industrial wastes. Common air pollutant.	NO_2 detector tube.
Oxygen	O_2	Colorless, odorless, tasteless. Supports combustion.	1.11	Normal air contains 20.8% of O_2. Man can tolerate down to 12%. Minimum safe 8 hour exposure, 14 to 16%. Below 10%, dangerous to life. Below 5 to 7% probably fatal.	—	—	— —	Variable at different levels.	Oxygen depletion from poor ventilation and absorption, or chemical consumption of oxygen.	Oxygen deficiency indicator.
Ozone	O_3	Irritant and poisonous. Strong electrical odor. Strong oxidizer. Colorless. At 1 ppm, strong sulfur-like odor.	1.66	Max. naturally occurring level is 0.04 ppm. 0.05 ppm causes irritation of eyes and nose. 1 to 10 ppm causes headache, nausea; can cause coma. Symptoms similar to radiation damage.	0.08	0.04	— —	Near bottom.	Where ozone is used for disinfection.	Detectable odor at 0.015 ppm.

Table C-1 Hazardous Gases (Continued)

Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air =1	Physiological Effect	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Sludge Gas	—***	Mostly a simple asphyxiant. May be practically odorless, tasteless.	Variable	Will not support life.	No data. Would vary widely with composition.		5.3 19.3	Near top of structure.	From digestion of sludge.	See components.
Sulfur Dioxide	SO_2	Colorless, pungent odor. Suffocating, corrosive, poisonous, non-flammable.	2.26	Inflammation of the eyes. 400 to 500 ppm immediately fatal.	50 to 100	10	— —	At bottom, can combine with water to form sulfurous acid.	Industrial waste, combustion, common air pollutant.	Detectable taste and odor at low concentration.
Toluene	C_5H_{12} to C_9H_{20}	Colorless, benzene-like odor.	3.14	At 200-500 ppm, headache, nausea, bad taste, lassitude.	200	100	1.27 7.0	At bottom.	Solvent.	Combustible gas indicator.
Turpentine	$C_{10}H_{16}$	Colorless, Characteristic odor.	4.84	Eye irritation. Headache, dizziness, nausea, irritation of the kidneys.	—	100		At bottom.	Solvent, used in paint.	1. Detectable odor at low concentrations. 2.Combustible gas indicator.
Xylene	C_8H_{10}	Colorless, flammable	3.66	Narcotic in high concentrations. less toxic than benzene.	—	100	1.1 7.0	At bottom.	Solvent	Combustible gas indicator.

* Percentages shown represent volume of gas in air.
** For concentration over 0.3%.
***Mostly methane and carbon dioxide with small amounts of hydrogen, nitrogen, hydrogen sulfide, and oxygen; occasionally traces of carbon monoxide.

6712 Portable Sampler

Appendix D Replacement Parts List

D.1 Replacement Parts Diagrams and Listings

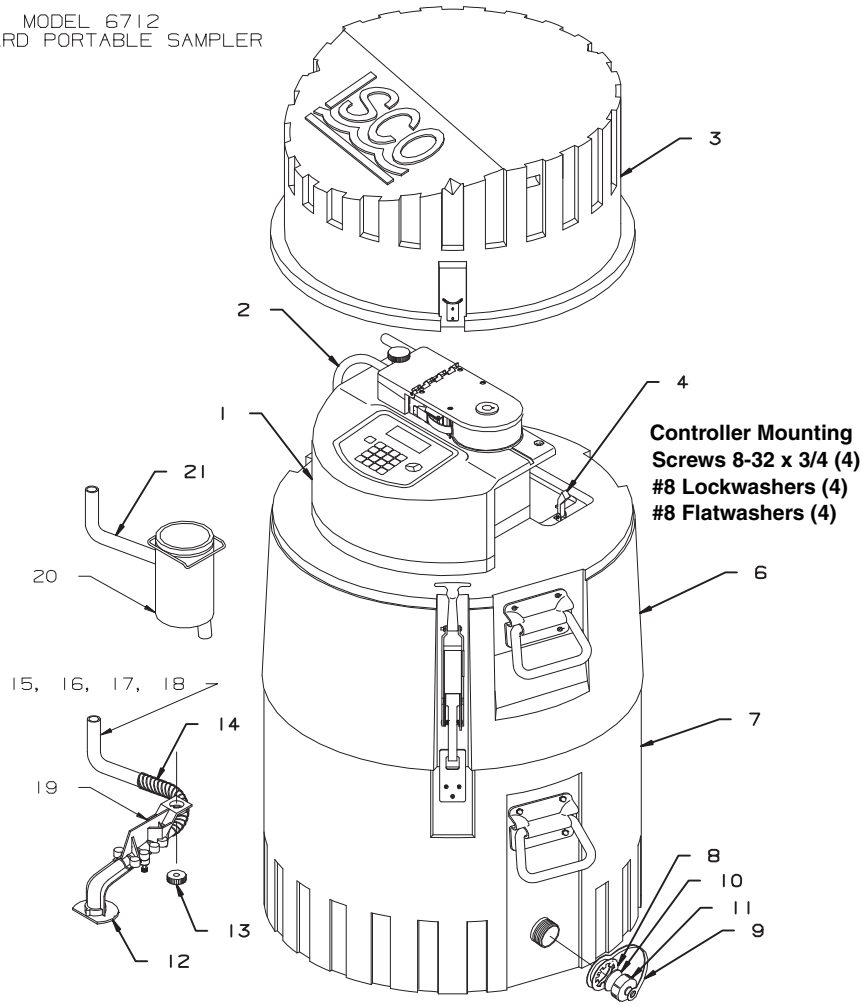
Replacement parts are called out in illustrations in this section. Reference the call-outs in the accompanying tables to determine the part number for the item.

Replacement parts can be purchased by contacting Teledyne Isco's Customer Service Department.

Teledyne Isco, Inc.
Customer Service Department
P.O. Box 82531
Lincoln, NE 68501 USA

Phone: (800) 228-4373
(402) 464-0231
FAX:(402) 465-3022

E-mail:IscoInfo@teledyne.com

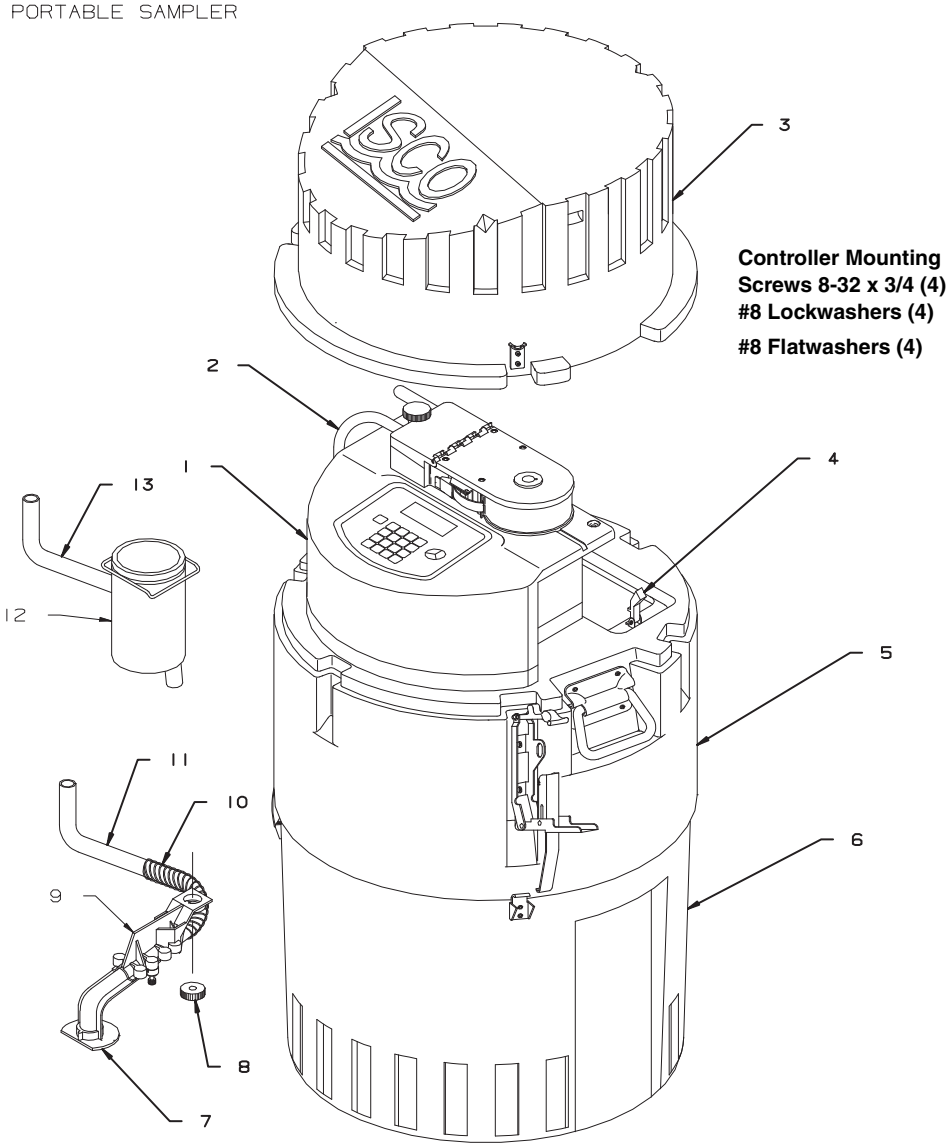


ITEM	INVENTORY NO.	DESCRIPTION
1	609004330	MODEL 6712 CONTROLLER
2	609004157	PUMP TUBE QUICK DISCONNECT
3	609004247	TOP COVER ASSY STD
4	109060503	DRAW LATCH ASSY SMALL
5*	609003088	BULKHEAD FITTING
6	609004246	CENTER SECTION ASSY STD (INCLUDES ITEM 4)
7	609004052	SAMPLE TUB ASSY STD (INCLUDES ITEMS 8-11)
8	209001828	RTNG RING SST .875SFT 1.20D
9	609003250	DRAIN CAP STRAP
10	603113032	GASKET CONNECTOR CAP
11	609003294	DRAIN CAP
12	609004020	DIST ARM ASSY BOTTOM
13	602923007	DISTRIBUTOR ARM NUT
14	609003317	SPRING DISTRIBUTOR ARM
15	609003260	DISCHARGE TUBE FOR STANDARD 24 BOTTLE KIT
16	609003262	DISCHARGE TUBE FOR STANDARD 12 BOTTLE KIT
17	609003264	DISCHARGE TUBE FOR STANDARD 8 BOTTLE KIT
18	609003266	DISCHARGE TUBE FOR STANDARD 4 BOTTLE KIT
19	609004019	DIST ARM TOP ASSY
20	609004051	COMPOSITE TUBE GUIDE (FOR STANDARD AND COMPACT)
21	609003271	DISCHARGE TUBE FOR STANDARD 1 BOTTLE KITS
22*	609004194	5 GALLON BOTTLE BASE

*-NOT SHOWN

DWG 60-9002-065

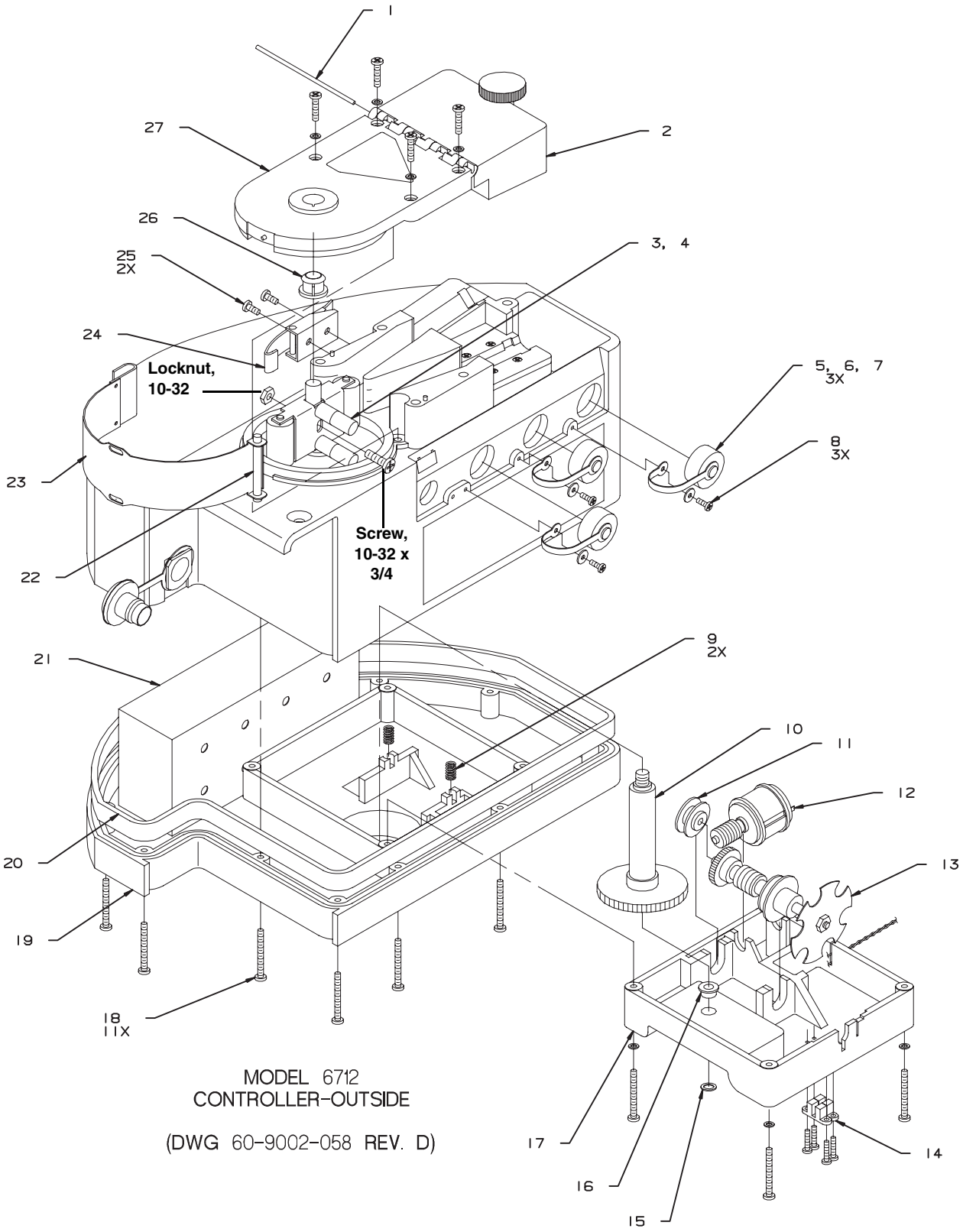
MODEL 6712
COMPACT PORTABLE SAMPLER



ITEM	INVENTORY NO.	DESCRIPTION
1	609004330	MODEL 6712 CONTROLLER
2	609004157	PUMP TUBE QUICK DISCONNECT
3	609004248	TOP COVER ASSY CMPT
4	109060503	DRAW LATCH ASSY SMALL
5	609004245	CENTER SECTION ASSY CMPT (INCLUDES ITEM 4)
6	603704129	SAMPLE TUB ASSY CMPCT
7	609004020	DIST ARM ASSY BOTTOM
8	602923007	DISTRIBUTOR ARM NUT
9	609004019	DIST ARM ASSY TOP
10	609003317	SPRING DISTRIBUTOR ARM
11	609003257	DISCHARGE TUBE FOR COMPACT 24 & 12 BOTTLE KITS
12	609004051	COMPOSITE TUBE GUIDE (FOR STANDARD AND COMPACT)
13	609003258	DISCHARGE TUBE FOR COMPACT 1 BOTTLE KITS
14*	609003088	BULKHEAD FITTING
15*	603704181	MINI BASE ASSEMBLY

*-NOT SHOWN

DWG 60-9002-066

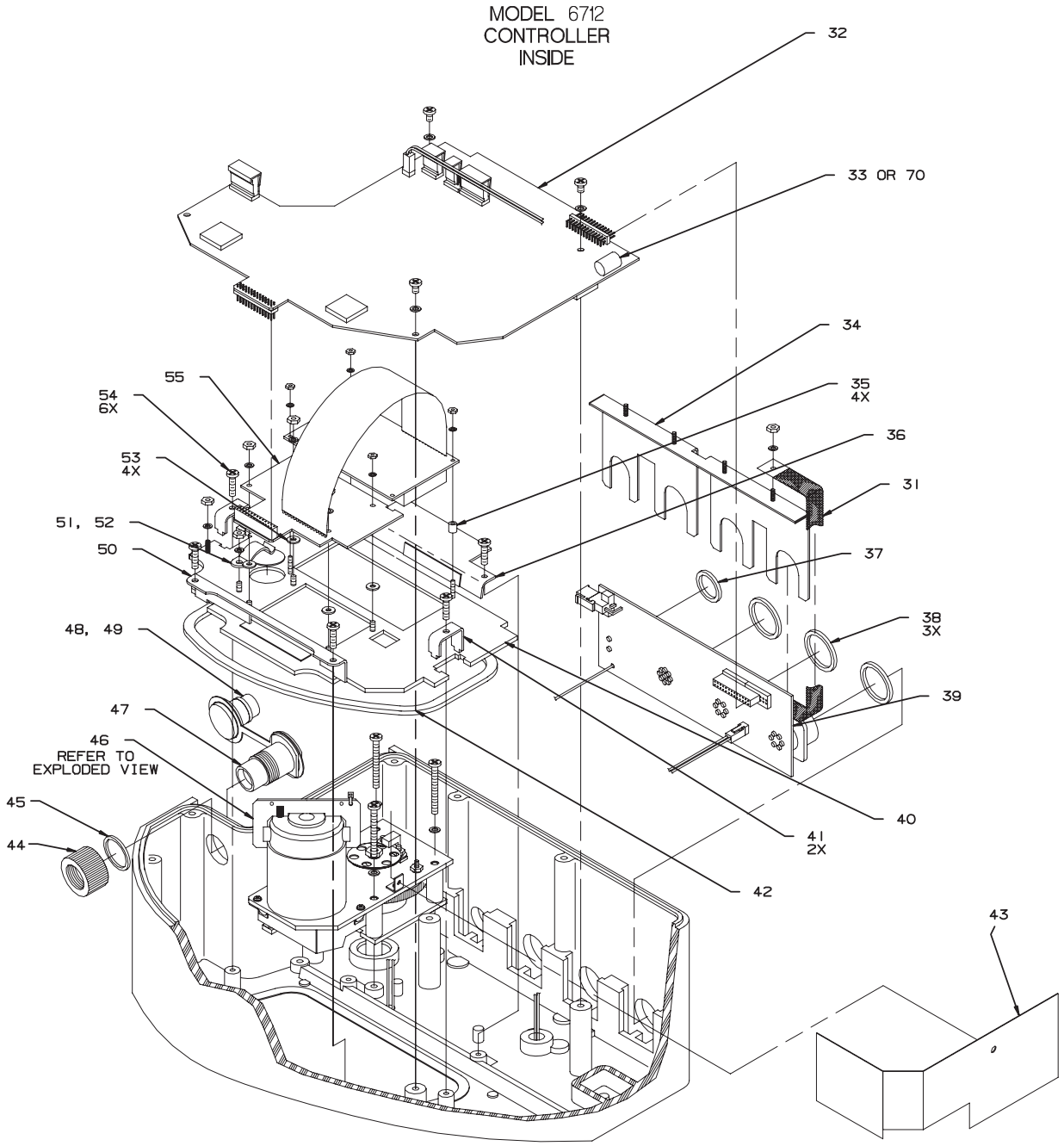


MODEL 6712
CONTROLLER-OUTSIDE

(DWG 60-9002-058 REV. D)

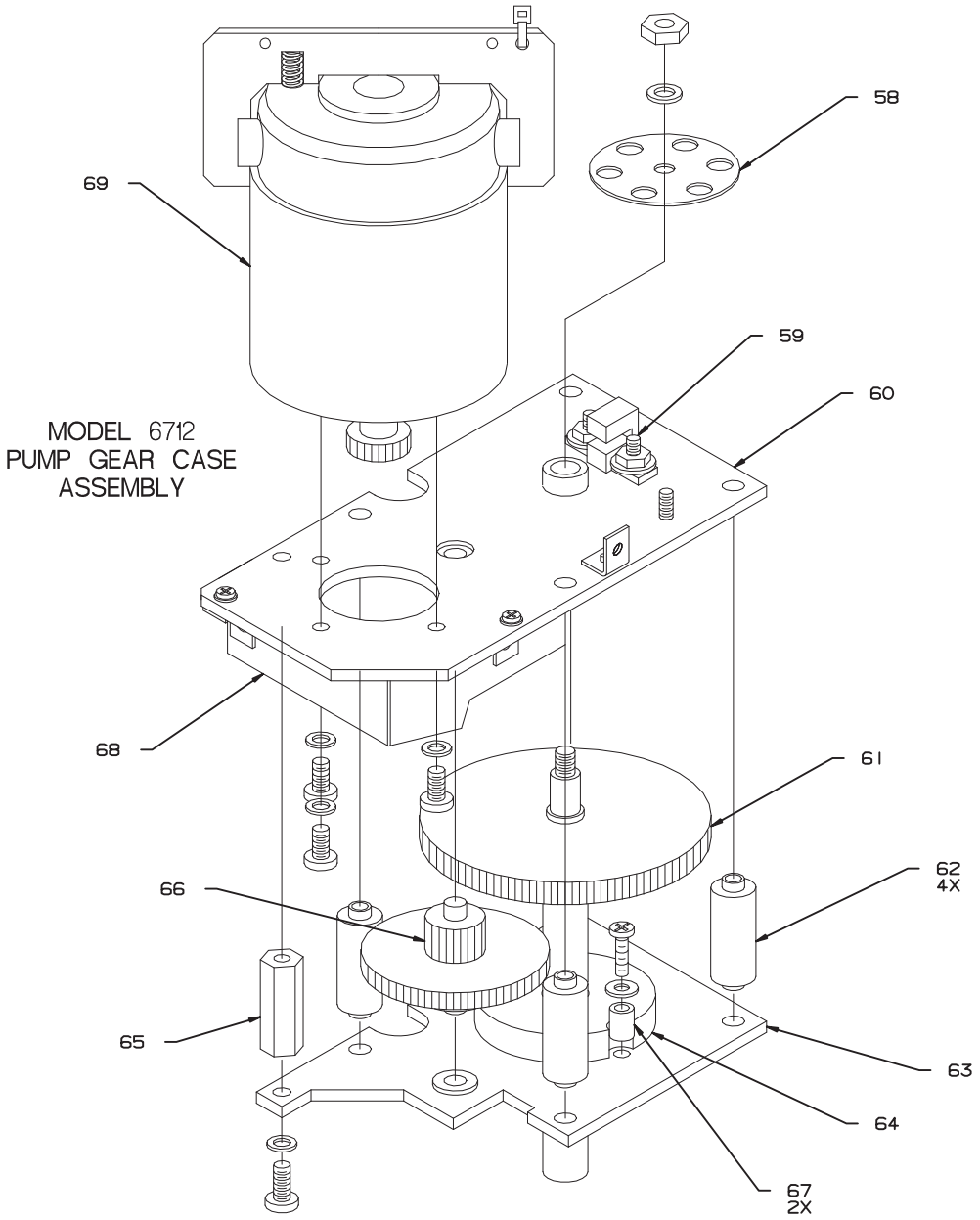
ITEM	INVENTORY NO.	DESCRIPTION
1	609003035	PIN HNG .09X3.635
2	609004013	LID ASSY LIQ DET
3	609004009	PMP PADDLE ASSY
4	232916101	NUT S 10-32
5	603113024	CAP CONN PTCTR MDM
6	603113032	GSKT CONN CAP MDM
7	609003291	STRAP CONN CAP
8	231310106	SCR SLFTPG #4X3/8
9	203012203	SPR CPRSN .042WIRE
10	609004016	SFT ASSY DISTR
11	609003040	BSHG .184 ID
12	609004014	DISTR MOT ASSY
13	609004015	SFT ASSY WORM
14	609004114	OPT SNSR ASSY
15	209000900	RTNG RING EXT.21ID
16	201312300	BRG CYL.250ID.380D
17	609003007	PL TOP DISTR (ENV)
18	231014436	SCR PNH 6-32X1 1/8
19	609004011	CONT BOX S/A BOT
20	609003054	GSKT CONT BOX
21	699003518	BOX 2.88X2.33X5.13
22	609003052	PIN HNG .18X2.000
23	609004300	PMP HSG BND ASSY
24	109080300	LCH DRAW SST
25	231311206	SCR SLFTPG #6X3/8
26	603703278	BSHG PMP (ENV)
27	609004295	PMP COV ASSY
*28	202999100	SEAL .625IDX1.000D

NOTE: * ITEM IS NOT SHOWN IN ILLUSTRATION


MODEL 6712
CONTROLLER
INSIDE
32
33 OR 70
34
35
4X
36
31
37
38
3X
39
40
41
2X
42
43
55
54
6X
53
4X
51, 52
50
48, 49
47
46
REFER TO
EXPLODED VIEW
45
44

ITEM	INVENTORY NO.	DESCRIPTION
31	609003407	STRAP INTCON 3.5"
32	609004324	CBA CPU YSI CE
33	340500000	BAT 2/3A LITHIUM (CYLINDER STYLE)
34	609004201	RTNG CLIP ASSY CE
35	609003077	SPCR .188 X 0.25 L
36	609003132	HLDN CONT PNL TOP
37	202400114	O RING .612ID .103
38	202400118	O-RING .862ID .103
39	609004346	CBA 6712 CONN 2001
40	609004328	CONT PNL ASSY CE
41	609003029	HLDN CONT PNL
42	609003066	GSKT CONT PNL
43	699003554	SHLD MN PCB
44	609003020	NUT CONN
45	202100018	O-RING .739ID .070
46	609004301	PMP GR CS ASSY CE (INCLUDES ITEMS 59 THRU 69)
47	609004206	CONN ASSY 8 PIN CE
48	609003074	STRAP P
49	609003075	P FL MDL CONN
50	609003133	HLDN CONT PNL BOT
51	209902138	CLIP TNSN .375 DIA
52	490001300	HMD INDCTR CARD
53	233040405	WSHR FL .125 NYL
54	231514920	SCR SLFTPG6-19X5/8
55	609004006	DSPL KYPD ASSY
57	232910100	NUT S 4-40
70	340503000	BATTERY .3AH COIN (DISK STYLE)

NOTE: * ITEM IS NOT SHOWN IN ILLUSTRATION



ITEM	INVENTORY NO.	DESCRIPTION
58	609003112	DISK OPT
59	609004203	WGR ASSY PMP SNSR
60	609004296	MOT MTG PL ASSY CE
61	609004304	PMP SFT ASSY
62	602703129	STDF DISTR GR CS
63	609004298	MTG PL ASSY PMP
64	609004305	SPCR 1.38 X 0.31 L
65	237263210	STDF 6-32 X 1.00 L
66	609004303	GR ASSY
67	237012000	SPACER, .140 ID X .313 OD X .312 LONG
68	699003555	SHLD DSPL
69	609004046	MOT ASSY

6712 Portable Sampler

Appendix E Accessories List

E.1 Order Information

Prices available on request. Additional items appear in *Appendix D, Replacement Parts List*. Many other items are available. To order any item, contact your sales representative or the factory. Note that the part name listed on your order acknowledgment and invoice may be different from the item name listed here. When examining these documents, use the part number for reference.

Teledyne Isco, Inc.
P.O. Box 82531
Lincoln, NE 68501
Telephone Within U.S.A.
Toll free: (800) 228-4373
Outside U.S.A:(402) 464-0231
Fax: (402) 465-3022
IscoCSR@teledyne.com

E.2 Controller, Center Sections, Top Covers, and Tubs

6712 Sampler Controller 68-6710-074
(Includes 2 Pump Tubes)

6712 Portable Sampler Instruction Manual 60-9004-334

6712 Portable Sampler Pocket Guide 60-9003-589

Compact Center Section 60-9004-245

Compact Tub 60-3704-129

Mini-Tub (for use with Compact Tub and multiple bottle carrier only) 60-3704-181

Compact Top Cover 60-9004-248

Standard Center Section 60-9004-246

Standard Top Cover 60-9004-247

Standard Tub 60-9004-052

E.3 Compact and Mini Sampler Bottle Kits

24-Bottle Kit (500-milliliter Polyethylene Bottles) 68-6700-022
(Includes Bottle Carrier, Bottles, Retaining Ring and 2 Discharge Tubes.)

12-Bottle Kit (500-milliliter Polyethylene Bottles) 68-6700-023
(Includes Bottle Carrier, Retaining Ring, Bottles, and 2 Discharge Tubes.)

12-Bottle Kit (375-milliliter Glass Bottles) 68-6700-024
(Includes Bottle Carrier, Retaining Ring, Bottles, and 2 Discharge Tubes.)

E.4 Compact Sampler Bottle Kits

1-Bottle Kit (9.4-liter Polyethylene) 68-6700-025
(Includes Bottle and 2 Discharge Tubes.)

1-Bottle Kit (9.4-liter Glass Bottle). 68-6700-026
(Includes Bottle and 2 Discharge Tubes.)

E.5 Standard Sampler Bottle Kits

24-Bottle Kit (1,000-milliliter Polypropylene Bottles) 68-6700-006
(Includes Retaining Ring, Bottles, and 2 Discharge Tubes.)

24-Bottle Kit (350-milliliter Glass Bottles) 68-6700-007
(Includes Retaining Ring, Bottles, and 2 Discharge Tubes.)

12-Bottle Kit (1,000-milliliter Polypropylene Bottles) 68-6700-008
(Includes Insert, Bottles, Retaining Ring, and 2 Discharge Tubes.)

12-Bottle Kit (950-milliliter Glass Bottles) 68-6700-009
(Includes Insert, Retaining Ring Bottles, and 2 Discharge Tubes.)

8-Bottle Kit (2.0-liter Polyethylene Bottles). 68-6700-010
(Includes Insert, Bottles, Retaining Ring, and 2 Discharge Tubes.)

8-Bottle Kit (1.8-liter Glass Bottles) 68-6700-011
(Includes Insert, Bottles, Retaining Ring, and 2 Discharge Tubes.)

4-Bottle Kit (3.7-liter Polyethylene Bottles). 68-6700-012
(Includes Bottles, Rack, and 2 Discharge Tubes.)

4-Bottle Kit (3.7-liter Glass Bottles) 68-6700-013
(Includes Bottles, Rack, and 2 Discharge Tubes.)

1-Bottle Kit (9.4-liter Polyethylene Bottle). 68-6700-014
(Includes Bottle and 2 Discharge Tubes.)

1-Bottle Kit (9.4-liter Glass Bottle). 68-6700-015
(Includes Bottle and 2 Discharge Tubes.)

4 (15 Liter) Gallon Bottle Configuration 68-6700-080

(Includes Jumbo Base, Polyethylene Bottle, Cap, Two Discharge Tubes, and Composite Tube Guide.)

5 Gallon (19 Liter) Bottle Configuration 68-6700-078
(Includes Jumbo Base, Glass Bottle, Cap, PTFE Cap Liner, Two Discharge Tubes, and Composite Tube Guide.)

5.5 Gallon (20.8 Liter) Bottle Configuration

(Includes Jumbo Base, Polyethylene Bottle, Cap, Two Discharge Tubes, and Composite Tube Guide.)

ProPak Starter Kit. 68-6700-112
(Includes 24 holders with caps, 100 liners, retaining ring, instruction video, instruction sheet.)

ProPak Configuration Kit for 6700 Full-size Samplers 68-6700-105
(Includes 25 holders, 1,000 liners, retaining ring, instruction video, instruction sheet.)

ProPak holders with caps, and standard liners (24) 68-6700-087

ProPak disposable liners, 1-liter polyethylene (100) 68-6700-113

ProPak disposable liners, 1-liter polyethylene (500) 68-6700-114

ProPak disposable liners, 1-liter polyethylene (1000) 68-6700-096

ProPak labels (1000) 68-6700-100

ProPak retaining ring for 24 holders 60-9003-475

E.6 Bottle Carriers, Retaining Rings and Racks, Bottle Inserts, Discharge Tubes

Bottle Carrier for Compact 12-Bottle Kits 60-9004-131
Bottle Carrier for Compact 24-Bottle Kits 60-9004-132
Retaining Ring for Compact 12-Bottle Kits 60-2904-062
Retaining Ring for Compact 24-Bottle Kits 60-9003-235
Retaining Ring for Standard 24-Bottle Kit (1000-milliliter Polypropylene Bottles) 60-9003-242
Retaining Ring for Standard 24-Bottle Kit (350 milliliter Glass Bottles) 60-2703-011
Retaining Ring for Standard 12-Bottle Kits 60-3704-112
Bottle Insert for Standard 12-Bottle Kits 60-9004-147
Retaining Ring for Standard 8-Bottle Kits 60-9004-149
Bottle Insert for Standard 8-Bottle Kits 60-9004-146
Retaining Rack for Standard 4-Bottle Kits 60-9004-351
Discharge Tube for Compact 12- Bottle Kit and 24-Bottle Kit 60-9003-257
Discharge Tube for Compact 1 Bottle Kit 60-9003-258
Discharge Tube for Standard 24-Bottle Kit 60-9003-260
Discharge Tube for Standard 12-Bottle Kit 60-9003-262
Discharge Tube for Standard 8-Bottle Kit 60-9003-264
Discharge Tube for Standard 4-Bottle Kit 60-9003-266
Discharge Tube for Standard 1-Bottle Kits 60-9003-271
Bulk Discharge Tube (10 foot Length) 60-6700-046
Bulk Discharge Tube (50 foot Length) 60-6700-047

E.7 Bulk Sets of Bottles with Lids

Set of 24, 500-milliliter Polyethylene Bottles with Polyethylene Foam Lined Lids 68-2900-002
Set of 100, 500-milliliter Polyethylene Bottles with Polyethylene Foam Lined Lids 68-6700-027
Set of 500, 500-milliliter Polyethylene Bottles with Polyethylene Foam Lined Lids 68-6700-028
Set of 12, 500-milliliter Polyethylene Bottles with Unlined Lids 68-2900-014
Set of 100, 500-milliliter Polyethylene Bottles with Unlined Lids 68-6700-029
Set of 500, 500-milliliter Polyethylene Bottles with Unlined Lids 68-6700-030
Set of 12, 375-milliliter Glass Bottles 68-2900-015
Set of 100, 375-milliliter Glass Bottles 68-6700-031
Set of 24, 1,000-milliliter Polypropylene Bottles with Polyethylene Foam Lined Lids 68-2100-007
Set of 100, 1,000-milliliter Polypropylene Bottles with Polyethylene Foam Lined Lids 68-3700-046
Set of 500, 1,000-milliliter Polypropylene Bottles with Polyethylene Foam Lined Lids 68-3700-047
Set of 24, 350-milliliter Glass Bottles with PTFE Lined Lids 68-2100-001
Set of 100, 350-milliliter Glass Bottles with PTFE Lined Lids 68-3700-048
Set of 12, 1,000-milliliter Polypropylene Bottles with Lids 68-3700-035
Set of 100, 1,000-milliliter Polypropylene Bottles with Lids 68-6700-016
Set of 500, 1,000-milliliter Polypropylene Bottles with Lids 68-6700-017
Set of 12, 950-milliliter Bottles 68-3700-023
Set of 100, 950-milliliter Bottles with PTFE Lined Lids 68-6700-018
Set of 8, 2.0-liter Polyethylene Bottles with Unlined Lids 68-2740-026
Set of 100, 2.0-liter Polyethylene Bottles with Unlined Lids 68-3720-028

Set of 8, 1.8-liter Glass Bottles with PTFE Lined Lids 68-2740-027
Set of 100, 1.8-liter Glass Bottles with PTFE Lined Lids 68-3720-030
3.7-liter Glass Bottles with PTFE Lined Lids 68-6700-147
3.7-liter Polyethylene Bottles with Unlined Lids 68-2910-003
Set of 4, 3.7-liter Glass Bottles with PTFE Lined Lids 68-6700-146
Set of 4, 3.7-liter Polyethylene Bottles with Unlined Lids 68-6700-020
9.4-liter (2 1/2-gallon) Glass Bottle with PTFE Lined Lid 68-2700-005
9.4-liter (2 1/2-gallon) Polyethylene Bottle with Lid 299-0013-04
18.9-liter (5-gallon) Glass Bottle with Cap and
Teflon Liner (for the 5 Gallon Bottle Base) 68-6700-079

E.8 General Accessories: Compact and Standard Samplers

Composite Tube Guide (Recommended for all 1-Bottle Kits) 60-9004-051
Distributor Arm 60-9004-050
Equipment Suspension Platform (For Suspending Samplers In Manhole or
Other Locations). 60-3004-151
Locking Assy, compact 6712 samplers (includes locking cables and padlock) 68-6710-111
Locking Assy, standard 6712 samplers (includes locking cables and padlock). 68-6700-134
Suspension Harness for Compact and Standard Samplers. 60-1394-014
1000-milliliter Plastic Graduated Cylinder 299-0020-00

E.9 Pump Tubes, Suction Line, Strainers

Pump Tube (Qty 5). 68-6700-062
Pump Tube (Qty 10). 68-6700-044
Pump Tube (Qty 25). 68-6700-045
3/8-inch Standard weighted polypropylene strainer with 10 foot Suction Line 60-9004-378
3/8-inch Standard weighted polypropylene strainer with 25 foot Suction Line 60-9004-379
PTFE Suction Line (10 foot length) 60-1683-146
PTFE Suction Line (25 foot length) 60-2703-114
Bulk Vinyl Suction Line (100 foot length) 68-1680-058
Bulk Vinyl Suction Line (500 foot length) 68-1680-059
3/8-inch Vinyl Suction Line Accessory Kit (includes tube coupling,
clamp, and instructions) 68-3700-007
3/8-inch Standard weighted polypropylene strainer. 60-9004-367
CPVC Plastic-coated Weighted Strainer. 60-3704-066
3/8-inch Stainless Steel Low Flow Strainer 69-2903-138
3/8-inch Suction Line Tubing Coupler. 69-4703-106

E.10 Data Collection Devices and Cables

581 Rapid Transfer Device (RTD) 60-9004-027
Power Cable 581 Rapid Transfer Device (RTD) 60-9004-077
Flowlink® for Windows Software – New License . . . . . call factory
Flowlink® for Windows Software – Upgrade . . . . . call factory
SAMPLINK Software (Includes Instruction Manual) 60-3774-013
Computer Connect Cable (25-pin) 60-2544-040
Computer Connect Cable (9-pin) 60-2544-044
Connector to Attach Non-Teledyne Isco Flow Meter to Customer Supplied Cable 68-1680-060
Serial Output Connect Cable (for use with the periodic serial output feature) 60-9004-263
External 12-volt DC Power Cable 60-1394-023
Flow-Meter to Two-Samplers Cable 60-3004-018
Dual Sampler Mode Interconnect Cable 60-3704-065
Dual Sampler Mode to Flow-Meter Cable 60-3704-080
Non-Teledyne Isco Flow-Meter to Sampler Cable 60-1394-077
Sampler to Flow Meter /1640 Liquid Level Actuator "Y" Cable 60-3004-019
Sampler to Flow Meter Cable 60-3004-107
2100 Series Sampler Interface Cable 60-2004-260
Solar Panel "Y" Cable 60-3004-098
Solar Panel/Interrogator Extension Cable 60-2544-028
Solar Panel Cable (25 foot length) 60-3004-097
Rain Gauge/Refrigerator Temperature Sensor "Y" cable 60-9004-294
4200T Modem . . . . . factory installed
(Contact your sales representative or Teledyne Isco Customer Service.)

Note

The modem is disabled when an interrogator cable is connected to the sampler's Interrogator port. It cannot receive incoming calls, and the alarm dialout is rendered inoperative, while this cable is connected. **Disconnect the interrogator cable in order to use the 4200T modem.**

CDMA Digital Cellular Modem 60-5314-489
GSM Digital Cellular Modem 60-5314-563
(Requires the purchase of a SIM card from your preferred provider.)

E.11 Power Sources and Chargers

913 High Capacity Power Pack (120-volt) 60-1684-088
914 Battery-Backed Power Pack (120-volt) 60-3004-130
921 Nickel-Cadmium Battery 60-1684-040
923 High Capacity Power Pack (240-volt) 60-1684-093
924 Battery-Backed Power Pack (240-volt) 60-3004-160
947 Lead-Acid Battery 60-3004-106
948 45-Amp-Hour Battery 68-3000-948
Portable 12-volt DC, 6-Amp Battery Charger for 948 Battery 341-0118-12
961 Battery Charger (120-volt) 60-3004-059

965 Five-Station Battery Charger, 120/240 V, with 120 V cord. 68-3000-965
965 Five-Station Battery Charger, 120/240 V, with 240 V cord. 68-3000-966
Solar Panel Battery Charger, 5-watt. 60-5314-478
Solar Panel Battery Charger, 40-watt. 60-5314-347
Solar Panel Battery Charger, 90-watt. 60-5314-399
Power Products Guide 60-9003-092

E.12 Modules, Rain Gauges, & Interfacing Instruments

(Note: Additional accessories for modules and interfacing instruments appear in the accessories list at the back of the manual for each module or instrument.)

701 pH Module with Double Junction pH Sensor with Temperature Sensor. 68-6700-052
710 Ultrasonic Flow Module 68-6700-049
720 Submerged Probe Module, 10 ft range. 68-6700-068
730 Bubbler Flow Module 68-6700-050
780 Analog Interface Module 60-9004-040
675 Rain Gauge 60-3284-013
1640 Liquid Level Actuator 60-1644-000
4-20 mA Sampler Input Interface 60-3704-075
Refrigerator Temperature Sensor with 5 ft (1.55 m) cable 68-6700-136
Internal three channel 4-20 mA programmable output. 60-9004-266
(Includes multi-analog output cable, 10 ft.)

E.13 SDI-12 Data Acquisition Connect Cables

Note: Y-connect cables can be combined with other Y-connect cables or SDI-12 adapter cables if multiple SDI-12 devices are to be connected.

Rain Gauge Y-Connect Cable 60-9004-294
(This cable allows connection of 2 of the following: rain gauge, SDI-12 adapter cable, SDI-12 Y-connect cable, I/O adapter, temperature sensor.)

YSI SDI-12 Adapter Cable. 60-9004-337
YSI SDI-12 Y-Connect Cable 60-9004-338
(This cable allows connection of a YSI SDI-12 sonde and a Teledyne Isco Rain Gauge.)

Hydrolab Quanta SDI-12 Adapter Cable 60-9004-339
Hydrolab Quanta SDI-12 Y-Connect Cable 60-9004-340
(This cable allows connection of a Hydrolab Quanta SDI-12 sonde and a Teledyne Isco Rain Gauge.)

SDI-12 Adapter Cable (6 foot length, no connector). 60-9004-341
(This is for use with a customer supplied connector to an SDI-12 device.)

SDI-12 Y-Connect Cable (6 foot length, no connector) 60-9004-342
(This is for use with a customer supplied connector to an SDI-12 device and a Teledyne Isco Rain Gauge.)

6712 Portable Sampler

Index

A

Accessories
- bulk discharge tubing, E-4
- bulk sets of bottles, E-3
- cables, E-5
- composite tube guide, E-4
- data collection accessories, E-5
- discharge tube, E-3
- distributor arm, E-4
- equipment suspension platform, E-4
- graduated cylinder, E-4
- power sources and battery chargers, E-5
- pump tube, E-4
- refrigerator temperature sensor, E-6
- strainers, E-4
- suction line, E-4
- suspension harness, E-4

acknowledge dialout alarm, 5-40
alarm acknowledgement, 5-40
alarms, 5-39
Alkaline battery
- battery warning, 8-13
- opening controller case, 8-11
- replacing, 8-13

Analog output, 5-41
analog output, 5-41

B

Backlighting, 5-30
Batteries, 2-9
Bottle kits
- collecting filled bottles, 2-17
- installing, 2-3

Bottle Number Signal, 5-31
Bottles-per-sample distribution, 4-6, 5-16

C

Cables
- External 12-Volt DC Power Connect Cable, 2-9
- Master/Slave-to-Flow-Meter Cable, 5-29

Calendar, 3-5
- setting clock and calendar, 3-6, 8-4

Calibration
- during a manual pause, 4-13
- sample volumes, 4-14

cleaning protocols, 8-2
Clock
- setting clock and calendar, 3-6, 8-4

Clock start-time menu, 3-6
Combined results report
- see Sampling reports

command responses, 5-45
commands, external, 5-44
Compatible Isco products, 1-4
Composite tube guide
- accessories list, E-4

Computer control, 7-1
- checksum validation, 7-8
- external program control, 7-4
- menu control, 7-2
- remote keypad, 7-8
- sampling reports, 7-3

Configuring reports, 4-20
Construction
- compact and standard sampler, 1-7

Continuous sampling, 2-17, 4-6, 5-17
Count Switched Distribution
- Sampler Enable, 5-23

D

Data collection accessories
- accessories list, E-5

data storage, 5-42
Desiccant
- opening controller case, 8-11

Diagnostic tests
- distributor test, 8-8

Diagnostics, 8-6
Dialout alarms, 5-39
dialout alarms, 5-39
Discharge tube
- accessories list, E-3

Display Backlighting, 5-30
Distribution, 4-6, 5-16
- bottles-per-sample distribution, 4-6, 5-16
- continuous sampling, 4-6, 5-17
- count-switched distribution, 5-16
- event pacing, 5-12
- multiple-bottle compositing, 5-16
- random-interval pacing, 5-15
- Samples per bottle, 4-6, 5-16
- sequential distribution, 4-6, 5-16
- time-switched distribution, 5-16

Distributor arm
- accessories list, E-4

Dual sampler mode, 5-29

E
Enable
see Sampler enable
Equipment suspension platform
accessories list, E-4
Error messages, 8-14
Event marks, 5-30
3-second pulse, 5-31
master/slave sampling, 5-29
timing diagram, 5-31
variable-duration pulse, 5-31
Event pacing, 5-12
Extended programming
extended programming features, 1-6
one-part and two-part programs, 5-1
showing extended screens, 4-1, 5-1
External 12-Volt DC Power Connect Cable, 2-9

F
Five gallon bottle base, 2-7
Flow pacing, 4-5
Flow proportional sample volumes, 5-19

G
Grab samples, 4-13, 4-15
Graduated cylinder
accessories list, E-4

H
hardware
analog output, 5-41
cellular modems, 5-40
dialout alarms, 5-39
I/O pin programming, 5-37
pager numbers, 5-40
rain gauge, 5-36
refrigerator temperature, 5-41
sonde, 5-36
Hardware set-up
master/slave sampling, 5-29
hardware setup, 5-36

I
I/O pin programming, 5-37
Installing
suction line, 2-13
Interrupting
interrupting a running program, 4-12
manual paused operation, 4-12

L
Line rinses, 5-12
Liquid detector enable/disable, 5-28
Locking the sampler, 2-16

M
Maintenance, 8-3
alkaline battery, 8-13
checklist, 8-8
cleaning guidelines, 8-1
cleaning protocols, 8-2
diagnostics, 8-6
maintenance programming screens, 8-3
opening controller case, 8-11
pump counts for pump tube warning, 8-8
pump tube, 8-8
pump tube alarm, 8-8
reinitializing, 8-8
Manual functions, 4-14
calibrate volume, 4-14
grab samples, 4-14
moving distributor, 4-18
running pump manually, 4-17
Manual paused operation, 4-12–4-14
Master/slave sampling, 5-29
event marks, 5-29
sampler enable, 5-29
Master/Slave-to-Flow-Meter Cable, 5-29
Materials
used in sampler construction, 1-7
Memory, 1-4
capacity, 1-2, 5-43
creating partitions, 5-42
partition sizes, 5-42
roll-over, 5-43
stored data will be lost!, 5-1
triggered, 5-43
memory, 5-42
Menu screens, 3-3
Modem, 7-9
Module summary report
see Sampling reports
Modules
700 Series Modules, 1-2
displayed readings, 4-11
Multiple-bottle compositing, 5-16

N
Nonuniform time pacing, 5-15

O
One-part programs, 5-1
Operating
running sampling programs, 4-10, 5-27
Other Functions
see Hardware setup, 4-14, 5-28
see Maintenance, 4-14, 5-28
see Manual functions, 4-14, 5-28
see Programming Style, 4-14, 5-28

P
Pacing, 4-5, 5-12

event pacing, 5-12
flow pacing, 4-5
nonuniform clock-time pacing, 5-15
nonuniform time pacing, 5-15
random-interval pacing, 5-15
time pacing, 4-5, 5-12
trigger pacing, 4-5
Partitions
creating, 5-42
Password Protected Functions, 5-35
Pause and resume, 5-27
Periodic serial output, 5-39
Power sources, 2-9
accessories list, E-5
Presample purge
event marks, 5-31
pressurized lines, 5-44
Program name menu
how to use, 3-7
Program settings report
see Sampling reports
Program storage
see Stored programs
Programming
changing program name, 3-8
changing site description, 3-8
clock and calendar, 3-5
extended programming features, 1-6
menu screens, 3-3
program name menu, 3-7
running programs, 4-10, 5-27
site description menu, 3-7
text entry, 3-7
Pump
running pump manually, 4-17
Pump Counts
pump tube warning, 8-8
Pump counts
purging a nonstandard suction line, 5-31
Pump tube
accessories list, E-4
replacing, 8-8
warning, 8-4
pump tube warning, 8-15

Q

Quick View Screens, 3-4
see Program Style

R

rain gauge setup, 5-36
Random-interval pacing, 5-15
Recovering the sampler, 2-17
refrigerator temperature, 5-41
Refrigerator temperature sensor, 5-41, E-6
Reinitialize controller
effects on stored programs, 8-8
Remote access
computer commands, 7-1
telephone commands, 7-9
Replacing internal alkaline battery, 8-13
Reports, 4-19
Resume, 5-27
Retries, 5-12
Rinses, 5-12
RS-232 communications, 7-1
Running programs, 4-10, 5-27

S

Sample volume
calibrating, 4-14
flow proportional, 5-19
measuring, 2-13
variable volume sampling, 5-19
Sampler enable, 4-9, 5-23
"dry period" option, 5-26
master/slave sampling, 5-29
repeatable enable, 5-25
sample at enable or disable, 5-25
start delay, 5-26
start times, 4-8
stay enabled, 5-25
Samples per bottle, 4-6, 5-16
Sampling programs
running programs, 4-10, 5-27
Sampling reports
Collecting reports, 4-19, 5-28
configuring, 4-20
sampling results report, 4-21
Viewing, 4-19
Sampling results report
see Sampling reports
Sampling retries, 5-12
Sequential distribution, 4-6, 5-16
Serial output, 5-39, 7-6
Servicing, 2-16
collecting filled bottles, 2-17
recovering the sampler, 2-17
service schedule, 2-17
Site description menu
how to use, 3-7
sonde setup, 5-36
Start times
clock start-time menu, 3-6
event pacing, 5-12
first valid day, 4-8, 5-27
sampler enable, 4-8
Stored data, 5-1
Stored programs, 5-2
effects of reinitializing controller to factory settings, 8-8
selecting a program, 5-2
Stormwater monitoring
Two-part programs, 5-2
Strainers
accessories list, E-4

selecting, 2-11
Suction head
auto suction head, 5-12
automatic determination, 5-12
manual (ENTER HEAD) settings, 5-12
variations in pump counts for fluctuating heads, 4-21
Suction line
accessories list, E-4
attaching to pump tube, 2-10
installing and routing, 2-13
measuring and cutting, 2-10
Suspension harness
accessories list, E-4
System IDs, 4-19

T

Telephone commands, 7-9
Text entry
numbers, 3-3
program names, 3-7
site descriptions, 3-7
text messaging, 5-40
Time pacing, 4-5, 5-12
Times and dates
entering times and dates, 3-5
Time-switched distribution, 5-16
pause and resume, 5-27
Trigger pacing, 4-5
Tube coupling
attaching suction line, 2-10
Two-part programs, 5-1
storm-water monitoring, 5-2

V

Variable volume sampling, 5-19
Variable-duration pulse, 5-31
event marks, 5-31
Voice modem, 7-9

W

warning messages, 8-15

Y

YSI 600
about the sonde, 1-2
displayed readings, 4-11

产品中有毒有害物质或元素的名称及含量

Name and amount of Hazardous Substances or Elements in the product

部件名称 Component Name	有毒有害物质或元素 Hazardous Substances or Elements					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr(VI))	多溴联苯 (PBB)	多溴二联苯 (PBDE)
线路板 Circuit Boards	X	O	O	O	O	O
显示 Display	X	O	O	O	O	O
接线 Wiring	O	O	O	O	X	O
内部电缆 Internal Cables	O	O	O	O	X	O
主电源线 Line Cord	O	O	O	O	X	O
直流电机 DC Motor	X	O	O	O	X	O
小键盘 Keypad	O	O	O	O	X	O
接头 Connectors	O	O	X	O	O	O

产品中有毒有害物质或元素的名称及含量：Name and amount of Hazardous Substances or Elements in the product

O: 表示该有毒有害物质在该部件所有均质材料中的含量均在ST/ 标准规定的限量要求以下。

O: Represent the concentration of the hazardous substance in this component's any homogeneous pieces is lower than the ST/ standard limitation.

X：表示该有毒有害物质至少在该部件的某一均质材料中的含量超出ST/ 标准规定的限量要求。

(企业可在此处，根据实际情况对上表中打"X" 的技术原因进行进一步说明。)

X: Represent the concentration of the hazardous substance in this component's at least one homogeneous piece is higher than the ST/ standard limitation.

(Manufacturer may give technical reasons to the "X"marks)

环保使用期由经验确定。

The Environmentally Friendly Use Period (EFUP) was determined through experience.

生产日期被编码在系列号码中。前三位数字为生产年(207 代表 2007 年) 。随后的一个字母代表月份：A 为一月，B 为二月，等等。

The date of Manufacture is in code within the serial number. The first three numbers are the year of manufacture (207 is year 2007) followed by a letter for the month. "A" is January, "B" is February and so on.

DECLARATION OF CONFORMITY

ISM1-A

Application of Council Directive:	89/336/EEC – The EMC Directive 73/23/EEC – The Low Voltage Directive
Manufacturer's Name:	Teledyne Isco, Inc.
Manufacturer's Address:	4700 Superior, Lincoln, Nebraska 68504 USA Mailing Address: P.O. Box 82531, Lincoln, NE 68501
Equipment Type/Environment:	Laboratory Equipment for Light Industrial/Commercial Environments
Trade Name/Model No:	6712 Sampler
Year of Issue:	2001
Standards to which Conformity is Declared:	EN 61326-1998 EMC Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use EN 61010-1 Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use

Standard	Description	Severity Applied	Performance Criteria
EN61000-4-2	Electrostatic Discharge	Level 2 - 4kV contact discharge Level 3 - 8kV air discharge	B B
EN61000-4-3	Radiated RF Immunity	80 MHz to 1000MHz 80% AM at 1kHz Level 1 – 10V/m	A
EN61000-4-4	Electrical Fast Transient	Level 2 - 2kV on ac lines	B
EN61000-4-5	Surge on AC Lines	2kV common mode, 1kV differential mode	B
EN61000-4-6	Conducted RF on AC lines	150 kHz to 80 MHz, 3V rms, 80% modulated	B
EN61000-4-11	Voltage Dips/Short Interruptions	0.5 cycle, each polarity/100%	B
CISPR11/ EN 55011	RF Emissions	Group 1, Class A Industrial, Scientific, and Medical Equipment	
EN61000-3-2, 3-3	Harmonic, Flicker		

We, the undersigned, hereby declare that the design of the equipment specified above conforms to the above Directive(s) and Standards as of March 6, 2001.

William Foster
USA Representative

TELEDYNE ISCO
A Teledyne Technologies Company

Williaml Foster
Director of Engineering
Teledyne Isco, Inc.
4700 Superior Street
Lincoln, Nebraska 68504

Phone: (402) 464-0231
Fax: (402) 464-4543

60-9002-068
Rev. A

DECLARATION OF CONFORMITY

ISM1-A

Application of Council Directive:	89/336/EEC – The EMC Directive 73/23/EEC – The Low Voltage Directive
Manufacturer's Name:	Teledyne Isco, Inc.
Manufacturer's Address:	4700 Superior, Lincoln, Nebraska 68504 USA Mailing Address: P.O. Box 82531, Lincoln, NE 68501
Equipment Type/Environment:	Laboratory Equipment for Light Industrial/Commercial Environments
Trade Name/Model No:	4200T Modem
Year of Issue:	2001
Standards to which Conformity is Declared:	EN 55024-1998 EMC Requirements for Information Technology Equipment EN 60950 Safety Requirements for Information Technology Equipment FCC Part 68

Standard	Description	Severity Applied	Performance Criteria
EN61000-4-2	Electrostatic Discharge	Level 2 - 4kV contact discharge Level 3 - 8kV air discharge	B B
EN61000-4-3	Radiated RF Immunity	80 MHz to 1000MHz 80% AM at 1kHz Level 1 – 10V/m	A
EN61000-4-4	Electrical Fast Transient	Level 2 - 2kV on ac lines	B
EN61000-4-5	Surge on AC Lines	2kV common mode, 1kV differential mode	B
EN61000-4-6	Conducted RF on AC lines	150 kHz to 80 MHz, 3V rms, 80% modulated	B
EN61000-4-11	Voltage Dips/Short Interruptions	0.5 cycle, each polarity/100%	B
EN 55022	RF Emissions	Group 1, Class A, Information Technology Equipment	
EN61000-3-2, 3-3	Harmonic, Flicker		

We, the undersigned, hereby declare that the design of the equipment specified above conforms to the above Directive(s) and Standards as of July 5, 2001.

William Foster
USA Representative

TELEDYNE ISCO
A Teledyne Technologies Company

William Foster
Director of Engineering
Teledyne Isco, Inc.
4700 Superior Street
Lincoln, Nebraska 68504

Phone: (402) 464-0231
Fax: (402) 464-4543

60-3212-049
Rev. A

*Teledyne Isco One Year Limited Factory Service Warranty **

Teledyne Isco warrants covered products against failure due to faulty parts or workmanship for a period of one year (365 days) from their shipping date, or from the date of installation by an authorized Teledyne Isco Service Engineer, as may be appropriate.

During the warranty period, repairs, replacements, and labor shall be provided at no charge. Teledyne Isco's liability is strictly limited to repair and/or replacement, at Teledyne Isco's sole discretion.

Failure of expendable items (e.g., charts, ribbon, tubing, lamps, glassware, seals, filters, fittings, and wetted parts of valves), or from normal wear, accident, misuse, corrosion, or lack of proper maintenance, is not covered. Teledyne Isco assumes no liability for any consequential damages.

This warranty does not cover loss, damage, or defects resulting from transportation between the customer's facility and the repair facility.

Teledyne Isco specifically disclaims any warranty of merchantability or fitness for a particular purpose.

This warranty applies only to products sold under the Teledyne Isco trademark and is made in lieu of any other warranty, written or expressed.

No items may be returned for warranty service without a return authorization number issued from Teledyne Isco.

The warrantor is Teledyne Isco, Inc.
4700 Superior, Lincoln, NE 68504, U.S.A.

*** This warranty applies to the USA and countries where Teledyne Isco Inc. does not have an authorized dealer. Custo mers in countries outside the USA, where Teledyne Isco has an authorized dealer, should contact their Teledyne Is co dealer for warranty service.**

In the event of instrument problems, always contact the Teledyne Isco Service Department, as problems can often be diagnosed and corrected without requiring an on-site visit. In the U.S.A., contact Teledyne Isco Service at the numbers listed below. International customers should contact their local Teledyne Isco agent or Teledyne Isco International Customer Service.

Return Authorization

A return authorization number must be issued prior to shipping. Following authorization, Teledyne Isco will pay for surface transportation (excluding packing/crating) both ways for 30 days from the beginning of the warranty period. After 30 days, expense for warranty shipments will be the responsibility of the customer.

Shipping Address: Teledyne Isco, Inc. - Attention Repair Service
4700 Superior Street
Lincoln NE 68504 USA

Mailing address: Teledyne Isco, Inc.
PO Box 82531
Lincoln NE 68501 USA

Phone: Technical Support (800)775-2965 (lab instruments)
(866)298-6174 (samplers & flow meters)
Sales & General Information: (800)228-4373 (USA & Canada)

Fax: (402) 465-3001

Email: iscoservice@teledyne.com **Web site:** www.isco.com

March 17, 2009 P/N 60-1002-040 Rev D

TELEDYNE ISCO
A Teledyne Technologies Company

750 Area Velocity Module

Installation and Operation Guide

TELEDYNE ISCO
A Teledyne Technologies Company

Part #60-9003-465
Copyright © 1996. All rights reserved, Teledyne Isco, Inc.
Revision K, September 18, 2009

Foreword

This instruction manual is designed to help you gain a thorough understanding of the operation of the equipment. Teledyne Isco recommends that you read this manual completely before placing the equipment in service.

Although Teledyne Isco designs reliability into all equipment, there is always the possibility of a malfunction. This manual may help in diagnosing and repairing the malfunction.

If the problem persists, call or e-mail the Teledyne Isco Technical Service Department for assistance. Simple difficulties can often be diagnosed over the phone.

If it is necessary to return the equipment to the factory for service, please follow the shipping instructions provided by the Customer Service Department, including the use of the **Return Authorization Number** specified. **Be sure to include a note describing the malfunction.** This will aid in the prompt repair and return of the equipment.

Teledyne Isco welcomes suggestions that would improve the information presented in this manual or enhance the operation of the equipment itself.

Teledyne Isco is continually improving its products and reserves the right to change product specifications, replacement parts, schematics, and instructions without notice.

Contact Information

Customer Service

Phone:	(800) 228-4373	(USA, Canada, Mexico)
	(402) 464-0231	(Outside North America)
Fax:	(402) 465-3022	
Email:	IscoCSR@teledyne.com	

Technical Support

Phone:	(800) 775-2965	(Analytical)
	(866) 298-6174	(Samplers and Flow Meters)
Email:	IscoService@teledyne.com	
Return equipment to:	4700 Superior Street, Lincoln, NE 68504-1398	

Other Correspondence

Mail to:	P.O. Box 82531, Lincoln, NE 68501-2531
Email:	IscoInfo@teledyne.com
Web site:	www.isco.com

Revised March 17, 2009

General Warnings

This product is often installed in confined spaces. Some examples of confined spaces are manholes, pipelines, digesters, and storage tanks. These spaces may become hazardous environments that can prove fatal for those unprepared. These spaces are governed by OSHA 1910.146 and require a permit before entering.

Hazard Severity Levels

This manual applies *Hazard Severity Levels* to the safety alerts, These three levels are described in the sample alerts below.

⚠ CAUTION

Cautions identify a potential hazard, which if not avoided, may result in minor or moderate injury. This category can also warn you of unsafe practices, or conditions that may cause property damage.

⚠ WARNING

Warnings identify a potentially hazardous condition, which if not avoided, could result in death or serious injury.

⚠ DANGER

DANGER – limited to the most extreme situations to identify an imminent hazard, which if not avoided, will result in death or serious injury.

Hazard Symbols

The equipment and this manual use symbols used to warn of hazards. The symbols are explained below.

Hazard Symbols	
Warnings and Cautions	
	The exclamation point within the triangle is a warning sign alerting you of important instructions in the instrument's technical reference manual.
	The lightning flash and arrowhead within the triangle is a warning sign alerting you of "dangerous voltage" inside the product.
	Pinch point. These symbols warn you that your fingers or hands will be seriously injured if you place them between the moving parts of the mechanism near these symbols.
Symboles de sécurité	
	Ce symbole signale l'existence d'instructions importantes relatives au produit dans ce manuel.
	Ce symbole signale la présence d'un danger d'électocution.
	Risque de pincement. Ces symboles vous avertit que les mains ou les doigts seront blessés sérieusement si vous les mettez entre les éléments en mouvement du mécanisme près de ces symboles
Warnungen und Vorsichtshinweise	
	Das Ausrufezeichen in Dreieck ist ein Warnzeichen, das Sie darauf aufmerksam macht, daß wichtige Anleitungen zu diesem Handbuch gehören.
	Der gepfeilte Blitz im Dreieck ist ein Warnzeichen, das Sei vor "gefährlichen Spannungen" im Inneren des Produkts warnt.
	Vorsicht Quetschgefahr! Dieses Symbol warnt vor einer unmittelbar drohenden Verletzungsgefahr für Finger und Hände, wenn diese zwischen die beweglichen Teile des gekennzeichneten Gerätes geraten.

750 Area Velocity Module

Table of Contents

Section 1 Introduction

1.1 Overview 1-1
1.2 Power Sources 1-2
1.3 Principles of Area/Velocity Flow Measurement. 1-2
1.3.1 Level Measurement 1-2
1.3.2 Velocity Measurement 1-2
1.3.3 Alternative Flow Measurement Systems 1-3
1.4 Technical Specifications 1-3

Section 2 Installation and Programming Basics

2.1 Installation Summary. 2-1
2.1.1 Installation Checklist 2-1
2.1.2 Installation Considerations 2-1
2.2 Rectangular and Trapezoidal Channels. 2-3
2.3 Mounting Rings for Circular Channels 2-3
2.3.1 Spring Rings 2-3
2.3.2 Scissors Rings 2-5
2.3.3 Completing the AV Sensor Installation 2-6
2.4 Programming Notes 2-7
2.4.1 Programmed Enable 2-7
2.5 Selecting a Site 2-7
2.6 Selecting a Flow Conversion Method. 2-12
2.6.1 Flow Conversion Without a Primary Device 2-12
2.6.2 Flow Conversion With a Primary Device 2-13
2.7 Measurements for Programming 2-13
2.8 Levels and Channel Dimensions 2-14
2.9 Offsets 2-15
2.10 Data Points 2-15
2.11 Minimum Depth for Velocity Measurements 2-16
2.12 Sampler Run Time Screens 2-17
2.13 Data Storage 2-17
2.13.1 Recovering Module Data 2-17

Section 3 Maintenance

3.1 Cleaning. 3-1
3.2 Cable Inspection 3-2
3.3 Desiccant Reactivation 3-2
3.4 Repair of the Module and Probe. 3-3
3.5 How to Get Help 3-3
3.6 Software Updates 3-3

Appendix A Replacement Parts and Accessories

A.1 Sensors A-1
A.2 Standard Spring Rings. A-1
A.3 Standard Scissors Rings. A-1

A.4 Street Level Installation System A-2
A.5 Miscellaneous A-2

Appendix B Material Safety Data Sheets

List of Figures

2-1 Isco Rectangular Mounting Plate 2-3
2-2 Sensor Installed on a Spring Ring 2-4
2-3 Scissors Ring Adjustment 2-6
2-4 6712 Programming: 750 Module Screens 2-9
2-5 6712 Programming: 750 Module Setup Screens 2-10
2-6 6712 Programming: 750 Module Quick View Screens 2-11
2-7 Ideal Conditions - Uniform Flow 2-14
2-8 Poor Conditions - Disturbed Flow 2-14
2-9 Offset Measurements 2-15
2-10 Determining Minimum Depth 2-17
2-11 Report: Program Settings 2-18
2-12 Summary Report (left) and Combined Results (right) 2-19

List of Tables

1-1 Technical Specifications for the 750 Area Velocity Module 1-3
1-2 Technical Specifications for the Standard AV Sensor 1-3
1-3 Technical Specifications for the Low Profile AV Sensor 1-5
2-1 Flow Conversion Methods 2-12

750 Area Velocity Module

Section 1 Introduction

1.1 Overview

The 750 Area Velocity Module is one of Teledyne Isco's interchangeable modules for the Avalanche and 6700 Series Samplers. The module enhances sampler operation by providing flow-pacing and additional sampler enable conditions. The sampler also displays the real-time level, velocity, flow rate, and total flow provided by the module. The sampler records this data for later analysis.

The area velocity (AV) sensor detects the average velocity of a liquid as it moves up or downstream. The sensor, equipped with an internal pressure transducer, also measures the level of the flow stream. Three AV sensor models are available:

- Standard range sensor – has a 25 ft (7.6 m) cable and a pressure transducer with a 10 ft (3.05 m) level measurement range.
- Extended range sensor – has a 50 ft (15.2 m) cable and a pressure transducer with a 30 ft (9.14 m) level measurement range.
- Low profile sensor – has a 25 ft (7.6 m) cable and a pressure transducer with a 10 ft (3.05 m) level measurement range. Its smaller size allows velocity measurements at very low liquid depths.

⚠ WARNING

The 750 module has not been approved for use in hazardous locations as defined by the National Electrical Code. Installation of this module in a hazardous location may cause fire or explosion, resulting in death, personal injury, or property damage. Before installing any device in a dangerous location, review safety precautions in your sampler manual. Check any applicable guidelines, codes, and regulations of federal, state, city, and county agencies.

1.2 Power Sources

We recommend using a Lead-Acid battery or a new 913 or 923 power pack when using the Model 750 Area Velocity Module. A nickel-cadmium battery may not be sufficient to finish a sample routine. For example, a nickel-cadmium battery should be expected to complete five sampling routines of 24 samples, each sample 200 ml, at one sample per hour with a 10 foot suction line and a 5 foot head. But if the routine is changed to flow-paced sampling or enabling the routine with a level, velocity, or flow rate condition, the battery capacity is significantly reduced.

1.3 Principles of Area/Velocity Flow Measurement

Area velocity flow conversion requires three measurements: level, velocity, and channel dimensions. The AV sensor provides the level and velocity measurements. You provide the third measurement, channel dimensions, during module programming.

The flow conversion is best represented as two steps. First, the module calculates the channel cross-section (or area) using the programmed channel dimensions and the level measurement. Next, the module multiplies the channel cross section and the velocity measurement to calculate the flow rate.

1.3.1 Level Measurement

The AV sensor's internal differential pressure transducer measures the liquid level. The transducer is a small piezo-resistive disk that detects the pressures transferred by a stainless steel diaphragm. The outer face of the diaphragm is exposed to the flow stream through the ports at the rear of the sensor. The inner face is exposed, or referenced, to the atmosphere through the internal vent tube that runs the full length of the sensor's cable. The difference between the pressures exerted on the diaphragm is the hydrostatic pressure. The transducer converts the hydrostatic pressure to analog signals. The signals are sent to the module.

Because pressure is proportional to the level of the stream, the module can convert the analog signal to a level measurement. The level measurement, in turn, is applied to the channel cross-section.

1.3.2 Velocity Measurement

The AV sensor measures average velocity by using ultrasonic sound waves and the Doppler effect. The Doppler effect states that the frequency of a sound wave (or other wave) passed from one body to another is relative to both their motions. As the two approach each other, the frequency increases; as they move apart, the frequency decreases.

The AV sensor contains a pair of ultrasonic transducers. One transducer transmits the ultrasonic sound wave. As the transmitted wave travels through the stream, bubbles and particles carried by the stream reflect the sound wave back towards the AV sensor. The second transducer receives the reflected wave.

The module compares the frequencies of the sound waves. An increase or decrease in the frequency of the reflected wave indicates forward or reverse flow. The degree of change is proportional to the average velocity of the flow stream.

1.3.3 Alternative Flow Measurement Systems

Because of the characteristics of area/velocity flow measurement, there may be some installations where this method is either unreliable or inaccurate. In these instances, it is worthwhile to consider using an alternate method of flow measurement.

In addition to the 750 Module, Teledyne Isco offers three other types of plug-and-play flow modules in the 700 Series: the 730 Bubbler Module, the 720 Submerged Probe Module, and the 710 Ultrasonic Module.

Information about these flow modules is available from the factory. Call for more information or visit our Web site at www.isco.com.

1.4 Technical Specifications

The following tables contain technical specification for the 750 module, both Standard Sensors, and the Low-Profile Sensor.

General notes:

- All weights may vary by ± 0.2 lb (0.1 kg).
- All lengths may vary by ± 0.25 inches (0.64 cm)

Table 1-1 Technical Specifications for the 750 Area Velocity Module

Weight	0.9 lbs (.4 kg)
Sensor Dimensions	4.9 × 5.7 × 2.0 inches (12.4 × 14.5 × 5.1 cm)
Material	Polystyrene
Operating Temperature	0° to 140°F (-18° to 60°C)
Storage Temperature	-40° to 140°F (-40° to 60°)
Enclosure Rating	NEMA 4X and 6, IP67
Power	9 to 14 VDC provided by the sampler
Memory	Nonvolatile ROM (Flash). Can be field updated through the sampler.
Level Resolution	0.002 ft (0.0006 m)
Velocity Resolution	0.024 ft/s (0.0073 m/s)
Velocity Accuracy	-5 to +5 ft/s: ± 0.1 ft/s (-1.5 + 1.5 m/s: ± 0.03 m/s) 2% of reading) (1.5 to 6.1 m/s: ±2% of reading)
Readings	Programmable through the sampler at 1, 2, 5, 10, 15, and 30 minute intervals. All readings are stored in the sampler.

Table 1-2 Technical Specifications for the Standard AV Sensor

Weight Standard Range Extended Range	2.1 lbs (.96 kg) 3.9 lbs (1.8 kg)
Sensor Dimensions	Length: 6.6 inches (6.8 cm) Width: 1.6 inches (4.1 cm) Height: 1.2 inches (3.0 cm)
Nose Angle	35° from horizontal

Table 1-2 Technical Specifications for the Standard AV Sensor (Continued)	
Cable Length Standard Range Extended Range	25 ft (7.6 m) 50 ft (15.2 m)
Materials	Sensor: Polybutadiene-based polyurethane, stainless-steel Cable: Polyvinyl chloride (PVC) chlorinated polyvinyl chloride (CPVC)
Operating Temperature	32° to 160°F (0° to 71°C)
Level Measurement Method	Submerged pressure transducer mounted in the flow stream
Transducer Type	Differential linear integrated circuit pressure transducer
Level Measurement Range Standard Range Extended Range	 0.05 to 10.0 ft (0.015 to 3.05 m) 0.05 to 30.0 ft (0.015 to 9.14 m)
Maximum Allowable level Standard Range Extended Range	 20 ft (6.1 m) 40 ft (12.2 m)
Level Measurement Accuracy Standard Range Extended Range	 0.033 to 5.0 ft: ± 0.008 ft/ft (0.01 to 1.52 m: ± 0.008 m/m) >5.0 ft: ± 0.012 ft/ft (>1.52 m: ± 0.012 m/m) 0.05 to 15.0 ft: ± 0.03 ft (0.015 to 4.57 m: ± 0.009 m) 0.05 to 21.0 ft: ± 0.09 ft (0.015 to 6.40 m: ± 0.027 m) 0.05 to 30.0 ft: ± 0.30 ft (0.015 to 9.14 m: ± 0.090 m) @77°F (25°C). Includes non-linearity, repeatability, and hysteresis. Does not include temperature coefficient.
Compensated Temperature Range	32° to 100°F (0° to 38°C)
Temperature Coefficient Standard Range Extended Range	 0.05 to 4.0 ft: ± 0.005 ft/°F (0.015 to 1.22 m: ± 0.0027 m/°C) 4.0 to 10.0 ft: ± 0.007 ft/°F (1.22 to 3.05 m: ± 0.0038 m/°C) 0.05 to 30.0 ft: ± 0.008 ft/°F (0.015 to 9.14 m: ± 0.0044 m/°C) Maximum error over compensated temperature range, per degree of temperature change.
Velocity Measurement Method	Doppler Ultrasonic
Frequency	500 kHz
Typical minimum depth for velocity measurement	0.25 ft (75 mm)
Range	-5 to +20 ft/s (-1.5 to +6.1 m/s)

Table 1-3 Technical Specifications for the Low Profile AV Sensor	
Weight	2.1 lbs (.95 kg) including cable and connector
Sensor Dimensions	Length: 6.00 inches (15.2 cm) Width: 1.31 inches (3.3 cm) Height: 0.75 inches (1.9 cm)
Nose Angle	110° from horizontal
Wetted Sensor Material	Epoxy, chlorinated polyvinyl chloride (CPVC), Stainless-steel
Cable Material	Polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC)
Cable Length	25 ft (7.6 m)
Maximum Distance (between sensor and module)	75 ft (22.8 m) with optional extension cables. The distance can be extended up to 1000 ft (300 m) with the optional Quick Disconnect Box.
Operating Temperature	32° to 122°F (0° to 50°C)
Storage Temperature	-40° to 160°F (-40° to 71°)
Level Measurement Range	0.033 to 10.0 ft (0.01 to 3.05 m)
Maximum Allowable level	20 ft (6.1 m)
Level Measurement Accuracy	0.033 to 5.0 ft: ± 0.008 ft/ft (0.01 to 1.52 m: ± 0.008 m/m) >5.0 ft: ± 0.012 ft/ft (>1.52 m: ±0.012 m/m) Accuracy per foot of change from calibrated depth @77°F (25°C). Includes non-linearity and hysteresis.
Temperature Coefficient	±0.0023 ft/°F (±0.0013 m/°C) Maximum error within operating temperature range at zero pressure (per degree of change from calibration temperature).
Maximum Long-term Drift	0.033 ft (±0.010 m)
Velocity Measurement Method	Doppler Ultrasonic
Frequency	500 kHz
Transmission Angle	20° from horizontal
Typical minimum depth for velocity measurement	0.8 ft (25 mm)
Range	-5 to +20 ft/s (-1.5 to +6.1 m/s)
Velocity Accuracy	-5 to +5 ft/s (-1.5 to +1.5 m/s): ± 0.1 ft/s (±0.03 m/s) 5 to 20 ft/s (1.5 to 6.1 m/s): 2% of reading Velocity accuracy for a uniform velocity profile in water with a speed-of-sound of 4850 ft/s.

750 Area Velocity Module

Section 2 Installation and Programming Basics

The 750 can be used in a wide range of applications. In the "Flow Meter" mode of operation, the module will produce sound results if you properly choose an installation site, select an appropriate flow conversion method, and program the module with accurate measurements. Guidelines for each are discussed in the following sections.

If you plan to use the "Level Only" mode of operation, the section Selecting a Flow Conversion Method does not apply.

2.1 Installation Summary

To install the module:

1. Turn the sampler off.
2. Remove the connector cap in the module bay and move it aside.
3. Slide the module into the bay.
4. Push against the module so the connector is fully seated.

To remove the module, turn the sampler off. Press the silver spring button and pull the module from the bay. Replace the connector cap in the module bay.

2.1.1 Installation Checklist

1. Check the desiccant cartridge. Make sure the desiccant is active (blue or yellow in color) and ***remove the red cap***.
2. Install the module and turn the sampler on.
3. Install the AV sensor in the channel.
4. Connect the AV sensor cable to the module.
5. Program the sampler and calibrate the module's level reading.
6. Set up the sampler. See details in the sampler manual.
7. Run the program.

2.1.2 Installation Considerations

⚠ CAUTION

Mounting hardware may have sharp edges. Cuts and abrasions are possible. Injuries from hardware contaminated by sewage may also become infected. To avoid these hazards:

- Wear leather gloves when handling the hardware.
- Clean the mounting hardware between installations.

⚠ CAUTION

Tests have shown that the 750 Module is affected by RF radiation such as that from radio and TV station towers that are located nearby. If sporadic changes in water level occur as indicated on the sampler's display, the instrument will have to be relocated. Walkie talkies or cell phones must not be operated within 3 meters (10 feet) of the instrument for the same reason.

- Abusive handling will damage the sensor. Although the sensor will survive normal handling and installation, treat the sensor with reasonable care. The internal components cannot be repaired.
- There is a vent tube inside the cable which must remain open. Do not kink the cable or overtighten the plastic ties while securing the cable.
- Install the Standard and Extended Range AV Sensors in flow streams where the liquid covers the sensor. These sensors detect levels above approximately 0.05 foot (0.6 inch or 15 mm) and velocities in streams with a minimum depth of 2 to 4 inches (50-100 mm).
- Install the Low Profile AV Sensors in streams where the liquid covers the sensor. Low Profile Sensors detect levels above approximately 0.033 feet (0.4 inch or 1.0 cm) and typically can measure velocities in streams as low as 0.08 ft (25 mm). Streams that run consistently below 1 inch are not a good application for the 750 and sensor.
- Velocity measurements depend on the presence of some particles in the stream; either air bubbles or suspended solids. If the stream lacks these particles, it may be necessary to aerate the water upstream from the sensor.
- You can install the sensor above the bottom of the flow stream or along the side of the channel, if the sensor will be continually submerged. The module can be calibrated to measure level with the sensor at nearly any depth. The sensor cannot, of course, measure a liquid level that falls below its position in the flow stream. Installing the sensor above the bottom has several advantages:
  - It avoids heavy concentrations of silt, sand, or other solids.
  - It aids installation in narrow or hard-to-reach locations.
  - It maximizes level resolution over a specific level range.
  - It can avoid obstructions in the flow stream.
- When the sensor is installed above the bottom of the channel, a "Zero Level Offset" must be entered during

programming. For more information, refer to Section 2.9, Offsets.

- Route and secure the sensor cable so that it does not collect debris or disturb the flow.
- You may use Teledyne Isco's vented 25 foot (7.6 m) extension cables to locate the sensor at greater distances from the sampler. You can combine vented extension cables, as long as the total cable length does not exceed 75 feet (22.8 m).

To locate the sensor more than 75 feet from the sampler and module, use the Area Velocity Sensor Quick Disconnect Box. The disconnect box increases the maximum distance between the module and the sensor to 1,000 feet (305 m).

2.2 Rectangular and Trapezoidal Channels

A flat, anchored mounting plate is a common mounting choice for installing sensors in rectangular or trapezoidal channels. See the *Isco Mounting Rings Installation and Operation Guide* for more information.

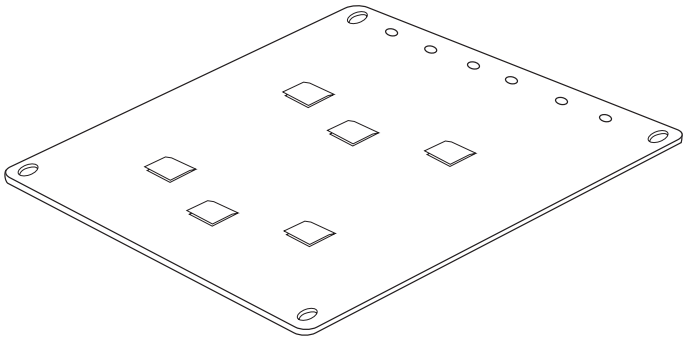


Figure 2-1 Isco Rectangular Mounting Plate

2.3 Mounting Rings for Circular Channels

Consult your Isco Mounting Rings Installation and Operation Guide for detailed hardware information.

The following sections describe sensor installation using the two options available for mounting the Sensor in pipes or round-bottomed flow streams. For pipes up to 15" (38.1 cm) in diameter, **stainless steel self-expanding mounting rings** (**Spring Rings**) are available. For pipes larger than 15" in diameter, Teledyne Isco offers the **Scissor Rings (Universal Mounting Rings)**. Area velocity sensors can also be installed using primary measuring devices.

2.3.1 Spring Rings

To install a spring ring, you compress the ring, slip it inside the pipe, and then allow it to spring out to contact the inside diameter of the pipe. The inherent outward spring force of the ring firmly secures it in place. A typical self-expanding mounting ring (with a probe mounted on it) is shown in Figure 2-2.

These mounting rings are available for use in pipes with inside diameters of 6" (15.2 cm), 8" (20.3 cm), 10" (25.4 cm), 12" (30.5 cm), and 15" (38.1 cm). The Teledyne Isco part numbers for the

various size mounting rings available are listed in Appendix B. These part numbers include not only the ring, but also the miscellaneous hardware necessary to mount the sensor on the ring.

⚠ CAUTION

Always wear leather gloves when handling the rings (either type). The metal is finished, but there is still a possibility of cutting your hands on the edges.

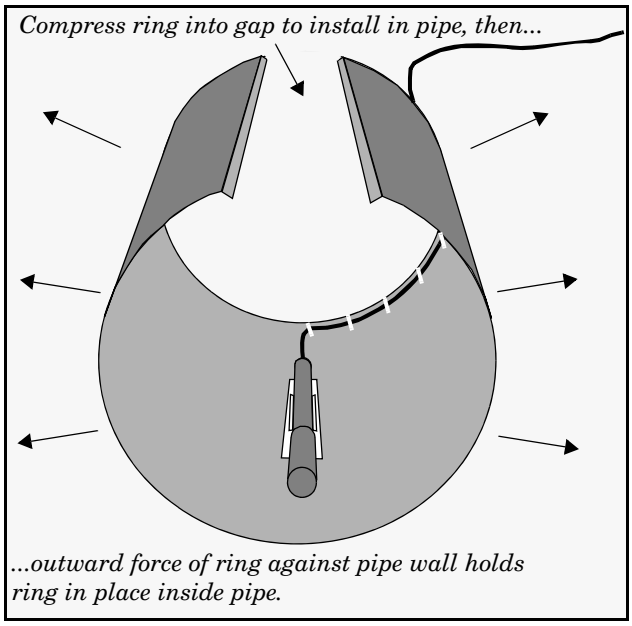


Figure 2-2 Sensor Installed on a Spring Ring

⚠ CAUTION

Make sure the slots on the sensor are completely pressed onto the tabs on the ring. This is particularly important where there is any possibility of reverse flows, or where flows are of high velocity. If the sensor is not fully pressed onto the mounting ring tabs, it might come loose in the stream, and could possibly be damaged or lost.

Completing the assembly

To complete the sensor-spring ring assembly procedure, attach the sensor cable to the downstream edge of the ring. Follow the cable routing shown in Figure 2-2. Other routing directions may affect measurement accuracy. The cable can actually create a stilling well downstream from the sensor, causing the level to read low. Use the self-locking plastic ties supplied with the ring. Install the ring in the pipe by compressing it. Press inward on both sides and slide the ring into the pipe.

Route the sensor cable out of the stream and secure it in position by placing the ties through the holes in the mounting ring and then locking them around the cable, as shown. To prevent debris from catching on the cable, it is important to attach the cable to the mounting ring so it offers as little resistance to the flow as possible.

⚠ CAUTION

Make sure the sensor cable is securely fastened along the back (downstream) edge of the ring. Otherwise, the sensor may provide **inaccurate level readings** under conditions of high velocity.
Do not overtighten the plastic cable ties; they should be tightened just enough to secure the cable in place, without greatly indenting the cable. Overtightening the plastic ties may collapse the reference tube in the cable, blocking it.

The spring ring may need anchoring. Under conditions of high velocity (greater than 5 feet per second or 1.5 meters per second), the ring may not have sufficient outward spring force to maintain a tight fit inside the pipe. The ring may start to lift off the bottom of the pipe in a waving fashion, or may even be carried downstream.

This problem is more prevalent in the larger diameter pipes (10", 12", and 15", and in pipes with smooth inside surfaces, such as plastic pipes). If any of these conditions are present, or if movement of the mounting ring is detected or suspected, you must anchor the ring in place. You can do this by setting screws through the ring into the pipe, or by other appropriate means. If there is a problem with the smaller diameter rings, it may be sufficient to simply increase the outward spring force of the ring by bending it into a less round configuration.

2.3.2 Scissors Rings

For pipes larger than 15" in diameter, Teledyne Isco offers the adjustable Scissors Ring (also known as the Universal Mounting Ring). This device consists of two or more metal strips that lock together with tabs to form a single assembly. There is a base section where the sensors are mounted, one or more extension sections (usually), and a scissors section at the top that expands the entire assembly and tightens it inside the pipe. The scissors mechanism includes a long screw that increases the width as it is tightened.

The assembled rings fit pipe diameters from 16" to 80". Secure the unit in place by tightening the scissors mechanism with a 5/8" socket wrench or other suitable tool. Ring sections are .040" thick half-hard 301 stainless steel sheet. All other parts are also stainless steel, except for the plastic cable ties in the hardware kit.

Each extension, 1, 2, 3, and 4, adds 9.0", 21.5", 31.5", or 41.5", respectively, to the circumference of the ring. Used alone, the base section fits pipe that is approximately 16" to 18" in diameter. The 9.0" (the smallest) extension exists so that in larger pipe sizes, where large variations in circumference can occur, you can use one or two of these extensions to take up or remove slack, to bring the scissors mechanism into a position where it can be effectively tightened.

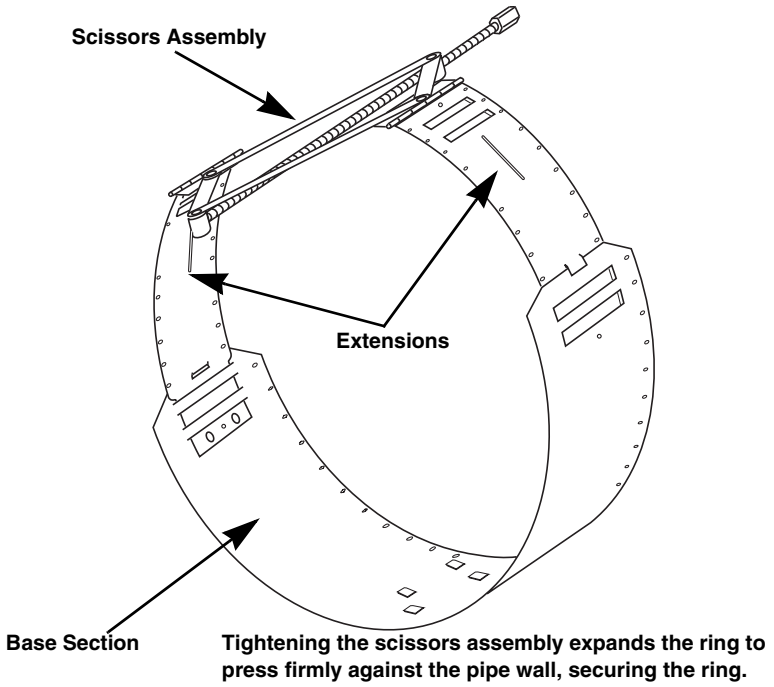


Figure 2-3 Scissors Ring Adjustment

Mounting ring kits are available for different pipe sizes. A kit is also available for partial pipe applications (consult your *Isco Mounting Rings Installation and Operation Guide*). For a listing of part numbers and ordering information, see Appendix A.

2.3.3 Completing the AV Sensor Installation

The AV sensor installation is finished by coiling any excess sensor cable and securing it using cable clamps or other means. The reference tube inside the cable can be restricted or blocked if the cable is kinked, sharply bent, or otherwise pinched. The sensor cable should be handled and mounted with care. Also, if there is any appreciable distance between the point where the sensor cable leaves the mounting apparatus and the location of the flow meter, *be sure* to attach the cable to the flow stream wall to prevent it from vibrating, moving around, tangling, or possibly collecting debris.

⚠ CAUTION

Under no circumstances should you leave any extra length of sensor cable dangling freely in the flow stream where it could trap debris or become tangled.

Use gloves and eye protection when assembling and installing the rings in a pipe. Though deburred, the edges of the stainless steel can cut if improperly handled. *Please read the information on how best to install this device.*

Observe general safety procedures when entering any manhole. See "General Safety Procedures" in the back of the manual for more information on general hazards and necessary precautions.

2.4 Programming Notes

You must install the module before turning the controller on. When the controller is turned on, it looks for a module. The controller will not recognize a newly installed module if it is not seen during this power-up routine. If you install a module while the controller is already on, turn the controller off and then on again to reconfigure the controller for use with the module.

When the controller is configured with the module, it adds the necessary screens for programming. The screens appear in Figures 2-4 through 2-6. These figures outline the steps for module programming and calibration. For 6712 programming and general programming information, see the sampler manual.

2.4.1 Programmed Enable

When the 750 is installed, additional sampler enable options are available. If programmed for LEVEL ONLY, the additional options are LEVEL and VELOCITY. If programmed for FLOW METER, the additional options are LEVEL, VELOCITY, and FLOW. For more information about programmed enables, see the sampler manual.

2.5 Selecting a Site

The 750 is designed to measure flow in open channels without a primary device. A primary device is a hydraulic structure, such as a weir or a flume, that modifies a channel so there is a known relationship between the liquid level and the flow rate.

The area velocity module's use is not limited to channels without a primary device. The software also supports installations where you must install the sensor with a primary device.

☑ *Note*

Primary devices limit the usefulness of the area velocity sensor's readings. In most cases, levels and velocities near these devices do not represent what normally occurs in the channel. If you must use area velocity flow conversion, or if your interest is the stream's velocity, do not install the sensor near a primary device. Move the sensor away to where the flow is unaffected.

When the sensor is installed without a primary device, find a section of channel with a minimum of disturbances to the flow. Avoid areas with elbows, outfalls, inverts, junctions, etc., that create turbulence near the AV sensor. The sensor should be located away from these disturbances to a point where the flow has stabilized. For best results, install the sensor where the flow is most uniform. Uniform flow is a condition where the water surface is parallel to the bottom of the channel.

If the sensor is installed in a primary measuring device, its location depends on the type of primary device. Most primary devices have a specific place for the head (level) measurement device. For more details about the location of the head measuring point, refer to the *Isco Open Channel Flow Measurement Handbook*, or to information provided by the manufacturer of the primary device.

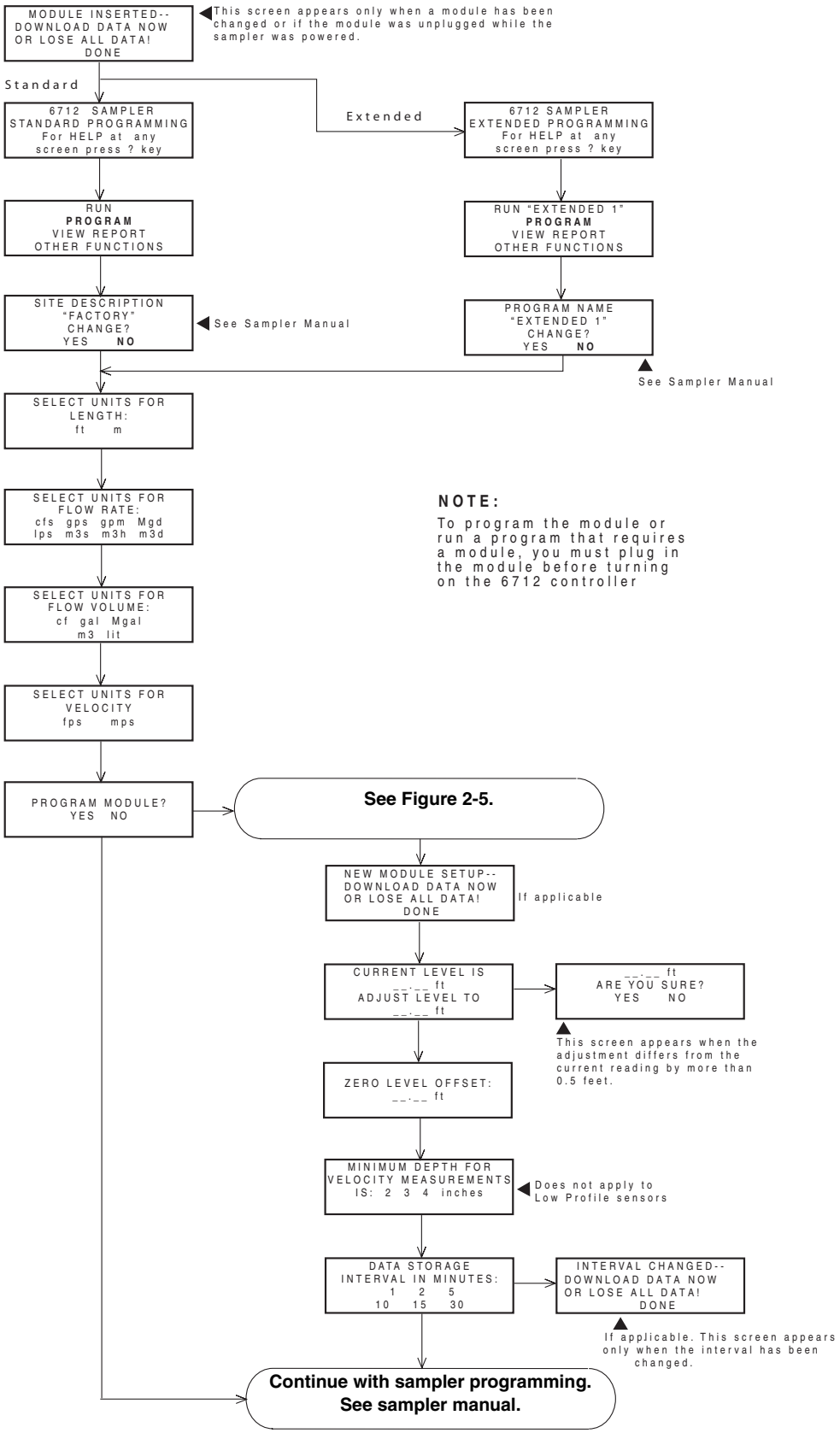


Figure 2-4 6712 Programming: 750 Module Screens

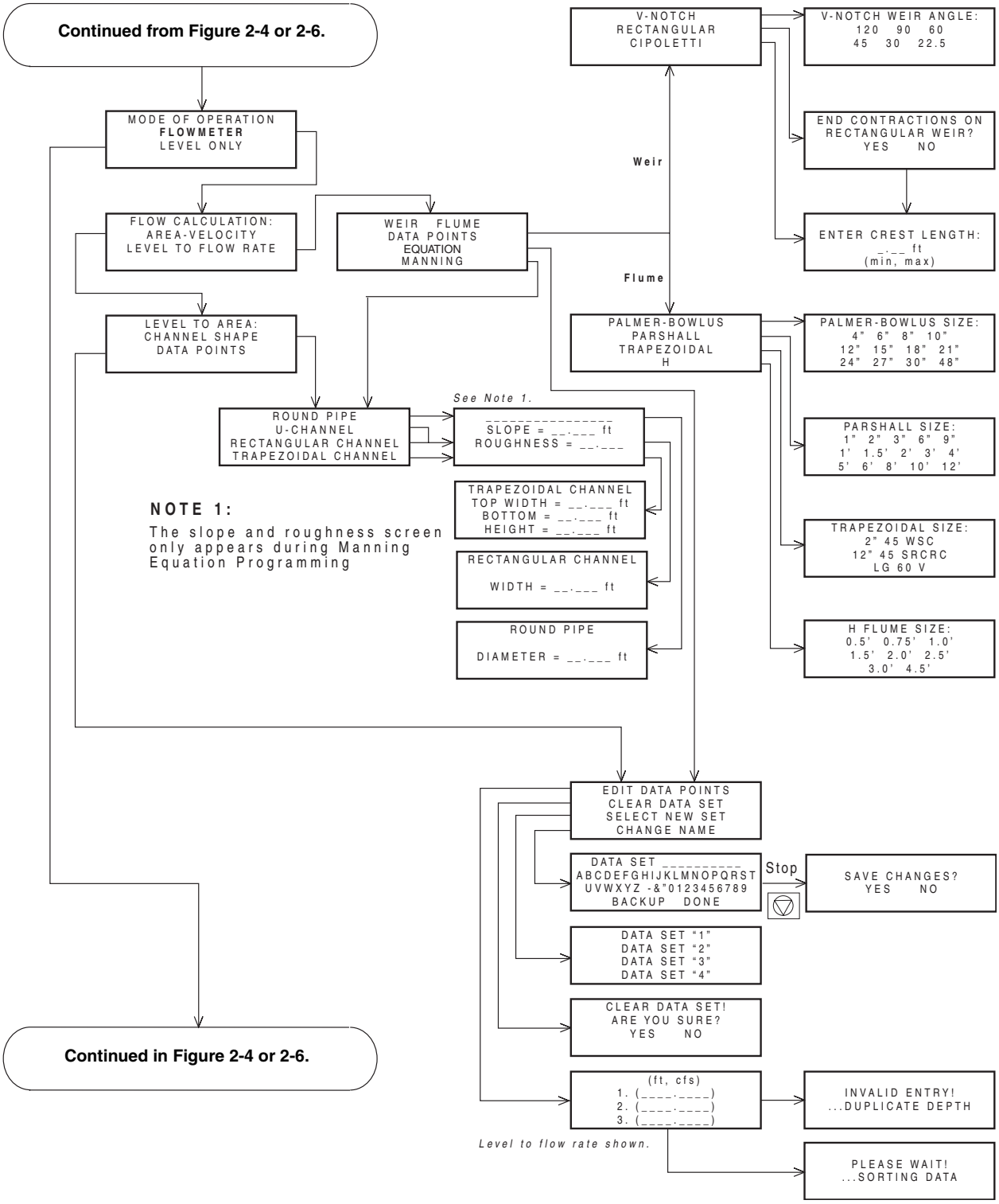
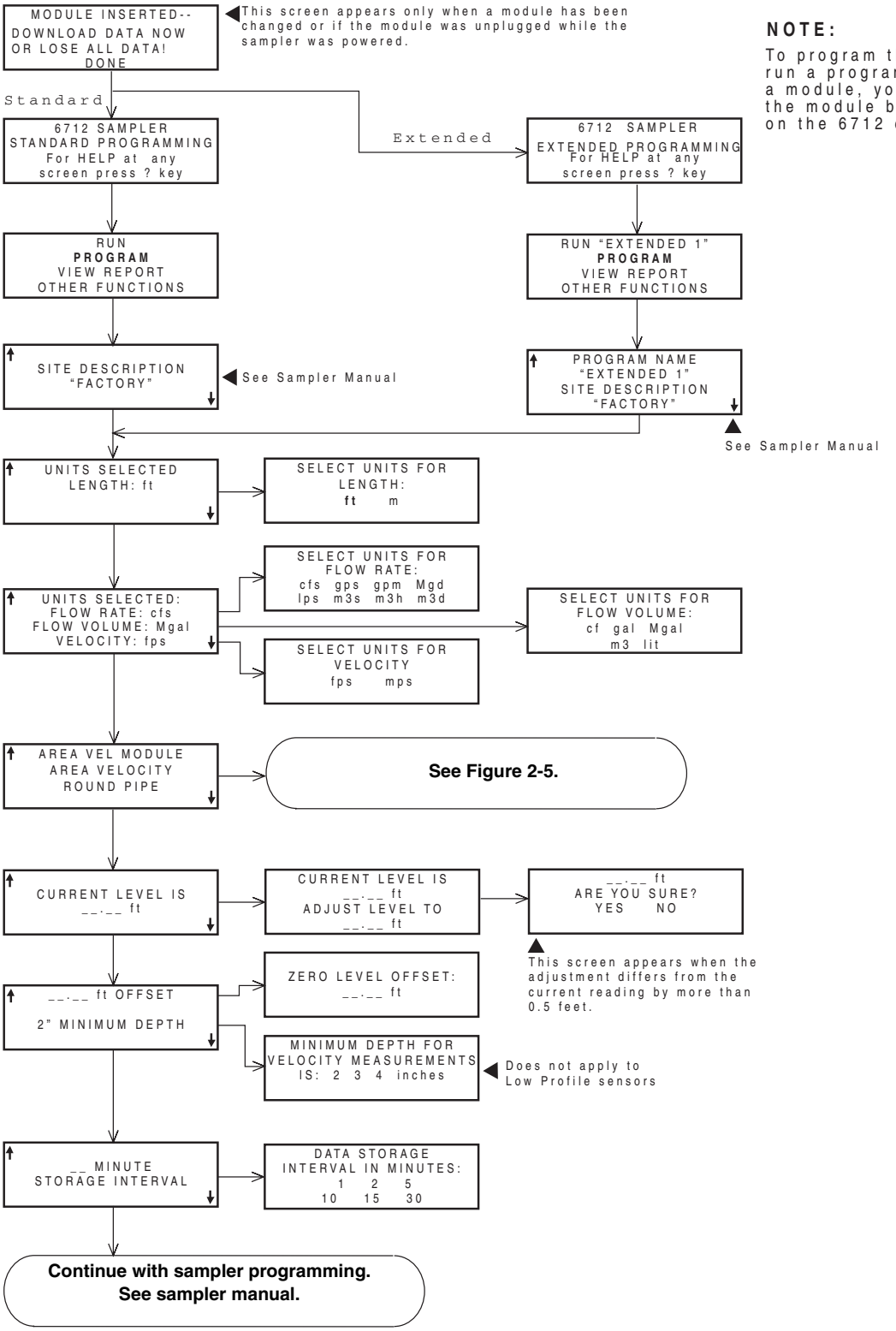


Figure 2-5 6712 Programming: 750 Module Setup Screens



NOTE:
To program the module or run a program that requires a module, you must plug in the module before turning on the 6712 controller

Figure 2-6 6712 Programming: 750 Module Quick View Screens

2.6 Selecting a Flow Conversion Method

The 750 is capable of determining flow rates using either area velocity conversion or level-to-flow rate conversion. A list of available flow conversions appears in Table 2-1, Flow Conversion Methods.

Table 2-1 Flow Conversion Methods

Conversion Type		Device, Formula, or Table	Size or Parameters
Area-Velocity	Channel Shape	Area × Velocity	Round Pipe, U-Channel, Rectangular, Trapezoidal
	Level-to-Area Data Points	User-developed Table	3 to 50 data points
Level to Flow	Weir	V-Notch Weir	22.5, 30, 45, 60, 90, 120 degrees
		Rectangular Weir with end contractions	Crest Length
		Rectangular Weir without end contractions	Crest Length
		Cipoletti Weir	Crest Length
	Flume	Palmer-Bowlus Flume	4, 6, 8, 10, 12, 15, 18, 21, 24, 27, 30, 48 inches
		Parshall Flume	1, 2, 3, 6, 9 inches 1, 1.5, 2, 3, 4, 5, 6, 8, 10, 12 feet
		Trapezoidal Flume	Large 60-degree V 2-inch, 45-degree WSC 12-inch, 45-degree SRCRC
		"H" Flume	0.5, 0.75, 1, 1.5, 2, 2.5, 3, 4.5 feet
	Equation	$Q = a \times H^{b+c} \times H^{d}$	Q = flow H = head a, b, c, & d = entered values
	Level-to-Flow Rate Data Points	User-developed tables for level-to-flow rate	3 to 50 data points
	Manning Equation	Round Pipe	Slope, Roughness, Diameter
		U-Channel Pipe	Slope, Roughness, Width
		Rectangular Pipe	Slope, Roughness, Width
		Trapezoidal	Slope, Roughness, Bottom Width, Top Width

2.6.1 Flow Conversion Without a Primary Device

There are several conversion options if you install the sensor in a channel without a primary device. The method you choose depends on the channel shape or the amount of information available to define the channel's characteristics.

Area velocity flow conversion is the method of choice for round pipe, U-channel, rectangular, and trapezoidal channels. Non-standard channels can still use area velocity flow conversion, but

you must provide at least three level-to-area data points. The data points define the cross-sectional area of the channel at various levels.

2.6.2 Flow Conversion With a Primary Device

The software supports level-to-flow conversion for many common weirs and flumes. Refer to Table 2-1. If your primary device is not listed, use a level-to-flow rate data set. A data set requires at least three data points to specify the level-to-flow rate relationship of your device. This information is normally available from the manufacturer of the primary device.

The software also supports level-to-flow conversion using the Manning formula. To use the Manning formula you must be able to provide the channel slope, a roughness coefficient, and a channel diameter or width. For more information on the Manning formula, refer to the *Isco Open Channel Flow Measurement Handbook*.

2.7 Measurements for Programming

At a minimum, module programming requires a level measurement and a zero level offset. The standard and extended range AV Sensors will also require a minimum depth for velocity measurement. Depending on the selected flow conversion method, you may also need to enter channel dimensions or data points.

The accuracy of the values you enter during programming directly affect your flow conversion results. These values can include the level adjustment, channel dimension measurements, zero level offset, and data points. All subsequent module calculations will be based upon these values.

Significant errors may be introduced if your measurements are inaccurate. We recommend that you take actual measurements from the installation site - do not use nominal values. The example below illustrates the importance of accurate measurements.

Example:

Nominal Pipe Diameter: 10 inches

Actual Pipe Diameter: 10.25 inches

Level Measured Near Outfall: 2.75 inches

Correct Level Measurement: 3 inches

During programming, you enter 10 inches for the round pipe diameter - from the pipe manufacturer's specification. You also enter the 2 3/4-inch level measurement taken behind the sensor near an outfall. Although each value has only a 1/4-inch error, the cumulative flow measurement error may exceed 14%!

2.8 Levels and Channel Dimensions

Channel dimensions and level measurements can vary at different points along the channel. It is important to use measurements from the same point that the AV sensor reads the velocity and level. An ultrasonic sound wave is transmitted in a cone-shaped pattern from the front of the sensor. Your level measurement should be taken at a point inside the ultrasonic cone. Since this cone cannot be seen, a general rule is to measure in front of the sensor along the channel centerline at a distance equal to the liquid depth. For example, if the stream is one foot deep, take the level and channel dimension measurements one foot upstream from the sensor. If the flow at this point is turbulent, consider relocating the sensor.

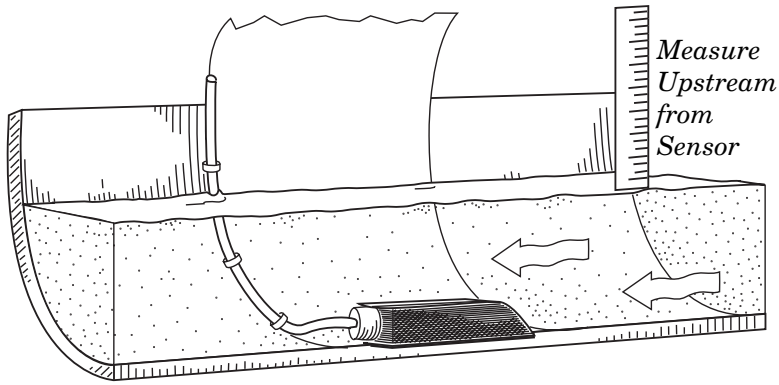


Figure 2-7 Ideal Conditions - Uniform Flow

Do not measure the level and channel dimensions right at the sensor, as the sensor and the mounting ring may cause a slight "jump" or localized rise in the level. At very low levels and high velocities, this jump in the liquid surface may become quite significant. Figure 2-8 shows very poor area velocity measurement conditions. The outfall is drawing down the liquid level and the sensor is disturbing the flow. In this example, the sensor should be moved forward to avoid the drawdown near the outfall. If the jump still exists, average several level measurements or measure the level with the sensor and mounting hardware out of the stream.

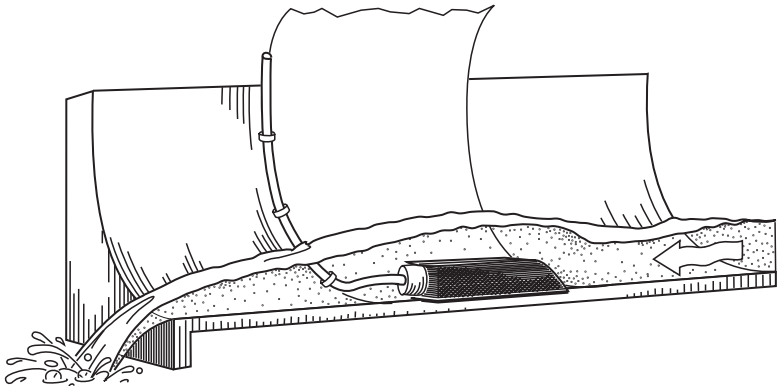
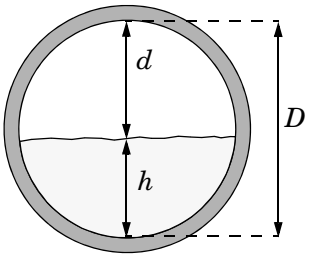


Figure 2-8 Poor Conditions - Disturbed Flow



Level (h) = D – d

In round pipes it is possible to measure the level without disturbing the stream surface. This method is preferred. Refer to the diagram in the margin. First measure the inside diameter of the pipe (D). Then measure the airspace (d) from the liquid surface to the peak of the inside diameter. Average this measurement if the surface is not calm. The level measurement that you enter (h) is calculated by subtracting the distance above the liquid (d) from the diameter (D).

2.9 Offsets

Sensors are sometimes offset to avoid heavy concentrations of silt, or to maximize the level resolution over a specific range. During module programming, you enter an offset measurement. Refer to Figure 2-9. Enter a value for the vertical distance the sensor is installed above the true zero level of the stream. For example, if the sensor is mounted on the side of the pipe one foot higher than the true zero level (the bottom center of the pipe), the Zero Level Offset is one foot. If the sensor is mounted at the bottom of the channel, enter zero.

Note

Do not confuse the circumferential distance between true zero and the location of the AV sensor with the vertical distance (height). If you install the AV sensor at the true zero level of the pipe or channel, you would enter “0” for the offset (ignoring the thickness of the mounting ring).

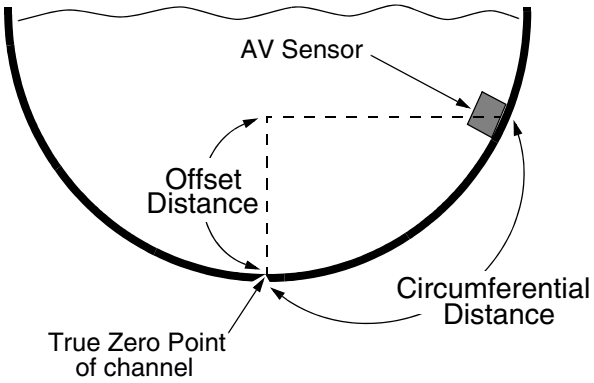


Figure 2-9 Offset Measurements

2.10 Data Points

Data point flow conversion is based on a set of user entered values that define the channel or primary device. A data set is a table of correlating level-to-area or level-to-flow rate data points. The module can interpolate areas or flow rates for all levels using this data set.

The sampler saves up to four different data sets. Each data set holds a minimum of 3 points and a maximum of 50.

The flow conversion accuracy increases with the number of points entered. Keep in mind that you are defining the entire channel shape mathematically; select points that best represent any curves or variations. Compound shapes will need many data points.

The module automatically calculates the maximum head and the flow rate at maximum head. The maximum head is 1.2 times the highest data point entered. For example, the module would calculate a 0.96-foot maximum head if the highest data point was 0.8 feet. The module extrapolates the flow rate at maximum head using the flow curve established by your data set.

To use **Level-to-Area** data points, you must enter at least three data points. Each data point entry contains two values – a level and the cross-sectional area of the channel at that level.

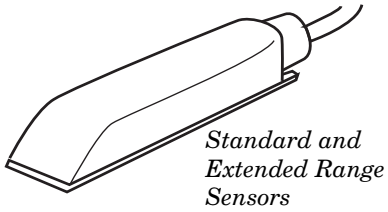
To use **Level-to-Flow** data points, you must enter at least three data points. Each data point entry contains two values – a level and the corresponding flow rate for that level.

Data point entries must use the same units of measure programmed for the sampler's length and flow rate units.

2.11 Minimum Depth for Velocity Measurements

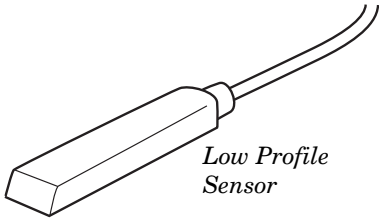
The Minimum Depth is the minimum level of liquid above the bottom of the sensor that is required to obtain a valid velocity reading. The depth varies with the velocity of the flow stream; in the same stream at higher velocities, the depth is greater. Velocity readings taken at too-shallow levels may be inaccurate.

The Minimum Depth setting allows you to program the level below which the module will stop taking velocity readings. When the water level falls below Minimum Depth, the 6712 will display the most recent valid velocity reading, followed by an asterisk (*), and the flow rate will be shown as "0". The asterisk means the velocity information has not been updated; it will disappear when the water rises above Minimum Depth and the module begins to take new readings.



Standard and Extended Range Sensors

Standard Velocity Sensors – Three selections are available for the Minimum Depth for Standard 10-foot and 30-foot range velocity probes: 2, 3, or 4 inches (50, 75, or 100 mm). In most installations, the 3-inch setting will be the optimum selection. You can use the 2-inch option when the channel produces flows of very low velocity. If, after examining the velocity data, you see a sharp decrease in velocity as the level readings approach Minimum Depth, increase the setting to 3 or 4 inches.



Low Profile Sensor

Low Profile Velocity Sensors – For Low Profile probes, the 6712 does not have a menu selection for Minimum Depth. Instead, the Minimum Depth is automatically set to 1 inch.

Probe Identification – When a probe is first connected, the 750 module will not know whether it is a Standard or Low-Profile until it takes a velocity reading. Since the 6712 only retrieves the module status (including probe type) at start-up, it will have to be re-started in order to display the correct probe information.

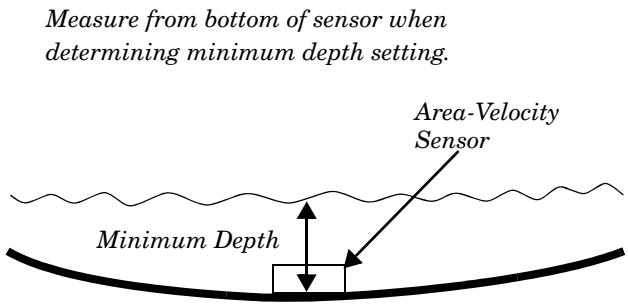


Figure 2-10 Determining Minimum Depth

2.12 Sampler Run Time Screens

```
BOTTLE 2
AFTER 702.1 cf
1.251 cfs     0.82 ft
00000002898 cf
```

```
BOTTLE 2
AFTER 700.8 cf

2.32 fps     0.82 ft
```

```
BOTTLE 2
AFTER 699.6 cf
SIGNAL STRENGTH: 85%
SPECTRUM: 63%
```

While running a sampling program, the sampler displays a variety of messages reporting the program's status. The 750 adds measurement and diagnostic information to these displays. Measurement information includes level, velocity, flow rate, and total flow. The spectrum and signal strength readings are diagnostic aids to help determine if the sensor is operating properly. Percentages near 100 indicate a strong, clear return signal. If both readings are zero, the sensor may not be plugged in, operating, or receiving a signal. Low signal strength or spectrum readings can indicate problems with the sensor, installation, or the characteristics of the flow stream.

The signal strength percentage represents the approximate strength of the return signal. Percentages from 10 to 90 are normal, and percentages from 50 to 90 are typical for sewers. Return signals below 10 percent are weak and the module may have difficulty measuring the stream velocity.

The spectrum percentage represents the approximate amount of noise in the return signal. The typical range of readings for most installations is from 40 to 90 percent. Percentages below 25 indicate a noisy return signal.

2.13 Data Storage

When the sampler is configured for use with the module, a memory partition is reserved. The module readings are stored in this sampler memory partition. For more information on data storage and partition management, see the sampler manual.

2.13.1 Recovering Module Data

The stored module data can be collected or viewed as "reports." Three of the sampler reports contain module information. Refer to the 6712 Sampler Instruction Manual for details on collecting and reading the reports.

Module data is compatible with Flowlink® 3 or 4 software. Flowlink provides additional data reporting options. See the Flowlink Instruction Manual for more information.

Note

An * (asterisk) appears next to the reading if the module was unable to take a reading. If an asterisk appears, the reading displayed is the last available reading.

```
SAMPLER ID# 2215220899  08:55 22-FEB-03
*********** PROGRAM SETTINGS ***********
     ----------

 SITE DESCRIPTION:
    "FACTORY   "

     ----------
   UNITS SELECTED:
     LENGTH: ft


     ----------
   UNITS SELECTED:
   FLOW RATE: cfs
 FLOW VOLUME: Mgal
   VELOCITY: fps
     ----------
  AREA-VEL MODULE:
   AREA*VELOCITY
     ROUND PIPE

     ----------
   0.000 ft OFFSET

  3" MINIMUM DEPTH

     ----------

      1 MINUTE
   DATA INTERVAL

     ----------
  24,  1000 ml BTLS

 10 ft SUCTION LINE

     ----------
      PACING:
    FLOW, EVERY
     0.075 Mgal

     ----------
    DISTRIBUTION:
     SEQUENTIAL

   200 ml SAMPLES
     ----------

 NO DELAY TO START

  RUN PROGRAM ONCE
```

Figure 2-11 Report: Program Settings

```
 SAMPLER ID# 2215220899  08:56 22-FEB-03

AREA-VEL MODULE: 1365
   SITE: FACTORY

  Summary Report for 21-FEB-03 (FR )

         Day's Flow:     003.930582 Mgal
      Average Flow Rate:      19.46 cfs
20:06 Minimum Flow Rate:      2.456 cfs
20:10 Maximum Flow Rate:      33.16 cfs

       Hourly Average Flow Rate
      00:00-01:00:       NO DATA
      01:00-02:00:       NO DATA
      02:00-03:00:       NO DATA
      03:00-04:00:       NO DATA
      04:00-05:00:       NO DATA
      05:00-06:00:       NO DATA
      06:00-07:00:       NO DATA
      07:00-08:00:       NO DATA
      08:00-09:00:       NO DATA
      09:00-10:00:       NO DATA
      10:00-11:00:       NO DATA
      11:00-12:00:       NO DATA
      12:00-13:00:       NO DATA
      13:00-14:00:       NO DATA
      14:00-15:00:       NO DATA
      15:00-16:00:       NO DATA
      16:00-17:00:     19.57 cfs
      17:00-18:00:     19.58 cfs
      18:00-19:00:     19.58 cfs
      19:00-20:00:     19.58 cfs
      20:00-21:00:     19.32 cfs
      21:00-22:00:     19.30 cfs
      22:00-23:00:     19.40 cfs
      23:00-24:00:     19.38 cfs

            *---+---+---+---+---+---+*
     19.60  +                       +
            I                       I
            I                 ###   I
            I                ####   I
            I                ####   I
     19.55  +                ####   +
            I                ####   I
            I                ####   I
            I                ####   I
            I                ####   I
     19.50  +                ####   +
            I                ####   I
            I                ####   I
            I                ####   I
            I                ####   I
     19.45  +                ####   +
            I                ####   I
            I                ####   I
            I                ####   I
            I                ####   I
     19.40  +                ####  # +
            I                ####  # I
            I                ####  ##I
            I                ####  ##I
            I                ####  ##I
     19.35  +                ####  ##+
            I                ####  ##I
            I                ####  ##I
            I                ##### ##I
            I                ##### ##I
     19.30  +                ########+
            *---+---+---+---+---+---+*
Hour Ending:       08:     16:     24:
            Units are 'cfs'
```

```
SAMPLER ID# 2215220899  08:56 22-FEB-03
 AREA-VEL MODULE: 1365
*********** COMBINED RESULTS ***********
   SITE: FACTORY
Program Started at 16:36 FR  21-FEB-03
Nominal Sample Volume =  200 ml
```

SAMPLE	BOTTLE	TIME	FLOW RATE cfs	TOTAL FLOW Mgal
1	1	16:44	35.34	000.075006
1	2	16:53	28.27	000.149821
1	3	17:02	21.20	000.224477
1	4	17:09	35.34	000.299454
1	5	17:19	35.34	000.374269
1	6	17:28	28.27	000.448872
1	7	17:36	10.01	000.523683
1	8	17:44	35.34	000.598452
1	9	17:53	28.27	000.673267
1	10	18:02	21.20	000.748082
1	11	18:10	2.062	000.822872
1	12	18:19	35.34	000.897662
1	13	18:28	28.27	000.972477
1	14	18:37	21.20	001.047398
1	15	18:44	35.34	001.122110
1	16	18:54	35.34	001.197002
1	17	19:03	28.27	001.271764
1	18	19:11	10.01	001.346536
1	19	19:19	35.34	001.421397
1	20	19:28	28.27	001.496106
1	21	19:37	21.20	001.570922
1	22	19:45	2.062	001.645719
1	23	19:54	35.34	001.720660
1	24	20:03	28.27	001.795369

Figure 2-12 Summary Report (left) and Combined Results (right)

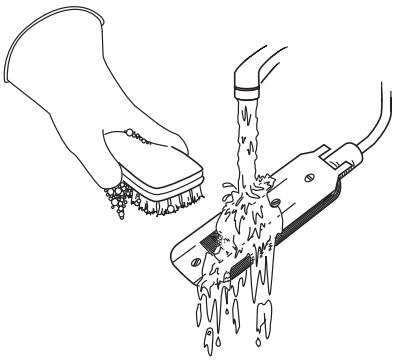
750 Area Velocity Module

Section 3 Maintenance

The area velocity sensor and cable require little maintenance. Because the sensor body offers a streamlined profile to the flow, solid materials rarely collect on the sensor. However, clean the channel up- and downstream from the sensor periodically. This maintains the hydrostatic conditions on which the level-to-area conversion is based.

3.1 Cleaning

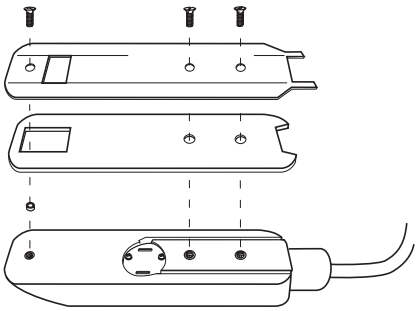
If the flow stream carries a great deal of debris, beware of organic materials that may collect inside the sensor. This material swells as it becomes saturated with water and may exert pressure on the transducer diaphragm inside the sensor. This can damage the diaphragm and permanently disable the sensor.



If the liquid ports in the sensor become blocked, clean the sensor. Cleaning the sensor not only protects t from damage, but assures you that the sensor will respond to the hydrostatic pressure above the sensor instead of the pressure created by swollen material inside.

1. Remove the sensor from its mounting ring or strap.
2. Scrape any accumulated solids off the exterior of the sensor. Use a brush and flowing water.

If the ports are thoroughly blocked or if you need to clean the sensor for storage, continue with steps 3 through 6 for standard and extended range sensors, 5 and 6 for low profile sensors.



3. Remove the mounting plate by unscrewing the three screws that hold the plate in place.
4. Carefully pull the mounting plate and urethane foam gasket away from the sensor.
5. Gently flush the sensor with water to remove any solid materials.
6. The pressure transducer is behind the small, round plate on the bottom of the sensor. *Gently* flush the transducer cavity with water to remove debris. *Do not remove the disk protecting the pressure transducer.*

3.2 Cable Inspection

Periodically inspect the sensor cable and connector for wear caused by abuse or exposure to the elements. A damaged cable can affect the operation of the sensor, particularly if the reference port vent tube inside the cable is collapsed or blocked. In some cases, a damaged connector can be replaced, but damaged cables cannot be spliced or repaired.

⚠ CAUTION

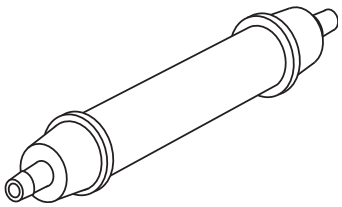
Do not allow the connector end of the probe cable to fall into water, or leave it disconnected without the plastic cap in place. Failure to do so can result in permanent internal water damage to both probe and module.

If the sensor cable is damaged, you must replace the entire assembly, as the sensor, cable, and connector are a factory-sealed unit. Keep the connector clean and dry. In permanent installations, install the cable so that it is not at risk of damage resulting form other activity taking place in the area.

In temporary installations, do not leave cables lying around where they may be run over by heavy equipment. Do not leave extra cable loose in the flow stream where it can trap debris.

In permanent installations, cables repeatedly subjected to abuse will fail and should be installed in conduit for protection. The conduit must be large enough to pass the connector, as you cannot remove or replace it.

3.3 Desiccant Reactivation



Desiccant Cartridge

There is a cartridge on the side of the module to dry the reference air. It contains a silica gel desiccant with a color indicator that changes from blue to pink, or yellow to green, when saturated. Pink or green desiccant cannot remove moisture and must be replaced or reactivated.

⚠ CAUTION

Desiccant may produce irritating fumes when heated. Observe the following precautions:
Use a vented oven in a well-ventilated room.
Do not remain in the room while the regeneration is taking place.
Use the recommended temperature. Avoid heating the desiccant at higher than recommended temperatures.

There have been reports of irritating fumes coming from the desiccant during reactivation. While our efforts to duplicate the problem have been unsuccessful, we still urge you to use caution. Material Safety Data Sheets are in the back of this manual.

To reactivate the desiccant, pour it out of the cartridge into a heat-resistant container. Never heat the plastic cartridge. Heat the silica gel in a vented convection oven at 212° to 350° F (100° to 175° C) for two to three hours, or until the blue or yellow color

returns. Allow the desiccant to cool and then refill the cartridge. The desiccant's ability to remove moisture may lessen with each saturation/reactivation cycle, resulting in a need for more frequent service. After several cycles, the desiccant may no longer be effective as it saturates too quickly. At this point, replace the desiccant.

The foam filters in the end caps keep small pieces of desiccant from falling out of the cartridge. When they become soiled, wash with dish soap and water, then allow to dry.

Note

A saturated desiccator will let moisture into the reference tube. The moisture may block the tube and cause reading errors and internal damage. Also, the air in many installations contains fumes that will form acids in the presence of moisture. These acids may corrode internal components.

3.4 Repair of the Module and Probe

The module has no user-serviceable parts. Its case is completely sealed to protect the internal components. To repair the unit, the case must be broken open and replaced.

The velocity sensor's pressure transducer, the ultrasonic transducers, cable, and the electronic components are encapsulated in plastic resin and are not user-serviceable.

If you think your module or probe requires repair, contact Teledyne Isco's Customer Service Department at 800-228-4373 for information on returning it to the factory.

3.5 How to Get Help

If you need help or have repair questions, contact Teledyne Isco's Technical Service department.

Teledyne Isco Technical Service Department

P.O. Box 82531
Lincoln, Nebraska, 68501 (USA)
E-mail: IscoService@teledyne.com
Telephone: (402) 464-0231
Toll Free: 866-298-6174 (Within USA, Canada, and Mexico)
FAX: (402) 464-3001

3.6 Software Updates

The module has Flash memory to store its software. With Flash technology, you can upgrade your module's software without sending it back to the factory or replacing a chip. To update the module software, install the module in a 6712 sampler. Then connect the sampler power source and turn the sampler on. Connect your computer to the sampler using the Computer Connect Cable (Interrogator Cable) and start the program Update Isco Instrument Software.

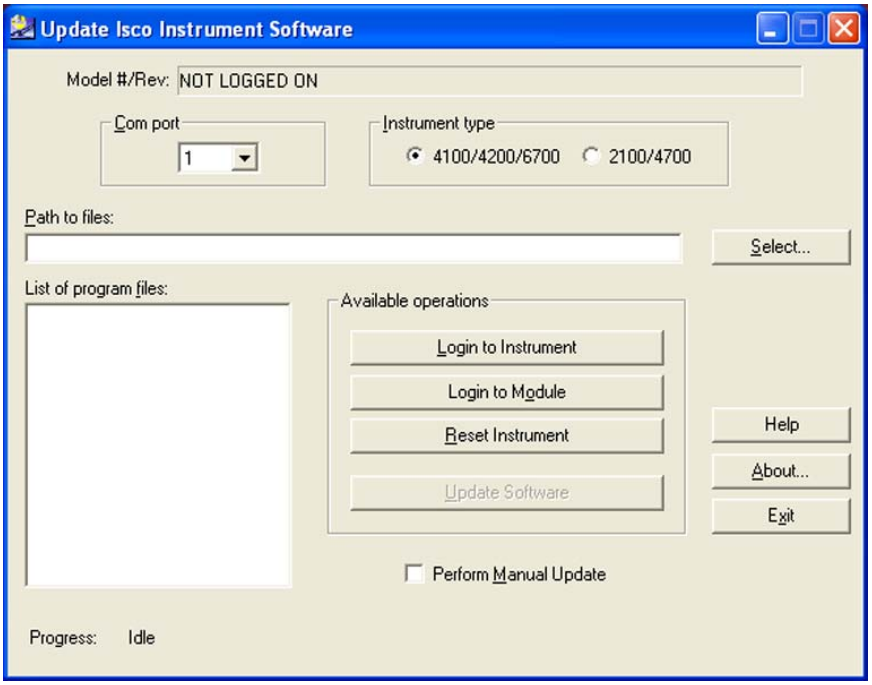


Figure 3-1 Open the software update program

Click the Help button and follow the steps listed under Update Instrument Software. Do not disturb the connection or stop the update while the file transfer is taking place. When the transfer is complete, the program displays an “Operation successful” message. Click OK and close the program.

750 Area Velocity Module

Appendix A Replacement Parts and Accessories

The following appendix contains the most commonly ordered parts and accessories for the 750 module, including part descriptions and order numbers.

Accessories can be purchased by contacting Teledyne Isco's Customer Service Department.

Teledyne Isco, Inc.
Customer Service Department
P.O. Box 82531
Lincoln, NE 68501 USA

Phone: (800) 228-4373
(402) 464-0231
FAX: (402) 465-3022

E-mail: IscoInfo@teledyne.com

A.1 Sensors

AV Sensor 10' range (with 25' cable) 60-3254-001
AV Sensor 30' range (with 50' cable) 60-3254-003
Low Profile AV Sensor 10' range (with 25' cable) 60-3254-021

A.2 Standard Spring Rings

Spring Ring - 6" Dia 68-3200-007
Spring Ring - 8" Dia 68-3200-008
Spring Ring - 10" Dia 68-3200-009
Spring Ring - 12" Dia 68-3200-010
Spring Ring - 15" Dia 68-3200-011
(Each spring ring includes plastic ties to fasten the cable)

A.3 Standard Scissors Rings

Scissors Ring for 16-23" Pipe 68-3000-042
Scissors Ring for 16-36" Pipe 68-3000-043
Scissors Ring for 39-43" Pipe 68-3000-044
Scissors Ring for 45-49" Pipe 68-3000-045
Scissors Ring for 58 to 63" Pipe 68-3000-046
Scissors Ring for 72" Pipe 68-3000-047
Scissors Ring for 16-80" Pipe 68-3000-048
(Each scissors ring includes a base section, scissors mechanism, extensions, plastic ties, and instructions)
Base Section (with plastic ties & instructions) 60-3004-169

A.4 Street Level Installation System

Multi-section Pole. 60-3204-012
(Includes instruction manual. To complete your system, you must also order a Street Level Mounting Ring)
Street Level Mounting Ring for 6" dia. pipe. 60-3204-014
Street Level Mounting Ring for 8" dia. pipe. 60-3204-015
Street Level Mounting Ring for 10" dia. pipe. 60-3204-016
Street Level Mounting Ring for 12" dia. pipe. 60-3204-017
Street Level Mounting Ring for 15" dia. pipe. 60-3204-018

A.5 Miscellaneous

Sensor Mounting Plate 68-3000-051
(Includes plastic ties and instructions)
L.P. AV sensor carrier 60-3204-029
(adapter to fit the low profile sensor on standard size rings)
Desiccant Cartridge Assy 60-9004-105
Area velocity sensor extension cable. 60-3254-005
Quick Disconnect Box 60-3254-004
Isco Open Channel Flow Measurement Handbook 60-3003-041

750 Area Velocity Module

Appendix B Material Safety Data Sheets

This appendix to the manual provides Material Safety Data Sheets for the desiccant used by the 750 Area Velocity Module.

Teledyne Isco cannot guarantee the accuracy of the data. Specific questions regarding the use and handling of the products should be directed to the manufacturer listed on the MSDS.

Material Safety Data Sheet

Indicating Silica Gel

Identity (Trade Name as Used on Label)

Manufacturer :	MULTISORB TECHNOLOGIES, INC. (formerly Multiform Desiccants, Inc.)	MSDS Number* :	M75
Address:	325 Harlem Road Buffalo, NY 14224	CAS Number* :	
Phone Number (For Information):	716/824-8900	Date Prepared:	July 6, 2000
Emergency Phone Number:	716/824-8900	Prepared By* :	G.E. McKedy

Section 1 - Material Identification and Information

Components - Chemical Name & Common Names (Hazardous Components 1% or greater; Carcinogens 0.1% or greater)	%*	OSHA PEL	ACGIH TLV	OTHER LIMITS RECOMMENDED
Silica Gel SiO_2	98.0	6mg/m^3 (total dust)	10mg/m^3 (total dust)	
Cobalt Chloride	>2.0	0.05mg/m^3 (TWA cobalt metal dust & fume)	.05mg/m^3 (Cobalt, TWA)	
Non-Hazardous Ingredients				
TOTAL	100			

Section 2 - Physical/Chemical Characteristics

Boiling Point	N/A	Specific Gravity (H_20 = 1)	2.1
Vapor Pressure (mm Hg and Temperature	N/A	Melting Point	N/A
Vapor Density (Air =1)	N/A	Evaporation Rate (_____=1)	N/A
Solubility in Water	Insoluble, but will adsorb moisture.	Water Reactive	Not reactive, but will adsorb moisture.
Appearance and Odor	Purple crystals, no odor.		

Section 3 - Fire and Explosion Hazard Data

Flash Point and Methods Used	N/A	Auto-Ignition Temperature	N/A	Flammability Limits in Air % by Volume	N/A	LEL	UEL
Extinguisher Media	Dry chemical, carbon dioxide and foam can be used.						
Special Fire Fighting Procedures	Water will generate heat due to the silica gel which will adsorb water and liberate heat.						
Unusual Fire and Explosion Hazards	When exposed to water, the silica gel can get hot enough to reach the boiling point of water. Flooding with water will reduce the temperature to safe limits.						

Section 4 - Reactivity Hazard Data

STABILITY ☐**Stable** ☐**Unstable**	Conditions To Avoid	Moisture and high humidity environments.
Incompatibility (Materials to Avoid)	Water.	
Hazardous Decomposition Products	Carbon dioxide, carbon monoxide, water	
HAZARDOUS POLYMERIZATION ☐May Occur	Conditions To Avoid	None.

*Optional

Indicating Silica Gel

Page 2

Section 5 - Health Hazard Data

PRIMARY ROUTES OF ENTRY	☐Inhalation ☐Skin Absorption	☐Ingestion ☐Not Hazardous	**CARCINOGEN LISTED IN**	☐NTP ☐IARC Monograph	☐OSHA ☐Not Listed
HEALTH HAZARDS	Acute	May cause eye, skin and mucous membrane irritation.			
	Chronic	Prolonged inhalation may cause lung damage.			
Signs and Symptoms of Exposure	Drying and irritation.				
Medical Conditions Generally Aggravated by Exposure	Asthma.				
EMERGENCY FIRST AID PROCEDURES - Seek medical assistance for further treatment, observation and support if necessary.					
Eye Contact	Flush with water for at least 15 minutes.				
Skin Contact	Wash affected area with soap and water.				
Inhalation	Remove affected person to fresh air.				
Ingestion	Drink at least 2 glasses of water.				

Section 6 - Control and Protective Measures

Respiratory Protection (Specify Type)	Use NIOSH approved dust mask or respirator.		
Protective Gloves	Light cotton gloves.	Eye Protection	Safety glasses.
VENTILATION TO BE USED	☐ Local Exhaust	☐Mechanical (General)	☐Special
	☐Other (Specify)		
Other Protective Clothing and Equipment	None.		
Hygienic Work Practices	Avoid raising dust. Avoid contact with skin, eyes and clothing.		

Section 7 - Precautions for Safe Handling and Use/Leak Procedures

Steps to be Taken if Material Is Spilled Or Released	Sweep or vacuum up and place the spilled material in a waste disposal container. Avoid raising dust.
Waste Disposal Methods	Dispose in an approved landfill according to federal, state and local regulations.
Precautions to be Taken In Handling and Storage	Cover promptly to avoid blowing dust. Wash after handling.
Other Precautions and/or Special Hazards	Keep in sealed containers away from moisture. The silica gel will readily adsorb moisture.

*Optional Indicating Silica Gel

MATERIAL SAFETY DATA SHEET

Effective Date March 8, 2005
MSDS Number M163

Section 1 – Product and Company Information

Product Name: **Silica gel, indicating, yellow**

Product Use: Desiccant, absorbent
Grades: Silica gel, indicating
Synonyms: Amorphous silica gel, SiO_2, silicon dioxide (amorphous)

Company; Multisorb Technologies, Inc.
Street Address: 325 Harlem Road
City, State, Zip, Country: Buffalo, NY 14224-1893 USA

Telephone Number: (716) 824 8900 [USA] Monday - Friday (8:00 - 5:00 EDT)
Fax Number: (716) 824 4091 [USA]
Website / E-Mail : multisorb.com

Section 2 – Composition / Information on Ingredients

Component Name	CAS Number	% by Weight
Synthetic amorphous silica gel (SiO_2)	112926-00-8	100
Phenolphthalein	77-09-08	100 ppm

While this material is not classified, this MSDS contains valuable information critical to the safe handling and proper use of this product. This MSDS should be retained and available for employees and other users of this product.

Section 3 – Hazard Identification

Emergency Overview: A yellow bead or granular material that poses little or no immediate hazard. This material is not combustible.

Potential Health Effects:
Eyes: Dust and or product may cause eye discomfort and irritation seen as tearing and reddening.

Skin: The product dust may cause drying of the skin. Silica gel may get hot enough to burn skin when it adsorbs moisture rapidly. Use an excess of water to cool the silica gel.

Ingestion: Material is not toxic and will pass through the body normally.

Inhalation: Slight irritation is possible but none is expected.

Medical Effects Generally Aggravated by Exposure: Respiratory ailments.

Chronic Effects/Carcinogenity: May cause eye, skin and mucous membrane irritation and drying.

Section 4 – First Aid Measures

Eyes: Rinse the eyes well with water while lifting the eye lids. If irritation persists, consult a physician.

Skin: Wash affected area with soap and water.

Ingestion: Ingestion is unlikely, this material will pass through the body normally.

Inhalation: Remove the affected person to fresh air and get medical attention if necessary.

Notes to Physician: Not applicable

Section 5 – Fire Fighting Measures

Flammable Properties: Not flammable

Flash Point: Not applicable **Method:** Not applicable

Flammable Limits: Not flammable

Lower Flammability Limit: Not applicable

Upper Flammability Limit: Not applicable

Autoignition Temperature: Not applicable

Hazardous Combustion Products: Not applicable

Extinguishing Media: Use extinguishing media that is appropriate for the surrounding fire. Silica gel is not combustible.

Fire Fighting Instructions: Not combustible

Unusual Fire and Explosion Hazards: None

Section 6 – Accidental Release Measures

Spill: Sweep or vacuum up and place the spilled material in a waste disposal container. Avoid raising dust. Wash with soap and water after handling.

Section 7 – Handling and Storage

Handling: Avoid raising dust and minimize the contact between worker and the material. Practice good hygienic work practices.

Storage: Store in a cool, dry location. Keep in sealed containers away from moisture. The silica gel will readily adsorb moisture.

Section 8 – Exposure Controls/Personal Protection

Engineering Controls: Use exhaust ventilation to keep the airborne concentrations below the exposure limits.

Respiratory Protection: Use NIOSH approved respirator when the air quality levels exceed the TLV's.

Skin Protection: Light gloves will protect against abrasion and drying of the skin.

Eye Protection: Safety glasses.

Component Name	Exposure Limits		
	OSHA PEL	**ACGIH TLV**	**Other Recommended Limits**
Silica gel	TWA 20 mppcf (80 mg / m^3 % SiO_2)	TWA 10 mg / m^3	NIOSH REL TWA 6 mg / m^3 IDLH 3000 mg / m^3
Phenolphthalein	Not Applicable	Not Applicable	Not Applicable

Section 9 – Physical and Chemical Properties

Appearance: Yellow beads or granules

Odor: None

Physical State: Solid bead

PH: Not applicable

Vapor Pressure: Not applicable

Vapor Density: Not applicable

Boiling Point: 4046° F (2230° C)

Melting Point: 3110° F (1710° C)

Solubility: Insoluble in water

Specific Gravity: 2.1

Section 10 – Stability and Reactivity

Stability: Stable

Conditions to avoid: Moisture and high humidity environments.

Incompatibility: Water, fluorine, oxygen difluoride, chlorine trifluoride

Hazardous Decomposition Products: None

Hazardous Polymerization: Will not occur

Section 11 – Toxicological Information

This product and its components are not listed on the NTP or OSHA Carcinogen lists.

Animal Toxicology Tests for DOT Hazard classification
(Tests Conducted on finely ground silica gel)

1 - hour LC_{50} (rat) > 2 mg / l
48 - hour oral LD_{50} (rat) est. > 31,600 mg / kg
48 - hour dermal LD_{50} (rabbit) est. > 2,000 mg / kg
Considered an ocular irritant

Human Toxicology Silica gel is a synthetic amorphous silica not to be confused with crystalline silica. Epidemiological studies indicate low potential for adverse health effects. In the activated form, silica gel acts as a desiccant and can cause a drying irritation of the mucous membranes and skin in cases of severe exposure. Multisorb Technologies Inc. knows of no medical conditions that are abnormally aggravated by exposure to silica gel. The primary route of entry is inhalation of dust.

Section 12 – Ecological Information

Not known to have any adverse effect on the aquatic environment. Silica gel is insoluble and non-toxic.

Section 13 – Disposal Information

Disposal Information If this product as supplied becomes a waste, it does not meet the criteria of a hazardous waste as defined under the Resource Conservation and Recovery Act (RCRA) 40 CFR 261. Materials of a hazardous nature that contact the product during normal use may be retained on the product. The user of the product must identify the hazards associated with the retained material in order to assess the waste disposal options. Dispose according to federal, state and local regulations.

Section 14 – Transportation Information

U.S. Department of Transportation Shipping Name: Not classified as a hazardous material. Not regulated.

Section 15 – Regulatory Information (Not meant to be all inclusive - selected regulations represented)

TSCA Listed: Yes

DSL/NDSL (Canadian) Listed: Yes

OSHA: TWA 20 mppcf (80 mg / m^3 % SiO_2) for Silica gel

NIOSH: REL TWA 6 mg / m^3 IDLH 3,000 mg / m^3 for silica gel
Animal tests conducted in 1976 - 1978. 18 month exposure at 15 mg / m^3 showed silica deposition in respiratory macrophages and lymph nodes, minimum lung impairment, no silicosis.

ACGIH: TLV - 10 mg / m^3 for Silica gel

DOT: Not classified as a hazardous material.

Section 16 – Other Information

HMIS – Hazardous Materials Identification System

HMIS Rating	
Health	0
Flammability	0
Reactivity	0

0 - minimal hazard, 1 - slight hazard, 2 - moderate hazard, 3 - serious hazard, 4 - severe hazard

This MSDS was prepared by: George E. Mckedy
Senior Applications Development Specialist
Multisorb Technologies, Inc.

This data and recommendations presented in this data sheet concerning the use of our product and the materials contained therein are believed to be correct but does not purport to be all inclusive and shall be used only as a guide. However, the customer should determine the suitability of such materials for his purpose before adopting them on a commercial scale. Since the use of our products is beyond our control, no guarantee, expressed or implied, is made and no responsibility assumed for the use of this material or the results to be obtained therefrom. Information on this form is furnished for the purpose of compliance with Government Health and Safety Regulations and shall not be used for any other purposes. Moreover, the recommendations contained in this data sheet are not to be construed as a license to operate under, or a recommendation to infringe, any existing patents, nor should they be confused with state, municipal or insurance requirements, or with national safety codes.

DECLARATION OF CONFORMITY

ISM1-A

Application of Council Directive:	89/336/EEC – The EMC Directive 73/23/EEC – The Low Voltage Directive
Manufacturer's Name:	Teledyne Isco, Inc.
Manufacturer's Address:	4700 Superior, Lincoln, Nebraska 68504 USA Mailing Address: P.O. Box 82531, Lincoln, NE 68501
Equipment Type/Environment:	Laboratory Equipment for Light Industrial/Commercial Environments
Trade Name/Model No:	750 Area Velocity Probe Module
Year of Issue:	2001
Standards to which Conformity is Declared:	EN 61326-1998 EMC Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use EN 61010-1 Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use

Standard	Description	Severity Applied	Performance Criteria
EN61000-4-2	Electrostatic Discharge	Level 2 - 4kV contact discharge Level 3 - 8kV air discharge	B B
EN61000-4-3 *	Radiated RF Immunity	80 MHz to 1000MHz 80% AM at 1kHz Level 1 - 10V/m	A
EN61000-4-4	Electrical Fast Transient	Level 2 - 2kV on ac lines	B
EN61000-4-5	Surge on AC Lines	2kV common mode, 1KV differential mode	B
EN61000-4-6 *	Conducted RF on AC lines	150 kHz to 80 MHz, 3V rms, 80% modulated	B
EN61000-4-11	Voltage Dips/Short Interruptions	0.5 cycle, each polarity/100%	B
CISPR11/ EN 55011	RF Emissions	Group 1, Class A Industrial, Scientific, and Medical Equipment	
EN61000-3-2, 3-3	Harmonic, Flicker		

*** Instrument is susceptible to 10V/M from 80MHz to 1000 MHz and 3 VRMS from 150 KHz to 80 MHz**
We, the undersigned, hereby declare that the design of the equipment specified above conforms to the above Directive(s) and Standards as of March 6, 2001.

William Foster
USA Representative

TELEDYNE ISCO
A Teledyne Technologies Company

Williams Foster
Director of Engineering
Teledyne Isco, Inc.
4700 Superior Street
Lincoln, Nebraska 68504

Phone: (402) 464-0231
Fax: (402) 464-4543

60-9002-069
Rev. A

*Teledyne Isco One Year Limited Factory Service Warranty **

Teledyne Isco warrants covered products against failure due to faulty parts or workmanship for a period of one year (365 days) from their shipping date, or from the date of installation by an authorized Teledyne Isco Service Engineer, as may be appropriate.

During the warranty period, repairs, replacements, and labor shall be provided at no charge. Teledyne Isco's liability is strictly limited to repair and/or replacement, at Teledyne Isco's sole discretion.

Failure of expendable items (e.g., charts, ribbon, tubing, lamps, glassware, seals, filters, fittings, and wetted parts of valves), or from normal wear, accident, misuse, corrosion, or lack of proper maintenance, is not covered. Teledyne Isco assumes no liability for any consequential damages.

This warranty does not cover loss, damage, or defects resulting from transportation between the customer's facility and the repair facility.

Teledyne Isco specifically disclaims any warranty of merchantability or fitness for a particular purpose.

This warranty applies only to products sold under the Teledyne Isco trademark and is made in lieu of any other warranty, written or expressed.

No items may be returned for warranty service without a return authorization number issued from Teledyne Isco.

The warrantor is Teledyne Isco, Inc.
4700 Superior, Lincoln, NE 68504, U.S.A.

*** This warranty applies to the USA and countries where Teledyne Isco Inc. does not have an authorized dealer. Custo mers in countries outside the USA, where Teledyne Isco has an authorized dealer, should contact their Teledyne Is co dealer for warranty service.**

In the event of instrument problems, always contact the Teledyne Isco Service Department, as problems can often be diagnosed and corrected without requiring an on-site visit. In the U.S.A., contact Teledyne Isco Service at the numbers listed below. International customers should contact their local Teledyne Isco agent or Teledyne Isco International Customer Service.

Return Authorization

A return authorization number must be issued prior to shipping. Following authorization, Teledyne Isco will pay for surface transportation (excluding packing/crating) both ways for 30 days from the beginning of the warranty period. After 30 days, expense for warranty shipments will be the responsibility of the customer.

Shipping Address: Teledyne Isco, Inc. - Attention Repair Service
4700 Superior Street
Lincoln NE 68504 USA

Mailing address: Teledyne Isco, Inc.
PO Box 82531
Lincoln NE 68501 USA

Phone: Technical Support (800)775-2965 (lab instruments)
(866)298-6174 (samplers & flow meters)
Sales & General Information: (800)228-4373 (USA & Canada)

Fax: (402) 465-3001

Email: iscoservice@teledyne.com **Web site:** www.isco.com

March 17, 2009 P/N 60-1002-040 Rev D

TELEDYNE ISCO
A Teledyne Technologies Company

APPENDIX G

QUALITY ASSURANCE PROJECT PLAN

QUALITY ASSURANCE PROJECT PLAN
FOR
STORMWATER SOURCE CONTROL MEASURES

Former Arkema Inc. Facility
Portland, Oregon

Prepared for
Legacy Site Services LLC
468 Thomas Jones Way
Exton, PA 19341

Prepared by

integral consulting inc

319 SW Washington Street
Suite 1150
Portland, OR 97204

September 30, 2011

SECTION A: PROJECT MANAGEMENT

A1 TITLE AND APPROVAL SHEET

QUALITY ASSURANCE PROJECT PLAN
FOR STORMWATER SOURCE CONTROL MEASURES
FORMER ARKEMA INC. FACILITY
PORTLAND, OREGON

Quality Assurance Plan Approvals

DEQ Project Manager:	Matt McClincy	_____	Date: _____
Legacy Site Services Project Manager:	Todd Slater	_____	Date: _____
Integral Project Manager:	Mike Martin	_____	Date: _____
Integral QA Manager:	Laura Jones	_____	Date: _____
CAS-Kelso Project Manager:	Greg Salata	_____	Date: _____
CAS-Kelso QA Manager:	Julie Gish	_____	Date: _____
CAS-Houston Project Manager:	Darren Biles	_____	Date: _____
CAS-Houston QA Manager:	Lan Le	_____	Date: _____

A2 TABLE OF CONTENTS

SECTION A: PROJECT MANAGEMENT II
A1 TITLE AND APPROVAL SHEET II
A2 TABLE OF CONTENTS III
LIST OF FIGURES v
LIST OF TABLES v
LIST OF ACRONYMS vi
A3 DISTRIBUTION LIST VIII
A4 INTRODUCTION AND PROJECT ORGANIZATION A-1
A4.1 Introduction A-1
A4.2 Project and Task Organization A-2
A5 PROBLEM DEFINITION AND BACKGROUND A-4
A6 TASK DESCRIPTION A-5
A6.1 Field Tasks A-5
A6.2 Laboratory Analyses and Deliverables A-5
A6.3 Data Quality Evaluation A-6
A6.4 Data Management A-6
A6.5 Reports A-6
A6.6 Project Schedule A-6
A7 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA A-7
A7.1 Data Quality Indicators A-7
A8 SPECIAL TRAINING/CERTIFICATION A-10
A9 DOCUMENTS AND RECORDS A-11
A9.1 Field Documentation A-11
A9.2 Laboratory Documentation A-11
A9.3 Data Quality Documentation A-13
SECTION B: DATA GENERATION AND ACQUISITION B-1
B1 SAMPLING PROCESS DESIGN B-1
B2 SAMPLE COLLECTION AND HANDLING B-1
B2.1 Field to Laboratory Sample Handling and Custody B-1
B2.2 Intra-laboratory Sample Transfer B-2
B3 ANALYTICAL METHODS B-2
B3.1 Chemical Analyses B-3
B3.2 Analyses in Field Blanks B-9

B4 QUALITY CONTROL B-9
B4.1 Field Quality Control Samples B-10
B4.2 Laboratory Quality Control B-10
B5 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE . B-11
B6 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY B-11
B7 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES B-11
B8 DATA MANAGEMENT B-12
B8.1 Field Data B-12
B8.2 Laboratory Data B-12

SECTION C: ASSESSMENT AND OVERSIGHT C-1
C1 ASSESSMENTS AND RESPONSE ACTIONS C-1
C2 REPORTS TO MANAGEMENT C-2

SECTION D: DATA VALIDATION AND USABILITY D-1
D1 CRITERIA FOR DATA REVIEW, VERIFICATION, AND VALIDATION D-1
D2 VERIFICATION AND VALIDATION METHODS D-2
D3 RECONCILIATION WITH USER REQUIREMENTS D-2

REFERENCES D-4

Attachment A. Laboratory Quality Assurance Manuals (Found on Accompanying CD)

Attachment B. Laboratory Chain of Custody Forms

LIST OF FIGURES

Figure A4-1. Project Organization

LIST OF TABLES

Table A4-1. Stormwater Monitoring Requirements

Table A4-2. Project Team Contact Information

Table A6-1. Summary of Samples and Chemical Analyses

Table A6-2. Laboratory Methods for Stormwater Samples

Table A6-3. Analytes and Method Reporting Limits for Stormwater Samples

Table A6-4. Analytes and Method Reporting Limits for Adaptive Management Sampling

Table A7-1. Summary of the DQOs Developed for the LSS Stormwater Source Control Measures

Table A7-2. Laboratory Control Limits for Surrogate Recoveries

Table A7-3. Laboratory Control Limits for Stormwater Matrix Spike and Laboratory Control Samples

Table A7-4. Laboratory Control Limits for Adaptive Management Matrix Spike and Laboratory Control Samples

Table B2-1. Sample Containers and Preservation Requirements

LIST OF ACRONYMS

ACG	analytical concentration goal
ARI	Analytical Resources Inc.
BMP	best management practice
CAS	Columbia Analytical Services
CLP	Contract Laboratory Program
COC	chain-of-custody
Consent Order	Order on Consent DEQ No. LOVC-NWR-08-04
COPC	constituent of potential concern
DEQ	Oregon Department of Environmental Quality
EDD	electronic data deliverable
EPA	U.S. Environmental Protection Agency
EQuIS	Environmental Quality Information System
GC/MS	gas chromatography/mass spectrometry
HAZWOPER	Hazardous Waste Operations and Emergency Response
HRGC/HRMS	high resolution gas chromatography/high resolution mass spectrometry
ICP/MS	inductively-coupled plasma/mass spectrometry
Integral	Integral Consulting Inc.
JSCS	Joint Source Control Strategy
LIMS	laboratory information management system
LSS	Legacy Site Services LLC
MAO	Mutual Agreement and Order No. WQ/I-NWR-10-175
MDL	method detection limit
MRL	method reporting limit
NPDES	National Pollutant Discharge Elimination System
PAH	polycyclic aromatic hydrocarbon
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCB	polychlorinated biphenyl
PMP	Performance Monitoring Plan

QAPP	quality assurance project plan
QA/QC	quality assurance and quality control
RPD	relative percent difference
SCM	source control measure
SLV	screening level value
SOP	standard operating procedure
SVOC	semivolatile organic compound
TSS	total suspended solids

A3 DISTRIBUTION LIST

DEQ Project Manager:	Matt McClincy
Arkema Project Manager:	Larry Patterson
Legacy Site Services Project Manager:	Todd Slater
Integral Principal-in-Charge:	David Livermore
Integral Stormwater Project Manager	Mike Martin
Integral QA Manager:	Laura Jones
Integral Field Coordinator:	Eron Dodak
Integral Data Manager:	Tom Schulz
ARI Project Manager:	Sue Dunnihoo
ARI QA Manager:	David Mitchell
CAS-Kelso Project Manager:	Greg Salata
CAS-Kelso QA Manager:	Julie Gish
CAS-Houston Project Manager:	Darren Biles
CAS-Houston QA Manager:	Lan Le

A4 INTRODUCTION AND PROJECT ORGANIZATION

A4.1 Introduction

On behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc., Integral Consulting Inc. has prepared this quality assurance project plan (QAPP) in support of the implementation of the stormwater source control measures (SCMs) at the former Arkema Portland Plant (the site) located at 6400 NW Front Avenue, Portland, Oregon. This QAPP is prepared pursuant to the Order on Consent, requiring SCMs, issued by the Oregon Department of Environmental Quality (DEQ), signed October 31, 2008 (DEQ No. LQVC-NWR-08-04) (Consent Order), and the new stormwater Mutual Agreement and Order No. WQ/I-NWR-10-175 (MAO) executed by DEQ and LSS on August 4, 2010. Refer to the contract documents for all locations and details of the work.

This QAPP describes quality assurance/quality control (QA/QC) procedures that will be used to address constituents of potential concern (COPCs) in treated stormwater that is discharged to the Willamette River following implementation of the SCMs identified in the Final Design Report. This QAPP has been prepared in accordance with U.S. Environmental Protection Agency (EPA) guidance for the preparation of QAPPs (USEPA 2002a).

The goal of the stormwater SCMs is to eliminate the potential for migration of COPCs in stormwater to the Willamette River at concentrations greater than values presented in Section 1 of the Final Design Report by implementing best management practices (BMPs), including erosion control and decommissioning the existing stormwater collection system, and structural treatment BMPs, including detention basin and filtration. Because this stormwater treatment system is being implemented in accordance with the MAO, and in conjunction with the facility's existing NPDES permit, new or revised numerical discharge limits are not part of the design basis for these SCMs; however, LSS has agreed to conduct performance monitoring of the SCMs and use an adaptive management approach to optimize performance of the stormwater treatment, based on comparisons of effluent concentrations to values presented in Section 1 of the Final Design Report. The final list of COPCs is included as Table A4-1. The final list includes water quality parameters that require monitoring on a monthly or quarterly basis under Schedule B of the site NPDES permit.

Stormwater sampling will include periodic composite samples. Periodic composite samples will consist of manually composited discrete grab samples collected over 24 hours (or the total rainfall duration, whichever is less), and will be collected on a basis that averages at least once per month in accordance with Attachment A of the MAO. These samples provide information on the "average" stormwater quality during a storm event and will be used to evaluate stormwater discharge concentrations and performance of stormwater SCMs.

Adaptive management sampling may include "first flush" (i.e., within the first 30 minutes) grab sampling, additional composite water sampling, and/or effluent sediment trap sampling (placed in the discharge from the sand filter) in the event that treatment system goals (Table 1-1 of the Final Design Report) are exceeded. Analytical data from these samples will provide information that will be used to troubleshoot issues within the SCMs.

A4.2 Project and Task Organization

This section presents the organizational structure for activities associated with the performance monitoring plan (PMP; Appendix F of the Final Design Report), including project management and oversight, fieldwork, sample analysis, and data management. Integral is conducting this work under contract with LSS, with direction from DEQ. Project team organization and contact information is provided in Figure A4-1 and Table A4-2.

A4.2.1 DEQ Organization and Responsibilities

DEQ will oversee activities associated with the PMP and will coordinate the development of technical and decision documents. The project manager for DEQ is Matt McClincy.

A4.2.2 Key Task Personnel

Personnel involved in the PMP are listed below.

Stormwater PMP Principal-in-Charge—David Livermore, a registered geologist in Oregon, is the Integral principal-in-charge. He will be responsible for overseeing the implementation and execution of the technical, quality assurance, and administrative aspects of the PMP. Mr. Livermore will be responsible for the quality and timeliness of Integral documents.

Stormwater PMP Project Manager—Mike Martin (Integral) is the PMP project manager, and is responsible for conducting the PMP. He will work closely with the principle-in-charge to ensure the objectives of the study are achieved. In the event that changes in the PMP or QAPP are needed, he will discuss proposed changes with LSS' and DEQ's project managers or other designated DEQ staff. Changes to the PMP and QAPP will not be made without prior approval from the DEQ project manager unless conditions in the field or laboratory require immediate response.

Field Operations Manager—Eron Dodak (Integral) is the field operations manager for the PMP. He will be responsible for the following activities:

- Oversee planning and coordination for all sampling efforts
- Oversee all aspects of sampling activities to ensure that the appropriate sampling, QA, and documentation procedures are used.

Mr. Dodak will work closely with the project manager and will be notified immediately if problems occur in the field. If changes to the PMP or QAPP are warranted, he will immediately notify the task manager.

Quality Assurance Manager—Laura Jones (Integral) will be the QA manager for the PMP. She will be responsible for the following activities:

- Provide QA support for the PMP
- Ensure that the QAPP and PMP contain all components necessary to meet EPA guidance (USEPA 2002a)
- Verify that the laboratories implement the requirements of the PMP and QAPP and address QA issues related to laboratory analyses
- Coordinate the activities of the laboratories and track laboratory progress
- Direct the validation of the chemical data
- Communicate data quality issues to the data users
- Work with data users and DEQ to address any data limitations.

Database Administrator—Tom Schulz (Integral) will have primary responsibility for data management and database maintenance and development. Mr. Schulz will be responsible for the following activities:

- Work with the field crew to ensure field data entries are correct and complete
- Work with the laboratories to ensure that data are delivered in the correct format for entry into the Environmental Quality Information System (EQuIS) database
- Work with data validators and the QA manager to ensure correct and efficient entry of data qualifiers
- Take all necessary measures to develop and maintain the integrity and completeness of the database
- Provide various data summaries to data users in the required formats for interpretation and for submittal to DEQ.

A4.2.3 Chemical Laboratories

Laboratory Project Manager—The laboratory project manager carries overall responsibility for the successful and timely completion of sample analyses for this project. The laboratory project manager will be responsible for the following tasks:

- Ensure that samples are received and logged in correctly, that the correct methods and modifications are used, that the required method detection limits (MDLs) are met, and that data are reported within specified turnaround times
- Review analytical data to ensure that procedures were followed as required in this QAPP, the cited methods, and laboratory standard operating procedures (SOPs)
- Keep the QA manager apprised of the schedule and status of sample analyses and data package preparation
- Notify the QA manager if problems occur in sample receiving, analysis, or scheduling, or if control limits or MDLs cannot be met
- Take appropriate corrective action as necessary
- Report data and supporting QA information as specified in this QAPP.

Laboratory Quality Assurance Manager—The Laboratory QA manager is responsible for overseeing the QA activities in the laboratory and ensuring the quality of the data for this project. Specific responsibilities include the following:

- Oversee and implement the laboratory's QA program
- Maintain QA records for each laboratory production unit
- Ensure that QA/QC procedures are implemented as required for each method and provide oversight of QA/QC practices and procedures
- Review and address or approve non-conformity and corrective action reports
- Coordinate response to any QC issues that affect this project with the laboratory project manager.

A5 PROBLEM DEFINITION AND BACKGROUND

The primary objective of the PMP is to design sampling and adaptive management approaches that address COPCs in treated stormwater that is discharged to the Willamette River from the site following implementation of the stormwater SCMs identified in the Final Design Report.

This QAPP addresses QA/QC activities, laboratory procedures, and data management procedures for stormwater samples. The analytical requirements and any additional QA/QC activities for any future sampling will be addressed in future QAPP addenda.

A6 TASK DESCRIPTION

The tasks to be completed for the PMP include sample collection, laboratory analyses, data quality evaluation, data management, and report preparation. Summaries of these tasks and references to detailed descriptions are provided in this section.

A6.1 Field Tasks

Tasks that will be completed in the field, including related documentation and QA/QC activities, are described in detail in Section 2 of the PMP. The following are addressed in the PMP:

- Sampling locations
- Sampling equipment and methods
- Sample identification
- Sample processing methods
- Documentation of sample information and field activities
- Sample handling and shipping procedures
- Chain-of-custody (COC) procedures
- Decontamination procedures
- Handling and disposal of investigation-derived wastes.

Integral will collect stormwater samples, and will prepare the samples for delivery to the laboratories. A list of samples and analyses is provided in Table A6-1. Sample locations are provided in Figure 2-1 of the PMP.

A6.2 Laboratory Analyses and Deliverables

Chemical analysis of stormwater samples, and associated field QC samples will be performed by Columbia Analytical Services (CAS) laboratories in Kelso, Washington, Houston, Texas, and Rochester, New York. Analyses will be completed using EPA methods (USEPA 1994; 2008a) and other established methods as indicated in Table A6-2 by the laboratories specified in this table. Water particle size distribution analyses may be completed by Analytical Resources Inc. (ARI), Tukwila, Washington, as part of the adaptive management sampling. Complete analyte lists with analytical concentration goals (ACGs), as applicable, MDLs, and method reporting limits (MRLs) have been provided in Tables A6-3 and A6-4.

Full laboratory data reports will be provided in hard copy, and electronic data deliverables (EDDs) will be provided in spreadsheet format as required for importing into the database. A list of hard copy data deliverables from the laboratory is provided in Section A9.2.

A6.3 Data Quality Evaluation

Data quality evaluation includes the components of data verification and data validation (USEPA 2002b). Data verification involves verifying that correct procedures were followed and that control limits were met. Data validation involves evaluating the quality and usability of the data in the context of project objectives. Data verification will initially be completed by the laboratories that generate the data. Integral's field staff will verify data generated in the field, and each laboratory will verify data generated at the laboratory, in accordance with its SOPs and QA manual. The accuracy and completeness of the final database will be verified by Integral under the direction of the database administrator.

Data validation and data verification will be completed by Integral. Verification and validation procedures are described in Section D2 of this QAPP.

A6.4 Data Management

Integral is responsible for data management for the PMP. The EQuIS database application is used as the final repository for all data related to the PMP and will be used to manage the field and laboratory data. Field data will by necessity be entered manually. Data will be provided electronically by the laboratories and imported directly into the database. Data management procedures are discussed in Section B8.

A6.5 Reports

Following receipt of laboratory analytical reports, sample data will be provided to DEQ along with monthly discharge monitoring reports, which are currently submitted as part of the NPDES permitting requirements for the site. By June 1 of the year following implementation of the stormwater SCMs, a data summary report will be provided to DEQ that includes analytical results from stormwater samples collected throughout the year. Reports are described in Section C2.

A6.6 Project Schedule

Periodic stormwater sampling activities will commence within 30 days following completion of construction of the stormwater and groundwater SCMs including all site restoration and cleanup. Sampling events will be scheduled when it is predicted that the following storm event criteria will be met:

- Storm event is preceded by a dry period (less than 0.1 in. rainfall) of at least 24 hours
- Storm event is predicted to produce more than 0.2 in. rainfall
- Storm event is predicted to occur over a minimum of 3 hours.

It is anticipated that post-construction stormwater sampling will be performed for one year following implementation of the stormwater SCMs.

A7 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

Project-specific data quality objectives have been developed for the PMP and are included in Table A7-1. Because this stormwater treatment system is being implemented in accordance with the MAO and in conjunction with the facility's existing NPDES permit, new or revised numerical discharge limits are not part of the design basis for the SCMs. However, stormwater treatment system effluent concentrations are provided in Table 1-1 of the Final Design Report as treatment system goals. LSS has agreed to conduct performance monitoring of the SCMs and use an adaptive management approach in order to optimize the stormwater treatment implementation at the site.

Data quality indicators such as the PARCC parameters (i.e., precision, accuracy or bias, representativeness, completeness, comparability) (USEPA 2002a) and analytical sensitivity will also be used to assess conformance of data with quality control criteria.

A7.1 Data Quality Indicators

The overall quality objective for the PMP is to develop and implement procedures that will ensure the collection of representative data of known and acceptable quality. The quality procedures and measurements that will be used for this project are based on EPA methods (USEPA 1994; 2008a) and on established laboratory methods from other sources (APHA, AWWA, and WEF 2010).

PARCC parameters are commonly used to assess the quality of environmental data.

Bias represents the degree to which a measured concentration conforms to the reference value. The results for matrix spikes, laboratory control samples, field blanks, and method blanks will be reviewed to evaluate bias of the data. The following calculation is used to determine percent recovery for a matrix spike sample:

$$\%R = \frac{M - U}{C} \times 100$$

%R = Percent recovery
M = Measured concentration in the spiked sample
U = Measured concentration in the unspiked sample
C = Concentration of the added spike

The following calculation is used to determine percent recovery for a laboratory control sample or reference material:

$$\%R = \frac{M}{C} \times 100$$

%R = Percent recovery
M = Measured concentration in the reference material
C = Established reference concentration

Results for field and method blanks can reflect systematic bias that results from contamination of samples during collection or analysis. Any analytes detected in field or method blanks will be evaluated as potential indicators of bias.

Precision reflects the reproducibility between individual measurements of the same property. Precision will be evaluated using the results of matrix spike duplicates, laboratory duplicates, field splits, and field replicates. Precision is expressed in terms of the relative standard deviation for three or more measurements and the relative percent difference (RPD) for two measurements. The following equation is used to calculate the RPD between measurements:

$$RPD = \frac{|C_1 - C_2|}{(C_1 + C_2)/2} \times 100$$

RPD = Relative percent difference
C_1 = First measurement
C_2 = Second measurement

The relative standard deviation is the ratio of the standard deviation of three or more measurements to the average of the measurements, expressed as a percentage.

Completeness will be calculated as the ratio of usable data (i.e., unqualified data and U- or J-qualified data) to generated data, expressed as a percentage. Completeness will be calculated for each suite of analytes for each sample type and sampling event.

Additional laboratory QC results will be evaluated to provide supplementary information regarding overall quality of the data, performance of instruments and measurement systems, and sample-specific matrix effects.

QC samples and procedures are specified in each method protocol that will be used for this project. Methods are summarized in Table A6-2. All QC requirements will be completed by

each laboratory as described in the protocols, including the following (as applicable to each analysis):

- Instrument tuning
- Initial calibration
- Initial calibration verification
- Continuing calibration verification
- Calibration or instrument blanks
- Method blanks
- Laboratory control samples
- Internal standards
- Surrogate spikes
- Serial dilutions
- Matrix spikes
- Matrix spike duplicates or laboratory duplicates.

To alert the data user to possible bias or imprecision, data qualifiers will be applied to reported analyte concentrations when associated QC samples or procedures do not meet control limits. Laboratory control limits for the methods that will be used for this project are provided in Tables A7-2 throughA7-4 and in the laboratory QA manuals (Attachment A of this QAPP). The laboratory control limits presented in these tables are current as of the writing of this document. Control limits are periodically updated by the laboratory, and the control limits that are in effect at the laboratory at the time of analysis will be used for sample analysis and data validation. Data validation criteria and procedures are described in Sections D1 and D2 of this QAPP.

MRLs reflect the sensitivity of the analysis. Target MRLs for this study are summarized in Tables A6-3 and A6-4. Method modifications are described in Section B4.

MDLs have been determined by each laboratory for each analyte, as required by USEPA (2008a; Tables A6-3 and A6-4). MDLs are statistically derived and reflect the concentration at which an analyte can be detected in a clean matrix (e.g., sand or distilled water) with 99 percent confidence that a false positive result has not been reported. MRLs are established by the laboratories at levels above the MDLs for the project analytes. The MRL values are based on the laboratories' experience analyzing environmental samples and reflect the typical sensitivity obtained by the analytical system in environmental samples. The concentration of the lowest standard in the initial calibration curve for each analysis is at the level of the MRL. This allows reliable quantification of concentrations to the MRL in the absence of matrix interferences.

For all chemical analyses except high-resolution gas chromatography/high-resolution mass spectrometry (HRGC/HRMS) analysis of chlorinated dioxins/furans, analyte concentrations for this investigation will be reported to the MDL. Analytes detected at concentrations between the MRL and the MDL will be reported with a J qualifier to indicate that the value is an estimate (i.e., the analyte concentration is below the calibration range). Non-detects will be reported at the MDL. The MDL will be adjusted by each laboratory, as necessary, to reflect sample dilution or matrix interference. The use of the MDL to report data for non-detects will be evaluated during data quality review. For analysis of chlorinated dioxins/furans by EPA Method 1613B, sample-specific detection limits will be reported as described in EPA Method 8290A (USEPA 2008a).

Representativeness and comparability are qualitative QA/QC parameters. Representativeness is the degree to which data represent a characteristic of an environmental condition. In the field, representativeness will be addressed primarily in the sampling design by the selection of sampling sites and sample collection procedures. In the laboratories, representativeness will be ensured by the proper handling and storage of samples and initiation of analysis within holding times.

Comparability is the qualitative similarity of one data set to another (i.e., the extent to which different data sets can be combined for use). Comparability will be addressed through the use of field and laboratory methods that are consistent with methods and procedures recommended by EPA and commonly used for stormwater studies.

A8 SPECIAL TRAINING/CERTIFICATION

Integral has assembled a project team with the requisite experience and technical skills to successfully complete the PMP. All consultant team personnel involved in sample collection have extensive environmental sampling experience. Minimum training and certification requirements for laboratory personnel are described in the laboratory QA manuals (Attachment A of this QAPP).

The Superfund Amendments and Reauthorization Act of 1986 required the Secretary of Labor to issue regulations providing health and safety standards and guidelines for workers engaged in hazardous waste operations. In response to this requirement, the U.S. Occupational Safety and Health Administration developed regulation 29 CFR§1910.120, the "Hazardous Waste Operations and Emergency Response" standard (HAZWOPER). This standard includes requirements for workers engaged in hazardous waste operations to complete a 40-hour training course and annual 8-hour refresher courses. The training provides employees with knowledge and skills that enable them to perform their jobs safely and with minimum risk to their personal health. All sampling personnel will have completed the 40-hour HAZWOPER training course and 8-hour refresher courses, as necessary. Documentation of course completion will be maintained in personnel files.

A9 DOCUMENTS AND RECORDS

Records will be maintained documenting all activities and data related to field sampling and chemical analyses at the laboratories. Results of data verification and validation activities will also be documented. Procedures for documentation of these activities are described in this section.

The PMP, this QAPP, and the health and safety plan will be provided to every project participant listed in Section A3. Any revisions or amendments to any of these documents will also be provided to these individuals.

A9.1 Field Documentation

The following field records will be maintained throughout the duration of sampling activities:

- Field logbooks
- Photo documentation
- Field data and sample collection information forms
- Field change request forms (as needed)
- Sample labels
- Sample COC forms
- Custody seals.

The content and use of these documents are described in SOPs (Attachment A of the PMP). Field documentation related to sample collection will be maintained in the project file in Integral's Portland office. The laboratories will return original completed COC forms to Integral. These will also be maintained in the project file.

The QA manager will ensure that the field team receives the final approved version of the PMP and this QAPP prior to the initiation of field activities.

A9.2 Laboratory Documentation

All activities and results related to sample analysis will be documented at each laboratory. Internal laboratory documentation procedures are described in the laboratory QA manuals (Attachment A to this QAPP).

Each laboratory will provide a data package for each sample delivery group or analysis batch that is comparable in content to a full Contract Laboratory Program (CLP) package. The format of the data may differ from CLP requirements. Each data package will contain all information required for a complete QA review, including the following:

- A cover letter discussing analytical procedures and any difficulties that were encountered
- A case narrative referencing or describing the procedures used and discussing any analytical problems and deviations from SOPs and this QAPP
- COC and cooler receipt forms
- A summary of analyte concentrations (to two significant figures, unless otherwise justified), MRLs, and MDLs
- Laboratory data qualifier codes appended to analyte concentrations, as appropriate, and a summary of code definitions
- Sample preparation and cleanup logs
- Instrument tuning check data
- Initial and continuing calibration data, including instrument printouts and quantification summaries, for all analytes
- Results for method and calibration blanks
- Results for all QA/QC checks, including but not limited to surrogate spikes, internal standards, laboratory control samples, matrix spike samples, matrix spike duplicate samples, and laboratory duplicate or triplicate samples provided on summary forms
- Instrument data quantification reports for all analyses and samples
- Florisil® check data and gel permeation chromatography calibration data
- Copies of all laboratory worksheets and standards preparation logs.

Data will be delivered in both hard-copy and electronic format to the Integral QA manager, who will be responsible for oversight of data verification and validation and for archiving the final data and data quality reports in the project file. Data packages will be provided to DEQ upon request by the DEQ project manager. Integral will maintain data packages and EDDs for chemical analyses.

EDDs will be compatible with Integral's EQuIS database.

Laboratory data will be maintained by each laboratory for a period of at least 5 years. These data will include the original instrument data files, reduced and verified data stored in the laboratory information management system (LIMS), and final hard-copy and EDDs. The laboratories will obtain approval from Arkema/LSS prior to discarding these data.

A9.3 Data Quality Documentation

Data validation reports will be prepared by Integral and provided to the QA manager. Results of the validation reports will be summarized in the summary report for the sampling event. Any limitations to the usability of the data will also be discussed in the summary report.

All electronic database entries provided by each laboratory will be verified against the validated hard-copy data in the data package. All changes to the database will be documented in an electronic log file that automatically enters a current time stamp when opened and allows the data editor to enter notes about changes to the database. Any data tables prepared from the database for data users will include all qualifiers that were applied by the laboratories and during data validation, unless otherwise requested.

SECTION B: DATA GENERATION AND ACQUISITION

B1 SAMPLING PROCESS DESIGN

Stormwater samples will be collected following implementation of the stormwater SCMs. Periodic stormwater samples will be analyzed for total and/or dissolved phase stormwater COPCs and conventional analytes including total suspended solids (TSS), and stormwater flow rate will be estimated. The sampling events will be conducted following implementation of the stormwater SCMs to help assess the effectiveness of the stormwater treatment system. Specific issues related to sampling methods and sample handling procedures are addressed in Section 2 of the PMP and in the SOPs (Attachment A of the PMP).

B2 SAMPLE COLLECTION AND HANDLING

Field sampling methods are described in Section 2.3 of the PMP. Stormwater samples will be collected in accordance with the manufacturer's equipment user manual (Attachment C of the PMP). Following a storm event, sampling activities will involve accessing the influent and effluent sampling points (upgradient of the detention basins and the sampling point for Outfall 004, respectively) and retrieving the discrete grab samples collected by the ISCO automatic sampler. When applicable, discrete samples will be manually composited into the appropriate sample bottles required by the analytical laboratory by field personnel following automatic sample collection. Sample filtration, if needed, will be done in the field or in the analytical laboratory.

Each sample collected in the field will be labeled in accordance with the SOP for sampling labeling (SOP AP-04, Attachment A of the PMP). Samples will be managed according to the protocols described in SOP AP-01, the SOP for sample packaging and shipping, and SOP AP-03, the SOP for sample custody (Attachment A of the PMP). Examples of relevant sampling forms and documents are provided in Attachment B of the PMP.

B2.1 Field to Laboratory Sample Handling and Custody

From the time of collection, all samples will be stored on ice or refrigerated at an approximate temperature of 4°C prior to processing. Requirements for sample containers, sample preservation, and holding times are summarized in Table B2-1.

The field task leader, or the designated field sample custodian, will be responsible for sample tracking in the field. Samples will remain in Integral's custody until COC forms and final sample inventory are completed in the field or at the field sample processing facility. COC forms will be used for samples that are in transit from the field site to the testing laboratories. The custodian will relinquish the samples to a designated analytical laboratory courier service

or commercial transport company (e.g., Federal Express). Custody of samples in the field or at the field processing facility will be documented in the field logs.

Samples are considered to be in custody if they are 1) in the custodian's possession or view, 2) in a secured location (under lock) with restricted access, or 3) in a container that is secured with an official seal(s) such that the sample cannot be reached without breaking the seal(s). The principal documents used to identify samples and to document possession are COC records, field logbooks, and field tracking forms. COC procedures will be used for all samples at all stages in the analytical or transfer process and for all data and data documentation whether in hard-copy or electronic format. An example of a COC form is provided in Attachment B of the PMP.

Sample packing and shipping procedures are detailed in SOP AP-01 (Attachment A of the PMP). Samples will be shipped to the laboratory in ice chests sealed with custody seals. Each ice chest will have three seals, one on the front of the chest and one on each side. The laboratory sample custodian will establish the integrity of the seals at the laboratory. The way bill of the carrier used to ship samples will provide additional custody and sample tracking information. The way bills will be maintained in the project file.

The sample custodian at each laboratory will accept custody and log samples into the LIMS. The sample custodian will check that the COC forms were properly completed and signed, that a sample receipt form is completed for each cooler, and that samples are stored under the required temperature conditions. Each laboratory will deliver a copy of the COC and sample receipt form to the chemistry QA manager. Any breaks in the COC or nonconformances will be noted and reported in writing to the chemistry QA manager within 24 hours of receipt of samples.

Specific laboratory COC procedures are described in the laboratory QA manual for each of the designated laboratories (Attachment A of this QAPP). An example COC form is provided in Attachment B of this QAPP.

B2.2 Intra-laboratory Sample Transfer

The laboratory project manager will ensure that a sample-tracking record is maintained that follows each sample through all stages of laboratory processing. The sample-tracking record must contain, at a minimum, the names of individuals responsible for performing the analysis; dates of sample extraction, preparation, and analysis; and the type of analysis being performed.

B3 ANALYTICAL METHODS

Laboratory methods to be used for the PMP are consistent with requirements provided in SW-846 (USEPA 2008a), and other established and widely accepted protocols. Analytes, MDLs, and

MRLs are provided in Tables A6-3 and A6-4. Laboratory methods are described below for stormwater samples.

B3.1 Chemical Analyses

Stormwater samples will be analyzed for the following:

- Conventional analyses (oil and grease, pH, TSS, and hardness)
- Inorganic analyses (dissolved hexavalent chromium)
- Metals
  - Arsenic – total
  - Arsenic, copper, lead, and zinc – total recoverable
  - Manganese –dissolved
- Polycyclic aromatic hydrocarbons (PAHs)
- Semivolatile organic compounds (SVOCs; pentachlorophenol only)
- Organochlorine pesticides
- Chlorinated dioxins and furans

Adaptive management samples may be analyzed for the following:

- Water
  - Conventional analyses
    - Water particle-size distribution
    - TSS
  - Metals
    - Total and dissolved arsenic, copper, lead, and zinc
- Sediment trap
  - Conventional analyses
    - Grain size, total solids, and total organic carbon
  - PAHs and pentachlorophenol
  - Organochlorine pesticides
  - Chlorinated dioxins and furans

The total number of samples and the analyses that will be conducted on each sample are summarized in Table A6-1. The laboratories performing the analyses and the methods for sample preparation and analysis are summarized in Table A6-2. The analyses will be

performed at the laboratories indicated in Table A6-2. Samples for dissolved hexavalent chromium will be field filtered through a 0.45-µm filter. Samples for all other dissolved constituents will be filtered through a 0.45-µm filter by the laboratory prior to sample preparation and analysis.

B3.1.1 Stormwater Sampling

B3.1.1.1 Conventional Analyses

CAS-Kelso will be responsible for the conventional analyses of stormwater samples. Conventional analyses will include oil and grease, pH, TSS, and hardness as $CaCO_3$. EPA and standard methods will be used as shown in Table A6-2.

Oil and grease will be determined according to EPA Method 1664. A one liter sample is acidified and serially extracted three times with n-hexane in a separatory funnel. The extract is dried over sodium sulfate. The solvent is distilled from the extract and the residue from the extract is desiccated. The amount of oil and grease (hexane-extractable material) in the extract is measured by weighing the dry residue on a balance.

pH will be determined electrometrically by using a standard hydrogen electrode and a reference electrode according to Method SM4500-H^+ B (APHA, AWWA, and WEF 2010).

TSS will be determined according to Method SM 2450D (APHA, AWWA, and WEF 2010). A well-mixed sample aliquot is filtered through a glass fiber filter, and the residue retained on the filter is dried to a constant weight at 103-105°C. TSS content is determined gravimetrically.

Hardness as $CaCO_3$ will be determined by measuring the calcium and magnesium ion content in the stormwater samples by titrating with ethylenediaminetetraacetic acid, according to Method 2340C (APHA, AWWA, and WEF 2010).

B3.1.1.2 Inorganic Analyses

CAS (Kelso, WA) in conjunction with CAS (Rochester, NY) will be responsible for the analyses of stormwater samples for dissolved hexavalent chromium. EPA Method 218.6 will be used for dissolved hexavalent chromium, as shown in Table A6-2. Dissolved hexavalent chromium samples will be field filtered through a 0.45-µm filter and placed in pre-preserved bottles with ammonium sulfate to a pH of 9.3–9.7. Upon receipt at the laboratory, the pH of these samples will be checked to ensure that they are within the correct pH range.

A measured volume of the filtered preserved sample is introduced into an ion chromatograph for analysis of dissolved hexavalent chromium according to EPA Method 218.6. A guard column removes organics from the sample before the hexavalent chromium is separated on a high capacity anion exchange separator column. Post-column derivatization of the hexavalent chromium with diphenylcarbazide is followed by detection of the colored complex at 530 nm.

B3.1.1.3 Metals

CAS-Kelso will be responsible for the metals analyses of stormwater samples. Metals analyses will include the following:

- Arsenic (total recoverable)
- Arsenic (total)
- Copper (total recoverable)
- Lead (total recoverable)
- Manganese (dissolved)
- Zinc (total recoverable).

The laboratory will filter samples for dissolved metals through a 0.45-µm filter prior to sample preparation and analysis. EPA methods will be used, as shown in Table A6-2.

Samples will be prepared for total recoverable metals and dissolved metals by heating with acid and substantially reducing the volume according to EPA Method 3005. The digestate is then filtered and diluted to volume.

Concentrations of the selected metals within the sample extracts will be determined by inductively-coupled plasma-mass spectrometry (ICP/MS) according to EPA Method 200.8.

B3.1.1.4 PAHs and Pentachlorophenol

CAS-Kelso will be responsible for the PAH and pentachlorophenol analyses of stormwater samples. Samples will be analyzed for both the total and dissolved fraction. In addition to pentachlorophenol, the following PAHs will be analyzed according to EPA methods shown in Table A6-2:

- Benz(a)anthracene
- Benzo(a)pyrene
- Benzo(k)fluoranthene
- Chrysene
- Dibenz(a,h)anthracene
- Indeno(1,2,3-cd)pyrene.

Samples are prepared according to EPA Method 3520C by continuous liquid-liquid extraction. Samples will be analyzed using quadruple gas chromatography/mass spectrometry (GC/MS) according to EPA Method 625. None of the PAH and pentachlorophenol analyses will be

performed using an ion trap GC/MS. Tentatively-identified compounds will not be reported. The surrogate compounds, nitrobenzene-d5, terphenyl-d14, and 2-fluorobiphenyl will be added to every sample, quality control sample, and selected instrument standards. Gel permeation chromatography cleanup (EPA Method 3640A) will be performed on the extract if necessary to achieve the MRL/MDLs specified in Table A6-3.

B3.1.1.5 Organochlorine Pesticides

CAS-Kelso will be responsible for analyzing stormwater samples for 2,4′ and 4,4′-DDD, 2,4′ and 4,4′-DDE, and 2,4′ and 4,4′-DDT. Samples will be analyzed according to EPA Method 625, as shown in Table A6-2.

Samples are prepared according to EPA Method 3510C by separatory funnel liquid-liquid extraction. The surrogate compounds tetrachloro-*m*-xylene and decachlorobiphenyl will be added to every sample, quality control sample, and selected instrument standards. Florisil column cleanup (EPA Method 3620), sulfur removal with mercury (EPA Method 3660B), and gel permeation chromatography cleanup (EPA Method 3640A) will be performed on the sample extract if necessary to achieve the MRL/MDLs specified in Table A6-3.

B3.1.1.6 Chlorinated Dioxins and Furans

CAS-Houston will be responsible for analyzing stormwater samples for chlorinated dioxins and furans. Samples will be analyzed according to EPA Method 1613B, as shown in Table A6-2.

Samples will be extracted with toluene in a Soxhlet/Dean Stark extractor. Cleanup procedures will include an acid extraction; additional cleanup procedures will be used as necessary to achieve the MRL/MDLs specified in Table A6-3. Samples will be analyzed by HRGC/HRMS. As described in EPA Method 1613B, detection limits are calculated on an individual compound and sample basis and depend on the signal-to-background ratio for the specific labeled isomer. The detection limits listed in Table A6-3 are representative of MDLs typically obtained when using the described procedure.

B3.1.2 Adaptive Management Sampling

B3.1.2.1 Conventional Analyses – Water

ARI will be responsible for the water particle size distribution and TSS analyses. Water samples will be analyzed using a Beckman Coulter LS Particle Size Analyzer. This laser diffraction instrument can determine particle size distributions (on a percentage basis) from 0.040 to 2,000 μm.

TSS will be determined gravimetrically according to SM 2540D. TSS results will be used to calculate the particle size distributions on a weight/volume basis.

B3.1.2.2 Metals – Water

CAS-Kelso will be responsible for the metals analyses of adaptive management water samples. Metals analyses will include the following:

- Arsenic (total and dissolved)
- Copper (total and dissolved)
- Lead (total and dissolved)
- Zinc (total and dissolved).

The laboratory will filter samples for dissolved metals through a 0.45-µm filter prior to sample preparation and analysis. EPA methods will be used, as shown in Table A6-2.

Samples will be prepared for total and dissolved metals by heating with acid and substantially reducing the volume according to EPA Method 3005. The digestate is then filtered and diluted to volume.

Concentrations of the selected metals within the sample extracts will be determined by ICP/MS according to EPA Method 200.8.

B3.1.2.3 Conventional Analyses – Sediment Trap

CAS-Kelso will be responsible for the conventional analyses of adaptive management sediment trap samples. Conventional analyses will include the following:

- Grain size
- Total solids
- Total organic carbon

Sediment trap samples will be analyzed for grain size using sieves and hydrometers according to PSEP methodologies. One sediment subsample will be produced for each particle size range. Particle size ranges will be as follows:

Description	Microns	Phi Size
Medium Gravel	>4,750	<–2
Fine Gravel	2,000 to 4,750	–2 to –1
Very Coarse Sand	1,000 to 2,000	–1 to 0
Coarse Sand	500 to 1,000	0 to 1
Medium Sand	250 to 500	1 to 2
Fine Sand	125 to 250	2 to 3
Very Fine Sand	62.5 to 125	3 to 4

Description	Microns	Phi Size
Coarse Silt	31 to 62.5	4 to 5
Medium Silt	15.6 to 31	5 to 6
Fine Silt	7.8 to 15.6	6 to 7
Very Fine Silt	3.9 to 7.8	7 to 8
8-9 Phi Clay	1.95 to 3.9	8-9
>9 Phi Clay	<1.95	>9

Depending on sample volume, sediment subsamples will be analyzed for some, if not all, the listed constituents (total solids, total organic carbon, PAHs, pentachlorophenol, pesticides, and dioxin/furans).

Total solids will be determined gravimetrically according to EPA Method 160.3. Total organic carbon will be determined coulometrically according to ASTM D4129-82.

B3.1.2.4 PAHs and Pentachlorophenol – Sediment Trap

CAS-Kelso will be responsible for the PAH and pentachlorophenol analyses of sediment trap subsamples. In addition to pentachlorophenol, the following PAHs will be analyzed according to EPA methods shown in Table A6-2:

- Benz(a)anthracene
- Benzo(a)pyrene
- Benzo(k)fluoranthene
- Chrysene
- Dibenz(a,h)anthracene
- Indeno(1,2,3-cd)pyrene.

Samples are prepared according to EPA Method 3541 by thermal Soxhlet extraction. Samples will be analyzed using quadruple GC/MS with selective ion monitoring according to EPA Method 8270C. None of the PAH and pentachlorophenol analyses will be performed using an ion trap GC/MS. Tentatively identified compounds will not be reported. The surrogate compounds, nitrobenzene-d5, terphenyl-d14, and 2-fluorobiphenyl will be added to every sample, quality control sample, and selected instrument standards. Gel permeation chromatography cleanup (EPA Method 3640A) will be performed on the extract if necessary to achieve the MRL/MDLs specified in Table A6-4.

B3.1.2.1 Organochlorine Pesticides – Sediment Trap

CAS-Kelso will be responsible for analyzing sediment trap subsamples for 2,4′ and 4,4′-DDD, 2,4′ and 4,4′-DDE, and 2,4′ and 4,4′-DDT. Samples will be analyzed according to EPA Method 8081, as shown in Table A6-2.

Samples are prepared according to EPA Method 3541 by thermal Soxhlet extraction. The surrogate compounds tetrachloro-*m*-xylene and decachlorobiphenyl will be added to every sample, quality control sample, and selected instrument standards. Florisil column cleanup (EPA Method 3620), sulfur removal with mercury (EPA Method 3660B), and gel permeation chromatography cleanup (EPA Method 3640A) will be performed on the sample extract, if necessary, to achieve the MRLs/MDLs specified in Table A6-4.

B3.1.2.1 Chlorinated Dioxins and Furans – Sediment Trap

CAS-Houston will be responsible for analyzing sediment trap subsamples for chlorinated dioxins and furans. Samples will be analyzed according to EPA Method 1613B, as shown in Table A6-2.

Samples will be extracted with toluene in a Soxhlet/Dean Stark extractor. Cleanup procedures will include an acid extraction; additional cleanup procedures will be used as necessary to achieve the MRLs/MDLs specified in Table A6-4. Samples will be analyzed by HRGC/HRMS. As described in EPA Method 1613B, detection limits are calculated on an individual compound and sample basis and depend on the signal-to-background ratio for the specific labeled isomer. The detection limits listed in Table A6-4 are representative of MDLs typically obtained when using the described procedure.

B3.2 Analyses in Field Blanks

Field blanks will be analyzed for all project COPCs using the methods as shown in Table A6-2. Method modifications are not anticipated for the analysis of field blanks. For each analytical method, the analysis of field blank samples will be performed at the same laboratory location that analyzes the associated stormwater samples.

Surrogate compounds will be added to every sample, quality control sample, and selected instrument standards as specified in the appropriate method.

B4 QUALITY CONTROL

Quality control samples will be prepared in the field and at the laboratories to monitor the bias and precision of the sample collection and analysis procedures.

B4.1 Field Quality Control Samples

Field quality control samples for this study will include field duplicates, field blanks, and temperature blanks. The frequency of collection of field duplicates and field blanks is summarized in Table A6-1. Temperature blanks will be added to each cooler. Each set of field QA/QC samples will consist of one field duplicate and one field blank (equipment rinsate blank).

Field QA/QC samples will be prepared at a frequency of 1 set per sampling event for the first 4 sampling events followed by 1 set per quarter thereafter until a maximum of 1 year of sampling is completed. After 1 year of sampling, field QA/QC sampling may be reduced or eliminated based on discussions with DEQ. Validation criteria and procedures for field quality control samples are described in Sections D1 and D2.

Because there are no clearly defined QA/QC requirements for stormwater sampling under the NPDES program, the proposed QA/QC sampling schedule is expected to meet or exceed what is typically performed under NPDES permitting. In addition, the following field-related sampling factors are anticipated to reduce the likelihood of resulting QA/QC issues: the stormwater sampling equipment is automated (see Section 2.3.1 of the PMP), the automated samplers that will be used perform two purges (pre-sample and post-sample) during the sampling cycle to clear the sampler suction line of residual liquid, and cleaned sample bottles will be provided new for each sampling event by the analytical laboratory. Once field-related sampling factors have been disregarded as QA/QC issues, QA/QC sampling should only need to be performed to maintain continuity in QA/QC evaluation. Note that all analyses will continue to be subject to the analytical laboratory's QA/QC program. Any reduction or cessation in QA/QC sampling frequency will be subject to DEQ approval.

B4.2 Laboratory Quality Control

Extensive and detailed requirements for laboratory quality control procedures are provided in the method protocols that will be used for this study (Table A6-2). Every method protocol includes descriptions of quality control procedures, and many incorporate additional quality control requirements by reference to separate quality control chapters. Quality control requirements include control limits and, in many cases, requirements for corrective action. Quality control procedures will be completed by the laboratories, as required in each method protocol and as indicated in this QAPP.

The frequency of analysis for laboratory control samples, matrix spike samples, matrix spike duplicates or laboratory duplicates, and method blanks will be one for every 20 samples or one per extraction batch, whichever is more frequent. Surrogate spikes and internal standards will be added to every field sample and quality control sample, as required by the method. Calibration procedures will be completed at the frequency specified in each method description. As required for EPA SW-846 methods (USEPA 2008a), performance-based control limits have

been established by each laboratory. These and all other control limits specified in the method descriptions will be used by the laboratories to establish the acceptability of the data or the need for reanalysis of the samples. Control limits for surrogate compounds, laboratory control samples/laboratory control sample duplicates, and matrix spike/matrix spike duplicates are provided for all matrices in Tables A7-2 through A7-4.

Where discrepancies exist between this QAPP and laboratory SOPs and QA manuals, this QAPP will take precedence.

B5 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

Analytical instrument testing, inspection, maintenance, setup, and calibration will be conducted by each laboratory in accordance with the requirements identified in the laboratory SOPs and manufacturer instructions. In addition, each of the specified analytical methods provides protocols for proper instrument setup and tuning, and critical operating parameters. Instrument maintenance and repair will be documented in maintenance logs or record books.

B6 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

Laboratory instruments will be properly calibrated, and the calibration will be verified with appropriate check standards and calibration blanks for each parameter before beginning each analysis. Instrument calibration procedures and schedules will conform to analytical protocol requirements and descriptions provided in the laboratories' QA manuals and SOPs (Attachment A of this QAPP).

All calibration standards will be obtained from either the EPA repository or a commercial vendor, and the laboratory will maintain traceability to the National Institute of Standards and Technology. Stock standards will be used to make intermediate standards and calibration standards. Special attention will be given to expiration dating, proper labeling, proper refrigeration, and prevention of contamination. Documentation relating to the receipt, mixing, and use of standards will be recorded in a laboratory logbook. All calibration and spiking standards will be checked against standards from another source.

B7 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

The quality of supplies and consumables used during sample collection and laboratory analysis can affect the quality of the project data. All equipment that comes into contact with the samples and extracts must be sufficiently clean to prevent detectable contamination, and the analyte concentrations must be accurate in all standards used for calibration and quality control purposes.

During sample collection, solvents of appropriate, documented purity will be used for decontamination. Solvent containers will be dated and initialed when they are opened. The quality of laboratory water used for decontamination will be documented at the laboratories. Cleaned and documented sample containers will be provided by the laboratories. All containers will be visually inspected prior to use, and any suspect containers will be discarded.

Reagents of appropriate purity and suitably cleaned laboratory equipment will also be used for all stages of laboratory analyses. Details for acceptance requirements for supplies and consumables at the laboratories are provided in the laboratory SOPs and QA manuals (Attachment A of this QAPP). All supplies will be obtained from reputable suppliers with appropriate documentation or certification. Supplies will be inspected to confirm that they meet use requirements, and certification records will be retained by Integral (i.e., for supplies used in the field) or the laboratories.

B8 DATA MANAGEMENT

Data for the PMP will be generated in the field and at the laboratories. The final repository for all sample information will be an EQuIS database. Procedures to be used to transfer data from the point of generation to the EQuIS database are described in this section.

B8.1 Field Data

Data that are generated during sample collection and sample preparation will be manually entered into the field logbook, sample collection forms, and COC forms. Data from these sources will be entered into the EQuIS database directly from the field logbook and sample collection forms. These data include station location coordinates, station names, sampling dates, sample identification codes, and additional station and sample information (e.g., sample type, field replicate number). All entries will be reviewed for accuracy and completeness by a second individual, and any errors will be corrected before the data are approved for release to data users.

B8.2 Laboratory Data

A variety of manually entered and electronic instrument data are generated at the laboratories. Data are manually entered into the following:

- Standard logbooks
- Storage temperature logs
- Balance calibration logs
- Instrument logs

- Sample preparation and analysis worksheets
- Maintenance logs
- Individual laboratory notebooks
- Results tables for conventional analyses (i.e., oil and grease, pH, and TSS).

The LIMS is the central data management tool for each laboratory. All manual data entry into the LIMS is proofed at the laboratory. All data collected from each laboratory instrument, either manually or electronically, are reviewed and confirmed by analysts before reporting. The LIMS is used for every aspect of sample processing, including sample log-in and tracking, instrument data storage and processing, generation of data reports for sample and quality control results, and preparation of EDDs.

Laboratory data will be entered directly into the EQuIS database from the EDD. A database printout will be used to verify database entries against the hard-copy laboratory data packages.

SECTION C: ASSESSMENT AND OVERSIGHT

This project will rely heavily on the knowledge and experience of the project team. The field team and laboratories will stay in close verbal contact with the Integral project and task managers and the task QA manager during all phases of this project. This level of communication will serve to keep the management team informed of activities and events, and will allow for informal but continuous project oversight. Few scheduled assessment activities are planned for this task because the scope of the sampling and analysis effort and the size of the team are relatively small.

C1 ASSESSMENTS AND RESPONSE ACTIONS

Assessment activities will include readiness reviews prior to sampling and prior to release of the final data to the data users, and internal review while work is in progress. An informal technical systems audit may be conducted if problems are encountered during any phase of this project.

Readiness reviews are conducted to ensure that all necessary preparations have been made for efficient and effective completion of each critical phase of project work. The first readiness review will be conducted prior to field sampling. The field operations manager will verify that all field equipment is ready for transfer to the site. The field operations manager will also verify that the field team and subcontractors have been scheduled and briefed and that the contracts for the subcontractors have been signed by both parties. Any deficiencies noted during this readiness review will be corrected prior to initiation of sampling activities.

The second readiness review will be completed before final data are released for use. The database administrator will verify that all results have been received from the laboratories, data validation and data quality assessment have been completed for all of the data, and data qualifiers have been entered into the database and verified. Any deficiencies noted during this review will be corrected by the data manager, the Integral QA manager, or their designee. Data will not be released for final use until all data have been verified and validated. No report will be prepared in conjunction with the readiness reviews. However, the project manager and data users will be notified when the data are ready for use.

Technical review of intermediate and final work products generated for this project will be completed throughout the course of all sampling, laboratory, data validation, data management, and data interpretation activities to ensure that every phase of work is accurate and complete and follows the QA procedures outlined in this QAPP. Any problems that are encountered will be resolved between the reviewer and the person completing the work. Any problems that cannot be easily resolved or that affect the final quality of the work product will

be brought to the attention of the Integral and LSS project managers. DEQ will be notified of any problems that may affect the final outcome of the project.

The laboratories have implemented a review system that serves as a formal surveillance mechanism for all laboratory activities. Each phase of work is reviewed by a supervisor before it is approved for release. Details are provided in the laboratory QA manuals (Attachment A of this QAPP).

Technical system audits may be conducted if serious problems are encountered during sampling or analysis operations. If completed, these audits will be conducted by the Integral QA manager or designee or by the laboratory QA managers. These audits may consist of onsite reviews of any phase of field or laboratory activities or data management. Results of any audits will be provided in the data summary report.

Any project team member who discovers or suspects a nonconformance is responsible for reporting the nonconformance to the project manager, the Integral QA manager, or the laboratory project or QA manager, as applicable. The project manager will ensure that no additional work dependent on the nonconforming activity is performed until a confirmed nonconformance is corrected.

C2 REPORTS TO MANAGEMENT

A data summary report will be provided to DEQ by June 1 of the year following implementation of the stormwater SCMs. The data summary report will include analytical results from stormwater samples collected during the previous year, stormwater flow rate data collected coincident with stormwater sample collection, a description of any stormwater treatment system maintenance issues identified during visual inspections of the treatment system and the subsequent resolution of those issues, a discussion of any deviations from the PMP and QAPP, and a discussion of the data quality. The data summary report will also include an evaluation of the effectiveness of the stormwater SCMs, as well as any recommendations, if necessary, for modifications and/or optimizations to the stormwater treatment system.

Data packages and EDDs will be prepared by the laboratory upon completion of analyses for each sample delivery group. The case narrative will include a description of any problems encountered, control limit exceedances, and a description and rationale for any deviations from protocol. Copies of corrective action reports generated at the laboratory will also be included with the data package.

A data validation report will be prepared for the collected data. A summary of any significant data quality issues will be provided as an attachment to the data summary report.

SECTION D: DATA VALIDATION AND USABILITY

Data generated in the field and at the laboratories will be verified and validated according to criteria and procedures described in this section. Data quality and usability will be evaluated, and a discussion will be included in the applicable site characterization summary report for each sampling event.

D1 CRITERIA FOR DATA REVIEW, VERIFICATION, AND VALIDATION

Field and laboratory data for this project will undergo a formal verification and validation process. All entries into the database will be verified. All errors found during the verification of field data, laboratory data, and the database will be corrected prior to release of the final data.

Data verification and validation will be conducted in accordance with *Guidance on Environmental Data Verification and Validation* (USEPA 2002b). Data verification and validation for organic compounds and metals will be completed according to methods described in the EPA guidance for data review (USEPA 1996, 2004, 2008b). Performance-based control limits established by the laboratory and control limits provided in the method protocols will be used to evaluate data quality and determine the need for data qualification. Current laboratory control limits for surrogate compounds, laboratory control samples and duplicates, and matrix spike samples and duplicates are provided in Tables A7-2 through A7-4. Control limits are updated periodically by the laboratories, and the control limits that are in affect at the laboratory at the time of analysis will be used for data validation.

No guidelines are available for validation of data for conventional analyses. These data will be validated using procedures described in the functional guidelines for inorganic data review (USEPA 2004), as applicable.

Results for field duplicates will be evaluated against a target control limit of 50 RPD. Data will not be qualified as estimated if this control limit is exceeded, but RPD results will be tabulated, and any exceedances will be discussed in the applicable QA report. Equipment rinse blanks will be evaluated and data qualifiers will be applied in the same manner as method blanks, as described in the applicable EPA guidance documents for data review (USEPA 1996, 2004, 2008b).

Data will be rejected if control limits for acceptance of data are not met, as described in USEPA (1996, 2004, 2008b).

D2 VERIFICATION AND VALIDATION METHODS

Field data will be verified during preparation of samples and COCs. Field data and COCs will be reviewed by the field task manager on a daily basis. After field data are entered into the project database, 100 percent verification of the entries will be completed by a second party to ensure the accuracy and completeness of the database. Any discrepancies will be resolved before the final database is released for use.

Procedures for verification and validation of laboratory data and field quality control samples will be completed as described in the following EPA guidance documents for data validation:

- *Guidance on Environmental Data Verification and Validation* (USEPA 2002b)
- *USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review* (USEPA 2008b)
- *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (USEPA 2004)
- *EPA Region 10 SOP for the Validation of Polychlorinated Dibenzodioxin (PCDD) and Polychlorinated Dibenzofuran (PCDF) Data* (USEPA 1996)
- *EPA Region 10 Guidance for Data Deliverables Utilizing SW-846 Methods 8081 and 8082 for the Analyses of Pesticides and PCB Aroclors* (USEPA 2005).

Control limits that will be used to qualify data are described in Section D1, above.

Validation for all data packages will be based on review of the summary forms for sample and QC data, equivalent to a Stage 2A validation as described in USEPA (2009). Validation will be performed by Integral.

MDL goals for this project are provided in Tables A6-3 and A6-4. Reporting limits for non-detects will be compared to the MDL goals to evaluate method sensitivity for each sample. Any exceedance of actual MDLs over the target MDLs will be discussed in the data validation report.

In addition to verification of field and laboratory data and information, data qualifier entries into the database will be verified. Any discrepancies will be resolved before the final database is released for use. The accuracy and completeness of the database will be verified at the laboratory and again as part of data validation. All entries to the database from the laboratory EDDs will be checked against the hard-copy data packages.

D3 RECONCILIATION WITH USER REQUIREMENTS

The goal of data validation is to determine the quality of each data point and to identify data points that do not meet the project criteria. Nonconforming data may be qualified as

undetected, estimated, or rejected as unusable during data validation if criteria for data quality are not met. Rejected data will not be used for any purpose. An explanation of the rejected data will be included in the applicable site characterization summary report for each sampling event.

Data qualified as estimated will be used for all intended purposes (Section A5) and will be appropriately qualified in the final project database. These data may be less precise or less accurate than unqualified data. The data users, in cooperation with Integral project management staff and the QA manager, will evaluate the effect of the inaccuracy or imprecision of the qualified data on site assessment and risk assessment procedures used to evaluate the site.

REFERENCES

APHA, AWWA, and WEF. 2010. Standard Methods for the Examination of Water and Wastewater (Online). Accessed at: http://www.standardmethods.org/. American Public Health Association, Washington, DC; American Water Works Association, Denver, CO; and Water Environment Federation, Alexandria, VA

Arkema. 2005. Stormwater Characterization Report, Portland Plant. Arkema, Inc., Portland, OR.

Integral. 2007. Stormwater interim remedial measures field sampling and data report, Arkema Portland facility. Prepared for Legacy Site Services LLC, Exton, PA. Prepared by Integral Consulting Inc., Portland, Oregon. November 2.

USEPA. 1994. Method 1613. Tetra- through Octa-Chlorinated Dioxins and Furans by Isotope Dilution HRGC/HRMS. October 1994. U.S. Environmental Protection Agency, Office of Water, Engineering and Analysis Division. Washington, DC.

USEPA. 1996. EPA Region 10 SOP for the Validation of Polychlorinated Dibenzodioxin (PCDD) and Polychlorinated Dibenzofuran (PCDF) Data. U.S. Environmental Protection Agency, Region 10, Environmental Services Division, Seattle, WA.

USEPA. 2002a. Guidance for Quality Assurance Project Plans. EPA QA/G-5. EPA/240/R-02/009. U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC.

USEPA. 2002b. Guidance on Environmental Data Verification and Validation. EPA AQ/G-8. U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC.

USEPA. 2004. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. 540-R-04-004. U.S. Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation, Washington, DC.

USEPA. 2005. EPA Region 10 Guidance for Data Deliverables from Laboratories Utilizing SW-846 Methods 8081 and 8082 for the Analyses of Pesticides and PCB as Aroclors. Draft. U.S. Environmental Protection Agency Region 10, Seattle, WA. April 11, 2005.

USEPA. 2008a. SW-846 On-line, Test Methods for Evaluating Solid Waste - Physical/Chemical Methods. U.S. Environmental Protection Agency. http://www.epa.gov/epaoswer/hazwaste/test/main.htm.

USEPA. 2008b. USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review. EPA-540-R-08-1. U.S. Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation, Washington, DC.

USEPA. 2009. Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

FIGURES

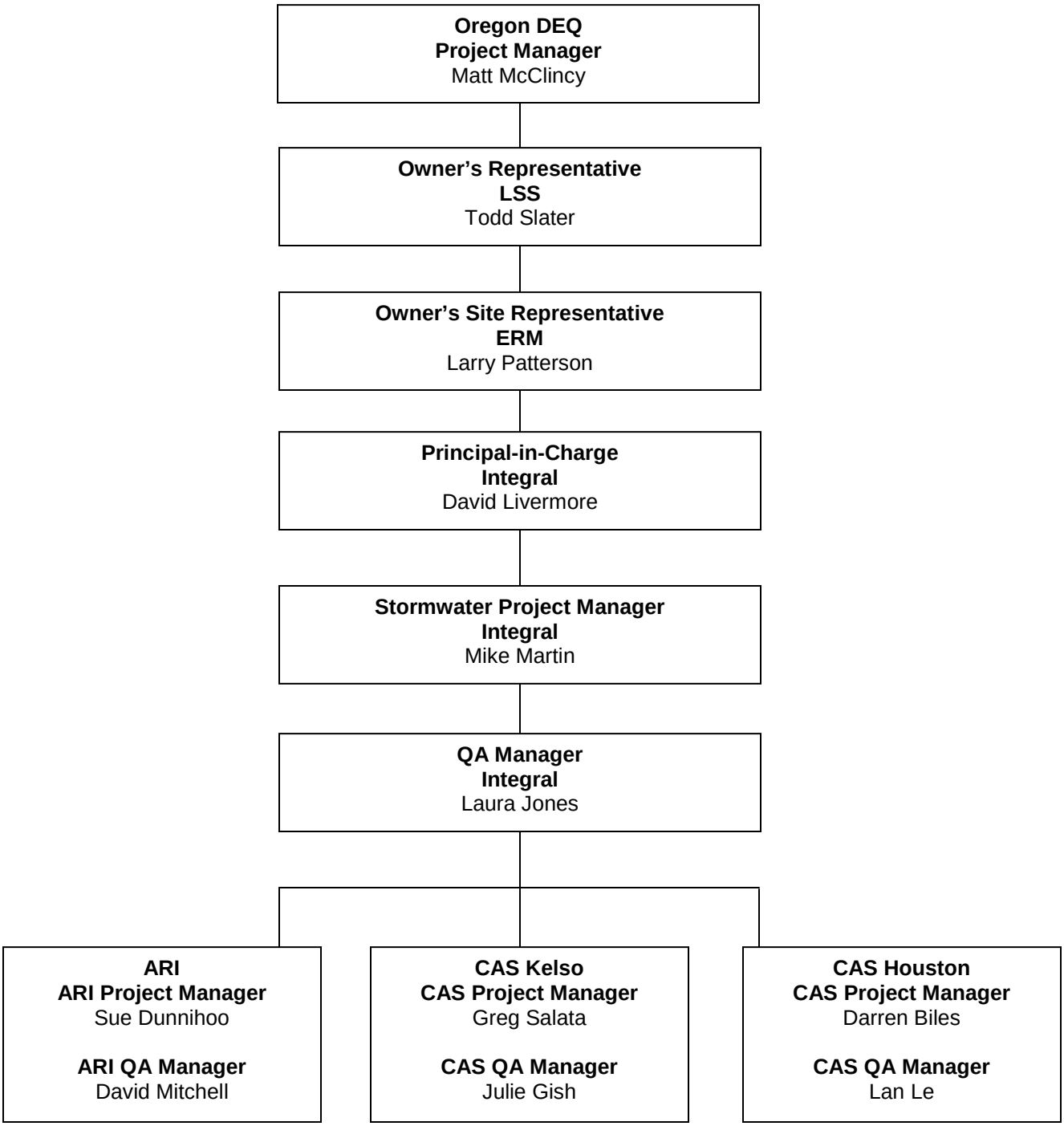


Figure A4-1
Project Organization Chart
Quality Assurance Project Plan
Final Design Report
Stormwater Source Control Measures

TABLES

Table A4-1. Stormwater Monitoring Requirements

Parameter	Minimum Frequency	Sample Type
Stormwater		
Visual Observations [a]		
Oil and grease sheen	1/Month	Grab
Floating solids	1/Month	Grab
Conventional Analyses		
Oil and grease	1/Month	Composite
pH	1/Month	Grab
Total suspended solids (TSS)	1/Month	Composite
Hardness (as $CaCO_3$)	1/Month	Composite
Metals		
Arsenic (total recoverable)	1/Month	Composite
Arsenic (inorganic)	1/Month	Composite
Hexavalent chromium (dissolved)	1/Month	Composite
Copper (total recoverable)	1/Month	Composite
Lead (total recoverable)	1/Month	Composite
Manganese (dissolved)	1/Month	Composite
Zinc (total recoverable)	1/Month	Composite
Polycyclic Aromatic Hydrocarbons (PAHs)		
Benzo(a)anthracene	1/Month	Composite
Benzo(a)pyrene	1/Month	Composite
Benzo(k)fluoranthene	1/Month	Composite
Chrysene	1/Month	Composite
Dibenzo(a,h)anthracene	1/Month	Composite
Indeno(1,2,3-cd)pyrene	1/Month	Composite
Semivolatile Organic Compounds		
Pentachlorophenol	1/Month	Composite
Organochlorine Pesticides		
2,4' and 4,4'-DDD	1/Month	Composite
2,4' and 4,4'-DDE	1/Month	Composite
2,4' and 4,4'-DDT	1/Month	Composite
Dioxins and Furans		
Chlorodibenzo-p-dioxins	1/Quarter	Composite
Chlorodibenzo-p-furans	1/Quarter	Composite
Adaptive Management Sampling [b]		
Water		
Conventional Analyses		
Water particle size distribution	TBD	Composite
Total suspended solids (TSS)	TBD	Composite

Table A4-1. Stormwater Monitoring Requirements

Parameter	Minimum Frequency	Sample Type
Metals		
Arsenic (total and dissolved)	TBD	Composite
Copper (total and dissolved)	TBD	Composite
Lead (total and dissolved)	TBD	Composite
Zinc (total and dissolved)	TBD	Composite
Sediment Trap		
Conventional Analyses		
Grainsize [c]	TBD	TBD
Total solids	TBD	TBD
Total organic carbon (TOC)	TBD	TBD
Polycyclic Aromatic Hydrocarbons (PAHs)		
Benzo(a)anthracene	TBD	TBD
Benzo(a)pyrene	TBD	TBD
Benzo(k)fluoranthene	TBD	TBD
Chrysene	TBD	TBD
Dibenzo(a,h)anthracene	TBD	TBD
Indeno(1,2,3-cd)pyrene	TBD	TBD
Semivolatile Organic Compounds		
Pentachlorophenol	TBD	TBD
Organochlorine Pesticides		
2,4' and 4,4'-DDD	TBD	TBD
2,4' and 4,4'-DDE	TBD	TBD
2,4' and 4,4'-DDT	TBD	TBD
Dioxins and Furans		
Chlorodibenzo-p-dioxins	TBD	TBD
Chlorodibenzo-p-furans	TBD	TBD

Notes

Additional details are contained in Appendix B.

[a] Visual observations will be noted upon sample collection.

[b] Adaptive management sampling contingent on an exceedance of treatment system effluent goals (Table 1-1 of the Final Design Report).

[c] Subsamples will be produced based on particle size ranges. Depending on sample volume, subsamples for each particle size range will be analyzed for some, if not all, the listed constituents (total solids, TOC, PAHs, pentachlorophenol, pesticides, and dioxin/furans).

TBD - to be determined

Table A4-2. Project Team Contact Information.

Name	Project Role	Phone	Fax	Email
Legacy Site Services				
Todd Slater	Project Manager	610-594-4430	610-594-4439	todd.slater@total.com
Oregon Department of Environmental Quality				
Matt McClincy	Project Manager	503-229-5538	503-229-6899	mcclincy.matt@deq.state.or.us
Integral Consulting				
David Livermore	Principal-in-Charge	503-284-5545 x13	503-284-5755	dlivermore@integral-corp.com
Mike Martin	Stormwater Project Manager	303-404-2944 x23	303-404-2945	mmartin@integral-corp.com
Laura Jones	Project QA Coordinator	503-284-5545 x11	503-284-5755	ljones@integral-corp.com
Eron Dodak	Health & Safety Officer & Field Operations Manager	503-284-5545 x14	503-284-5755	edodak@integral-corp.com
Reid Carscadden	Senior Technical Advisor	206-230-9600 x29	206-230-9601	rcarscadden@integral-corp.com
Analytical Resources Inc.				
Sue Dunnihoo	Laboratory Project Manager	206-695-6207	206-695-6201	sue@arilabs.com
David Mitchell	Laboratory QA Manager	206-695-6205	206-695-6201	davem@arilabs.com
CAS-Kelso				
Greg Salata	Laboratory Project Manager	360-577-7222	360-636-1068	gsalata@caslab.com
Julie Gish	Laboratory QA Manager	360-577-7222	360-636-1068	jgiles@caslab.com
CAS-Houston				
Darren Biles	Laboratory Project Manager	713-266-1599	713-266-0130	dbiles@caslab.com
Lan Le	Laboratory QA Manager	713-266-1599	713-266-0130	lle@caslab.com

Table A6-1. Summary of Samples and Chemical Analyses

Analysis	Sample Type	Frequency	Number of Samples: Field Samples	Field Duplicates [a]	Field Blank [a]	Total
Stormwater						
Conventional Analyses						
Oil and grease	Composite	Monthly	1	1	1	3
pH	Grab	Monthly	1	1	1	3
Total suspended solids (TSS)	Composite	Monthly	1	1	1	3
Hardness (as $CaCO_3$)	Composite	Monthly	1	1	1	3
Inorganic Analyses						
Hexavalent chromium (dissolved)	Composite	Monthly	1	1	1	3
Metals						
Arsenic (total recoverable)	Composite	Monthly	1	1	1	3
Arsenic (total)	Composite	Monthly	1	1	1	3
Copper (total recoverable)	Composite	Monthly	1	1	1	3
Lead (total recoverable)	Composite	Monthly	1	1	1	3
Manganese (dissolved)	Composite	Monthly	1	1	1	3
Zinc (total recoverable)	Composite	Monthly	1	1	1	3
Polycyclic Aromatic Hydrocarbons	Composite	Monthly	1	1	1	3
Semivolatile Organic Compounds						
Pentachlorophenol	Composite	Monthly	1	1	1	3
Organochlorine Pesticides						
2,4'- and 4,4'-DDD, -DDE, -DDT	Composite	Monthly	1	1	1	3
Chlorinated Dioxins and Furans	Composite	Quarterly	1	1	1	3
Adaptive Management Sampling [b]						
Water						
Conventional Analyses						
Water particle size distribution	Composite	TBD	TBD	TBD	TBD	TBD
Total suspended solids	Composite	TBD	TBD	TBD	TBD	TBD
Metals						
Arsenic (total and dissolved)	Composite	TBD	TBD	TBD	TBD	TBD
Copper (total and dissolved)	Composite	TBD	TBD	TBD	TBD	TBD
Lead (total and dissolved)	Composite	TBD	TBD	TBD	TBD	TBD
Zinc (total and dissolved)	Composite	TBD	TBD	TBD	TBD	TBD
Sediment Trap						
Conventional Analyses						
Grainsize [c]	TBD	TBD	TBD	TBD	TBD	TBD
Total solids	TBD	TBD	TBD	TBD	TBD	TBD
Total organic carbon	TBD	TBD	TBD	TBD	TBD	TBD
Polycyclic Aromatic Hydrocarbons	TBD	TBD	TBD	TBD	TBD	TBD

Table A6-1. Summary of Samples and Chemical Analyses

Analysis	Number of Samples					
	Sample Type	Frequency	Field Samples	Field Duplicates [a]	Field Blank [a]	Total
Semivolatile Organic Compounds						
Pentachlorophenol	TBD	TBD	TBD	TBD	TBD	TBD
Organochlorine Pesticides						
2,4'- and 4,4'-DDD, -DDE, -DDT	TBD	TBD	TBD	TBD	TBD	TBD
Chlorinated Dioxins and Furans	TBD	TBD	TBD	TBD	TBD	TBD

Notes:

[a] Field duplicates and field blanks will be collected at a frequency of 1 per event for the first 3 months, and then quarterly thereafter.

[b] Adaptive management sampling contingent on an exceedance of treatment system effluent goals (Table 1-1 of the Final Design Report).

[c] Subsamples will be produced based on particle size ranges. Depending on sample volume, subsamples for each particle size range will be analyzed for some, if not all, the listed constituents (total solids, total organic carbon, PAHs, pentachlorophenol, pesticides, and dioxin/furans).

TBD - to be determined

Table A6-2. Laboratory Methods for Stormwater Samples

Analytes	Laboratory	Sample Preparation		Quantitative Analysis	
		Protocol	Procedure	Protocol	Procedure
Stormwater					
Conventional Analyses					
Oil and grease	CAS-Kelso	EPA 1664	Extraction and drying	EPA 1664	Gravimetric
pH	CAS-Kelso	--	--	SM 4500H$^+$ B	Electrometric
Total suspended solids (TSS)	CAS-Kelso	SM 2540D	Filtration and drying	SM 2540D	Gravimetric
Hardness (as $CaCO_3$)	CAS-Kelso	SM 2340C	Acid digestion	SM 2340C	ICP-AES/titrimetric
Inorganic Analyses					
Hexavalent chromium (dissolved)	CAS-Rochester	EPA 218.6	Field filtration through 0.45-μm filter and preserved to pH 9.3-9.7 with ammonium sulfate	EPA 218.6	Ion chromatography
Metals					
Arsenic, copper, lead, zinc (total recoverable)	CAS-Kelso	EPA 3005	Acid digestion	EPA 200.8	ICP-MS
Arsenic (total)	CAS-Kelso	EPA 3005	Acid digestion	EPA 200.8	ICP-MS
Manganese (dissolved) [a]	CAS-Kelso	EPA 3005	Acid digestion	EPA 200.8	ICP-MS
Polycyclic Aromatic Hydrocarbons and Semivolatile Organic Compounds	CAS-Kelso	EPA 3520C	Continuous liquid-liquid extraction	EPA 625	GC/MS
		EPA 3640A	Gel permeation cleanup		
Organochlorine Pesticides	CAS-Kelso	EPA 3510C	Separatory funnel liquid-liquid extraction	EPA 625	GC/MS
		EPA 3660B	Sulfur cleanup		
		EPA 3630C	Florisil® cleanup		
		EPA 3640A	Gel permeation cleanup		
Chlorinated Dioxins and Furans	CAS-Houston	EPA 1613B	Extraction/cleanup [b]	EPA 1613B	HRGC/HRMS
Adaptive Management Sampling [c]					
Water					
Conventional Analyses					
Water particle size distribution	ARI	--	--	Beckman Coulter LS Particle Size Analyzer	Laser diffraction
Total suspended solids	ARI	SM 2540D	Oven drying	SM 2540D	Gravimetric
Metals					
Arsenic (total and dissolved)	CAS-Kelso	EPA 3005	Acid digestion	EPA 200.8	ICP-MS
Copper (total and dissolved)	CAS-Kelso	EPA 3005	Acid digestion	EPA 200.8	ICP-MS
Lead (total and dissolved)	CAS-Kelso	EPA 3005	Acid digestion	EPA 200.8	ICP-MS
Zinc (total and dissolved)	CAS-Kelso	EPA 3005	Acid digestion	EPA 200.8	ICP-MS

Table A6-2. Laboratory Methods for Stormwater Samples

Analytes	Laboratory	Sample Preparation		Quantitative Analysis	
		Protocol	Procedure	Protocol	Procedure
Sediment Trap					
Conventional Analyses					
Grainsize [d]	CAS-Kelso	--	--	PSEP	Sieve and hydrometer
Total solids	CAS-Kelso	EPA 160.3	Oven drying	EPA 160.3	Gravimetric
Total organic carbon (TOC)	CAS-Kelso	ASTM D4129-82	Oxidation	ASTM D4129-82	Coulometric
Polycyclic Aromatic Hydrocarbons and Semivolatile Organic Compounds	CAS-Kelso	EPA 3541	Thermal Soxhlet extraction	EPA 8270C	GC/MS-SIM
		EPA 3640A	Gel permeation cleanup		
Organochlorine Pesticides	CAS-Kelso	EPA 3541	Thermal Soxhlet extraction	EPA 8081	Dual column GC/ECD
		EPA 3660B	Sulfur cleanup		
		EPA 3630C	Florisil® cleanup		
		EPA 3640A	Gel permeation cleanup		
Chlorinated Dioxins and Furans	CAS-Houston	EPA 1613B	Extraction/cleanup [b]	EPA 1613B	HRGC/HRMS

Notes:

[a] Samples for the dissolved fraction will be filtered at the laboratory.

[b] Sample cleanups may include back-extraction with acid and/or base, and gel permeation, alumina, silica gel, Florisil, and activated carbon chromatography.

[c] Adaptive management sampling contingent on an exceedance of treatment system effluent goals (Table 1-1 of the Final Design Report).

[d] Subsamples will be produced based on particle size ranges. Depending on sample volume, subsamples for each particle size range will be analyzed for some, if not all, the listed constituents (total solids, TOC, PAHs, pentachlorophenol, pesticides, and dioxin/furans).

ARI - Analytical Resources Inc.
CAS - Columbia Analytical Services
EPA - U.S. Environmental Protection Agency
ICP-AES - inductively-coupled plasma-atomic emission spectroscopy
ICP-MS - inductively-coupled plasma-mass spectrometry
GC/ECD - gas chromatography/electron capture detection
GC/MS - gas chromatography/mass spectromety
GFAAS - graphite furnace atomic absorption spectrometry
HRGC/HRMS - high resolution gas chromatography/high resolution mass spectrometry
SIM - selective ion monitoring
SM - Standard Methods for the Examination of Water and Wastewater
TBD - to be determined

Table A6-3. Analytes and Method Reporting Limits for Stormwater Samples

Analyte	CAS Number [a]	Responsible Lab	Units	MDL [b]	MRL	Daily Maximum ACGs [c]	Monthly Average ACGs [d]
Conventional Analyses							
Oil and grease	30-13-3	CAS-Kelso	mg/L	5	5	NA	NA
pH	--	CAS-Kelso	pH units	NA	NA	6.5 - 8.5 [e]	6.5 - 8.5 [e]
Total suspended solids	10-05-3	CAS-Kelso	mg/L	5	5	130 [e]	130 [e]
Hardness (as $CaCO_3$)	10-02-4	CAS-Kelso	mg/L	2	2	NA	NA
Inorganic Analyses							
Hexavalent chromium (dissolved) [f]	18540-29-9	CAS-Rochester	µg/L	1	10	16	10
Metals							
Arsenic (total recoverable)	7440-38-2	CAS-Kelso	µg/L	0.1	0.5	10	10
Arsenic (total)	7440-38-2	CAS-Kelso	µg/L	0.1	0.5	10	10
Copper (total recoverable)	7440-50-8	CAS-Kelso	µg/L	0.02	0.1	18	10
Lead (total recoverable)	7439-92-1	CAS-Kelso	µg/L	0.005	0.02	5	5
Manganese (dissolved)	7439-96-5	CAS-Kelso	µg/L	0.006	0.05	87	50
Zinc (total recoverable)	7440-66-6	CAS-Kelso	µg/L	0.2	0.5	117	68
Polycyclic Aromatic Hydrocarbons							
Benz(a)anthracene	56-55-3	CAS-Kelso	µg/L	0.25	1	1	1
Benzo(a)pyrene	50-32-8	CAS-Kelso	µg/L	0.37	1	1	1
Benzo(k)fluoranthene	207-08-9	CAS-Kelso	µg/L	0.32	1	1	1
Chrysene	218-01-9	CAS-Kelso	µg/L	0.4	1	1	1
Dibenz(a,h)anthracene	53-70-3	CAS-Kelso	µg/L	0.41	1	1	1
Indeno(1,2,3-cd)pyrene	193-39-5	CAS-Kelso	µg/L	0.45	1	1	1
Semivolatile Organic Compounds							
Pentachlorophenol	87-86-5	CAS-Kelso	µg/L	0.38	2	2	2
Organochlorine Pesticides							
4,4'-DDD	72-54-8	CAS-Kelso	µg/L	NE [g]	NE [g]	0.05	0.01
4,4'-DDE	72-55-9	CAS-Kelso	µg/L	NE [g]	NE [g]	0.05	0.01
4,4'-DDT	50-29-3	CAS-Kelso	µg/L	NE [g]	NE [g]	0.05	0.01
2,4'-DDD	53-19-0	CAS-Kelso	µg/L	NE [g]	NE [g]	0.05	0.01
2,4'-DDE	3424-82-6	CAS-Kelso	µg/L	NE [g]	NE [g]	0.05	0.01
2,4'-DDT	789-02-6	CAS-Kelso	µg/L	NE [g]	NE [g]	0.05	0.01
Chlorinated Dioxin and Furans							
2,3,7,8-TCDD	1746-01-6	CAS-Houston	pg/L	0.370	10	NA	NA
1,2,3,7,8-PeCDD	40321-76-4	CAS-Houston	pg/L	0.475	50	NA	NA
1,2,3,4,7,8-HxCDD	57653-85-7	CAS-Houston	pg/L	0.348	50	NA	NA

Table A6-3. Analytes and Method Reporting Limits for Stormwater Samples

Analyte	CAS Number [a]	Responsible Lab	Units	MDL [b]	MRL	Daily Maximum ACGs [c]	Monthly Average ACGs [d]
1,2,3,6,7,8-HxCDD	39227-28-6	CAS-Houston	pg/L	0.448	50	NA	NA
1,2,3,7,8,9-HxCDD	19408-74-3	CAS-Houston	pg/L	0.377	50	NA	NA
1,2,3,4,6,7,8-HpCDD	35822-46-9	CAS-Houston	pg/L	0.716	50	NA	NA
OCDD	3268-87-9	CAS-Houston	pg/L	0.653	100	NA	NA
2,3,7,8-TCDF	51207-31-9	CAS-Houston	pg/L	0.555	10	NA	NA
1,2,3,7,8-PeCDF	57117-41-6	CAS-Houston	pg/L	0.361	50	NA	NA
2,3,4,7,8-PeCDF	57117-31-4	CAS-Houston	pg/L	0.331	50	NA	NA
1,2,3,4,7,8-HxCDF	57117-44-9	CAS-Houston	pg/L	0.313	50	NA	NA
1,2,3,6,7,8-HxCDF	72918-21-9	CAS-Houston	pg/L	0.336	50	NA	NA
1,2,3,7,8,9-HxCDF	70648-26-9	CAS-Houston	pg/L	0.387	50	NA	NA
2,3,4,6,7,8-HxCDF	60851-34-5	CAS-Houston	pg/L	0.325	50	NA	NA
1,2,3,4,6,7,8-HpCDF	67562-39-4	CAS-Houston	pg/L	0.402	50	NA	NA
1,2,3,4,7,8,9-HpCDF	55673-89-7	CAS-Houston	pg/L	0.443	50	NA	NA
OCDF	39001-02-0	CAS-Houston	pg/L	0.596	100	NA	NA
Total TCDD	41903-57-5	CAS-Houston	pg/L	NA	10	NA	NA
Total PeCDD	36088-22-9	CAS-Houston	pg/L	NA	50	NA	NA
Total HxCDD	34465-46-8	CAS-Houston	pg/L	NA	50	NA	NA
Total HpCDD	37871-00-4	CAS-Houston	pg/L	NA	50	NA	NA
Total TCDF	55722-27-5	CAS-Houston	pg/L	NA	10	NA	NA
Total PeCDF	30402-15-4	CAS-Houston	pg/L	NA	50	NA	NA
Total HxCDF	55684-94-1	CAS-Houston	pg/L	NA	50	NA	NA
Total HpCDF	38998-75-3	CAS-Houston	pg/L	NA	50	NA	NA

Notes:

[a] CAS registry numbers are unique numerical identifiers for chemical compounds. They are also referred to as CAS numbers, CAS RNs or CAS #s. Chemical Abstracts Service (CAS), a division of the American Chemical Society, assigns these identifiers to every chemical that has been described in the literature. The intention is to make database searches more convenient, as chemicals often have many names. Almost all molecule databases today allow searching by CAS number.

[b] The laboratory's current MDL is provided when an MDL study has been completed for the proposed method. When no MDL is provided, the laboratory will complete an MDL study prior to analysis of samples for this project. MDLs are estimated for analysis for DDT isomers by EPA Method 625 because the MDL study has not yet been

[c] ACGs are the daily maximum effluent level from Table 1-1 of the Final Design Report, except for arsenic which is the MCL.

[d] ACGs are the monthly average effluent levels from the June 16, 2009 DEQ Memorandum from Matt McClincy, NWR Cleanup, to Rob Burkhart, NWR Water Quality, except for arsenic which is the MC

[e] Analyte benchmarks listed from the National Pollution Discharge Elimination System permit for the Arkema facility (No. 100752).

[f] A project-specific reporting limit of 16 µg/L will be used for total and dissolved hexavalent chromium.

[g] MDL study has not been completed by CAS-Kelso.

ACG - analytical concentration goal
CAS-Kelso/Houston - Columbia Analytical
MDL - method detection limit
µg/L - microgram per liter
mg/L - milligram per liter
MRL - method reporting limit
NA - not applicable
NE - not established
pg/L - picogram per liter

Table A6-4. Analytes and Method Reporting Limits for Adaptive Management Sampling

Analyte	CAS Number [a]	Responsible Lab	Units	MDL [b]	MRL	ACGs [c]
Water						
Conventional Analyses						
Water particle size distribution	NA	ARI	percent	--	0.01	NA
Total suspended solids	NA	ARI	mg/L	--	1	NA
Metals						
Arsenic (total and dissolved)	7440-38-2	CAS-Kelso	µg/L	0.1	0.5	10
Copper (total and dissolved)	7440-50-8	CAS-Kelso	µg/L	0.02	0.1	18
Lead (total and dissolved)	7439-92-1	CAS-Kelso	µg/L	0.005	0.02	5
Zinc (total and dissolved)	7440-66-6	CAS-Kelso	µg/L	0.2	0.5	117
Sediment Trap						
Conventional Analyses						
Grainsize	NA	CAS-Kelso	percent	NA	NA	NA
Total solids	NA	CAS-Kelso	percent	NA	NA	NA
Total organic carbon	7440-44-0	CAS-Kelso	percent	0.02	0.05	NA
Polycyclic Aromatic Hydrocarbons						
Benz(a)anthracene	56-55-3	CAS-Kelso	µg/kg	0.75	5	NA
Benzo(a)pyrene	50-32-8	CAS-Kelso	µg/kg	0.76	5	NA
Benzo(k)fluoranthene	207-08-9	CAS-Kelso	µg/kg	0.87	5	NA
Chrysene	218-01-9	CAS-Kelso	µg/kg	0.80	5	NA
Dibenz(a,h)anthracene	53-70-3	CAS-Kelso	µg/kg	0.80	5	NA
Indeno(1,2,3-cd)pyrene	193-39-5	CAS-Kelso	µg/kg	0.87	5	NA
Semivolatile Organic Compounds						
Pentachlorophenol	87-86-5	CAS-Kelso	µg/kg	6	200	NA
Organochlorine Pesticides						
4,4'-DDD	72-54-8	CAS-Kelso	µg/kg	1	5	NA
4,4'-DDE	72-55-9	CAS-Kelso	µg/kg	0.11	5	NA
4,4'-DDT	50-29-3	CAS-Kelso	µg/kg	0.85	5	NA
2,4'-DDD	53-19-0	CAS-Kelso	µg/kg	1.4	5	NA
2,4'-DDE	3424-82-6	CAS-Kelso	µg/kg	0.94	5	NA
2,4'-DDT	789-02-6	CAS-Kelso	µg/kg	0.50	5	NA
Chlorinated Dioxin and Furans						
2,3,7,8-TCDD	1746-01-6	CAS-Houston	ng/kg	0.0664	1	NA
1,2,3,7,8-PeCDD	40321-76-4	CAS-Houston	ng/kg	0.0656	5	NA
1,2,3,4,7,8-HxCDD	57653-85-7	CAS-Houston	ng/kg	0.0500	5	NA
1,2,3,6,7,8-HxCDD	39227-28-6	CAS-Houston	ng/kg	0.0616	5	NA
1,2,3,7,8,9-HxCDD	19408-74-3	CAS-Houston	ng/kg	0.0525	5	NA

Table A6-4. Analytes and Method Reporting Limits for Adaptive Management Sampling

Analyte	CAS Number [a]	Responsible Lab	Units	MDL [b]	MRL	ACGs [c]
1,2,3,4,6,7,8-HpCDD	35822-46-9	CAS-Houston	ng/kg	0.0539	5	NA
OCDD	3268-87-9	CAS-Houston	ng/kg	0.0990	10	NA
2,3,7,8-TCDF	51207-31-9	CAS-Houston	ng/kg	0.0726	1	NA
1,2,3,7,8-PeCDF	57117-41-6	CAS-Houston	ng/kg	0.0501	5	NA
2,3,4,7,8-PeCDF	57117-31-4	CAS-Houston	ng/kg	0.0444	5	NA
1,2,3,4,7,8-HxCDF	57117-44-9	CAS-Houston	ng/kg	0.0489	5	NA
1,2,3,6,7,8-HxCDF	72918-21-9	CAS-Houston	ng/kg	0.0521	5	NA
1,2,3,7,8,9-HxCDF	70648-26-9	CAS-Houston	ng/kg	0.0688	5	NA
2,3,4,6,7,8-HxCDF	60851-34-5	CAS-Houston	ng/kg	0.0490	5	NA
1,2,3,4,6,7,8-HpCDF	67562-39-4	CAS-Houston	ng/kg	0.0482	5	NA
1,2,3,4,7,8,9-HpCDF	55673-89-7	CAS-Houston	ng/kg	0.0561	5	NA
OCDF	39001-02-0	CAS-Houston	ng/kg	0.0782	10	NA
Total TCDD	41903-57-5	CAS-Houston	ng/kg	NA	1	NA
Total PeCDD	36088-22-9	CAS-Houston	ng/kg	NA	5	NA
Total HxCDD	34465-46-8	CAS-Houston	ng/kg	NA	5	NA
Total HpCDD	37871-00-4	CAS-Houston	ng/kg	NA	5	NA
Total TCDF	55722-27-5	CAS-Houston	ng/kg	NA	1	NA
Total PeCDF	30402-15-4	CAS-Houston	ng/kg	NA	5	NA
Total HxCDF	55684-94-1	CAS-Houston	ng/kg	NA	5	NA
Total HpCDF	38998-75-3	CAS-Houston	ng/kg	NA	5	NA

Notes:

[a] CAS registry numbers are unique numerical identifiers for chemical compounds. They are also referred to as CAS numbers, CAS RNs or CAS #s. Chemical Abstracts Service (CAS), a division of the American Chemical Society, assigns these identifiers to every chemical that has been described in the literature. The intention is to make database searches more convenient, as chemicals often have many names. Almost all molecule databases today allow searching by CAS number.

[b] The laboratory's current MDL is provided when an MDL study has been completed for the proposed method. When no MDL is provided, the laboratory will complete an MDL study prior to analysis of samples for this project. MDLs are estimated for analysis for DDT isomers by EPA Method 625 because the MDL study has not yet been

[c] ACGs are the effluent level from Table 1-1 of the Final Design Report, except for arsenic which is the MCL.

ACG - analytical concentration goal
ARI - Analytical Resources Inc.
CAS-Kelso/Houston - Columbia Analytical
MDL - method detection limit
µg/L - microgram per liter
mg/L - milligram per liter
MRL - method reporting limit
NA - not applicable
pg/L - picogram per liter

Table A7-1 Summary of the DQOs Developed for the LSS Stormwater Source Control Measures

Problem Statement	Identify the Decision	Identify Inputs to the Decision	Define the Boundaries of the Study	Identify the Analytic Approach	Specify Performance or Acceptance Criteria	Develop the Plan for Obtaining Data
The objective of the stormwater SCMs design is to implement an adaptive management approach for addressing COPCs including DDx in stormwater discharges to the Willamette River from the site. The approach includes implementation of a stormwater SCM in accordance with an MAO with DEQ. The stormwater SCMs include erosion control, decommissioning the existing stormwater collection system, and structural treatment, including a detention basin and filtration.	The goal of the study is to collect stormwater samples following implementation of the groundwater and stormwater SCMs to evaluate the presence of COPCs in treated stormwater and to evaluate the performance of the stormwater SCMs.	Two types of site-specific data are needed to evaluate the presence of COPCs in treated stormwater: 1) approximately monthly influent and effluent samples analyzed for COPCs, and 2) monthly stormwater flow rate measurements. Monthly composite stormwater samples will be analyzed for total and/or dissolved-phase stormwater COPCs and conventional parameters, including total suspended solids. The performance monitoring data will be used to assess the effectiveness of the stormwater treatment system.	Periodic stormwater sampling activities will commence within 30 days following completion of construction of the groundwater and stormwater SCMs. Sampling events will be scheduled when it is predicted that the following storm event criteria will be met: • Storm event is preceded by a dry period (less than 0.1 in. rainfall) of at least 24 hours • Storm event is predicted to produce more than 0.2 in. rainfall • Storm event is predicted to occur over a minimum of 3 hours.	Periodic composite samples will consist of manually composited discrete grab samples collected over 24 hours (or the total rainfall duration, whichever is less), and will be collected on a basis that averages once per month. Composite samples will be collected approximately monthly and analyzed for conventionals, metals, PAHs, SVOCs, and pesticides (see Table A4-1); composite samples will be analyzed for dioxins and furans on a quarterly basis.	To monitor system performance, the system effluent monitoring data will be compared to the treatment system effluent goals presented in Table 1-1 of the Final Design Report.	Collect stormwater samples following implementation of the stormwater SCM. Twelve stormwater sampling events will be distributed over the first year. The following numbers of samples will be targeted for each month: • November, December, January, February, and March—Minimum of 9 composite samples over this period (target of 2 samples each month). • September, October, April, and May—Minimum of 2 composite samples over this period (target of 1 sample each month). • June, July, and August—Minimum of 1 composite sample over this period (target of 1 sample each month). In addition, stormwater flow rate will be measured monthly during sample collection. Composite stormwater samples will be used to monitor the performance of the stormwater SCMs and determine whether influent and effluent concentrations of COPCs in stormwater have decreased following implementation of the stormwater SCMs and to monitor stormwater treatment system performance.

Notes:
COPC = constituent of potential concern
DEQ = Oregon Department of Environmental Quality
DQO = data quality objective
MAO = Mutual Agreement and Order No. WQ/I-NWR-10-175
PAH = polycyclic aromatic hydrocarbon
SCM = source control measure
SVOC = semivolatile organic compound

Table A7-2. Laboratory Control Limits for Surrogate Recoveries

Analyte	Control Limits for Percent Recovery
Stormwater	
CAS-Kelso	
PAHs and Pentachlorophenol	
Nitrobenzene-d5	43 - 120
2-Fluorobiphenyl	45 - 115
Terphenyl-d14	28 - 147
Organochlorine Pesticides	
Tetrachloro-m-xylene	TBD
Decachlorobiphenyl	TBD
CAS-Houston	
Polychlorinated Dioxins and Furans	
13C-2,3,7,8-TCDD	25 - 164
13C-1,2,3,7,8-PeCDD	25 - 181
13C-1,2,3,4,7,8-HxCDD	32 - 141
13C-1,2,3,6,7,8-HxCDD	28 - 130
13C-1,2,3,4,6,7,8-HpCDD	23 - 140
13C-OCDD	17 - 157
13C-2,3,7,8-TCDF	24 - 169
13C-1,2,3,7,8-PeCDF	24 - 185
13C-2,3,4,7,8-PeCDF	21 - 178
13C-1,2,3,4,7,8-HxCDF	26 - 152
13C-1,2,3,6,7,8-HxCDF	26 - 123
13C-2,3,4,6,7,8-HxCDF	28 - 136
13C-1,2,3,4,6,7,8-HpCDF	28 - 143
13C-1,2,3,4,7,8,9-HpCDF	26 - 138
Adaptive Management Sampling	
CAS-Kelso	
PAHs and Pentachlorophenol	
Nitrobenzene-d5	29 - 116
2-Fluorobiphenyl	32 - 104
Terphenyl-d14	32 - 130
Organochlorine Pesticides	
Tetrachloro-m-xylene	20 - 116
Decachlorobiphenyl	22 - 130
CAS-Houston	
Polychlorinated Dioxins and Furans	
13C-2,3,7,8-TCDD	20 - 175
13C-1,2,3,7,8-PeCDD	21 - 227
13C-1,2,3,4,7,8-HxCDD	21 - 193
13C-1,2,3,6,7,8-HxCDD	25 - 163
13C-1,2,3,4,6,7,8-HpCDD	26 - 166
13C-OCDD	13 - 199
13C-2,3,7,8-TCDF	22 - 152

Table A7-2. Laboratory Control Limits for Surrogate Recoveries

Analyte	Control Limits for Percent Recovery
13C-1,2,3,7,8-PeCDF	21 - 192
13C-2,3,4,7,8-PeCDF	13 - 328
13C-1,2,3,4,7,8-HxCDF	19 - 202
13C-1,2,3,6,7,8-HxCDF	21 - 159
13C-1,2,3,7,8,9-HxCDF	17 - 205
13C-2,3,4,6,7,8-HxCDF	22 - 176
13C-1,2,3,4,6,7,8-HpCDF	21 - 158
13C-1,2,3,4,7,8,9-HpCDF	20 - 186
37Cl-2,3,7,8-TCDD	31 - 191

Notes:

Control limits are updated periodically by the laboratories. Control limits that are in effect at the laboratory at the time of analysis will be used for sample analysis and data validation. These may differ slightly from the control limits shown in this table.

Table A7-3. Laboratory Control Limits for Stormwater Matrix Spike and Laboratory Control Samples

Analyte	Responsible Lab	Accuracy		Precision	
		Matrix Spike Recovery (percent)	LCS Recovery (percent)	Type of Duplicate	Control Limit RPD
Conventional Analyses					
Oil and grease	CAS-Kelso	79 - 114	79 - 114	LD	18
pH	CAS-Kelso	NA	NA	LD	20
Total suspended solids	CAS-Kelso	NA	80 - 120	LD or LCSD	20
Hardness (as $CaCO_3$)	CAS-Kelso	NA	NA	LD	20
Inorganic Analyses					
Hexavalent chromium (dissolve	CAS-Kelso	90 - 110	90 - 110	MSD or LCSD	20
Metals					
Arsenic (total recoverable)	CAS-Kelso	89 - 112	72 - 129	MSD or LCSD	20
Arsenic (total)	CAS-Kelso	89 - 112	72 - 129	MSD or LCSD	20
Copper (total recoverable)	CAS-Kelso	89 - 113	74 - 114	MSD or LCSD	20
Lead (total recoverable)	CAS-Kelso	90 - 112	76 - 117	MSD or LCSD	20
Manganese (dissolved)	CAS-Kelso	89 - 115	25 - 180	MSD or LCSD	20
Zinc (total recoverable)	CAS-Kelso	86 - 119	65 - 126	MSD or LCSD	20
PAHs and Pentachlorophenol					
Benz(a)anthracene	CAS-Kelso	66 - 113	66 - 113	MSD or LCSD	30
Benzo(a)pyrene	CAS-Kelso	57 - 119	57 - 119	MSD or LCSD	30
Benzo(k)fluoranthene	CAS-Kelso	62 - 119	62 - 119	MSD or LCSD	30
Chrysene	CAS-Kelso	64 - 113	64 - 113	MSD or LCSD	30
Dibenz(a,h)anthracene	CAS-Kelso	64 - 119	64 - 113	MSD or LCSD	30
Indeno(1,2,3-cd)pyrene	CAS-Kelso	65 - 116	65 - 116	MSD or LCSD	30
Pentachlorophenol	CAS-Kelso	52 - 117	52 - 117	MSD or LCSD	30
Organochlorine Pesticides					
2,4' and 4,4'-DDD	CAS-Kelso	TBD	TBD	MSD or LCSD	30
2,4' and 4,4'-DDE	CAS-Kelso	TBD	TBD	MSD or LCSD	30
2,4' and 4,4'-DDT	CAS-Kelso	TBD	TBD	MSD or LCSD	30
Chlorinated Dioxin and Furans					
2,3,7,8-TCDD	CAS-Houston	67 - 158	67 - 158	MSD or LCSD	50
1,2,3,7,8-PeCDD	CAS-Houston	70 - 142	70 - 142	MSD or LCSD	50
1,2,3,4,7,8-HxCDD	CAS-Houston	70 - 164	70 - 164	MSD or LCSD	50
1,2,3,6,7,8-HxCDD	CAS-Houston	76 - 134	76 - 134	MSD or LCSD	50
1,2,3,7,8,9-HxCDD	CAS-Houston	64 - 162	64 - 162	MSD or LCSD	50
1,2,3,4,6,7,8-HpCDD	CAS-Houston	70 - 140	70 - 140	MSD or LCSD	50
OCDD	CAS-Houston	78 - 144	78 - 144	MSD or LCSD	50
2,3,7,8-TCDF	CAS-Houston	75 - 158	75 - 158	MSD or LCSD	50
1,2,3,7,8-PeCDF	CAS-Houston	80 - 134	80 - 134	MSD or LCSD	50
2,3,4,7,8-PeCDF	CAS-Houston	68 - 160	68 - 160	MSD or LCSD	50
1,2,3,4,7,8-HxCDF	CAS-Houston	72 - 134	72 - 134	MSD or LCSD	50
1,2,3,6,7,8-HxCDF	CAS-Houston	84 - 130	84 - 130	MSD or LCSD	50
1,2,3,7,8,9-HxCDF	CAS-Houston	78 - 130	78 - 130	MSD or LCSD	50
2,3,4,6,7,8-HxCDF	CAS-Houston	70 - 156	70 - 156	MSD or LCSD	50
1,2,3,4,6,7,8-HpCDF	CAS-Houston	82 - 132	82 - 132	MSD or LCSD	50
1,2,3,4,7,8,9-HpCDF	CAS-Houston	78 - 138	78 - 138	MSD or LCSD	50
OCDF	CAS-Houston	63 - 170	63 - 170	MSD or LCSD	50
Total TCDD	CAS-Houston	NA	NA	NA	NA
Total PeCDD	CAS-Houston	NA	NA	NA	NA
Total HxCDD	CAS-Houston	NA	NA	NA	NA
Total HpCDD	CAS-Houston	NA	NA	NA	NA
Total TCDF	CAS-Houston	NA	NA	NA	NA
Total PeCDF	CAS-Houston	NA	NA	NA	NA

Table A7-3. Laboratory Control Limits for Stormwater Matrix Spike and Laboratory Control Samples

Analyte	Responsible Lab	Accuracy		Precision	
		Matrix Spike Recovery (percent)	LCS Recovery (percent)	Type of Duplicate	Control Limit RPD
Total HxCDF	CAS-Houston	NA	NA	NA	NA
Total HpCDF	CAS-Houston	NA	NA	NA	NA

Notes:

Control limits are updated periodically by the laboratories. Control limits that are in effect at the laboratory at the time of analysis will be used for sample analysis and data validation. These may differ slightly from the control limits shown in this table.

CAS - Columbia Analytical Services
LCS - laboratory control sample
LCSD - laboratory control sample duplicate
LD - lab duplicate
MSD - matrix spike duplicate
NA - not applicable
PAH - polycyclic aromatic hydrocarbon
RPD - relative percent difference

Table A7-4. Laboratory Control Limits for Adaptive Management Matrix Spike and Laboratory Control Samples

Analyte	Responsible Lab	Accuracy		Precision	
		Matrix Spike Recovery (percent)	LCS Recovery (percent)	Type of Duplicate	Control Limit RPD
Water					
Conventional Analyses					
Water particle size distributior	ARI	NA	NA	LD	20
Total suspended solids	ARI	NA	NA	LD	20
Metals					
Arsenic (total and dissolved)	CAS-Kelso	89 - 112	72 - 129	MSD or LCSD	20
Copper (total and dissolved)	CAS-Kelso	89 - 113	74 - 114	MSD or LCSD	20
Lead (total and dissolved)	CAS-Kelso	90 - 112	76 - 117	MSD or LCSD	20
Zinc (total and dissolved)	CAS-Kelso	86 - 119	65 - 126	MSD or LCSD	20
Sediment Trap					
Conventional Analyses					
Grainsize	CAS-Kelso	NA	NA	LD	20
Total solids	CAS-Kelso	NA	NA	LD	20
Total organic carbon	CAS-Kelso	74 - 118	69 - 123	LD or LCSD	20
PAHs and Pentachlorophenol					
Benz(a)anthracene	CAS-Kelso	35 - 122	46 - 120	MSD or LCSD	40
Benzo(a)pyrene	CAS-Kelso	37 - 123	49 - 122	MSD or LCSD	40
Benzo(k)fluoranthene	CAS-Kelso	38 - 124	55 - 120	MSD or LCSD	40
Chrysene	CAS-Kelso	36 - 126	49 - 120	MSD or LCSD	40
Dibenz(a,h)anthracene	CAS-Kelso	32 - 125	43 - 125	MSD or LCSD	40
Indeno(1,2,3-cd)pyrene	CAS-Kelso	28 - 133	40 - 128	MSD or LCSD	40
Pentachlorophenol	CAS-Kelso	10 - 117	10 - 117	MSD or LCSD	40
Organochlorine Pesticides					
4,4'-DDD	CAS-Kelso	19 - 143	46 - 146	MSD or LCSD	40
4,4'-DDE	CAS-Kelso	22 - 142	46 - 141	MSD or LCSD	40
4,4'-DDT	CAS-Kelso	19 - 154	46 - 151	MSD or LCSD	40
2,4'-DDD	CAS-Kelso	12 - 147	53 - 115	MSD or LCSD	40
2,4'-DDE	CAS-Kelso	24 - 141	49 - 112	MSD or LCSD	40
2,4'-DDT	CAS-Kelso	15 - 141	44 - 120	MSD or LCSD	40
Chlorinated Dioxin and Furans					
2,3,7,8-TCDD	CAS-Houston	67 - 158	67 - 158	MSD or LCSD	50
1,2,3,7,8-PeCDD	CAS-Houston	70 - 142	70 - 142	MSD or LCSD	50
1,2,3,4,7,8-HxCDD	CAS-Houston	70 - 164	70 - 164	MSD or LCSD	50
1,2,3,6,7,8-HxCDD	CAS-Houston	76 - 134	76 - 134	MSD or LCSD	50
1,2,3,7,8,9-HxCDD	CAS-Houston	64 - 162	64 - 162	MSD or LCSD	50
1,2,3,4,6,7,8-HpCDD	CAS-Houston	70 - 140	70 - 140	MSD or LCSD	50
OCDD	CAS-Houston	78 - 144	78 - 144	MSD or LCSD	50
2,3,7,8-TCDF	CAS-Houston	75 - 158	75 - 158	MSD or LCSD	50
1,2,3,7,8-PeCDF	CAS-Houston	80 - 134	80 - 134	MSD or LCSD	50
2,3,4,7,8-PeCDF	CAS-Houston	68 - 160	68 - 160	MSD or LCSD	50
1,2,3,4,7,8-HxCDF	CAS-Houston	72 - 134	72 - 134	MSD or LCSD	50
1,2,3,6,7,8-HxCDF	CAS-Houston	84 - 130	84 - 130	MSD or LCSD	50
1,2,3,7,8,9-HxCDF	CAS-Houston	78 - 130	78 - 130	MSD or LCSD	50
2,3,4,6,7,8-HxCDF	CAS-Houston	70 - 156	70 - 156	MSD or LCSD	50
1,2,3,4,6,7,8-HpCDF	CAS-Houston	82 - 122	82 - 122	MSD or LCSD	50
1,2,3,4,7,8,9-HpCDF	CAS-Houston	78 - 138	78 - 138	MSD or LCSD	50
OCDF	CAS-Houston	63 - 170	63 - 170	MSD or LCSD	50
Total TCDD	CAS-Houston	NA	NA	NA	NA
Total PeCDD	CAS-Houston	NA	NA	NA	NA
Total HxCDD	CAS-Houston	NA	NA	NA	NA
Total HpCDD	CAS-Houston	NA	NA	NA	NA
Total TCDF	CAS-Houston	NA	NA	NA	NA

Table A7-4. Laboratory Control Limits for Adaptive Management Matrix Spike and Laboratory Control Samples

Analyte	Responsible Lab	Accuracy		Precision	
		Matrix Spike Recovery (percent)	LCS Recovery (percent)	Type of Duplicate	Control Limit RPD
Total PeCDF	CAS-Houston	NA	NA	NA	NA
Total HxCDF	CAS-Houston	NA	NA	NA	NA
Total HpCDF	CAS-Houston	NA	NA	NA	NA

Notes:

Control limits are updated periodically by the laboratories. Control limits that are in effect at the laboratory at the time of analysis will be used for sample analysis and data validation. These may differ slightly from the control limits shown in this table.

ARI - Analytical Resources Inc.
CAS - Columbia Analytical Services
LCS - laboratory control sample
LCSD - laboratory control sample duplicate
LD - lab duplicate
MSD - matrix spike duplicate
NA - not applicable
PAH - polycyclic aromatic hydrocarbon
RPD - relative percent difference

Table B2-1. Sample Containers and Preservation Requirements

Analysis	Laboratory	Container		Preservation	Holding Time
		Type	Size		
Stormwater					
Conventional Analyses					
Oil and grease	CAS-Kelso	AG	1 L	4 ± 2°C; HCl to pH <2	28 days
pH	CAS-Kelso	HDPE	250 mL	None	Analyze immediately
Total suspended solids	CAS-Kelso	HDPE	500 mL	4 ± 2°C	7 days
Hardness	CAS-Kelso	HDPE	250 mL	4 ± 2°C; HNO_3 to pH <2	6 months
Inorganic Analyses					
Hexavalent chromium (dissolved)	CAS-Rochester	HDPE	250 mL	Field filtered w/ 0.45-μm filter Ammonium sulfate to pH 9.3-9.7 4 ± 2°C	28 days
Metals					
Arsenic, copper, lead, zinc (total recoverable) Arsenic (total)	CAS-Kelso	HDPE	250 mL	4 ± 2°C; HNO_3 to pH <2	6 months
Manganese (dissolved) [b]	CAS-Kelso	HDPE	250 mL	4 ± 2°C	6 months
PAHs and SVOCs	CAS-Kelso	AG, Teflon-lined cap	1 L	4 ± 2°C	7 / 40 days [a]
Organochlorine Pesticides	CAS-Kelso	AG, Teflon-lined cap	2 - 1 L	4 ± 2°C	7 / 40 days [a]
Chlorinated Dioxin and Furans	CAS-Houston	AG	2 - 1 L	4 ± 2°C	1 year
Adaptive Management Sampling					
Water					
Conventional Analyses					
Water particle size distribution	ARI	HDPE	1 L	4 ± 2°C	7 days
Total suspended solids	ARI	HDPE	1 L	4 ± 2°C	7 days
Metals					
Arsenic, copper, lead, zinc (total)	CAS-Kelso	HDPE	250 mL	4 ± 2°C; HNO_3 to pH <2	6 months

Table B2-1. Sample Containers and Preservation Requirements

Analysis	Laboratory	Container		Preservation	Holding Time
		Type	Size		
Arsenic, copper, lead, zinc (dissolved) [b]	CAS-Kelso	HDPE	250 mL	4 ± 2°C	6 months
Sediment Trap					
Conventional Analyses					
Grainsize	CAS-Kelso	AG	16 oz.	4 ± 2°C	6 months
Total solids	CAS-Kelso	AG	8 oz.	4 ± 2°C	6 months
Total organic carbon					28 days
PAHs and SVOCs	CAS-Kelso	AG, Teflon-lined cap	8 oz.	Frozen (-20°C)	1 year
Organochlorine Pesticides	CAS-Kelso	AG, Teflon-lined cap	8 oz.	Frozen (-20°C)	1 year
Chlorinated Dioxin and Furans	CAS-Houston	AG	8 oz.	Frozen (-20°C)	1 year

Notes:

[a] The holding time is 7 days from collection to extraction and 40 days from extraction to analysis.

[b] Samples for the dissolved fractions will be filtered at the laboratory, unless stated otherwise.

AG - amber glass
ARI - Analytical Resources Inc.
CAS - Columbia Analytical Services
HDPE - high density polyethylene
HNO_3 - nitric acid
H_2SO_4 - sulfuric acid
PAHs - polycyclic aromatic hydrocarbons
SVOCs - semivolatile organic compounds

ATTACHMENT A

LABORATORY QUALITY ASSURANCE MANUALS

UNCONTROLLED COPY

QUALITY ASSURANCE MANUAL

Columbia Analytical Services, Inc.

1317 South 13th Avenue

Kelso, Washington 98626

(360) 577-7222

Effective Date: October 1, 2010

Approved by:

Laboratory Director/Technical Director: _____ 9/23/10
Jeff Grindstaff — Date

Quality Assurance Program Manager: Julie Gish 9/23/10
Julie Gish — Date

Technical Director – Metals: _____ 9/23/10
Jeff Coronado — Date

Technical Director – General Chemistry: _____ 9/27/10
Harvey Jacky — Date

Technical Director –Orgaincs GC: _____ 9/27/10
Aqilla Kamawal — Date

Technical Director – Organics GC/MS HPLC: _____ 9/23/10
Jon James — Date

© Columbia Analytical Services, Inc. 2010

DOCUMENT CONTROL

NUMBER: _____
Initials: _____
Date: _____

1.0 TABLE OF CONTENTS

Section	Heading	Page
-	Title Page with Provision Signatures	1
1.0	Table of Contents	2
2.0	Introduction and Company Quality Assurance Policy	4
3.0	Program Description	5
4.0	Professional Conduct, Data Integrity, and Ethics	12
5.0	Organization and Responsibilities	15
6.0	Information Management	18
7.0	Sample Management	20
8.0	Analytical Procedures	36
9.0	Calibration Procedures	40
10.0	Quality Control	45
11.0	Data Processing, Validation, and Reporting	52
12.0	Performance and System Audits	59
13.0	Preventive Maintenance	61
14.0	Corrective and Preventive Action	63
15.0	Quality Assurance Reports and Management Review	65
16.0	Personnel Training	66
17.0	References for Quality Systems, External Documents, Manuals, Standards, and Analytical Procedures	70

Tables Page

Table 5-1 Summary of Technical Experience and Qualifications 17
Table 7-1 Sample Preservation and Holding Times 24
Table 11-1 Descriptions of Data Deliverables.....58

Figures Page

Figure 3-1 Relationships of Quality Management Systems.....6
Figure 3-2 Columbia Analytical/(Location) Laboratory Floor Plan 11
Figure 7-1 Chain of Custody Form.....33
Figure 7-2 Cooler Receipt and Preservation Check Form.....34
Figure 7-3 Tier V Form …….35
Figure 14-1Corrective Action Report..... 64
Figure 16-1Initial Demonstration of Proficiency Requirements..... 69

Appendices

Appendix AList of QA Program Documents and Standard Operating Procedures
Appendix BOrganizational Chart and Resumes of Key Personnel
Appendix C Major Analytical Equipment
Appendix D Data Qualifiers and Acronyms
Appendix EPreventive Maintenance Procedures
Appendix FLaboratory SOP List
Appendix G Certifications, Accreditations, and Primary NELAP Accredited Methods

2.0 INTRODUCTION AND COMPANY QUALITY ASSURANCE POLICY

Columbia Analytical Services, Inc. (CAS) is an employee-owned professional analytical services laboratory which performs chemical and microbiological analyses on a wide variety of sample matrices, including drinking water, groundwater, surface water, wastewater, soil, sludge, sediment, tissue, industrial and hazardous waste, air, and other material. Columbia Analytical operates a network of laboratory facilites located in Arizona, California, Florida, New York, Texas, and Washington.

We recognize that quality assurance requires a commitment to quality by everyone in the organization - individually, within each operating unit, and throughout the entire laboratory. Laboratory management is committed to ensuring the effectiveness of its quality systems and to ensure that all tests are carried out in accordance to customer requirements. Key elements of this commitment are set forth in the Columbia Analytical Services, Inc. Quality and Ethics Policy Statement, March 2009 (Appendix A) and in this Quality Assurance Manual (QAM). Columbia Analytical Services, Inc. is committed to operate in accordance with these requirements and those of regulatory agencies, accrediting authorities, and certifying organizations.

Quality Management Systems are established, implemented and maintained by management. Policies and procedures are established in order to meet requirements of accreditation bodies and applicable programs, such as the Department of Defense (DOD) Environmental Laboratory Accreditation Program, as well as client's quality objectives. Systems are designed so that there will be sufficient Quality Assurance (QA) activities conducted in the laboratory to ensure that all analytical data generated and processed will be scientifically sound, legally defensible, of known and documented quality, and will accurately reflect the material being tested. Quality Systems are applicable to all fields of testing in which the laboratory in involved.

Quality Control (QC) procedures are used to continually assess performance of the laboratory and quality systems. Columbia Analytical maintains control of analytical results by adhering to written standard operating procedures (SOPs), using analytical control parameters with all analyses, and by observing sample custody requirements. All analytical results are calculated and reported in units consistent with project specifications to allow comparability of data.

This QAM is applicable to the facility listed on the title page. The information in this QAM has been organized according to requirements found in the National Environmental Laboratory Accreditation Program (NELAP) Quality Systems Standards (2003 and 2009), the EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5, USEPA, 2001; and *General Requirements for the Competence of Testing and Calibration Laboratories*, ISO/IEC 17025:2005.

3.0 PROGRAM DESCRIPTION

The purpose of the QA program at Columbia Analytical is to ensure that our clients are provided with analytical data that is scientifically sound, legally defensible, and of known and documented quality. The concept of Quality Assurance can be extended, and is expressed in the mission statement of Columbia Analytical:

> "The mission of Columbia Analytical Services, Inc. is to provide high quality, cost-effective, and timely professional testing services to our customers. We recognize that our success as a company is based on our ability to maintain customer satisfaction. To do this requires constant attention to customer needs, maintenance of state-of-the-art testing capabilities and successful management of our most important asset - our people - in a way that encourages professional growth, personal development and company commitment."

3.1 Quality Management Systems

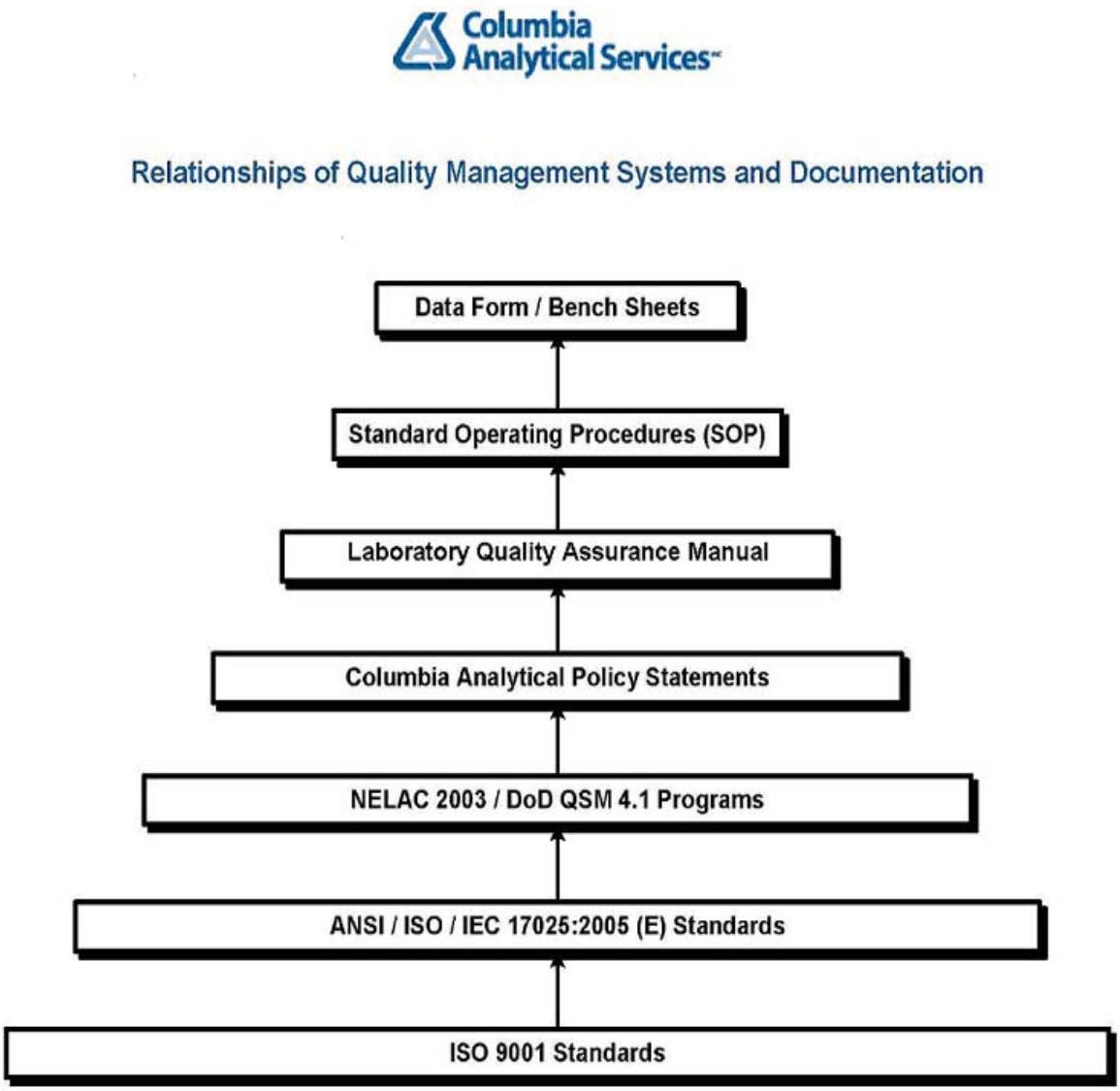
In support of this mission, the laboratory has developed a Quality Management System to ensure all products and services meet our client's needs. The system is implemented and maintained by the Quality Assurance Program Manager (QA PM) with corporate oversight by the Chief Quality Officer (CQO). These systems are based upon ISO 17025:2005 standards, upon which fundamental programs (NELAC 2003, 2009 and DoD QSM) are based. Implementation and documentation against these standards are communicated in corporate policy statements, this QAM, and SOPs. Actual procedures, actions and documentation are defined in both administrative and technical SOPs. Figure 3-1 shows the relationships of the quality systems and associated documentation. Quality systems include:

- Standard Operating Procedures
- Sample Management and Chain of Custody procedures
- Statistical Control Charting
- Standards Traceability
- Ethics Training
- Document Control
- Corrective Action Program
- Management Reviews
- Demonstration of Capability

The effectiveness of the quality system is assessed in several ways, including:

- Internal and External Audits covering all aspects of the organization
- Annual Management Reviews
- Analysis of Customer Feedback
- Internal and External Proficiency Testing

Figure 3-1


Relationships of Quality Management Systems and Documentation
Data Form / Bench Sheets
Standard Operating Procedures (SOP)
Laboratory Quality Assurance Manual
Columbia Analytical Policy Statements
NELAC 2003 / DoD QSM 4.1 Programs
ANSI / ISO / IEC 17025:2005 (E) Standards
ISO 9001 Standards

3.2 Facilities, Equipment, and Security

Columbia Analytical Services Kelso facility features over 45,000 square feet of laboratory and administrative workspace. The laboratory has been designed and constructed to provide safeguards against cross-contamination of samples and is arranged according to work function, which enhances the efficiency of analytical operations. The ventilation system has been specially designed to meet the needs of the analyses performed in each work space. Also, Columbia Analytical minimizes laboratory contamination sources by employing janitorial and maintenance staff to ensure that good housekeeping and facilities maintenance are performed. In addition, the segregated laboratory areas are designed for safe and efficient handling of a variety of sample types. These specialized areas (and access restrictions) include:

- Shipping and Receiving/Purchasing
- Sample Management Office, including controlled-access sample storage areas
- Inorganic/Metals Sample Preparation Laboratories (2)
- Inorganic/Metals “clean room” sample preparation laboratory
- ICP-AES Laboratory
- ICP-MS Laboratory
- AA Laboratory
- Water Chemistry & General Chemistry Laboratories (3)
- Semi-volatile Organics Sample Preparation Laboratory
- Gas Chromatography/High Performance Liquid Chromatography Laboratories
- Gas Chromatography/Mass Spectrometry Laboratory
- Petroleum Hydrocarbon Laboratory
- Semi-volatile Organics Drinking Water Laboratories (2)
- Volatile Organics Laboratory
    - Separate sample preparation laboratory
    - Access by semi-volatile sample preparation staff only after removing lab coat and solvent-contaminated gloves, etc.
- Microbiology Laboratory
- Laboratory Deionized Water Systems (2)
- Laboratory Management, Client Service, Report Generation and Administration
- Data Archival, Data Review and support functions areas
- Information Technology (IT) and LIMS

In addition, the designated areas for sample receiving, refrigerated sample storage, dedicated sample container preparation and shipping provide for the efficient and safe handling of a variety of sample types. Figure 3-2 shows the facility floor plan. The laboratory is equipped with state-of-the-art analytical and administrative support equipment. The equipment and instrumentation are appropriate for the procedures in use. Appendix C lists the major equipment, illustrating the laboratory's overall capabilities and depth.

3.3 Technical Elements of the Quality Assurance Program

The laboratory's technical procedures are based upon procedures published by various agencies or organizations (See Section 17). The Quality Assurance Program provides to the laboratory organization, procedures, and policies by which the laboratory operates. The necessary certifications and approvals administered by external agencies are maintained by the QA department. This includes method approvals and audit administration. In addition, internal audits are performed to assess compliance with policies and procedures. SOPs are maintained for technical and administrative functions. A document control system is used for SOPs, as well as laboratory notebooks, and this QA Manual. A list of QA Program documents is provided in Appendix A and SOPs in Apppendix F.

Acceptable calibration procedures are defined in the SOP for each test procedure. Calibration procedures for other laboratory equipment (balances, thermometers, etc.) are also defined. Quality Control (QC) procedures are used to monitor the testing performed. Each analytical procedure has associated QC requirements to be achieved in order to demonstrate data quality. The use of method detection limit studies, control charting, technical training and preventive maintenance procedures further ensure the quality of data produced. Proficiency Testing (PT) samples are used as an external means of monitoring the quality and proficiency of the laboratory. PT samples are obtained from qualified vendors and are performed on a regular basis. In addition to method proficiency, documentation of analyst training is performed to ensure proficiency and competency of laboratory analysts and technicians. Sample handling and custody procedures are defined in SOPs. Procedures are also in place to monitor the sample storage areas. The technical elements of the QA program are discussed in further detail in later sections of this QA manual.

3.4 Operational Assessments and Service to the Client

The laboratory uses a number of systems to assess its daily operations. In addition to the routine quality control (QC) measurements, the senior laboratory management examines a number of other indicators to assess the overall ability of the laboratory to successfully perform analyses for its clients including; on-time performance, customer complaints, training reports and non-conformity reports. A frequent, routine assessment must also be made of the laboratory's facilities and resources in anticipation of accepting an additional or increased workload.

Columbia Analytical utilizes a number of different methods to ensure that adequate resources are available for service demands. Senior staff meetings, tracking of outstanding proposals and an accurate, current synopsis of incoming work all assist the senior staff in properly allocating sufficient resources. All Requests for Proposal (RFP) documents are reviewed by the Project Chemist and appropriate managerial staff to identify any project specific requirements that differ from the standard practices of the laboratory. Any requirements that cannot be met are noted and communicated to the client, as well as requesting the client to provide any project specific Quality Assurance Project Plans (QAPPs) if available. Status/production meetings are also conducted regularly with the laboratory and project chemists to inform the staff of the status of incoming work, future projects, or project requirements.

When a customer requests a modification to an SOP, policy, or standard specification the Project chemist will discuss the proposed deviation with the Client Services Manager, Laboratory Director, and department manager to obtain approval for the deviation. The Quality Assurance Manager may also be involved. All project-specific requirements must be on-file and with the service request upon logging in the samples. The modification or deviation must be documented. A Project-Specific Communication Form, Form V, or similar, may be used to document such deviations.

The laboratory shall afford clients cooperation to clarify the client's request and to monitor the laboratory's performance in relation to the work performed, provided that the laboratory ensures confidentiality to other clients. The laboratory maintains and documents timely communication with the client for the purposes of seeking feedback and clarifying customer requests. Feedback is used and analyzed to improve the quality of services. The *SOP for Handling Customer Feedback* (ADM-FDBK) is in place for these events.

3.5 Document Control and Records

Procedures for control and maintenance of documents are described in the *SOP for Document Control (ADM-DOC_CTRL).* The requirements of the SOP apply to all laboratory logbooks (standards, maintenance, run logbooks, etc), certificates of analysis, SOPs, QAMs, quality assurance project plans (QAPPs), Environmental Health & Safety (EHS) manuals, and other controlled Columbia Analytical documents.

Each controlled copy of a controlled document will be released only after a document control number is assigned and the recipient is recorded on a document distribution list. Filing and distribution is performed by the Quality Assurance Manager, or designee, and ensure that only the most current version of the document is distributed and in use. A document control number is assigned to logbooks. Completed logbooks that are no longer in use are archived in a master logbook file. Logbook entries are standardized following the *SOP for Making Entries into Logbooks and onto Analytical Records* (ADM-DATANTRY). The entries made into laboratory logbooks are reviewed and approved at a regular interval (quarterly).

A records system is used which ensures all laboratory records (including raw data, reports, and supporting records) are retained and available. The archiving system is described in the *SOP for Data Archiving (ADM-ARCH).*

3.6 Subcontracting

Analytical services are subcontracted when the laboratory needs to balance workload or when the requested analyses are not performed by the laboratory. Subcontracting is only done with the knowledge and approval of the client and to qualified laboratories. Subcontracting to another Columbia Analytical laboratory is preferred over external-laboratory subcontracting. Further, subcontracting is done using capable and qualified laboratories. Established procedures are used to qualify external subcontract laboratories. These procedures are described in the *SOP for Qualification of Subcontract Laboratories (ADM-SUBLAB).* The Corporate Quality Assurance staff is responsible for maintaining a list of qualified subcontract laboratories.

3.7 Procurement

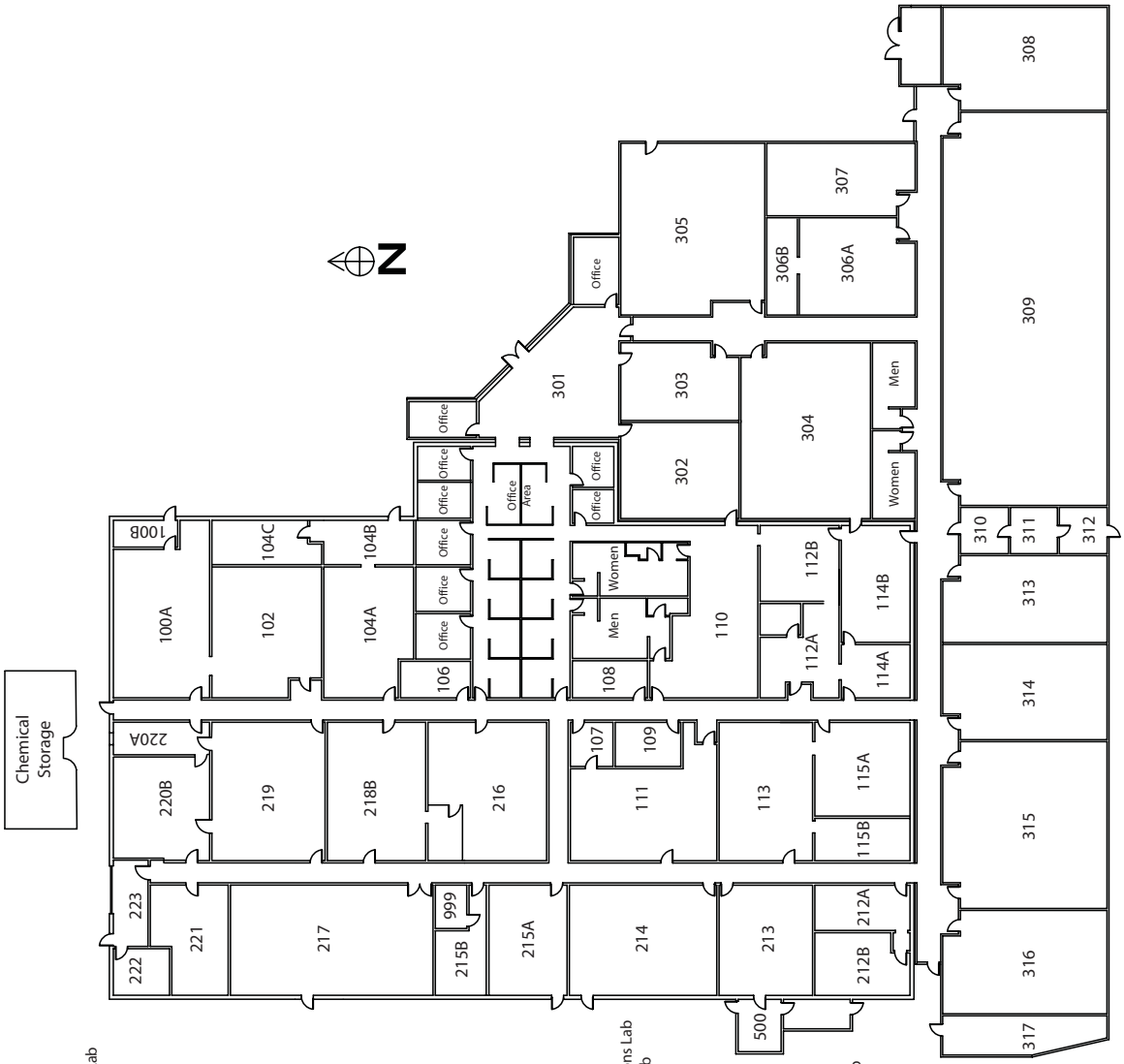
The quality level of reagents and materials (grade, traceability, etc.) required is specified in analytical SOPs. Department supervisors ensure that the proper materials are purchased. Inspection and verification of material ordered is performed at the time of receipt by receiving personnel. The receiving staff labels the material with the date received. Expiration dates are assigned as appropriate for the material. Storage conditions and expiration dates are specified in the analytical SOP. The corporate Policy for Standards and Reagents Expiration Dates provides default expiration requirements. Supplies and services that are critical in maintaining the quality of laboratory testing are procured from pre-approved vendors. The policy and procedure for purchasing and procurement are described in the *SOP for Purchasing and Approval of Vendors* (ADM-PUR). Also, refer to section 9.4 for a discussion of reference materials.

Receipt procedures include technical review of the purchase order/request to verify that what was received is identical to the item ordered. The laboratory checks new lots of reagents for unacceptable levels of contamination prior to use in sample preservation, sample preparation, and sample analysis by following the *SOP for Checking New Lots of Chemicals for Contamination* (ADM-CTMN).

3.8 Review of Requests, Tenders and Contracts (Procedures for Accepting New Work)

Requests for new work are reviewed prior to signing any contracts or otherwise agreeing to perform the work. The specific methods to be used are agreed upon between the laboratory and the client. A capability review is performed to determine if the laboratory has or needs to obtain certification to perform the work, to determine if the laboratory has the resources (personnel, equipment, materials, capacity, skills, expertise) to perform the work, and if the laboratory is able to meet the client's required reporting and QC limits. The results of this review are communicated to the client and any potential conflict, deficiency, lack of appropriate accreditation status, or concerns of the ability to complete the client's work are resolved. Any differences between the request or tender and the contract shall be resolved before any work commences. The client should be notified at this time if work is expected to be subcontracted. Each contract shall be acceptable both to the laboratory and the client. Records are maintained of pertinent discussions with a client relating to the client's requirements or the results of the work. If a contract needs to be amended after work has commenced, the contract review process is repeated and any amendments are communicated to all affected personnel. Changes in accreditation status affecting ongoing projects must be reported to the client.

Figure 3-2
Columbia Analytical/ (Location) Laboratory Floor Plan



Room #

100A	Semivolatile Organics GC Instrument Lab
100B	Electrical Room
102	Semivolatile Organics GC Office
104 A - C	Organics LC Labs and Offices
106	Deionized Water System Room
107	Oven Room
108	Zero Headspace Extraction Lab
109	Storeroom
110	Lunch Room
111	General Chemistry Lab
112A	Microbiology Lab
112B	Copy Center
113	ICP MS Lab
114A	Grain Size
114B	Total Solids/Oven Room
115A	ICP Lab
115B	Metals Reporting
212A	Mercury and Flame AA Lab
212B	Low Level Mercury Lab
213	General Chemistry Lab
214	General Chemistry Lab
215A	Drinking Water Lab
215B	Information Technology
216	Data Review & Storage
217	Sample Storage
218	Volatiles Organics Lab
219	Semivolatile Organics GC/MS Lab
220A	Semivolatile Organics GC/MS Office
220B	Semivolatile Organics GC/MS Extractions Lab
221	Drinking Water Sample Preparation Lab
222	Purchasing Office
223	General Receiving
301	Reception Lobby
302	Lunch Room
303	Conference Room
304	Sample Storage
305	Sample Receiving
306A	Pharmaceutical Metals
306B	Pharmaceutical Microbiology
307	Pharmaceutical Instrument Lab
308	Pharmaceutical General Chemistry Lab
309	Organics Sample Preparation Lab
310	Communication Room
311	Electrical Room
312	Fire Room/Water System
313	Glass Wash Room
314	Clean Room
315	Metals Digestion Room
316	Tissue Preparation
317	Mechanical
500	Janitorial Room
999	Computer Room

Revised 9/21/10

4.0 PROFESSIONAL CONDUCT, DATA INTEGRITY, AND ETHICS

One of the most important aspects of the success of CAS is the emphasis placed on the integrity of the data provided and the services rendered. This success is reliant on both the professional conduct of all employees within CAS as well as established laboratory practices. All personnel involved with environmental testing and calibration activities must familiarize themselves with the quality documentation and implement the policies and procedures in their work.

4.1 Professional Conduct

To promote quality, CAS requires certain standards of conduct and ethical performance among employees. The following examples of documented CAS policy are representative of these standards, and are not intended to be limiting or all-inclusive:

- Under no circumstances is the willful act of fraudulent manipulation of analytical data condoned. Such acts are to be reported immediately to senior management for appropriate corrective action.
- Unless specifically required in writing by a client, alteration, deviation or omission of written contractual requirements is not permitted. Such changes must be in writing and approved by senior management.
- Falsification of data in any form will not be tolerated. While much analytical data is subject to professional judgment and interpretation, outright falsification, whenever observed or discovered, will be documented, and appropriate remedies and punitive measures will be taken toward those individuals responsible.
- It is the responsibility of all Columbia Analytical employees to safeguard sensitive company information, client data, records, and information; and matters of national security concern should they arise. The nature of our business and the well being of our company and of our clients is dependent upon protecting and maintaining proprietary company/client information. All information, data, and reports (except that in the public domain) collected or assembled on behalf of a client is treated as confidential. Information may not be given to third parties without the consent of the client. Unauthorized release of confidential information about the company or its clients is taken seriously and is subject to formal disciplinary action. All employees sign a confidentiality agreement upon hire to protect the company and client's confidentiality and proprietary rights.

4.2 Prevention and Detection of Improper, Unethical or Illegal Actions

It is the intention of CAS to proactively prevent and/or detect any improper, unethical or illegal action conducted within the laboratory. This is performed by the implementation of a program designed for not only the detection but also prevention. Prevention consists of educating all laboratory personnel in their roles and duties as employees, company policies, inappropriate practices, and their corresponding implications as described here.

In addition to education, appropriate and inappropriate practices are included in SOPs such as manual integration, data review and specific method procedures. Electronic and hardcopy data audits are performed regularly, including periodic audits of chromatographic electronic data. Requirements are described in the Policy for Internal Quality Assurance Audits and details are listed in laboratory admininstrative SOPs. All aspects of this program are documented and retained on file according to the company policy on record retention.

The CAS Employee Handbook also contains information on the CAS ethics and data integrity program, including mechanisms for reporting and seeking advice on ethical decisions.

4.3 Laboratory Data Integrity and Ethics Training

Each employee receives in-depth (approximately 6-8 hour) core Data Integrity/Ethics Training. New employees are given a QA and Ethics orientation within the first month of hire, followed by the the core training within 1 year of hire. On an ongoing basis, all employees receive semi-annual ethics refresher training. Topics covered are documented in writing and all training is documented. It is the responsibility of the Quality Assurance Manager to ensure that the training is conducted as described.

Key topics covered are the organizational mission and its relationship to the critical need for honesty and full disclosure in all analytical reporting, how and when to report data integrity issues and record keeping. Training includes discussion regarding all data integrity procedures, data integrity training documentation, in-depth data monitoring and data integrity procedure documentation.

Trainees are required to understand that any infractions of the laboratory data integrity procedures will result in a detailed investigation that could lead to very serious consequences including immediate termination, or civil/criminal prosecution.

The training session includes many concepts and topics, numerous examples of improper actions (defined by DoD as deviations from contract-specified or method-specified analytical practices and may be intentional or unintentional), legal and liability implications (company and personal), causes, prevention, awareness, and reporting mechanisms.

4.4 Management and Employee Commitment

Columbia Analytical makes every attempt to ensure that employees are free from any commercial, financial, or other undue pressures that might affect their quality of work. Related policies are described in the Columbia Analytical Employee Handbook. This includes:

- CAS Open Door Policy (CAS Employee Handbook) – Employees are encouraged to bring any work related problems or concerns to the attention of local management or their Human Resources representative. However, depending on the extent or sensitivity of the concern, employees are encouraged to directly contact any member of upper management.

- CAS Corporate Ethics Point Program – An anonymous and confidential reporting system available to all employees that is used to communicate misconduct and other concerns. The program shall help minimize negative morale, promote a positive work place, and encourage reporting suspected misconduct without retribution. Associated upper management is notified and the investigations are documented.
- Use of flexible work hours. Within reason and as approved by supervisors, employees are allowed flexible work hours in order to help ease schedule pressures which could impact decision-making and work quality.
- Operational and project scheduling assessments are continually made to ensure that project planning is performed and that adequate resources are available during anticipated periods of increased workloads. Procedures for subcontracting work are established, and within the Columbia Analytical laboratory network additional capacity is typically available for subcontracting, if necessary.
- Gifts and Favors (CAS Employee Handbook) – To avoid possible conflict of interest implications, employees do not receive unusual gifts or favors to, nor accept such gifts or favors from, persons outside the Company who are, or may be, in any way concerned with the projects on which the Company is professionally engaged.

All employees are required to sign and adhere to the requirements set forth in the Columbia Analytical *Confidentiality and Conflicts of Interest Employee Agreement* and the Columbia Analytical *Commitment to Excellence in Data Quality* (see Appendix A).

5.0 ORGANIZATION AND RESPONSIBILITIES

The Columbia Analytical/Kelso staff, consisting of approximately 140 employees, includes chemists, technicians and support personnel. They represent diverse educational backgrounds and experience, and provide the comprehensive skills that the laboratory requires. During seasonal workload increases, additional temporary employees may be hired to perform specific tasks.

CAS is committed to providing an environment that encourages excellence. All employees share the responsibility for maintaining and improving the quality of our analytical services. The responsibilities of key personnel within the laboratory are described below. Table 5-1 lists the Columbia Analytical/Kelso personnel assigned to these key positions. Managerial staff members are provided the authority and resources needed to perform their duties. An organizational chart of the laboratory, as well as the resumes of these key personnel, can be found in Appendix B.

- The role of the **Laboratory Director** is to provide technical, operational, and administrative leadership through planning, allocation and management of personnel and equipment resources. The Laboratory Director provides leadership and support for the QA program and is responsible for overall laboratory efficiency and the financial performance of the Kelso facility. The Laboratory Director has the authority to stop work in response to quality problems. The Laboratory Director also provides resources for implementation of the QA program, reviews and approves this QA Manual, reviews and approves standard operating procedures (SOPs), and provides support for business development by identifying and developing new markets through continuing support of the management of existing client activities.
- The responsibility of the **Quality Assurance Program Manager** (QA PM) is to oversee implementation of the quality program and to coordinate QA activities within the laboratory. The QA PM is responsible for ensuring compliance with NELAC standards (and ISO, DoD QSM, etc. as applicable). The QA PM works with laboratory staff to establish effective quality control and assessment plans and has the authority to stop work in response to quality problems. The QA PM is responsible for maintaining the QA Manual and performing an annual review of it; reviewing and approving SOPs and ensuring the annual review of each SOP; maintaining QA records such as metrological records, archived logbooks, PT study results, etc.; document control; conducting PT sample studies; approving nonconformity and corrective action reports; maintaining the laboratory's certifications and approvals; performing internal QA audits; preparing QA activity reports; etc. The QA PM reports directly to the Laboratory Director and also works closely with the Chief Quality Officer. It is important to note that when evaluating data, the QA PM does so in an objective manner and free of outside, or managerial, influence.

  The Chief Quality Officer (CQO) is responsible for the overall QA program at all the Columbia Analytical laboratories. The CQO is responsible for oversight of QA PMs regulatory compliance efforts (NELAC, ISO, DOD, etc). The CQO performs annual internal audits at each laboratory; maintains a database of laboratory certification/accreditation programs; approves company-wide SOPs; maintains a database of approved subcontract laboratories; provides assistance to the laboratory QA staff and laboratory managers; prepares a quarterly QA activity report; etc.

- In the case of absence of the Laboratory Director or QA PM, deputies are assigned to act in that role. Default deputies for these positions are the Client Services Manager (for the Laboratory Director) and the CQO or Laboratory Director (for the QA PM).

- The **Environmental Health and Safety Officer** (EH&S) is responsible for the administration of the laboratory health and safety policies. This includes the formulation and implementation of safety policies, the supervision of new-employee safety training, the review of accidents, incidents and prevention plans, the monitoring of hazardous waste disposal and the conducting of departmental safety inspections. The EH&S officer is also designated as the Chemical Hygiene Officer. The EH&S Officer has a dotted-line reporting responsibility to Columbia Analytical's EH&S Director.

- The **Client Services Manager** is responsible for the Client Services Department (customer services/project chemists, and Electronic Data Deliverables group) and the sample management office/bottle preparation sections. The Client Services Department provides a complete interface with clients from initial project specification to final deliverables. The sample management office handles all the activities associated with receiving, storage, and disposal of samples. The Client Services Manager has the authority to stop subcontractor work in response to quality problems.

- The **Project Chemist** is a scientist assigned to each client to act as a technical liaison between the client and the laboratory. The project chemist is responsible for ensuring that the analyses performed by the laboratory meet all project, contract, and regulatory-specific requirements. This entails coordinating with the Columbia Analytical laboratory and administrative staff to ensure that client-specific needs are understood and that the services Columbia Analytical provides are properly executed and satisfy the requirements of the client.

- The Analytical Laboratory is divided into operational units based upon specific disciplines. Each department is responsible for establishing, maintaining and documenting a quality control program based upon the unique requirements within the department. Each **Department Manager and Supervisor** has the responsibility to ensure that quality control functions are carried out as planned, and to guarantee the production of high quality data. Department managers and bench-level supervisors have the responsibility to monitor the day-to-day operations to ensure that productivity and data quality objectives are met. Each department manager has the authority to stop work in response to quality problems in their area. Analysts have the responsibility to carry out testing according to prescribed methods, SOPs, and quality control guidelines particular to the laboratory in which he/she is working.

- The **Sample Management Office** plays a key role in the laboratory QA program by maintaining documentation for all samples received by the laboratory, and by assisting in the archival of all laboratory results. The sample management office staff is also responsible for the proper disposal of samples after analysis.

- **Information Technology** (IT) staffs are responsible for the administration of the Laboratory Information Management System (LIMS) and other necessary support services. Other functions of the IT staff include laboratory network maintenance, IT systems development and implementation, education of analytical staff in the use of scientific software, Electronic Data Deliverable (EDD) generation, and data back-up, archival and integrity operations.

Table 5-1
Summary of Technical Experience and Qualifications

Personnel	Years of Experience	Project Role
Jeff Grindstaff, B.S.	21	Laboratory Director
Julie Gish, M.S.	19	Quality Assurance Program Manager
Lynda Huckestein, B.S.	21	Client Services Manager Sample Management Office Manager
Jeff Coronado, B.S.	20	Metals Department Manager
Harvey Jacky, B.S.	21	General Chemistry Department Manager
Aqilla Kamawal, B.A.	10	Semi-Volatile Organics Department Manager
Jon James, B.A.	19	HPLC, GC/MS Organics Department Manager
Elieen Arnold, B.A.	28	Environmental Health and Safety Officer
Todd Poyfair, B.S.	19	Information Technology Director
Mike Sullivan, B.S.	10	Systems and Network Administrator
Jeff Christian, B.S.	31	Chief Operations Officer
Lee Wolf, B.S.	25	Chief Quality Officer/Quality Assurance Director
Jim Carlson, B.S.	24	President/CEO

6.0 INFORMATION MANAGEMENT

The generation, compilation, reporting, and archiving of electronic data is a critical component of laboratory operations. In order to generate data of known and acceptable quality, the quality assurance systems and quality control practices for electronic data systems must be complete and comprehensive and in keeping with the overall quality assurance objectives of the organization. CAS management provides the tools and resources to implement electronic data systems and establishes information technology standards and policies. Appendix C lists major computing equipment.

6.1 Software Quality Assurance Plan

Columbia Analytical has defined practices for assuring the quality of the computer software used throughout all laboratory operations to generate, compile, report, and store electronic data. These practices are described in the *CAS Software Quality Assurance Plan (SQAP)*. The purpose of the SQAP is to describe the policies and practices for the procurement, configuration management, development, validation and verification, data security, maintenance, and use of computer software. The policies and practices described in the plan apply to purchased computer software as well as to internally developed computer software. Key components of this plan are policies for software validation and control.

6.2 IT Support

The local Columbia Analytical Information Technology (IT) department is established to provide technical support for all computing systems. The IT department staff continually monitors the performance and output of operating systems. The IT department oversees routine system maintenance and data backups to ensure the integrity of all electronic data. A software inventory is maintained. Additional IT responsibilities are described in the SQAP.

In addition to the local IT department, Columbia Analytical corporate IT provides support for network-wide systems. Columbia Analytical also has personnel assigned to information management duties such as development and implementation of reporting systems; data acquisition, and Electronic Data Deliverable (EDD) generation.

6.3 Information Management Systems

Columbia Analytical has various systems in place to address specific data management needs. The Columbia Analytical Laboratory Information Management System (LIMS) is used to manage sample information and invoicing. Access is controlled by password. This system defines sample identification, analysis specifications, and provides a means of sample tracking. This system is used during sample login to generate the internal service request. Included on the service request is a summary of client information, sample identification, required analyses, work instructions, deliverable requirements. The LIMS is used to track the status of a sample and is important in maintaining internal chain of custody.

Where possible, instrument data acquired locally is immediately moved to a server (Microsoft Windows2003® domain). This provides a reliable, easily maintained, high-volume acquisition and storage system for electronic data files. With password entry, users may access the system from many available computer stations, improving efficiency and flexibility. The server is also used for data reporting, EDD generation, and administrative functions. Access to these systems is controlled by password. A standardized EDI (electronic data interchange) format is used as a reporting platform, providing functionality and flexibility for end users. With a common standardized communication platform, the EDI provides data reporting in a variety of hardcopy and electronic deliverable formats, including Staged Electronic Data Deliverable (SEDD) format.

6.4 Backup and Security

Columbia Analytical laboratory data is either acquired directly to the centralized acquisition server or acquired locally and then transferred to the server. All data is eventually moved to the centralized data acquisition server for reporting and archiving. Differential backups are performed on all file server information once per day, Sunday through Thursday. Full backups are performed each Friday night. Tapes are physically stored in a locked media cabinet within a locked, temperature controlled computer room, with every other full backup also securely stored offsite.

Access to sample information and data is on a need-to-know basis. Access is restricted to the person's areas of responsibility. Passwords are required on all systems. No direct external, non- Columbia Analytical access is allowed to any of our network systems.

The external e-mail system and Internet access is established via a single gateway to discourage unauthorized entry. Columbia Analytical uses a closed system for company e-mail. Files, such as electronic deliverables, are sent through the external e-mail system only via a trusted agent. The external messaging system operates through a single secure gateway. Email attachments sent in and out of the gateway are subject to a virus scan. Because the Internet is not regulated, we use a limited access approach to provide a firewall for added security. Virus screening is performed continuously on all network systems.

7.0 SAMPLE MANAGEMENT

7.1 Sampling and Sample Preservation

The quality of analytical results is highly dependent upon the quality of the procedures used to collect, preserve and store samples. Columbia Analytical recommends that clients follow sampling guidelines described in 40 CFR 136, 40 CFR 141, USEPA SW-846, and state-specific sampling guidelines, if applicable. Sampling factors that must be taken into account to insure accurate, defensible analytical results include:

- Amount of sample taken
- Type of container used
- Type of sample preservation
- Sample storage time
- Proper custodial documentation

Columbia Analytical uses the sample preservation, container, and holding-time recommendations published in a number of documents. The primary documents of reference are: USEPA SW-846, Third Edition and Updates I, II, IIA, IIB, III, IV for hazardous waste samples; USEPA 600/4-79-020, 600/4-91-010, 600/4-82-057, 600/R-93/100, 600/4-88-039, 600/R-94-111, and Supplements; EPA 40CFR parts 136 and 141; and *Standard Methods for the Examination of Water and Wastewater* for water and wastewater samples (see Section 18 for complete citations). The container, preservation and holding time information for these references is summarized in Table 7-1 for soil, water, and drinking water.. Where allowed by project sampling and analysis protocols (such as Puget Sound Protocols) the holding time for sediment, soil, and tissue samples may be extended for a defined period when stored frozen at -20°C.

Columbia Analytical routinely provides sample containers with appropriate preservatives for our clients. Containers are purchased as precleaned to a level 1 status, and conform to the requirements for samples established by the USEPA. Certificates of analysis for the sample containers are available to clients if requested. Reagent water used for sampling blanks (trip blanks, etc.) and chemical preservation reagents are tested by the laboratory to ensure that they are free of interferences and documented. Our sample kits typically consist of foam-lined, precleaned shipping coolers, (cleaned inside and out with appropriate cleaner, rinsed thoroughly and air-dried), specially prepared and labeled sample containers individually wrapped in protective material, (VOC vials are placed in a specially made, foam holder), chain-of-custody (COC) forms, and custody seals. Container labels and custody seals are provided for each container.

Figure 7-1 shows the chain-of-custody form routinely used at Columbia Analytical and included with sample kits. For large sample container shipments, the containers may be shipped in their original boxes. Such shipments will consist of several boxes of labeled sample containers and sufficient materials (bubble wrap, COC forms, custody seals, shipping coolers, etc.) to allow the sampling personnel to process the sample containers and return them to Columbia Analytical. The proper preservative is added to the sample containers prior to shipment, unless otherwise instructed by the client.

If any returning shipping cooler exhibits an odor or other abnormality after receipt and subsequent decontamination by laboratory personnel, a second, more vigorous decontamination process is employed. Containers exhibiting an odor or abnormality after the second decontamination process are promptly and properly discarded. Columbia Analytical keeps client-specific shipping requirements on file and utilizes major transportation carriers to guarantee that sample shipping requirements (same-day, overnight, etc.) are met. Columbia Analytical also provides courier service that makes regularly scheduled trips to the Greater Portland, Oregon Metropolitan area.

When Columbia Analytical ships environmental samples to other laboratories for analysis each sample bottle is wrapped in protective material and placed in a plastic bag (preferably Ziploc®) to avoid any possible cross-contamination of samples during shipping. The sample management office (SMO) follows formalized procedures (SMO-GEN) for maintaining the samples' chain of custody, packaging and shipment. Dry ice gel ice is the only temperature preservative used by Columbia Analytical, unless otherwise specified by the client or receiving laboratory.

7.2 Sample Receipt and Handling

Standard Operating Procedures (SMO-GEN) are established for the receiving of samples into the laboratory. These procedures ensure that samples are received and properly logged into the laboratory, and that all associated documentation, including chain of custody forms, is complete and consistent with the samples received.

Once samples are delivered to the Columbia Analytical sample management office (SMO), a Cooler Receipt and Preservation Check Form (CRF - See Figure 7-2 for an example) is used to assess the shipping cooler and its contents as received by the laboratory personnel. Verification of sample integrity includes the following activities:

- Assessment of custody seal presence/absence, location and signature;
- Temperature of sample containers upon receipt;
- Chain of custody documents properly used (entries in ink, signature present, etc.);
- Sample containers checked for integrity (broken, leaking, etc.);

- Sample is clearly marked and dated (bottle labels complete with required information);
- Appropriate containers (size, type) are received for the requested analyses;
- The minimum amount of sample material is provided for the analysis.
- Sample container labels and/or tags agree with chain of custody entries (identification, required analyses, etc.);
- Assessment of proper sample preservation (if inadequate, corrective action is employed); and
- VOC containers are inspected for the presence/absence of bubbles. (Assessment of proper preservation of VOC containers is performed by lab personnel).

Samples are logged into a Laboratory Information Management System (LIMS). Any anomalies or discrepancies observed during the initial assessment are recorded on the CRF and COC documents. Potential problems with a sample shipment are addressed by contacting the client and discussing the pertinent issues. When the Project Chemist and client have reached a satisfactory resolution, the login process may continue and analysis may begin. During the login process, each sample container is given a unique laboratory code and a service request form is generated. The LIMS generates a Service Request that contains client information, sample descriptions, sample matrix information, required analyses, sample collection dates, analysis due dates and other pertinent information. The service request is reviewed by the appropriate Project Chemist for accuracy, completeness, and consistency of requested analyses and for client project objectives.

Samples are stored as per method requirements until they undergo analysis, unless otherwise specified, using various refrigerators or freezers, or designated secure areas. Columbia Analytical has six walk-in cold storage units which house the majority of sample containers received at the laboratory. In addition, there are four additional refrigerators, including dedicated refrigerated storage of VOC samples. The dedicated storage areas for VOC samples are monitored using storage blanks, as described in the *SOP for VOA Storage Blanks (VOC-BLAN)*. Columbia Analytical also has six sub-zero freezers capable of storing samples at -20° C primarily used for tissue and sediment samples requiring specialized storage conditions. Samples subject to USDA foreign soil handling requirements are isolated in a separate refrigerated storage unit. The temperature of each sample storage unit is monitored daily and the data recorded in a bound logbook. Continuous-graph temperature recorders have also been placed in the walk-in refrigerators to provide a permanent record of the storage conditions to which samples are exposed.

Columbia Analytical adheres to the method-prescribed or project-specified holding times for all analyses. The sampling date and time are entered into the LIMS system at the time of sample receipt and login. Analysts then monitor holding times by obtaining analysis-specific reports from the LIMS. These reports provide holding time information on all samples for the analysis, calculated from the sampling date and the holding time requirement. To document holding time compliance, the date and time analyzed is printed or written on the analytical raw data. For analyses with a holding time prescribed in hours it is essential that the sample collection time is provided, so holding time compliance can be demonstrated. If not, the sample collection time is assumed as the earliest in the day (i.e. the most conservative).

Unless other arrangements have been made in advance, upon completion of all analyses and submittal of the final report, aqueous samples and sample extracts are retained at ambient temperature for 30 days, soil samples are retained at ambient temperature for 60 days, and tissue samples are retained frozen for 3 months. Upon expiration of these time limits, the samples are either returned to the client or disposed of according to approved disposal practices. All samples are characterized according to hazardous/non-hazardous waste criteria and are segregated accordingly. All hazardous waste samples are disposed of according to formal procedures outlined in the *CAS Environmental Health and Safety Manual.* All waste produced at the laboratory, including the laboratory's own various hazardous waste streams, is treated in accordance with applicable local and Federal laws. Documentation is maintained for each sample from initial receipt through final disposal to ensure that an accurate history of the sample from "cradle to grave" is available.

7.3 Sample Custody

Sample custody transfer at the time of sample receipt is documented using chain-of-custody (COC) forms accompanying the samples. During sample receipt, it is also noted if custody seals were present. This is described in the *SOP for Sample Receiving (SMO-GEN)*. Figure 7-1 is a copy of the chain-of-custody form routinely used at Columbia Analytical.

Facility security and access is important in maintaining the integrity of samples received at Columbia Analytical/Kelso. Access to the laboratory facility is limited by use of locked exterior doors with a coded entry, except for the reception area and sample receiving doors, which are manned during business hours and locked at all other times. In addition, the sample storage area within the laboratory is a controlled access area with locked doors with a coded entry. The Columbia Analytical facility is equipped with an alarm system and Columbia Analytical employs a private security firm to provide nighttime and weekend security.

A barcoding system is used to document internal sample custody. Each person removing or returning samples from/to sample storage while performing analysis is required to document this custody transfer. The system uniquely identifies the sample container and provides an electronic record of the custody of each sample. For sample extracts and digestates the analyst documents custody of the sample extract or digestate by signing on the benchsheet, or custody record, that they have accepted custody. The procedures are described in the *SOP for Sample Tracking and Internal Chain of Custody (SMO-SCOC).*

7.4 Project Setup

The analytical method(s) used for sample analysis are chosen based on the client's requirements. Unless specified otherwise, the most recent versions of reference methods are used. The Project Chemist will ensure that the correct method version is used. LIMS codes are chosen to identify the analysis method used for analysis. The Project Chemist ensures that the correct methods are selected for analysis, deliverable requirements are identified, and due dates are specified on the service request. To communicate and specify project-specific requirements, a Tier V form (Figure 7-3) is used and accompanies the service request form.

Table 7-1
Sample Preservation and Holding Times

DETERMINATION[a]	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Bacterial Tests				
Coliform, Colilert (SM 9223)	W, DW	P, Bottle or Bag	Cool, 4°C, 0.008% $Na_2S_2O_3$[d]	6-24 hours[e]
Coliform, Fecal and Total (SM 9221, 9222D)	W, DW	P,G	Cool, 4°C, 0.008% $Na_2S_2O_3$[d]	6-24 hours[e]
Fecal Streptococci (SM 9230B)	W	P,G	Cool, 4°C, 0.008% $Na_2S_2O_3$[d]	6-24 hours[e]
Inorganic Tests				
Acidity (SM 2310B)	W	P,G	Cool, 4°C	14 days[EPA]
Alkalinity (SM 2320B)	W, DW	P,G	Cool, 4°C	14 days[EPA]
Ammonia (SM 4500NH3)	W, DW	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Biochemical Oxygen Demand(SM 5210B)	W	P,G	Cool, 4°C	48 hours
Bromate (EPA 300.1)	W, DW	P,G	50mg/L EDA, cool to 4°C	28 days
Bromide (EPA 300.1)	W, DW	P,G	None Required	28 days
Chemical Oxygen Demand (SM 5220C)	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Chloride (EPA 300.0)	W, DW	P,G	None Required	28 days
Chloride (EPA 9056)	W, S	P,G	Cool, 4°C	28 days
Chlorine, Total Residual (SM 4500 Cl F)	W,S	P,G	None Required	24 hours
Chlorite (EPA 300.1)	W, DW	P,G	50mg/L EDA, cool to 4°C	14 days
Chlorophyll-A (SM 11200H)	W	G Amber	Cool, 4°C	Analyze immediately
Chromium VI (EPA 7196A)	W	P,G	Cool, 4°C	24 hours
Color (SM 2120B)	W, DW	P,G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination (EPA 335.4, 9010, 9012) (SM 4500CN E,G)	W, S,DW	P,G	Cool, 4°C, NaOH to pH>12, plus 0.6 g Ascorbic Acid	14 days

Table 7-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION[a]	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Inorganic Tests				
Cyanide, Weak Acid Dissociable (SM 4500CN I)	W,S	P,G	Cool, 4°C, NaOH to pH >12	14 days
Ferrous Iron (CAS SOP)	W, D	G Amber	Cool, 4°C	24 hours
Fluoride (EPA 300.0, SM 4500 F-C)	W,S	P,G	Cool, 4°C	28 days
Fluoride (EPA 9056)	W,S	P,G	Cool, 4°C	Analyze immediately
Formaldehyde (ASTM D6303)	W	G Amber	Cool, 4°C	48 hours
Hardness (SM 2340C)	W, DW	P,G	HNO_3 to pH<2	6 months
Hydrogen Ion (pH) (SM 4500H B)	W, DW	P,G	None Required	Analyze immediately
Kjeldahl and Organic Nitrogen (ASTM D3590-89)	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Nitrocellulose	S	G	Cool, 4°C	28 days
Nitrate (EPA 300.0)	W, DW	P,G	Cool, 4°C	48 hours
Nitrate (EPA 353.2)	W, S	P,G	Cool, 4°C, H_2SO_4 to pH<2	48 hours
Nitrate (EPA 9056)	W,S	P,G	Cool, 4°C	Analyze immediately
Nitrate-Nitrite (EPA 353.2)	W, DW	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Nitrite (EPA 300.0)	W, DW	P,G	Cool, 4°C	48 hours
Nitrite (EPA 353.2)	W, S	P,G	Cool, 4°C, H_2SO_4 to pH<2	48 hours
Nitrite (EPA 9056)	W,S	P,G	Cool, 4°C	Analyze immediately
Orthophosphate (SM 4500 P-E)	W, DW	P,G	Cool, 4°C	Analyze immediately
Oxygen, Dissolved (Probe) (SM 4500O G)	W, DW	G, Bottle and Top	None Required	Analyze immediately

Table 7-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION[a]	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Inorganic Tests				
Oxygen, Dissolved (Winkler)	W, DW	G, Bottle and Top	Fix on Site and Store in Dark	8 hours
Phenolics, Total (EPA 420.1,9056)	W, S	G Amber	Cool, 4°C, H_2SO_4 to pH<4	28 days
Perchlorate (EPA 314.0)	W, DW,S	P,G	Protect from temp. extremes	28 days
Phosphorus, Total (EPA 365.3)	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Residue, Total (SM 2540B)	W	P,G	Cool, 4°C	7 days
Residue, Filterable (TDS) (SM2540C)	W	P,G	Cool, 4°C	7 days
Residue, Nonfilterable (TSS) (SM 2540D)	W	P,G	Cool, 4°C	7 days
Residue, Settleable (SM 2540F)	W	P,G	Cool, 4°C	48 hours
Residue, Volatile (EPA 160.4)	W	P,G	Cool, 4°C	7 days
Silica (SM 4500SiO2 C)	W	P Only	Cool, 4°C	28 days
Specific Conductance(SM 2510 B)	W, DW	P,G	Cool, 4°C	28 days
Sulfate (EPA 300.0)	W, DW	P,G	Cool, 4°C	28 days
Sulfate (EPA 9056)	W, S	P,G	Cool, 4°C	28 days
Sulfide (SM 4500S2 D)	W	P,G	Cool, 4°C, Add Zinc Acetate,plus Sodium Hydroxide to pH>9	7 days
Sulfide (SM 4500S2 F)	W	P,G	Cool, 4°C, Add Zinc Acetate,plus Sodium Hydroxide to pH>9	7 days
Sulfide (9030/934)	W, S	P,G	Cool, 4°C, Add Zinc Acetate,plus Sodium Hydroxide to pH>9	7 days
Sullfides, Acid Voaltile	S	G	Cool, 4°C	14 days
Sulfite (SM 4500SO3 B)	W	P,G	None Required	24 hours
Surfactants (MBAS) (SM 5540 C)	W	P,G	Cool, 4°C	48 hours

Table 7-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION[a]	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Inorganic Tests				
Tannin and Lignin (SM 5550B)	W	P,G	Cool, 4°C	28 days
Turbidity (EPA 180.1)	W, DW	P,G	Cool, 4°C	48 hours
Oil and Grease, Hexane Extractable Material (EPA 1664)	W	G, Teflon-Lined Cap	Cool, 4°C, H_2SO_4 to pH<2	28 days
Organic Carbon, Total (9060 & SM 5310 C)	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Organic Halogens, Total (EPA 9020)	W	G, Teflon-Lined Cap	Cool, 4°C, H_2SO_4 to pH<2, No headspace	28 days
Organic Halogens, Adsorbable (EPA 1650B)	W	G, Teflon-Lined Cap	Cool, 4°C, HNO_3 to pH<2	6 months

DETERMINATION[a]	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Metals				
Chromium VI (EPA 7195/7191)	W	P,G	Cool, 4°C	24 hours
Metals (200.7, 200.8, 200.9, 6010, 6020)	W,DW	P,G	HNO_3 to pH<2	6 months
Metals (200.7, 200.8, 200.9, 6010, 6020)	S	G, Teflon-Lined cap	Cool, 4°C	6 months
Mercury (EPA 245.1, 7470, 7471)	W, DW	P,G	HNO_3 to pH<2	28 days
Mercury (7471)	S	P,G	Cool, 4°C	28 days
1631E	W	F	Cool, 4°C, HCl or H_2SO_4 to pH<2	90 days
1631E	S	F	Freeze < -15ºC	1 Yr
Methyl Mercury 1630	W	F	HCL to pH<2	6 months
Arsenic, Total Inorganic 1632	W	G	HCL to pH<2, Cool < 4ºC	28 days

Table 7-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION[a]	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Volatile Organics				
Gasoline Range Organics (8015, NWTPH-Gx)	W	G, Teflon-Lined, Septum Cap	Cool, 4°C, HCl to pH<2, No headspace	14 days
Gasoline Range Organics (8015, NWTPH-Gx)	S	G, Teflon-Lined Cap	Cool, 4ºC, Minimize Headspace	14 days
Purgeable Halocarbons (624, 8021, 8260)	W	G, Teflon-Lined, Septum Cap	**No Residual Chlorine Present**: HCl to pH<2, Cool, 4°C, No Headspace	14 days
Purgeable Halocarbons (624, 8021, 8260)	W	G, Teflon-Lined, Septum Cap	**Residual Chlorine Present**: 10% $Na_2S_2O_3$, HCl to pH<2, Cool, 4°C	14 days
Purgeable Halocarbons (8021, 8260)	S	G, Teflon-Lined Cap	Cool, 4°C, Minimize Headspace	14 days
Purgeable Halocarbons (8021, 8260)	S	Method 5035	Encore, Freeze at -20°C Methanol, Cool, 4C	48 hrs to prepare from Encore, 14 days after preparation.
Purgeable Halocarbons (8021, 8260)	S	Method 5035	Sodium Bisulfate Cool, 4°C	48 hrs to prepare from Encore, 14 days after preparation.
Purgeable Aromatic Hydrocarbons (including BTEX and MTBE 624, 8021, 8260)	W	G, Teflon-Lined,Septum Cap, No Headspace	**No Residual Chlorine Present**: HCl to pH<2, Cool, 4°C, No Headspace	14 days
Purgeable Aromatic Hydrocarbons (including BTEX and MTBE 624, 8021, 8260)	W	G, Teflon-Lined,Septum Cap, No Headspace	**Residual Chlorine Present**: 10% $Na_2S_2O_3$, HCl to pH<2, Cool 4°C	14 days

Table 7-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION[a]	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Volatile Organics				
Purgeable Aromatic Hydrocarbons (including BTEX and MTBE 624, 8021, 8260)	S	G, Teflon-Lined Cap	Cool, 4°C, Minimize Headspace	14 days
Purgeable Aromatic Hydrocarbons (including BTEX and MTBE 624, 8021, 8260)	S	Method 5035	Encore, Freeze at -20°C Methanol, Cool, 4C	48 hrs to prepare from Encore, 14 days after preparation.
Purgeable Aromatic Hydrocarbons (including BTEX and MTBE 624, 8021, 8260)	S	Method 5035	Sodium Bisulfate Cool, 4°C	48 hrs to prepare from Encore, 14 days after preparation.
Acrolein, Acrylonitrile, Acetonitrile (624, 8260)	W	G, Teflon-Lined, Septum Cap	Adjust pH to 4-5, Cool, 4°C, No headspace	7 days
EDB and DBCP (EPA 8260)	W,S	G, Teflon-Lined Cap	Cool, 4°C, 3 mg $Na_2S_2O_3$, No Headspace	28 days
Vinyl chloride,styrene, 2-chloroethyl vinyl ether (8260)	W	G, Teflon-Lined, Septum Cap	Cool, 4°C, Minimize Headspace	7 days

DETERMINATION[a]	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Semivolatile Organics				
Nonyl Phenols	W	G, Teflon-Lined Cap	H2SO4 to pH<2, Cool, 4°Cg	28 days
Organotins (CAS SOP)	W,S	G, Teflon-Lined Cap	Cool, 4°C	7[f] days until extraction;40 days after extraction
Otto Fuel	W	G, Teflon-Lined Cap	Cool, 4°C	7[f] days until extraction;40 days after extraction
Resin and Fatty Acids (NCASI 85.02)	W	G, Teflon-Lined Cap	NaOH to pH >10, Cool, 4°Cg	30 days until extraction; 30 days after extraction

Table 7-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION[a]	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Semivolatile Organics				
Petroleum Hydrocarbons, Extractable (Diesel-Range Organics) (EPA 8015)	W,S	G, Teflon-Lined Cap	Cool, 4°C	7[f] days until extraction;40 days after extraction
Alcohols and Glycols (EPA 8015)	W,S	G, Teflon-Lined Cap	Cool, 4°Cg	7[f] days until extraction;40 days after extraction
Acid Extractable Semivolatile Organics (EPA 625, 8270)	W,S	G, Teflon-Lined Cap	Cool, 4°Cg	7[f] days until extraction;40 days after extraction
Base/Neutral Extractable Semivolatile Organics (EPA 625, 8270)	W,S	G, Teflon-Lined Cap	Cool, 4°Cg	7[f] days until extraction;40 days after extraction
Chlorinated Herbicides (EPA 8151)	W,S	G, Teflon-Lined Cap	Cool, 4°Cg	7[f] days until extraction;40 days after extraction
Chlorinated Phenolics (EPA 1653)	W	G, Teflon-Lined Cap	H2SO4 to pH<2, Cool, 4°Cg	30 days until extraction; 30 days after extraction
Polynuclear Aromatic Hydrocarbons (EPA 625, 8270)	W,S	G, Teflon-Lined Cap	Cool, 4°C, Store in Darkg	7[f] days until extraction;40 days after extraction
Organochlorine Pesticides and PCBs (EPA 608, 8081, 8082, GC/MS/MS)	W,S	G, Teflon-Lined Cap	Cool, 4°C	7[f] days until extraction;40 days after extraction
Organophosphorus Pesticides (EPA 8141, GC/MS/MS)	W,S	G, Teflon-Lined Cap	Cool, 4°C, Store in Darkg	7[f] days until extraction;40 days after extraction
Nitrogen- and Phosphorus-Containing Pesticides (EPA 8141)	W,S	G, Teflon-Lined Cap	Cool, 4°Cg	7[f] days until extraction;40 days after extraction

Table 7-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION[a]	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Drinking Water Organics				
Purgeable Organics (EPA 524.2)	DW	G, Teflon-Lined, Septum cap	Ascorbic Acid, HCl to pH≤2, Cool, 4°C, No Headspace	14 days
EDB, DBCP, and TCP (EPA 504.1)	DW	G, Teflon-Lined, Septum cap	Cool, 4°C, 3 mg $Na_2S_2O_3$, No Headspace	14 days
Carbamates, Carbamoyloximes (EPA 531.1)	DW	G, Amber, Teflon-Lined Cap	1.8 mL monochloroacetic acid to pH<3; 80 mg/L $Na_2S_2O_3$ if Res.Cl.; Cool, 4°C	28 days
Chlorinated Herbicides (EPA 515.4)	DW	G, Amber, Teflon-Lined Cap	If Res.Cl, 2mg/4omL NaS; Cool , <6ºC	14 days until extraction; 21 days after extraction
Chlorinated Pesticides (EPA 508.1, 525.2)	DW	G, Amber, Teflon-Lined Cap	50 mg/L NaS, HCl to pH≤ 2;Cool 4ºC	14 days until extraction; 30 days after extraction
Diquat and Paraquat (EPA 549.2)	DW	G, Amber, Teflon-Lined Cap	100 mg/L $Na_2S_2O_3$ if Res.Cl.Cool 4ºC	7days until extraction; 21 days after extraction
Endothall (EPA 548.1)	DW	G, Amber, Teflon-Lined Cap	Cool, 4°C	7 days until extraction; 14 days after extraction
Glyphosate (EPA 547)	DW	G, Amber, Teflon-Lined Cap	100 mg/L $Na_2S_2O_3$,Cool, 4°C	14 days
Haloacetic Acids (EPA 552.2)	DW	G, Amber, Teflon-Lined Cap	100 mg/L NH_4Cl,Cool, 4°C	14 days until extraction; 7 days after extraction
Semivolatile Organics (EPA 525.2)	DW	G, Amber, Teflon-Lined Cap	50 mg/L NaS, HCl to pH≤ 2;Cool, 4°C	14 days until extraction; 30 days after extraction
Nitrosoamines (EPA 521)	DW	G, Amber, Teflon-Lined Cap	Dechlorinate at collection[g]	14 days until extraction; 28 days after extraction
Selected Pesticides and Flame Retardants (EPA 527)	DW	G, Amber, Teflon-Lined Cap	See Method, Cool, 4°C	14 days until extraction; 28 days after extraction
Explosives (EPA 529)	DW	G, Amber, Teflon-Lined Cap	See Method, Cool, 4°C	14 days until extraction; 30 days after extraction

Table 7-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION[a]	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Toxicity Characteristic Leaching Procedure (TCLP)				
Semivolatile Organics (EPA 1311/8270)	HW	G, Teflon-Lined Cap	Sample: Cool, 4°C, Store in Dark[g]	14 days until TCLP ext'n;
			TCLP extract: Cool, 4°C, Store in Dark[g]	7 days until extraction; 40 days after extraction
Organochlorine Pesticides (EPA 1311/8081)	HW	G, Teflon-Lined Cap	Sample: Cool, 4°C	14 days until TCLP ext'n;
			TCLP extract: Cool, 4°C	7 days until extraction; 40 days after extraction
Chlorinated Herbicides (EPA 1311/8151)	HW	G, Teflon-Lined Cap	Sample: Cool, 4°C	14 days until TCLP ext'n;
			TCLP extract: Cool, 4°C	7 days until extraction; 40 days after extraction
Mercury(EPA 1311/7470)	HW	P,G	Sample: Cool, 4°C	28 days until extraction
			TCLP extract: HNO_3 to pH<2	28 days after extraction
Metals, except Mercury (EPA 1311/6010)	HW	P,G	Sample: Cool, 4°C	180 days until extraction;
			TCLP extract: HNO_3 to pH<2	14 days until TCLP ext'n;
Volatile Organics (EPA 1311/8260)	HW	G, Teflon-Lined Cap	Sample: Cool, 4°C , Minimize Headspace	14 days until TCLP ext'n;
			Extract: Cool 4°C, HCL to pH,2, No Headspace	14 days after extraction

a For EPA SW-846 methods the method number is listed generically, without specific revision suffixes.

b DW = Drinking Water, W = Water; S = Soil or Sediment; HW = Hazardous Waste

c P = Polyethylene; G = Glass, F- Fluoropolymer

d For chlorinated water samples

e The maximum holding time is dependent upon the geographical proximity of sample source to the laboratory.

f Fourteen days until extraction for soil, sediment, and sludge samples.

g If the water sample contains residual chlorine, 10% sodium thiosulfate is used to dechlorinate.

Figure 7-1
Chain of Custody Form

Columbia Analytical Services™
1317 South 13th Ave. • Kelso, WA 98626 • (360) 577-7222 • (800) 695-7222x07 • FAX (360) 636-1068

CHAIN OF CUSTODY

SR#:_____ PAGE _____ OF _____ COC #_____

PROJECT NAME
PROJECT NUMBER
PROJECT MANAGER
COMPANY/ADDRESS
CITY/STATE/ZIP
E-MAIL ADDRESS
PHONE # FAX #
SAMPLER'S SIGNATURE

SAMPLE I.D.	DATE	TIME	LAB I.D.	MATRIX	NUMBER OF CONTAINERS	Semivolatile Organics by GC/MS 625 ☐ 8270 ☐ 8270LL ☐	Volatile Organics 624 ☐ 8260 ☐ 8021 ☐ BTEX ☐	Hydrocarbons (*see below) Gas ☐ Diesel ☐ Oil ☐	NW-HCID Screen ☐ Fuel Fingerprint (FID)	Oil & Grease/TRPH 1664 HEM ☐ 1664 SGT ☐	PCB's Congeners ☐ Aroclors ☐	Pesticides/Herbicides 608 ☐ 8081A ☐ 8141A ☐ 8151M	Chlorophenolics - 8151M Tri ☐ Tetra ☐ PCP ☐	PAHS 8310 ☐ SIM ☐	Metals, Total or Dissolved (See list below)	Cyanide ☐ Hex-Chrom ☐	pH, Cond., Cl, SO4, PO4, F, NO2, NO3, BOD, TSS, TDS (circle) NH3-N, COD, Total-P, TKN, TOC, DOC (circle) NO2+NO3	TOX 9020 ☐ AOX 1650 ☐ 506 ☐	REMARKS

REPORT REQUIREMENTS
___ I. Routine Report: Method Blank, Surrogate, as required
___ II. Report Dup., MS, MSD as required
___ III. Data Validation Report (includes all raw data)
___ IV. CLP Deliverable Report
___ V. EDD

INVOICE INFORMATION
P.O. # _____
Bill To: _____

Circle which metals are to be analyzed:
Total Metals: Al As Sb Ba Be B Ca Cd Co Cr Cu Fe Pb Mg Mn Mo Ni K Ag Na Se Sr Tl Sn V Zn Hg
Dissolved Metals: Al As Sb Ba Be B Ca Cd Co Cr Cu Fe Pb Mg Mn Mo Ni K Ag Na Se Sr Tl Sn V Zn Hg

TURNAROUND REQUIREMENTS
___24 hr. ___48 hr.
___5 Day
___Standard (10-15 working days)
___Provide FAX Results
_____Requested Report Date

*INDICATE STATE HYDROCARBON PROCEDURE: AK CA WI NORTHWEST OTHER:_____(CIRCLE ONE)

SPECIAL INSTRUCTIONS/COMMENTS:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Signature _____ Date/Time _____	Signature _____ Date/Time _____	Signature _____ Date/Time _____	Signature _____ Date/Time _____
Printed Name _____ Firm _____	Printed Name _____ Firm _____	Printed Name _____ Firm _____	Printed Name _____ Firm _____

RCOC #1 06/08

Figure 7-2

Columbia Analytical Services, Inc.
Cooler Receipt and Preservation Form

PC_____

Client / Project:_____ Service Request *K09*_____

Received:_____ Opened:_____ By:_____

1. Samples were received via? ***US Mail*** ***Fed Ex*** ***UPS*** ***DHL*** ***GH*** ***GS*** ***PDX*** ***Courier*** ***Hand Delivered***
2. Samples were received in: (circle) ***Cooler*** ***Box*** ***Envelope*** ***Other***_____ ***NA***
3. Were custody seals on coolers? NA Y N If yes, how many and where?_____
   If present, were custody seals intact? Y N If present, were they signed and dated? Y N
4. Is shipper's air-bill filed? If not, record air-bill number:_____ NA Y N
   _____ _____ _____
5. **Temperature of cooler(s) upon receipt (°C):** _____ _____ _____ _____
   Temperature Blank (°C): _____ _____ _____ _____
   Thermometer ID: _____ _____ _____ _____
6. If applicable, list Chain of Custody Numbers: _____ _____ _____ _____
7. Packing material used. ***Inserts*** ***Baggies*** ***Bubble Wrap*** ***Gel Packs*** ***Wet Ice*** ***Sleeves*** ***Other***_____
8. Were custody papers properly filled out (ink, signed, etc.)? NA Y N
9. **Did all bottles arrive in good condition (unbroken)?** *Indicate in the table below.* NA Y N
10. Were all sample labels complete (i.e analysis, preservation, etc.)? NA Y N
11. Did all sample labels and tags agree with custody papers? *Indicate in the table below* NA Y N
12. **Were appropriate bottles/containers and volumes received for the tests indicated?** NA Y N
13. Were the pH-preserved bottles tested* received at the appropriate pH? *Indicate in the table below* NA Y N
14. Were VOA vials and 1631 Mercury bottles received without headspace? *Indicate in the table below.* NA Y N
15. **Are CWA Microbiology samples received with >1/2 the 24hr. hold time remaining from collection?** NA Y N
16. Was C12/Res negative? NA Y N

Sample ID on Bottle	Sample ID on COC	Sample ID on Bottle	Sample ID on COC

Sample ID	Bottle Count	Bottle Type	Out of Temp	Head-space	Broken	pH	Reagent	Volume added	Reagent Lot Number	Initials

**Does not include all pH preserved sample aliquots received. See sample receiving SOP (SMO-GEN).*

Additional Notes, Discrepancies, & Resolutions:_____

Page 1 of: *1* *2*

Figure 7-3

Tier V Form

Client:
Project Name:
Project Number:
Project Description:

Project Chemist:
Service Request:
LIMS Template ID:

QAPP/SOW Information:

Reporting

TierLevel:
PFD:
Report to:
In results field use:
Flagging Requirements:
Other Requirements:

Sample Considerations:

Sample Limitations:
Sample Prep/Analysis:
Non-Standard Holdtimes:
Historical Data:
Comments:

8.0 ANALYTICAL PROCEDURES

Columbia Analytical employs methods and analytical procedures from a variety of external sources. The primary method references are: USEPA SW-846, Third Edition and Updates I, II, IIA, IIB, III, IVA, IVB, and online updates for hazardous waste samples, and USEPA 600/4-79-020, 600/4-91-010, 600/4-82-057, 600/R-93/100, 600/4-88-039, 600/R-94-111, EPA 40CFR parts 136 and 141, and Supplements; and *Standard Methods for the Examination of Water and Wastewater* for water and wastewater samples. Complete citations for these references can be found in Section 17.0. Other published procedures, such as state-specific methods, program-specific methods (such as Puget Sound Protocols), or in-house methods may be used. Several factors are involved with the selection of analytical methods to be used in the laboratory. These include the method detection limit, the concentration of the analyte being measured, method selectivity, accuracy and precision of the method, the type of sample being analyzed, and the regulatory compliance objectives. The implementation of methods by Columbia Analytical is described in SOPs specific to each method. A list of NELAP-accredited methods is given in Appendix G. Further details are described below.

8.1 Standard Operating Procedures (SOPs) and Laboratory Notebooks.

Columbia Analytical maintains SOPs for use in both technical and administrative functions. SOPs are written following standardized format and content requirements as described in the *SOP for Preparation of Standard Operating Procedures*. Each SOP is reviewed and approved by a minimum of two managers (the Laboratory Director and/or Department Manager and the Quality Assurance Program Manager). All SOPs undergo a documented annual review to make sure current practices are described. The QA Manager maintains a comprehensive list of current SOPs. The document control process ensures that only the most currently prepared version of an SOP is being used. The QA Manual, QAPPs, SOPs, standards preparation logbooks, maintenance logbooks, et al., are controlled documents. The procedures for document control are described in the *SOP for Document Control* (ADM-DOC_CTRL). In addition to SOPs, each laboratory department maintains a current file, accessible to all laboratory staff, of the current methodology used to perform analyses. Laboratory notebook entries are standardized following the guidelines in the *SOP for Making Entries into Logbooks and onto Analytical Records* (ADM-DATANTRY). Entries made into laboratory notebooks are reviewed and approved by the appropriate supervisor at a regular interval.

8.2 Deviation from Standard Operating Procedures

When a customer requests a modification to an SOP (such as a change in reporting limit, addition or deletion of target analyte(s), etc.), the project chemist handling that project must discuss the proposed deviation with the department manager in charge of the analysis and obtain their approval to accept the project. The project chemist is responsible for documenting the approved or allowed deviation from the SOP by placing a detailed description of the deviation attached to the quotation or in the project file and also providing an appropriate comment on the service request when the samples are received.

For circumstances when a deviation or departure from company policies or procedures involving any non-technical function is found necessary, approval must be obtained from the appropriate supervisor, manager, the laboratory director, or other level of authority. Frequent departure from policy is not encouraged. However, if frequent departure from any policy is noted, the laboratory director will address the possible need for a change in policy.

8.3 Modified Procedures

Columbia Analytical strives to perform published methods as described in the referenced documents. If there is a material deviation from the published method, the method is cited as a "Modified" method in the analytical report. Modifications to the published methods are listed in the standard operating procedure. Standard operating procedures are available to analysts and are also available to our clients for review, especially those for "Modified" methods. Client approval is obtained for the use of "Modified" methods prior to the performance of the analysis.

8.4 Analytical Batch

The basic unit for analytical quality control is the analytical batch. The definition that Columbia Analytical has adopted for the analytical batch is listed below. The overriding principle for describing an analytical batch is that all the samples in a batch, both field samples and quality control samples are to be handled exactly the same way, and all of the data from each analysis is to be manipulated in exactly the same manner. The minimum requirements of an analytical batch are:

1) The number of (field) samples in a batch is not to exceed 20.
2) All (field) samples in a batch are of the same matrix.
3) The QC samples to be processed with the (field) samples include:
   a) Method Blank (a.k.a. Laboratory Reagent Blank)

      Function: Determination of laboratory contamination.

   b) Laboratory Control Sample

      Function: Assessment of method performance

   c) Matrix Spiked (field) Sample (a.k.a. Laboratory Fortified Sample Matrix)*

      Function: Assessment of matrix bias

   d) Duplicate Matrix Spiked (field) Sample or Duplicate (field) Sample (a.k.a. Laboratory Duplicate)*

      Function: Assessment of batch precision

   * A sample identified as a field blank, an equipment blank, or a trip blank is not to be matrix spiked or duplicated.
4) A single lot of reagents are used to process the batch of samples.

5) Each operation within the analysis is performed by a single analyst, technician, chemist, or by a team of analysts/technicians/chemists.
6) Samples are analyzed in a continuous manner over a timeframe not to exceed 24-hours between the start of processing of the first and last sample of the batch.
7) Samples are analyzed in a continuous manner over a timeframe not to exceed 24-hours.
8) (Field) samples are assigned to batches commencing at the time that sample processing begins. For example: for analysis of metals, sample processing begins when the samples are digested. For analysis of organic constituents, it begins when the samples are extracted.
9) The QC samples are to be analyzed in conjunction with the associated field samples prepared with them. However, for tests which have a separate sample preparation step that defines a batch (digestion, extraction, etc.), the QC samples in the batch do not require analysis each time a field sample within the preparation batch is analyzed (multiple instrument sequences to analyze all field samples in the batch need not include re-analyses of the QC samples).
10) The batch is to be assigned a unique identification number that can be used to correlate the QC samples with the field samples.
11) Batch QC refers to the QC samples that are analyzed in a batch of (field) samples.
12) Project-specific requirements may be exceptions. If project, program, or method requirements are more stringent than these laboratory minimum requirements, then the project, program, or method requirements will take precedence. However, if the project, program, or method requirements are less stringent than these laboratory minimum requirements, these laboratory minimum requirements will take precedence.

8.5 Specialized Procedures

Columbia Analytical not only strives to provide results that are scientifically sound, legally defensible, and of known and documented quality; but also strives to provide the best solution to analytical challenges. Procedures using specialized instrumentation and methodology have been developed to improve sensitivity (provide lower detection limits), selectivity (minimize interferences while maintaining sensitivity), and overall data quality for low concentration applications. Examples are trace-level Mercury and Methylmercury analyses, reductive precipitation metals analysis, specialized GC/MS analyses, LC/MS analyses, and ultra-low level organics analyses (including PAHs, pesticides and PCBs).

8.6 Sample Cleanup

Columbia Analytical commonly employs several cleanup procedures to minimize known common interferences prior to analysis. EPA methods (3620, 3630, 3640, 3660, and 3665) for cleanup of sample extracts for organics analysis are routinely used to minimize or eliminate interferences that may adversely affect sample results and data usability.

9.0 CALIBRATION PROCEDURES

All equipment and instruments used at Columbia Analytical are operated, maintained and calibrated according to the manufacturer's guidelines and recommendations, as well as to criteria set forth in the applicable analytical methodology. Operation and calibration are performed by personnel who have been properly trained in these procedures. Documentation of calibration information is maintained with each analytical batch. Brief descriptions of the calibration procedures for our major laboratory equipment and instruments are described below. Calibration verification is performed according to the applicable analytical methodology. Calibration verification procedures and criteria are listed in laboratory Standard Operating Procedures. Documentation of calibration verification is maintained with each analytical batch. Records are maintained to provide traceability of reference materials.

Laboratory support equipment (thermometers, balances, and weights) are routinely verified on an annual basis by a vendor accredited to A2LA or ISO/IEC 17025:2005 International Standards. All analytical measurements generated at Columbia Analytical are performed using materials and/or processes that are traceable to a reference material. Metrology equipment (analytical balances, thermometers, etc.) are calibrated using reference materials traceable to the National Institute of Standards and Technology (NIST). These primary reference materials are themselves recertified on an annual basis. Vendors used for metrology support are required to verify compliance to International Standards by supplying the laboratory with a copy of their scope of accreditation.

Equipment subjected to overloading or mishandling, or shown by verification to be defective; is taken out of service until it is repaired. The equipment is placed back in service only after verifying, by calibration, that the equipment performs satisfactorily.

9.1 Temperature Control Devices

Temperatures are monitored and recorded for all of the temperature-regulating support equipment such as sample refrigerators, freezers, and standards refrigerators. Bound record books are kept which contain daily-recorded temperatures, identification and location of equipment, acceptance criteria and the initials of the technician who performed the checks. The procedure for performing these measurements is provided in the *SOP for Support Equipment Monitoring and Calibration (SOP ADM-SEMC).* The SOP also includes the use of acceptance criteria and correction factors.

Where the operating temperature is specified as a test condition (such as ovens, incubators, evaporators) the temperature is recorded on the raw data. All thermometers are identified according to serial number, and the calibration is checked annually against a National Institute of Standards and Technology (NIST) certified thermometer. The NIST thermometer is recertified by a vendor accredited to A2LA or ISO/IEC 17025:2005 International Standard on an annual basis.

9.2 Analytical Balances

The calibration of each analytical balance is checked by the user each day of use with three Class S or S-1 weights, which assess the accuracy of the balance at low, mid-level and high levels bracketing the working range. Records are kept which contain the recorded measurements, identification of the balance, acceptance criteria, and the initials of user who performed the check. The procedure for performing these measurements and use of acceptance criteria is described in the SOP ADM-SEMC. The weights are recertified using NIST traceable standards by an accredited metrology organization on an annual basis.

As needed, the balances are recalibrated using the manufacturers recommended operating procedures. Analytical balances are serviced on a semi-annual basis by an accredited metrology organization.

9.3 Water Purification Systems

Columbia Analytical uses two independent water purification systems designed to produce deionized water meeting method specifications. One system consists of a series of pumps, filters, and resin beds designed to yield deionized water meeting the specifications of ASTM Type II water, and *Standard Methods for the Examination of Water and Wastewater* (SM1080, 20th Ed.) *High Quality* water. Activated carbon filters are also in series with the demineralizers to produce "organic-free" water. A second system consists of pumps, filters, and treatment components designed to yield deionized water meeting the specifications of ASTM Type I water, and *Standard Methods for the Examination of Water and Wastewater* (SM1080, 20th Ed.) *High Quality* water. The status of each system is monitored continuously for conductivity and resistivity with an on-line meter and indicator light, and readings recorded daily in a bound record book (SOP FAC-WATER). The in-line conductivity meter is calibrated annually. Deionizers are rotated and replaced on a regular schedule. Microbiology water is checked on a daily basis at a point downstream of the purification system at a tap in the laboratory.

9.4 Source and Preparation of Standards and Reference Materials

Consumable reference materials routinely purchased by the laboratories (e.g., analytical standards) are purchased from nationally recognized, reputable vendors. All vendors have fulfilled the requirements for ISO 9001 certification and/or are accredited by A_2LA. Consumable primary stock standards are obtained from certified commercial sources or from sources referenced in a specific method. Supelco, Ultra Scientific, AccuStandard, Chem Services, Inc., Aldrich Chemical Co., Baker, Spex, etc. are examples of the vendors used. Reference material information is recorded in the appropriate logbook(s) and materials are stored under conditions that provide maximum protection against deterioration and contamination. The logbook entry includes such information as an assigned logbook identification code, the source of the material (i.e. vendor identification), solvent (if applicable) and concentration of analyte(s), reference to the certificate of analysis and an assigned expiration date. The date the laboratory receives the standard is marked on the container. When the reference material is used for the first time, the date of usage and the initials of the analyst are also recorded on the container.

Stock solutions and calibration standard solutions are prepared fresh as often as necessary according to their stability. All standard solutions are properly labeled as to analyte concentration, solvent, date, preparer, and expiration date; these entries are also recorded in the appropriate

notebook(s) following the *SOP for Making Entries into Logbooks and onto Analytical Records* (SOP ADM-DATANTRY). Prior to sample analysis, all calibration reference materials are verified with a second, independent source of the material (see section 10.3.5).

9.5 Inductively Coupled Plasma-Atomic Emission Spectrograph (ICP-AES)

Each emission line on the ICP is calibrated daily against a blank and against standards. Analyses of calibration standards, initial and continuing calibration verification standards, and inter-element interference check samples are carried out as specified in the applicable method SOP and analytical method.

9.6 Inductively Coupled Plasma-Mass Spectrometer (ICP-MS)

Each element of interest is calibrated for using a blank and a single standard. Prior to calibration, a short-term stability check is performed on the system. Following calibration, an independent check standard is analyzed, and a continuing calibration verification standard (CCV) is analyzed with every ten samples.

9.7 Atomic Absorption Spectrophotometers (AAS)

These instruments are calibrated daily using a minimum of four standards and a blank. Calibration is validated using reference standards, and is verified at a minimum frequency of once every ten samples. Initial calibration points cannot be “dropped” from the resulting calibration curve.

9.8 GC/MS Systems

All GC/MS instruments are calibrated at a minimum of five different concentration levels for the analytes of interest (unless specified otherwise) using procedures outlined in Standard Operating Procedures and/or appropriate USEPA method citations. All reference materials used for this function are vendor-certified standards. Calibration verification is performed at method-specified intervals following the procedures in the SOP and reference method. For isotope dilution procedures, the internal standard response(s) and labeled compound recovery must meet method criteria. Method-specific instrument tuning is regularly checked using bromofluorobenzene (BFB) for volatile organic chemical (VOC) analysis, or decafluorotriphenylphosphine (DFTPP) for semi-volatile analysis. Mass spectral peaks for the tuning compounds must conform both in mass numbers and in relative intensity criteria before analyses can proceed. Calibration policies for organics chromatographic analyses are described in the *SOP for Calibration of Instruments for Organics Chromatographic Analyses (SOP SOC-CAL)* or the determinative method’s laboratory SOP.

9.9 Gas Chromatographs and High Performance Liquid Chromatographs

Calibration and standardization follow SOP guidelines and/or appropriate USEPA method citations. All GC and HPLC instruments are calibrated at a minimum of five different concentration levels for the analytes of interest (unless specified otherwise). The lowest standard is equivalent to the method reporting limit; additional standards define the working range of the GC or LC detector. Results are used to establish response factors (or calibration

curves) and retention-time windows for each analyte. Calibration is verified at a minimum frequency of once every ten samples, unless otherwise specified by the reference method. *SOP for Calibration of Instruments for Organics Chromatographic Analyses (SOP SOC-CAL).*

9.10 LC/MS Systems

Calibration and tuning procedures are included in analytical SOPs written specifically for these tests. In general, multiple concentration levels for the analytes of interest are used to generate calibration curves. All reference materials used for this function are vendor-certified standards. Calibration and tuning verification is performed at SOP-defined intervals. Any other system performance checks are described in the applicable SOP. Calibration policies for organics chromatographic analyses are described in the *SOP for Calibration of Instruments for Organics Chromatographic Analyses (SOP SOC-CAL).*

9.11 UV-Visible Spectrophotometer (manual colorimetric analyses)

Routine calibrations for colorimetric and turbidimetric analyses involve generating a 5-point calibration curve including a blank. Initial calibration points cannot be “dropped” from the resulting calibration curve. Correlation coefficients must meet method or SOP specifications before analysis can proceed. Independent calibration verification standards (ICVs) are analyzed with each batch of samples. Continuing calibration is verified at a minimum frequency of once every ten samples. Typical UV-Visible spectrophotometric methods at Columbia Analytical include total phenolics, phosphates, surfactants and tannin-lignin.

9.12 Flow Injection Analyzer (automated colorimetric analysis)

A minimum of six standards and a blank are used to calibrate the instrument for cyanide analysis. A blank and (minimum of) five standards are used to calibrate the instrument for all other automated chemistries. Initial calibration points cannot be “dropped” from the resulting calibration curve. Standard Columbia Analytical acceptance limits are used to evaluate the calibration curve prior to sample analysis.

9.13 Ion Chromatographs

Calibration of the ion chromatograph (IC) involves generating a calibration curve with the method-specified number of points (or more). Initial calibration points cannot be “dropped” from the resulting calibration curve. A correlation coefficient of $\geq$ 0.995 for the curve is required before analysis can proceed. Quality Control (QC) samples that are routinely analyzed include blanks and laboratory control samples. The target analytes typically determined by the IC include nitrate, nitrite, chloride, fluoride, sulfate and drinking water inorganic disinfection byproducts. Calibration verification is performed at method-specified intervals following the procedures in the SOP and reference method.

9.14 Turbidimeter

Calibration of the turbidimeter requires analysis of three Nephelometric Turbidity Unit (NTU) formazin standards. Quality Control samples that are routinely analyzed include blanks, Analytical Products Group® QC samples (or equivalent) and duplicates.

9.15 Ion-selective electrode

The method-prescribed numbers of standards are used to calibrate the electrodes before analysis. The slope of the curve must be within acceptance limits before analysis can proceed. Quality Control samples that are routinely analyzed include blanks, LCSs and duplicates.

9.16 Pipets

The calibration of pipets and autopipettors used to make critical-volume measurements is verified following the *SOP Checking Volumetric Labware (ADM-VOLWARE)*. Both accuracy and precision verifications are performed, at intervals applicable to the pipet and use. The results of all calibration verifications are recorded in a logbooks.

9.17 Other Instruments

Calibration for the total organic carbon (TOC), total organic halogen (TOX), and other instruments is performed following manufacturer's recommendations and applicable SOPs.

10.0 QUALITY CONTROL

A primary focus of Columbia Analytical's QA Program is to ensure the accuracy, precision and comparability of all analytical results. Prior to using a procedure for the analysis on field samples, acceptable method performance is established by performing demonstration of capability analyses. Performance characteristics are established by performing method detection limit studies and assessing accuracy and precision according to the reference method. Columbia Analytical has established Quality Control (QC) objectives for precision and accuracy that are used to determine the acceptability of the data that is generated. These QC limits are either specified in the test methodology or are statistically derived based on the laboratory's historical data. Quality Control objectives are defined below.

10.1 Quality Control Objectives

10.1.1 Demonstration of Capability - A demonstration of capability (DOC) is made prior to using any new test method or when a technician is new to the method. This demonstration is made following regulatory, accreditation, or method specified procedures. In general, this demonstration does not test the performance of the method in real world samples, but in the applicable clean matrix free of target analytes and interferences.

A quality control sample material may be obtained from an outside source or may be prepared in the laboratory. The analyte(s) is (are) diluted in a volume of clean matrix (for analytes which do not lend themselves to spiking, e.g., TSS, the demonstration of capability may be performed using quality control samples). Where specified, the method-required concentration levels are used. Four aliquots are prepared and analyzed according to the test procedure. The mean recovery and standard deviations are calculated and compared to the corresponding acceptance criteria for precision and accuracy in the test method or laboratory-generated acceptance criteria (if there are not established mandatory criteria). All parameters must meet the acceptance criteria. Where spike levels are not specified, actual Laboratory Control Sample results may be used to meet this requirement, provided acceptance criteria is met.

10.1.2 Accuracy - Accuracy is a measure of the closeness of an individual measurement (or an average of multiple measurements) to the true or expected value. Accuracy is determined by calculating the mean value of results from ongoing analyses of laboratory-fortified blanks, standard reference materials, and standard solutions. In addition, laboratory-fortified (i.e. matrix-spiked) samples are also measured; this indicates the accuracy or bias in the actual sample matrix. Accuracy is expressed as percent recovery (% REC.) of the measured value, relative to the true or expected value. If a measurement process produces results whose mean is not the true or expected value, the process is said to be biased. Bias is the systematic error either inherent in a method of analysis (e.g., extraction efficiencies) or caused by an artifact of the measurement system (e.g., contamination).

Columbia Analytical utilizes several quality control measures to eliminate analytical bias, including systematic analysis of method blanks, laboratory control samples and independent calibration verification standards. Because bias can be positive or negative, and because several types of bias can occur simultaneously, only the net, or total, bias can be evaluated in a measurement.

10.1.3 Precision - Precision is the ability of an analytical method or instrument to reproduce its own measurement. It is a measure of the variability, or random error, in sampling, sample handling and in laboratory analysis. The American Society of Testing and Materials (ASTM) recognizes two levels of precision: repeatability - the random error associated with measurements made by a single test operator on identical aliquots of test material in a given laboratory, with the same apparatus, under constant operating conditions, and reproducibility - the random error associated with measurements made by different test operators, in different laboratories, using the same method but different equipment to analyze identical samples of test material.

"Within-batch" precision is measured using replicate sample or QC analyses and is expressed as the relative percent difference (RPD) between the measurements. The "batch-to-batch" precision is determined from the variance observed in the analysis of standard solutions or laboratory control samples from multiple analytical batches.

10.1.4 Control Limits - The control limits for accuracy and precision originate from two different sources. For analyses having enough QC data, control limits are calculated at the 99% confidence limits. For analyses not having enough QC data, or where the method is prescriptive, control limits are taken from the method on which the procedure is based. If the method does not have stated control limits, then control limits are assigned method-default or reasonable values. Control limits are updated periodically when new statistical limits are generated for the appropriate surrogate, laboratory control sample, and matrix spike compounds (typically once a year) or when method prescribed limits change. The updated limits are reviewed by the QA PM. The new control limits replace the previous limits and data is assessed using the new values. Current acceptance limits for accuracy and precision are available from the laboratory. For inorganics, the precision limit values listed are for laboratory duplicates. For organics, the precision limit values listed are for duplicate laboratory control samples or duplicate matrix spike analyses. Procedures forestablishing control limits are found in the *SOP for Control Limits* (ADM-CTRL_LIM).

10.1.5 Representativeness - Representativeness is the degree to which the field sample, being properly preserved, free of contamination, and analyzed within holding time, represents the overall sample site or material. This can be extended to the sample itself, in that representativeness is the degree to which the subsample that is analyzed represents the entire field sample submitted for analysis. Columbia Analytical has sample handling procedures to ensure that the sample used for analysis is representative of the entire sample. These include the *SOP for Subsampling and Compositing of Samples (GEN-SUBS)* and the *SOP for Tissue Sample Preparation (MET-TISP)*. Further, analytical SOPs specify appropriate sample handling and sample sizes to further ensure the sample aliquot that is analyzed is representative in entire sample.

10.1.6 Comparability – Comparability expresses the confidence with which one data set can be compared to another and is directly affected by data quality (accuracy and precision) and sample handling (sampling, preservation, etc). Only data of known quality can be compared. The objective is to generate data of known quality with the highest level of comparability, completeness, and usability. This is achieved by employing the quality controls listed below and standard operating procedures for the handling and analysis of all samples. Data is reported in units specified by the client and using Columbia Analytical or project-specified data qualifiers.

10.2 Method Detection Limits, Method Reporting Limits, and Limits of Detection/Quantitation

Method Detection Limits (MDL) for methods performed at Columbia Analytical/Kelso are determined during initial method set up and if any significant changes are made. If an MDL study is not performed annually, the established MDL is verified by performing a limit of detection (LOD) verification on every instrument used in the analysis. The MDLs are determined by following the *SOP for Performing Method Detection Limits Studies and Establishing Limits of Detection and Quantitation (ADM-MDL),* which is based on the procedure in 40 CFR Part 136, Appendix B. As required by NELAP and DoD protocols, the validity of MDLs is verified using LOD verification samples.

The Method Reporting Limit (MRL) is the lowest amount of an analyte in a sample that can be quantitatively determined with stated, acceptable precision and accuracy under stated analytical conditions (i.e. limit of quantitation- LOQ). LOQ are analyzed on an annual basis and cannot be lower than the lowest calibration standard. Current MDLs and MRLs are available from the laboratory.

10.3 Quality Control Procedures

The specific types, frequencies, and processes for quality control sample analysis are described in detail in method-specific standard operating procedures and listed below. These sample types and frequencies have been adopted for each method and a definition of each type of QC sample is provided below.

10.3.1 Method Blank (a.k.a. Laboratory Reagent Blank)

The method blank is an analyte-free matrix (water, soil, etc.) subjected to the entire analytical process. When analyte-free soil is not available, anhydrous sodium sulfate, organic-free sand, or an acceptable substitute is used. The method blank is analyzed to demonstrate that the analytical system itself does not introduce contamination. The method blank results should be below the Method Reporting Limit (MRL) or, if required for DoD projects, < ½ MRL for the analyte(s) being tested. Otherwise, corrective action must be taken. A method blank is included with the analysis of every sample preparation batch, every 20 samples, or as stated in the method, whichever is more frequent.

10.3.2 Calibration Blanks

For some methods, calibration blanks are prepared along with calibration standards in order to create a calibration curve. Calibration blanks are free of the analyte of interest and, where applicable, provide the zero point of the calibration curve. Additional project-specific requirements may also apply to calibration blanks.

10.3.3 Continuing Calibration Blanks

Continuing calibration blanks (CCBs) are solutions of analyte-free water, reagent, or solvent that are analyzed in order to verify the system is contamination-free when CCV standards are analyzed. The frequency of CCB analysis is either once every ten samples or as indicated in the method, whichever is greater. Additional project-specific requirements may also apply to continuing calibration blanks.

10.3.4 Calibration Standards

Calibration standards are solutions of known concentration prepared from primary standard or stock standard materials. Calibration standards are used to calibrate the instrument response with respect to analyte concentration. Standards are analyzed in accordance with the requirements stated in the particular method being used.

10.3.5 Initial (or Independent) Calibration Verification Standards

Initial (or independent) calibration verification standards (ICVs) are standards that are analyzed *after* calibration but *prior to* sample analysis, in order to verify the validity and accuracy of the standards used in for calibration. Once it is determined that there is no defect or error in the calibration standard(s), standards are considered valid and may be used for subsequent calibrations and quantitative determinations (as expiration dates and methods allow). The ICV standards are prepared from materials obtained from a source independent of that used for preparing the calibration standards ("second-source"). ICVs are also analyzed in accordance with method-specific requirements.

10.3.6 Continuing Calibration Verification Standards

Continuing calibration verification standards (CCVs) are midrange standards that are analyzed in order to verify that the calibration of the analytical system is still acceptable. The frequency of CCV analysis is either once every ten samples, or as indicated in the method.

10.3.7 Internal Standards

Internal standards are known amounts of specific compounds that are added to each sample prior to instrument analysis. Internal standards are generally used for GC/MS, HPLC/MS and ICP-MS procedures to correct sample results that have been affected by changes in instrument conditions or changes caused by matrix effects. The requirements for evaluation of internal standards are specified in each method and SOP.

10.3.8 Surrogates

Surrogates are organic compounds which are similar in chemical composition and chromatographic behavior to the analytes of interest, but which are not normally found in environmental samples. Depending on the analytical method, one or more of these compounds is added to method blanks, calibration and check standards, and samples (including duplicates, matrix spike samples, duplicate matrix spike samples and laboratory control samples) prior to extraction and analysis in order to monitor the method performance on each sample. The percent recovery is calculated for each surrogate, and the recovery is a measurement of the overall method performance.

Recovery (%) = (M/T) x 100

Where: M = The measured concentration of analyte,
T = The theoretical concentration of analyte added.

10.3.9 Laboratory Control Samples

The laboratory control sample (LCS) is an aliquot of analyte-free water or analyte-free solid (or anhydrous sodium sulfate or equivalent) to which known amounts of the method analyte(s) is (are) added. A reference material of known matrix type, containing certified amounts of target analytes, may also be used as an LCS. An LCS is prepared and analyzed at a minimum frequency of one LCS per 20 samples, with every analytical batch or as stated in the method, whichever is more frequent. The LCS sample is prepared and analyzed in exactly the same manner as the field samples.

The percent recovery of the target analytes in the LCS is compared to established control limits and assists in determining whether the methodology is in control and whether the laboratory is capable of making accurate and precise measurements at the required reporting limit. Comparison of batch-to-batch LCS analyses enables the laboratory to evaluate batch-to-batch precision and accuracy.

Recovery (%) = (M/T) x 100

Where: M = The measured concentration of analyte,
T = The theoretical concentration of analyte added.

10.3.10 Laboratory Fortified Blanks - LFB

A laboratory blank fortified at the MRL used to verify the minimum reporting limit. The LFB is carried through the entire extraction and analytical procedure. A LFB is required with every batch of drinking water samples.

10.3.11 Matrix Spikes (a.k.a. Laboratory Fortified Sample Matrix)

Matrix spiked samples are aliquots of samples to which a known amount of the target analyte (or analytes) is (are) added. The samples are then prepared and analyzed in the same analytical batch and in exactly the same manner as are routine samples. For the appropriate methods, matrix spiked samples are prepared and analyzed and at a minimum frequency of one spiked sample (and one duplicate spiked sample, if appropriate) per twenty samples. The spike recovery measures the effects of interferences caused by the sample matrix and reflects the accuracy of the method for the particular matrix in question. Spike recoveries are calculated as follows:

$$Recovery\ (\%) = (S - A) \times 100 \div T$$

Where: S = The observed concentration of analyte in the spiked sample,
A = The analyte concentration in the original sample, and
T = The theoretical concentration of analyte added to the spiked sample.

10.3.12 Laboratory Duplicates and Duplicate Matrix Spikes

Duplicates are additional replicates of samples that are subjected to the same preparation and analytical scheme as the original sample. Depending on the method of analysis, either a duplicate analysis (and/or a matrix spiked sample) or a matrix spiked sample and duplicate matrix spiked sample (MS/DMS) are analyzed. The relative percent difference between duplicate analyses or between an MS and DMS is a measure of the precision for a given method and analytical batch. The relative percent difference (RPD) for these analyses is calculated as follows:

$$Relative\ Percent\ Difference\ (RPD) = (S1 - S2) \times 100 \div S_{ave}$$

Where S1 and S2 = The observed concentrations of analyte in the sample and its duplicate, or in the matrix spike and its duplicate matrix spike, and

S_{ave} = The average of observed analyte concentrations in the sample and its duplicate, or in the matrix spike and its duplicate matrix spike.

Depending on the method of analysis, either duplicates (and/or matrix spikes) or MS/DMS analyses is performed at a minimum frequency of one set per 20 samples. If an insufficient quantity of sample is available to perform a laboratory duplicate or duplicate matrix spikes, duplicate LCSs will be prepared and analyzed.

10.3.13 Interference Check Samples

An interference check sample (ICS) is a solution containing both interfering and analyte elements of known concentration that can be analyzed to verify background and interelement correction factors in metals analyses. The ICS is prepared to contain known concentrations (method or program specific) of elements that will provide an adequate test of the correction factors. The ICS is analyzed at the beginning and end of an analytical run or at a method-specified frequency. Results must meet method criteria and any project-specific criteria.

10.3.14 Post Digestion Spikes

Post digestion spikes are samples prepared for metals analyses that have an analyte spike added to determine if matrix effects may be a factor in the results. The spike addition should produce a method-specified minimum concentration above the method reporting limit. A post digestion spike is analyzed with each batch of samples and recovery criteria are specified for each method.

10.3.15 Control Charting

The generation of control charts is routinely performed at Columbia Analytical. Surrogate, Matrix Spike and LCS recoveries are all monitored and charted. In addition, the laboratory also monitors the Relative Percent Difference (RPD) measurement of precision. Control charts are available to each laboratory unit to monitor the data generated to identify various trends in the analytical results. If trends in the data are perceived, various means of corrective action may then be employed in order to prevent future problems with the analytical system(s). Finally, data quality reports using control charts are generated for specific clients and projects pursuant to contract requirements. The control charting procedure is described in the SOP for *Control Charting Quality Control Data* (ADM-CHRT).

10.3.16 Glassware Washing

Glassware washing and maintenance play a crucial role in the daily operation of a laboratory. The glassware used at Columbia Analytical undergoes a rigorous cleansing procedure prior to every usage. A number of SOPs have been generated that outline the various procedures used at Columbia Analytical; each is specific to the end-use of the equipment as well as to the overall analytical requirements of the project. In addition, other equipment that may be routinely used at the laboratory is also cleaned following instructions in the appropriate SOP.

11.0 DATA PROCESSING, VALIDATION, AND REPORTING

Columbia Analytical reports the analytical data produced in its laboratories to the client via the certified analytical report. This report includes a transmittal letter, a case narrative, client project information, specific test results, quality control data, chain of custody information, and any other project-specific support documentation. The following procedures describe our data reduction, validation and reporting procedures.

11.1 Data Reduction and Review

Results are generated by the analyst who performs the analysis and works up the data. All data is initially reviewed and processed by analysts using appropriate methods (e.g., chromatographic software, instrument printouts, hand calculation, etc.). Equations used for calculation of results are found in the applicable analytical SOPs. The resulting data set is either manually entered (e.g., titrimetric or microbiological data) into an electronic report form or is electronically transferred into the report from the software used to process the original data set (e.g., chromatographic software). Once the complete data set has been transferred into the proper electronic report form(s), it is then printed. The resulting hardcopy version of the electronic report is then reviewed by the analyst for accuracy. Once the primary analyst has checked the data for accuracy and acceptability, the hardcopy is forwarded to the supervisor or second qualified analyst, who reviews the data for errors. Where calculations are not performed using a validated software system, the reviewer rechecks a minimum of 10% of the calculations. When the entire data set has been found to be acceptable, a final copy of the report is printed and signed by the laboratory supervisor, departmental manager or designated laboratory staff. The entire data package is then placed into the appropriate service request file, and an electronic copy of the final data package is forwarded to the appropriate personnel for archival. Data review procedures are described in the *SOP for Laboratory Data Review Process.*

Policies and procedures for manual editing of data are established. The analyst making the change must initial and date the edited data entry, without obliteration of the original entry. The policies and procedures are described in the *SOP for Making Entries into Logbooks and onto Analytical Records* (ADM-DATANTRY).

Policies and procedures for electronic manual integration of chromatographic data are established. The analyst performing the integration must document the integration change by printing both the “before” and “after” integrations and including them in the raw data records. The policies and procedures are described in the *SOP for Manual Integration of Chromatographic Peaks* (ADM-INT).

11.2 Confirmation Analysis

11.2.1 Gas Chromatographic and Liquid Chromatographic Analyses

For gas chromatographic (GC) and liquid chromatographic (LC) analyses, all positive results are confirmed by a second column, a second detector, a second wavelength (HPLC/UV), or by GC/MS analysis, unless exempted by one of the following situations:

- The analyte of interest produces a chromatogram containing multiple peaks exhibiting a characteristic pattern, which matches appropriate standards. This is limited to petroleum hydrocarbon analyses (e.g., gasoline and diesel) and does not include polychlorinated biphenyls.
- The sample meets all of the following requirements:
    1. All samples (liquid or solid) come from the same source (e.g., groundwater samples from the same well) for continuous monitoring. Samples of the same matrix from the same site, but from different sources (e.g., different sampling locations) are not exempt.
    2. All analytes have been previously analyzed in sample(s) from the same source, identified and confirmed by a second column or by GC/MS. The chromatogram is largely unchanged from the one for which confirmation was carried out. The documents indicating previous confirmation must be available for review.

11.2.2 Confirmation Data

Confirmation data will be provided as specified in the method. Identification criteria for GC, LC or GC/MS methods are summarized below:

- GC and LC Methods
    1. The analyte must fall within plus or minus three times the standard deviation (established for the analyte/column) of the retention time of the daily midpoint standard in order to be qualitatively identified. The retention-time windows will be established and documented, as specified in the appropriate Standard Operating Procedure (SOP).
    2. When sample results are confirmed by two dissimilar columns or detectors, the agreement between quantitative results must be evaluated. The relative percent difference between the two results is calculated and evaluated against SOP and/or method criteria.
- GC/MS Methods - Two criteria are used to verify identification:
    1. Elution of the analyte in the sample will occur at the same relative retention time (RRT) as that of the analyte in the standard.
    2. The mass spectrum of the analyte in the sample must, in the opinion of a qualified analyst or the department manager, correspond to the spectrum of the analyte in the standard or the current GC/MS reference library.

11.3 Data Review and Validation of Results

The integrity of the data generated is assessed through the evaluation of the sample results, calibrations, and QC samples (method blanks, laboratory control samples, sample duplicates, matrix spikes, trip blanks, etc.). A brief description of the evaluation of these analyses is described below, with details listed in applicable SOPs. The criteria for evaluation of QC samples are listed within each method-specific SOP. Other data evaluation measures may include (as necessary) a check of the accuracy check of the QC standards and a check of the system sensitivity. Data transcriptions and calculations are also reviewed.

Note: Within the scope of this document, all possible data assessment requirements for various project protocols cannot be included in the listing below. This listing gives a general description of data evaluation practices used in the laboratory in compliance with NELAP Quality Systems requirements. Additional requirements exist for certain programs, such as projects under the DoD QSM protocols, and project-specific QAPPs.

- Method Calibration – Following the analysis of calibration blanks and standards according to the applicable SOP the calibration correlation coefficient, average response factor, etc. is calculated and compared to specified criteria. If the calibration meets criteria analysis may continue. If the calibration fails, any problems are isolated and corrected and the calibration standards reanalyzed. Following calibration and analysis of the independent calibration verification standard(s) the percent difference for the ICV is calculated. If the percent difference is within the specified limits the calibration is complete. If not, the problem associated with the calibration and/or ICV are isolated and corrected and verification and/or calibration is repeated.
- Continuing Calibration Verification (CCV) – Following the analysis of the CCV standard the percent difference is calculated and compared to specified criteria. If the CCV meets the criteria analysis may continue. If the CCV fails, routine corrective action is performed and documented and a 2nd CCV is analyzed. If this CCV meets criteria, analysis may continue, including any reanalysis of samples that were associated with a failing CCV. If the routine corrective action failed to produce an immediate CCV within criteria, then either acceptable performance is demonstrated (after additional corrective action) with two consecutive calibration verifications or a new initial calibration is performed.
- Method Blank – Results for the method blank are calculated as performed for samples. If results are less than the MRL (<½ MRL for DoD projects), the blank may be reported. If not, associated sample results are evaluated to determine the impact of the blank result. If possible, the source of the contamination is determined. If the contamination has affected sample results the blank and samples are reanalyzed. If positive blank results are reported, the blank (and sample) results are flagged with an appropriate flag, qualifier, or footnote.

- Sample Results (Inorganic) – Following sample analysis and calculations (including any dilutions made due to the sample matrix) the result is verified to fall within the calibration range. If not, the sample is diluted and analyzed to bring the result into calibration range. When sample and sample duplicates are analyzed for precision, the calculated RPD is compared to the specified limits. The sample and duplicate are reanalyzed if the criteria are exceeded. The samples may require re-preparation and reanalysis. For metals, additional measures as described in the applicable SOP may be taken to further evaluate results (dilution tests and/or post-digestion spikes). Results are reported when within the calibration range, or as estimates when outside the calibration range. When dilutions are performed the MRL is elevated accordingly and qualified. Efforts are made to meet the project MRL's including alternative analysis.
- Sample Results (Organic) – For GC/MS analyses, it is verified that the analysis was within the prescribed tune window. If not, the sample is reanalyzed. Following sample analysis and calculations (including any dilutions made due to the sample matrix) peak integrations, retention times, and spectra are evaluated to confirm qualitative identification. Internal standard responses and surrogate recoveries are evaluated against specified criteria. If internal standard response does not meet criteria, the sample is diluted and reanalyzed. Results outside of the calibration range are diluted to within the calibration range. For GC and HPLC tests, results from confirmation analysis are evaluated to confirm positive results and to determine the reported value. The procedure to determine which result to report is described in the SOP for *Confirmation Procedure for GC and HPLC Analysis (SOC-CONF).* If obvious matrix interferences are present, additional cleanup of the sample using appropriate procedures may be necessary and the sample is reanalyzed. When dilutions are performed the MRL is elevated accordingly and qualified. Efforts are made to meet the project MRL's including additional cleanup.
- Surrogate Results (Organic) – The percent recovery of each surrogate is compared to specified control limits. If recoveries are acceptable, the results are reported. If recoveries do not fall within control limits, the sample matrix is evaluated. When matrix interferences are present or documented, the results are reported with a qualifier that matrix interferences are present. If no matrix interferences are present and there is no cause for the outlier, the sample is reprepared and reanalyzed. However, if the recovery is above the upper control limit with non-detected target analytes, the sample may be reported. All surrogate recovery outliers are appropriately qualified on the report.
- Duplicate Sample and/or Duplicate Matrix Spike Results – The RPD is calculated and compared to the specified control limits. If the RPD is within the control limits the result is reported. If not, an evaluation of the sample is made to verify that a homogenous sample was used. Despite the use of homogenizing procedures prior to sample preparation or analysis, the sample may not be homogenous or duplicate sample containers may not have been sample consistently. If non-homogenous, the result is reported with a qualifier about the homogeneity of the sample. Also, the results are compared to the MRL. If the results are less than five times the MRL, the results are reported with a qualifier that the high RPD is due to the results being near the MRL. If the sample is homogenous and results above five times the MRL, the samples and duplicates are reanalyzed. If re-analysis also produces out-of-control results, the results are reported with an appropriate qualifier.

- Laboratory Control Sample Results – The LCS percent recovery is calculated and compared to specified control limits. If the recovery is within control limits, the analysis is in control and results may be reported. If not, this indicates that the analysis is not in control. Samples associated with the 'out of control' LCS, shall be considered suspect and the samples re-extracted or re-analyzed or the data reported with the appropriate qualifiers. For analysis where a large number of analytes are in the LCS, it becomes more likely that some analytes (marginal exceedences) will be outside the control limits. The procedure described in the 2003 NELAC standards, Appendix D.1.1.2.1 are used to determine if the LCS is effective in validating the analytical system and the associated samples.
- Matrix Spike Results – The MS percent recovery is calculated and compared to specified control limits. If the recovery is within control limits the results are reported. If not, and the LCS is within control limits, this indicates that the matrix potentially biases analyte recovery. It is verified that the spike level is at least five times the background level. If not, the results are reported with a qualifier that the background level is too high for accurate recovery determination. If matrix interferences are present or results indicate a potential problem with sample preparation, steps may be taken to improve results; such as performing any additional cleanups, dilution and reanalysis, or re-preparation and reanalysis. Results that do not meet acceptance limits are reported with an appropriate qualifier.

11.4 Data Reporting

When an analyst determines that a data package has met the data quality objectives (and/or any client-specific data quality objectives) of the method and has qualified any anomalies in a clear, acceptable fashion, the data package is reviewed by a trained chemist. Prior to release of the report to the client, the project chemist reviews and approves the entire report for completeness and to ensure that any and all client-specified objectives were successfully achieved. The original raw data, along with a copy of the final report, is filed in project files by service request number for archiving. Columbia Analytical maintains control of analytical results by adhering to standard operating procedures and by observing sample custody requirements. All data are calculated and reported in units consistent with project specifications, to enable easy comparison of data from report to report.

To the extent possible, samples shall be reported only if all QC measures are acceptable. If a QC measure is found to be out of control, and the data is to be reported, all samples associated with the failed quality control measure shall be reported with the appropriate data qualifier(s). The *SOP for Data Reporting and Report Generation* addresses the flagging and qualification of data. The Columbia Analytical-defined data qualifiers, state-specific data qualifiers, or project-defined data qualifiers are used depending on project requirements. A case narrative may be written by the project chemist to explain problems with a specific analysis or sample, etc.

For subcontracted analyses, the Project Chemist verifies that the report received from the subcontractor is complete. This includes checking that the correct analyses were performed, the analyses were performed for each sample as requested, a report is provided for each analysis, and the report is signed. The Project Chemist accepts the report if all verification items are complete. Acceptance is demonstrated by forwarding the report to the client.

11.5 Documentation

Columbia Analytical maintains a records system which ensures that all laboratory records of analysis data retained and available. Analysis data is retained for 5 years from the report date unless contractual terms or regulations specify a longer retention time. The archiving system is described in the *SOP for Data Archiving*.

12.5.1 Documentation and Archiving of Sample Analysis Data

The archiving system includes the following items for each set of analyses performed:

- Benchsheets describing sample preparation (if appropriate) and analysis;
- Instrument parameters (or reference to the data acquisition method);
- Sample analysis sequence;
- Instrument printouts, including chromatograms and peak integration reports for all samples, standards, blanks, spikes and reruns;
- Logbook ID number for the appropriate standards;
- Copies of report sheets submitted to the work request file; and
- Copies of Nonconformity and Corrective Action Reports, if necessary.

Individual sets of analyses are identified by analysis date and service request number. Since many analyses are performed with computer-based data systems, the final sample concentrations can be automatically calculated. If additional calculations are needed, they are written on the integration report or securely stapled to the chromatogram, if done on a separate sheet.

For organics analysis, data applicable to all analyses within the batch, such as GCMS tunes, CCVs, batch QC, and analysis sequences; are kept using a separate documentation system. This system is used to archive data on a batch-specific basis and is segregated according to the date of analysis. This system also includes results for the most recent calibration curves, as well as method validation results.

11.6 Deliverables

In order to meet individual project needs, Columbia Analytical provides several levels of analytical reports. Standard specifications for each level of deliverable are described in Table 11-1. Variations may be provided based on client or project specifications.

When requested, Columbia Analytical provides Electronic Data Deliverables (EDDs) in the format specified by client need or project specification. Columbia Analytical is capable of generating EDDs with many different formats and specifications. The EDD is prepared by report production staff using the electronic version of the laboratory report to minimize transcription errors. User guides and EDD specification outlines are used in preparing the EDD. The EDD is reviewed and compared to the hard-copy report for accuracy.

Table 11-1
Descriptions of Columbia Analytical Standard Data Deliverables

Tier I. Routine Certified Analytical Report (CAR) includes the following:

1. Transmittal letter
2. Chain of custody documents and sample/cooler receipt documentation
3. Sample analytical results
4. Method blank results
5. Surrogate recovery results and acceptance criteria for applicable organic methods
6. Dates of sample preparation and analysis for all tests
7. Case narrative - **optional**

Tier II. In addition to the Tier I Deliverables, this CAR includes the following:

1. Matrix spike result(s) with calculated recovery and including associated acceptance criteria
2. Duplicate or duplicate matrix spike result(s) (as appropriate to method), with calculated relative percent difference
3. Laboratory Control Sample result(s) with calculated recovery and including associated acceptance criteria
4. Case narrative - **optional**

Tier III. Data Validation Package. In addition to the Tier II Deliverables, this CAR includes the following:

1. Case narrative - **required**
2. Summary forms for all associated QC and Calibration parameters, with associated control criteria/acceptance limits

Note: Other summary forms specified in QAPPs or project/program protocols, or those related to specialized analyses such as HRGC/MS will be included.

Tier IV. Full Data Validation Package.

1. All raw data associated with the sample analysis, including but not limited to:
   a. Preparation and analysis bench sheets and instrument printouts,
   b. For organics analyses, all applicable chromatograms, spectral, confirmation, and manual integration raw data. For GC/MS this includes tuning results, mass spectra of all positive hits, and the results and spectra of TIC compounds when requested.
   c. QC data,
   d. Calibration data (initial, verification, continuing, etc),
   e. Calibration blanks or instrument blanks (as appropriate to method).
2. If a project QAPP or program protocol applies, the report will be presented as required by the QAPP.

12.0 PERFORMANCE AND SYSTEM AUDITS

Quality audits are an essential part of Columbia Analytical/Kelso quality assurance program. There are two types of audits used at the facility: System Audits are conducted to qualitatively evaluate the operational details of the QA program, while Performance Audits are conducted by analyzing proficiency testing samples in order to quantitatively evaluate the outputs of the various measurement systems.

12.1 System Audits

The system audit examines the presence and appropriateness of laboratory systems. External system audits of Columbia Analytical/Kelso are conducted regularly by various regulatory agencies and clients. Appendix G lists the certification and accreditation programs in which Columbia Analytical/Kelso participates. Programs and certifications are added as required. Additionally, internal system audits are conducted regularly under the direction of the Quality Assurance Program Manager. The internal audit procedures are described in the *SOP for Internal Audits*. The internal audits are performed as follows:

- Comprehensive lab-wide system audit – performed annually. This audit is conducted such that systems, technical operations, hardcopy data, and electronic data are assessed.
- Technical/method audits – minimum of 3 per quarter
- Hardcopy report audits – minimum of 2 per quarter.
- Chromatographic electronic data audits – each applicable instrument per quarter.

All audit findings, and corrective actions are documented. The results of each audit are reported to the Laboratory Director and Department Managers for review. Any deficiencies identified are summarized in the audit report. Managers must respond with a root casue analysis and corrective actions within a defined timeframe. Should problems impacting data quality be found during an internal audit, any client whose data is adversely impacted will be given written notification within the corrective action period (if not already provided).

Electronic data audits may be performed in conjunction with hardcopy data audits. The electronic audits focus on organic chromatographic data and include an examination of audit trails, peak integrations, calibration practices, GCMS tuning data, peak response data, use of appropriate files, and other components of the analysis. The audit also verifies that the electronic data supports the hardcopy reported data.

Additional internal audits or data evaluations may be performed as needed to address any potential data integrity issues that may arise.

12.2 Performance Audits

Columbia Analytical/Kelso also participates in the analysis of interlaboratory proficiency testing (PT) samples. Participation in PT studies is performed on a regular basis and is designed to evaluate all analytical areas of the laboratory. General procedures for these analyses are described in the SOP for *Proficiency Sample Testing Analysis* (ADM-PTS). Columbia Analytical routinely participates in the following studies:

- Water Pollution (WP) and additional water parameters, 2 per year.
- Water Supply (WS) PT studies, 2 per year.
- Hazardous Waste/Soil PT studies, 2 per year.
- Underground Storage Tank PT studies, 2 per year.
- Microbiology (WS and WP) PT studies, 2 per year.
- Other studies as required for specific certifications, accreditations, or validations.

PT samples are processed by entering them into the LIMS system as samples (assigned Service Request, due date, testing requirements, etc.) and are processed the same as field samples. The laboratory sections handle samples the same as field samples, performing the analyses following method requirements and performing data review. The laboratory sections submit results to the QA Manager for subsequent reporting to the appropriate agencies or study provider. Results of the performance evaluation samples and audits are reviewed by the QA PM, Laboratory Director, the laboratory staff, and the Chief Quality Officer. For any results outside acceptance criteria, the analysis data is reviewed to identify a root cause for the deficiency, and corrective action is taken and documented through nonconformance (NCAR) procedures.

13.0 PREVENTIVE MAINTENANCE

Preventive maintenance is a crucial element of the Quality Assurance program. Instruments at Columbia Analytical Services/Kelso (e.g., ICP/MS and ICP systems, GC/MS systems, atomic absorption spectrometers, analytical balances, gas and liquid chromatographs, etc.) are maintained under commercial service contracts or by qualified, in-house personnel. All instruments are operated and maintained according to the instrument operating manuals. All routine and special maintenance activities pertaining to the instruments are recorded in instrument maintenance logbooks. The maintenance logbooks used at Columbia Analytical contain extensive information about the instruments used at the laboratory.

An initial demonstration of analytical control is required on every instrument used at Columbia Analytical before it maybe used for sample analysis. If an instrument is modified or repaired, a return to analytical control is required before subsequent sample analyses can occur. When an instrument is acquired at the laboratory, the following information is noted in a bound maintenance notebook specifically associated with the new equipment:

- The equipment's serial number;
- Date the equipment was received;
- Date the equipment was placed into service;
- Condition of equipment when received (new, used, reconditioned, etc.); and
- Prior history of damage, malfunction, modification or repair (if known).

Preventive maintenance procedures, frequencies, etc. are available for each instrument used at Columbia Analytical. They may be found in the various SOPs for routine methods performed on an instrument and may also be found in the operating or maintenance manuals provided with the equipment at the time of purchase.

Responsibility for ensuring that routine maintenance is performed lies with the section supervisor. The supervisor may perform the maintenance or assign the maintenance task to a qualified bench level analyst who routinely operates the equipment. In the case of non-routine repair of capital equipment, the section supervisor is responsible for providing the repair, either by performing the repair themselves with manufacturer guidance or by acquiring on-site manufacturer repair. Each laboratory section maintains a critical parts inventory. The parts inventories include the items needed to perform the preventive maintenance procedures listed in Appendix E.

This inventory or “parts list” also includes the items needed to perform any other routine maintenance and certain in-house non-routine repairs such as gas chromatography/mass spectrometry jet separators and electron multipliers and ICP/MS nebulizer. When performing maintenance on an instrument (whether preventive or corrective), additional information about the problem, attempted repairs, etc. is also recorded in the notebook. Typical logbook entries include the following information:

- Details and symptoms of the problem;
- Repairs and/or maintenance performed;
- Description and/or part number of replaced parts;
- Source(s) of the replaced parts;
- Analyst's signature and date; and
- Demonstration of return to analytical control.

See the table in Appendix E for a list of preventive maintenance activities and frequency for each instrument.

14.0 CORRECTIVE AND PREVENTIVE ACTION

The laboratory takes all appropriate steps necessary to ensure all sample results are reported with acceptable quality control results. When sample results do not conform to established quality control procedures, responsible management will evaluate the significance of the nonconforming work and take corrective action to address the nonconformance.

Nonconforming events such as errors, deficiencies, deviations from SOP, proficiency (PT) failure or results that fall outside of established QC limits are documented using a *Nonconformity and Corrective Action Report* form (See Figure 14-1). The procedure and responsibilities for addressing nonconforming work is defined in the SOP ADM-CA *Corrective Action.* Nonconformances are reported to the client using various means (voice, email, narrative, etc). When a nonconformance occurs that casts doubt on the validity of the test results or additional client instructions are needed, the Prjoject Chemist notifies the client the same business day that the nonconformance is confirmed and reported. The QA PM reviews each problem, ensuring that appropriate corrective action has been taken by the appropriate personnel. The Nonconformity and Corrective Action Report (NCAR) is filed in the associated service request file and a copy is kept by the QA PM. The QA PM periodically reviews all NCARs looking for chronic, systematic problems that need more in-depth investigation and alternative corrective action consideration. In addition, the appropriate project chemist is promptly notified of any problems in order to inform the client and proceed with any action the client may want to initiate.

If a quality control measure is found to be out of control, and the data is to be reported, all samples associated with the failed quality control measure shall be reported with the appropriate data qualifier(s). Failure to meet established analytical controls, such as the quality control objectives, prompts corrective action. Corrective action may take several forms and may involve a review of the calculations, a check of the instrument maintenance and operation, a review of analytical technique and methodology, and reanalysis of quality control and field samples. If a potential problem develops that cannot be solved directly by the responsible analyst, the supervisor, team leader, the department manager, and/or the QA PM may examine and pursue alternative solutions. In addition, the appropriate project chemist is notified in order to ascertain if the client needs to be notified.

Part of the corrective action process involves determining the root cause. Identifying the root cause of a nonconformance can be difficult, but important for implementing effective corrective action. Root cause principles are used to determine assignable causes, which leads to corrective action taken to prevent recurrence. Various preventive action processes are used for eliminating a potential problem or averting a problem before it occurs. This is explained in the *SOP for Preventive Action* (ADM-PA).

In addition to internal communication of data issues, the laboratory also maintains a system for dealing with customer complaints. The person who initially receives the feedback (typically the project chemist) is responsible for documenting the complaint. If the project chemist is unable to satisfy the customer, the complaint is brought to the attention of the Client Services Manager, Laboratory Director, or Quality Assurance Manager for final resolution. The complaint and resolution are documented. The procedure is described in the *SOP for Handling Customer Feedback* (ADM-FDBK).

Figure 14-1
Nonconformity and Corrective Action Report

NCAR No: Assigned by QA

PROCEDURE (SOP or METHOD): EVENT DATE: _____

EVENT: ☐ Missed Holding Time ☐ QC Failure ☐ Lab Error (spilled sample, spiking error, etc.)
☐ Method Blank Contamination ☐ Login Error ☐ Project Management Error
☐ Equipment Failure ☐ Unacceptable PT Sample Result
☐ SOP Deviation ☐ Other (describe):

SAMPLES / PROJECTS / CUSTOMERS / SYSTEMS AFFECTED

DETAILED DESCRIPTION

ORIGINATOR: _____ DATE: _____

PROJECT MANAGER(S): _____ NOTIFIED BY: _____ DATE: _____

ROOT CAUSE OF NON-CONFORMITY (DO NOT RESTATE THE PROBLEM. INVESTIGATE CAUSE OF THE NON-CONFORMITY. ASK WHY 4 TIMES TO HELP IDENTIFY ROOT CAUSE.)

What is the cause of the error or finding:

CORRECTIVE ACTION AND OUTCOME

Re-establishment of conformity must be demonstrated and documented. Describe the steps that were taken, or are planned to be taken, to correct the particular Nonconformity. Include Project Manager Instructions here.

Is the data to be flagged in the Analytical Report with an appropriate qualifier? ☐ **No** ☐ **Yes**

Target date for completion of corrective action:_____

Is this an isolated deviation? ☐ **Yes** ☐ **No** If not isolated to this deviation then Preventative Action process may be initiated by Management or QA.

APPROVAL AND NOTIFICATION

Supervisor Verification and Approval of Corrective Action _____ Date: _____
Comments:

QA PM Verification and Approval of Corrective Action _____ Date: _____
Comments:

Project Manager Verification and Approval of Corrective Action _____ Date: _____
Comments:

Customer Notified by ☐ Telephone ☐ Fax ☐ E-mail ☐ Narrative ☐ Not notified

(Attach record or cite reference where record is located.)

15.0 QUALITY ASSURANCE REPORTS AND MANAGEMENT REVIEW

Quality assurance requires an active, ongoing commitment by Columbia Analytical personnel at all levels of the organization. Communication and feedback mechanisms are designed so that analysts, supervisors and managers are aware of QA issues in the laboratory. Analysts performing routine testing are responsible for generating a data quality narrative or data review document with every analytical batch processed. This report also allows the analyst to provide appropriate notes and/or a narrative if problems were encountered with the analyses. A Non-Conformity and Corrective Action Report (NCAR) (see Section 14.0) may also be attached to the data prior to review. Supervisors or qualified analysts review all of the completed analytical batches to ensure that all QC criteria have been examined and any deficiencies noted and addressed.

It is the responsibility of each laboratory unit to provide the project chemist with a final report of the data, accompanied by signature approval. Footnotes and/or narrative notes must accompany any data package if problems were encountered that require further explanation to the client. Each data package is submitted to the appropriate project chemist, who in turn reviews the entire collection of analytical data for completeness and to ensure that any and all client-specified objectives were successfully achieved. A case narrative is written by the project chemist to explain any unusual problems with a specific analysis or sample, etc.

The QA Manager provides overview support to the project chemists as required (e.g., contractually specified, etc.). The QA Manager is also responsible for the oversight of all internal and external audits, for all proficiency testing sample and analysis programs, and for all laboratory certification/accreditation responsibilities. The QA Manager provides the Laboratory Director with quarterly reports that summarize the various QA/QC activities that occurred during the previous quarter. The report addresses such topics as the following:

- Status, schedule, and results of internal and external audits;
- Status, schedule, and results of internal and external proficiency testing studies;
- Status of certifications, accreditations, and approvals;
- Status of QA Manual and SOP review and revision;
- Status of MDLs studies;
- Discussion of QC problems in the laboratory;
- Discussion of corrective action program issues;
- Status of staff training and qualification; and
- Other topics as appropriate.

An annual management review of the quality and testing systems is perfomed as described in the *SOP for Managerial Reviews of the Laboratory's Quality Systems and Testing Activities* (ADM-MGMTRVW). This is done to identify any necessary changes or improvements to the quality system or quality assurance policies. This review is documented in a Managerial Review of the Laboratory's Quality Systems and Testing Activities and sent to senior management.

16.0 PERSONNEL TRAINING

Technical position descriptions are available for all employees, regardless of position or level of seniority. These documents are maintained by the Human Resources personnel and are available for review. In order to assess the technical capabilities and qualifications of a potential employee, all candidates for employment at Columbia Analytical are evaluated, in part, against the appropriate technical description.

Training begins the first day of employment at Columbia Analytical when the company policies are presented and discussed. Safety and QA/QC requirements are integral parts of all technical SOPs and, consequently, are integral parts of all training processes at Columbia Analytical. Safety training begins with the reading of the *Environmental Health and Safety Manual.* Employees are also required to attend periodic safety meetings where additional safety training may be performed by the Environmental, Health and Safety Officer.

Employees are responsible for complying with the requirements of the QA Manual and QA/QC requirements associated with their function(s). Quality Systems training begins with Quality Assurance orientation for new employees and reading the Quality Assurance Manual. During the employees first year, the employee attends Core Ethics training and learns about Columbia Analytical Services quality systems. Each employee participates in annual Ethics Refresher training, which is part of the Columbia Analytical Improper Practices Prevention Program.

Columbia Analytical also encourages its personnel to continue to learn and develop new skills that will enhance their performance and value to the Company. Ongoing training occurs for all employees through a variety of mechanisms. The The corporate, company-wide training and development program, external and internal technical seminars and training courses, and laboratory-specific training exercises are all used to provide employees with professional growth opportunities.

All technical training is documented and records are maintained in the QA department. Training requirements and its documentation are described in the *SOP for Documentation of Training.* (ADM-TRANDOC). A training plan is developed whenever an employee starts a new procedure to new position. The training plan includes a description of the step-by-step process for training an employee and for initial demonstration of capability. Where the analyst performs the entire procedure, a generic training plan may be used.

16.1 Initial Demonstration of Capability (IDOC)

Training in analytical procedures typically begins with the reading of the Standard Operating Procedure (SOP) for the method. Hands-on training begins with the observation of an experienced analyst performing the method, followed by the trainee performing the method under close supervision, and culminating with independent performance of the method on quality control samples. Successful completion of the applicable Demonstration of Capability analysis qualifies the analyst to perform the method independently. Demonstration of Capability is performed by one of the following:

- Successful completion of an Initial Precision and Recovery (IPR) study (required where mandated by the method).
- Analysis of 4 consecutive Laboratory Control Samples, with acceptable accuracy and precision.
- Where spiking is not possible but QC standards are used ("non-spiked" Laboratory Control Samples), analysis of 4 consecutive Laboratory Control Samples with acceptable accuracy and precision.
- Where one of the three above is not possible, special requirements are as follows:
    - Total Settleable Solids: Successful single-blind PT sample analysis and duplicate results with RPD<10%.
    - Color: Four consecutive prepared LCSs with acceptable accuracy and precision of <10% RSD.
    - Physical Tests (Grain size, Corrosivity to Steel, etc.): Supervisor acknowledgement of training and approval.

A flowchart identifying the Demonstration of Proficiency requirements is given in Figure 16-1. The flowchart identifies allowed approaches to assessing Demonstration of Capability when a 4-replicate study is not mandated by the method, when spiking is not an option, or when QC samples are not readily available.

16.2 Continuing Demonstration of Proficiency

A periodic demonstration of proficiency is required to maintain continuing qualification. Continuing Demonstration of Proficiency is required each year, and may be performed one of the following ways:

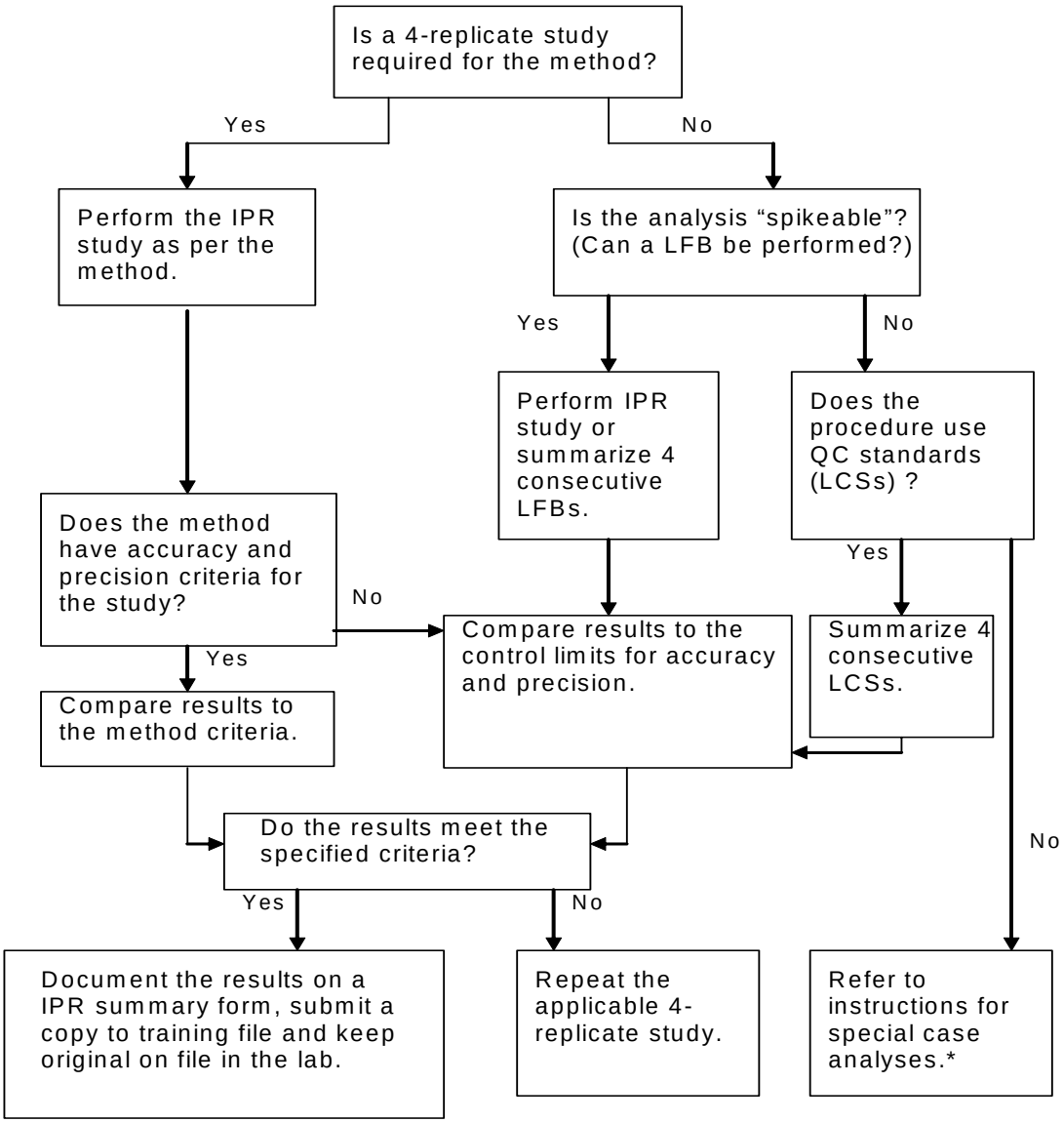
- Successful performance on external (independent) single-blind sample analyses using the test method, or a similar test method using the same technology. I.e. PT sample or QC sample blind to the analyst.
- Performing Initial Demonstration of Capability as described above, with acceptable levels of precision and accuracy.
- Analysis of at least 4 consecutive LCSs with acceptable levels of accuracy and precision from in-control analytical batches.
- If the above cannot be performed, analysis of authentic samples with results statistically indistinguishable from those obtained by another trained analyst.

- For methods for which PT samples are not available and a spiked analysis (LFB, MDL, etc.) is not possible, analysis of field samples that have been analyzed by another analyst with statistically indistinguishable results.

16.3 Documentation of Training

Records are maintained to indicate the employee has the necessary training, education, and experience to perform their functions. Information of previously acquired skills and abilities for a new employee is maintained in Human Resources personnel files and Columbia Analytical resumes. QA maintains a database to record the various technical skills and training acquired while employed by Columbia Analytical. Information includes the employee's name, a description of the skill including the appropriate method and SOP reference, the mechanism used to document proficiency, and the date the training was completed. General procedures for documenting technical training are described in the *SOP for Documentation of Training* (ADM-TRANDOC).

Figure 16-1
Initial Demonstration of Capability Requirements[a]



[a] For IDOC IPR or LFB studies, "second-source" reference materials are used, as per NELAP requirements
* Refer to the SOP for Documentation of Training for details.

17.0 REFERENCES FOR QUALITY SYSTEMS, EXTERNAL DOCUMENTS, MANUALS, STANDARDS, AND ANALYTICAL PROCEDURES

The analytical methods used at Columbia Analytical generally depend upon the end-use of the data. Since most of our work involves the analysis of environmental samples for regulatory purposes, specified federal and/or state testing methodologies are used and followed closely. Typical methods used at Columbia Analytical are taken from the following references:

- National Environmental Laboratory Accreditation Program (NELAP), 2003 Quality Standards.
- TNI Standard – Environmental Laboratory Sector, Volume 1, *Management and Technical Requirements for Laboratories Performing Environmental Analysis,* EL-V1-2009.
- American National Standard *General requirements for the competence of testing and calibration laboratories,* ANSI/ISO/IEC 17025:2005(E)
- *Department of Defense Quality Systems Manual for Environmental Laboratories*, Final Version 3 (January 2006).
- *DoD Quality Systems Manual for Environmental Laboratories,* Version 4.1, 4/22/2009
- *Good Automated Laboratory Practices, Principles and Guidance to Regulations For Ensuring Data Integrity In Automated Laboratory Operations*, EPA 2185 (August 1995).
- *Manual for the Certification of Laboratories Analyzing Drinking Water*, 5th Edition, EPA 815-R-05-004 (January 2005).
- *Procedure Manual for the Environmental Laboratory Accredditation Program,* Washington Department of Ecology, 02-03-055, November 2002.
- *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, SW-846, Third Edition, (September 1986) and Updates I (July 1992), II (September 1994), IIA (August 1993), IIB (January 1995), III (December 1996), Final Update IV (February 2007), and updates posted online at http://www.epa.gov/epaoswer/hazwaste/test/sw846.htm. See Chapters 1, 2, 3, and 4.
- *Methods for Chemical Analysis of Water and Wastes*, EPA-600/4-79-020, (Revised March 1983).
- *Methods for the Determination of Inorganic Substances in Environmental Samples*, EPA/600/R-93/100 (August 1993).
- *Methods for the Determination of Metals in Environmental Samples*, EPA/600/4-91/010 (June 1991) and Supplements.
- *Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater*, EPA 600/4-82-057 (July 1982) and 40 CFR Part 136, Appendix A.
- *Methods for the Determination of Organic Compounds in Drinking Water*, EPA/600/4-88/039 (December 1988) and Supplements.

- *Standard Methods for the Examination of Water and Wastewater*, 18th Edition (1992); 19th Edition (1995), 20th Edition (1998). See Introduction in Part 1000.
- 40 CFR Part 136, Guidelines for Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act.
- 40 CFR Part 141, National Primary Drinking Water Regulations.
- *Analytical Methods for Petroleum Hydrocarbons*, ECY 97-602, Washington State Department of Ecology, June 1997.
- State-specific total petroleum hydrocarbon methods for the analysis of samples for gasoline, diesel, and other petroleum hydrocarbon products (Alaska, Arizona, California, Oregon, Washington, Wisconsin, etc.).
- Annual Book of ASTM Standards, Part 31, Water.
- National Institute for Occupational Safety and Health (NIOSH) *Manual of Analytical Methods*, Third Edition (August 1987); Fourth Edition (August 1994).
- *Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound*, for USEPA and USACE (March 1986), with revisions through April 1997.
- *Identification and Listing of Hazardous Waste,* California Code of Regulations, Title 22, Division 4.5, Chapter 11.
- *Analytical Methods for the Determination of Pollutants in Pulp and Paper Industry Wastewater*, EPA 821-R-93-017 (October 1993).
- *Analytical Methods for the Determination of Pollutants in Pharmaceutical Manufacturing Industry Wastewaters*, EPA 821-B-98-016 (July 1998).
- National Council of the Pulp and Paper Industry for Air and Stream Improvement (NCASI).

APPENDIX A

Approved Signatories

QA Program Documents

Corporate Policies

Administrative Corporate SOP List

APPROVED SIGNATORIES FOR ANALYTICAL REPORTS

Columbia Analytical Services, Kelso, WA

ARNOLD, EILEEN
CORONADO, JEFFREY
DEGNER, CARL
DIVVELA, PRADEEP
GRINDSTAFF, JEFF
HOLMES, HOWARD
HUCKESTEIN, LYNDA
JACKY, HARVEY
JAMES, JON
KAMAWAL, AQUILLA
KENNEDY, LES
LEAF, CHRIS
MIHAI-LAZAR, CARMEN
PORTWOOD, LOREN
SALATA, GREGORY
SENKBEIL, RANI
SHELTON, MIKE
WALLACE, ED

Update: September 7, 2010 Approved by: Lynda Huckestein/Client Services Manager

QA Program Files

Program	Location
Quality Assurance Manual	10/1/2010
Software Quality Assurance Plan	7/11/05
CAS-Kelso Certifications/Accreditations	Cert_kel.xls
Columbia Analytical Services MDL Tracking Spreadsheet	Mdl_list.r1.xls
Technical Training Summary Database	TrainDat.mdb
Approved Signatories List	Approved Signatories.doc
Personnel resumes/qualifications	HR Department
Personnel Job Descriptions	HR Department
CAS/KELSO DATA QUALITY OBJECTIVES	CAS Kelso DQO.xls
Master Logbook of Laboratory Logbooks	Masterlog-001
Standard Operating Procedure Database	TrainDat.mdb

Corporate – Policies

POLICY TITLE	POLICY DATE	DATE APPROVED	DATE EFFECTIVE
CAS Quality and Ethics Policy Statement	September 2010	9/28/10	9/28/10
Policy for Data Review and Validation	September 2010	9/9/10	9/10/10
Policy for Internal Quality Assurance Audits	May 2009	5/5/09	7/1/09
Policy for Standards and Reagents Expiration Dates	September 2009	9/15/09	9/28/09
Policy for Use of Accreditation Organization's Name, Symbols, and Logos	September 2009	9/21/09	10/1/09
Policy for Conducting Research, Technical Investigations, and Method Development	December 2009	12/15/09	12/17/09

Administrative SOP Corporate

SOP TITLE	SOP Code
SOP for Checking New Lots of Chemicals for Contamination	ADM-CTMN
SOP for Control Limits	ADM-CTRL_LIM
SOP for Corrective Action	ADM-CA
SOP for Data Recall	ADM-DATARECALL
SOP for Document Control	ADM-DOC_CTRL
SOP for Documentation of Training	ADM-TRANDOC
SOP for Estimation of Uncertainty of Measurements	ADM-UNCERT
SOP for Handling Customer Feedback	ADM-FDBK
SOP for Making Entries into Logbooks and onto Analytical Records	ADM-DATANTRY
SOP for Managerial Review of the Laboratory's Quality Systems	ADM-MGMTRVW
SOP for Manual Integration of Chromatographic Peaks	ADM-INT
SOP for Performing Method Detection Limit Studies and Establishing Limits of Detection and Quantitation	ADM-MDL
SOP for Preparation of Electronic-data for Organic Analyses for Electronic-data Audits	ADM-E_DATA
SOP for Preparation of SOPs	ADM-SOP
SOP for Preventive Action	ADM-PA
SOP for Proficiency Testing Sample Analysis	ADM-PTS
SOP for Purchasing Through SOP Purchasing Agent in Kelso	ADM-PUR
SOP for Qualification of Subcontract Laboratories Outside of SOP Network	ADM_SUBLAB
SOP for Significant Figures	ADM-SIGFIG

Columbia Analytical Services™

CAS Quality and Ethics Policy Statement
September 2010

Columbia Analytical Services (CAS) is committed to excellence and superior performance in everything we do. This includes ethics and professional practice where CAS is committed to the highest standards of ethical behavior and quality of its analytical testing. We will not sacrifice our ethical principles in order to achieve business success, because unethical behavior carries a heavy price - one that we do not want to bear. This includes diminished self respect, loss of reputation, loss of business, civil and criminal penalties, and government and customer sanctions.

This means we will always strive to conduct business honestly and with integrity. We will always follow and obey the laws and statutes applicable to the operation of our business. We will always follow, to the best of our ability, standard operating procedures, rules and regulations that apply to our industry and specifically to our laboratory operations. Our customers, employees, suppliers and communities that we serve expect and deserve nothing less than the highest standards of conduct and compliance.

The following are the critical elements of the Quality and Ethics program at CAS.

- The Executive Management and Board of Directors of CAS sponsor and support the Quality and Ethics program through their personal commitment and by providing the necessary resources to promote this program throughout the organization.
- Chief Quality and Ethics Officer. The position is responsible for the quality and ethics program, ensures that appropriate resources are provided, reviews and recommends changes in the program, and resolves ethical and quality issues brought to management attention. This Officer periodically provides a quality and ethics report directly to the Board of Directors.
- Core Values. The CAS Statement of Core Values was developed internally with input from the entire company. We are committed to ensuring the integrity and quality of data, and meeting the needs of our clients, while conducting business with high ethical standards. We hold strong to the core values of Honor, Truth, and Fairness. We are committed to these values and rely on them when confronted by difficult choices.
- Code of Conduct. CAS supports the ethical codes established for the laboratory industry by the American Council of Independent Laboratories (ACIL) and is committed to meeting the data integrity and ethics requirements of accreditation bodies; including NELAP and the Department of Defense (DOD). The "CAS Commitment to Excellence in Data Quality" statement must be acknowledged and signed by all employees; and all employees are expected to comply with standards outlined in Section 6, Employee Conduct, of our Employee Handbook. All personnel concerned with analytical testing activities within the laboratory are required to be familiar with the quality documentation and to implement these policies and procedures in their work.

- Open Door Policy. CAS will maintain a work environment where employees have the right and obligation for open communications to ask questions, seek guidance, and report incorrect practices and wrong doing without fear of retribution. This is described in the CAS Open Door Policy in the Employee Handbook. CAS believes that using the chain-of-command channels for this dialogue is generally most appropriate. However, if there is apprehension or a concern that using this approach is not appropriate, employees are free to take their concerns to the President/CEO, the Director of Human Resources, or the Chief Quality Officer. Employees may do so without fear of retribution.
- Ombudsman Program. In addition to the Open Door Policy, CAS has implemented an external ombudsman/hotline program through EthicsPoint, a phone and internet-based reporting system. This is another mechanism available to enhance communication and empower employees to promote quality, data integrity, and ethical behavior. Employees can file a report anonymously to address ethics, data integrity, or improper conduct issues in the workplace.
- Internal Audits. Policies are established to ensure that internal systems and data audits are conducted periodically in addition to external agency and client audits. The data audits include assessments of both hardcopy data and electronic data to ensure on-going data integrity and compliance with the CAS Quality program.
- Certification/Accreditation Compliance. CAS management is committed to ensuring compliance with the accreditation or certification standards applicable to each CAS laboratory, including NELAP accreditations at laboratories conducting environmental testing and DOD ELAP accreditation at laboratories performing testing for the DOD. Required quality systems are documented in QA Manuals, administrative Standard Operating Procedures (SOPS) and policies; and technical SOPs.
- Ethics Training. CAS provides training to its employees with respect to quality, ethics, data integrity, and business conduct. This includes introductory training on employment policies, quality, and ethics at the time of hire; in-depth "core" ethics training within one year of hire, and on-going ethics refresher training on a semi-annual basis.

The CAS Quality and Ethics Program has been in place for several years. However, this is a "living" program that will change and improve as the company grows and changes.

Jim Carlson, President/CEO — 9-28-10 Date

Lee Wolf, Chief Quality and Ethics Officer — 9-21-10 Date

Columbia Analytical Services

Policy for Data Review and Validation

September 2010
Effective September 10, 2010

The purpose of this policy is to identify the requirements for performing data review and validation prior to releasing data and reports to customers of Columbia Analytical Services. It is a requirement of NELAC (TNI) quality system standards and Department of Defense (DoD) agencies to have data review procedures established.

This policy is applicable to the review of raw and reported data generated in all laboratories. Specific data review and validation processes or logistics may vary somewhat from facility to facility, or vary for data generated using different methodologies however; the policies described here are to be followed. The documentation practices should be consistent within the facility. Automated validation processes are encouraged, but must be sufficiently described in an SOP.

In general, the data review and validation practices used at each facility will meet the requirements of NELAP quality system standards, the DoD Quality System Manual (QSM), and ISO 17025. Specific data review and validation policies are as follows:

1. Each laboratory facility will have a written and approved standard operating procedure (SOP) for conducting data review/validation that meets the standard CAS requirements for administrative SOPs. The SOP will list details of data review practices for the facility. The SOP will also give a detailed explanation of the review documentation procedures for each type of data.

2. Data review will be performed by qualified personnel who have documented training on either the analysis itself or training specific to the data review SOP. Personnel preparing reports who may do some level of clerical review or proofreading do not need technical knowledge of the test, but must be knowledgeable of reporting systems and requirements.

3. All data will be reviewed by a minimum of two persons. Data generated or reported by one person may not be released without another person's review.

4. However defined, one review (typically a "primary" technical review) must focus on the validity of the analysis and raw data generated, the technical accuracy and correctness of the analysis (the analytical procedure is in control), use of valid and approved procedures and methods, and interpretation of sample results.

5. The secondary review will be performed by someone other than the technical reviewer. The secondary review will make the same assessments as the primary reviewer, and check the interpretations, data manipulations, and decisions made by the primary reviewer. Additionally, the secondary reviewer will review the outputs from the initial review to the raw data. This includes such things as data processing results/outputs, calculations, runlogs, bench sheets, QC analyses, etc. The secondary review verifies the completeness and validity of the data to be reported.

6. All client-ready final reports will be reviewed in the format, and as presented to, the client; either by analysis fraction or in their entirety. This review will include verification of the accurate and correct reporting of sample and QC results; including accurate translation of results from data to report forms, report format, use of qualifiers and flags, and method citations. This review will also include verification of the correct project information; such as client name, project name, sample I.D.s, etc. The report review should ensure that the report is error-free and contains no inconsistencies. For upper tier deliverables, this review will verify that all deliverables are included in the report package.

7. The Project Manager will review all complete reports prior to signing the report and submitting to the client. The review of the reported data will focus on the following items:
    a. Consistency with client, contract, and/or project specifications.
    b. Acceptability of any data qualifiers or footnotes.
    c. Accuracy and completeness of explanations or discussion in the report cover letter or case narrative.
    d. As needed depending on the scope of testing, an additional level of technical review of all data generated.
    e. A general overview of the completed service request file with respect to overall reasonableness, and if available, with historical project information.

8. Data review must be documented. Persons performing data and report review must sign (or initial) and date the applicable data reviewed. Checklists or review summaries should be used for guidance and documentation. Documentation processes must be described in the laboratory SOP. Where electronic signatures are used in place of wet ink signatures, the electronic signature must be authenticated in a manner compatible with the software in use; and the authentication procedure described in the SOP.

Lee Wolf, Chief Quality Officer — Date: 9-9-10

Jim Carlson, President — Date: 9-9-10

Policy for Internal Quality Assurance Audits

May 2009
Effective July 1, 2009

The purpose of this policy is to identify the requirements for performing internal systems audits and data audits in the laboratories of Columbia Analytical Services. Internal audits are necessary to ensure that laboratory operations work within the quality systems and that these systems yield data of high quality. Internal audits are also necessary in order to meet certification and accreditation requirements. The internal auditing practices used at each facility will meet the requirements of NELAC quality system standards, the Department of Defense (DoD) Quality System Manual (QSM), and ISO 17025.

For systems audits, the concept of this policy is that corporate quality assurance audits will evaluate the laboratory QA systems and operation horizontally, or as an overall 'umbrella' assessment, whereas local QA audits will be 'drill down' audits focused on technical correctness and data validity. It is practical to verify related systems implementation as these audits are conducted.

For electronic data auditing, the concept is to assess critical data from high liability steps of procedures, from all applicable instruments, in a frequent manner (quarterly) so as to identify any potential problems relatively quickly. This is in contrast to performing 100% data assessment from a subset of instruments quarterly and taking a long period of time to assess all instruments.

Definitions

- System audits are audits used to evaluate quality system implementation, policies, procedures, laboratory practices, and testing activities of the laboratory.

- Data audits are used to assess reported laboratory data. This includes all data used to generate the reported results and the final report itself. These are performed as 'desk audits' of reported data packages, and supporting data if not included in the reported data.

- Electronic data audits are used to assess laboratory data that is processed, interpreted, used by the analyst in electronic format. This is generally limited to electronic chromatographic data.

    - "Critical" and "high liability" data – Data related to the tuning, calibration, calibration verification, and QC analyses for an analysis; as well as data vulnerable to improper manipulation (improper processing/reprocessing of files, clock changes, poor interpretation of control data, peak integrations, etc., as described in CAS Ethics policies).

Specific internal auditing policies are as follows:

1. A comprehensive internal audit will be conducted annually (approximately every 12 months) at each laboratory. The audit will address all elements of the quality system and will include environmental testing activities, and used to meet the annual internal audit requirements of NELAC, DoD, and ISO 17025. In general, the comprehensive audit will be conducted and lead by the Quality Assurance Director (QAD), with assistance from the laboratory Quality Assurance Program Manager (QA PM).

   The laboratory QA PM will not be required to conduct an additional comprehensive audit. While performing the system and data audits described below, the QA PM will verify ongoing implementation of many QA systems.

2. Each laboratory QA PM will conduct three technical systems audits per calendar quarter. These audits will be technically-focused audits of three different test procedures and technologies.
   a. The three procedures will be varied throughout the year such that analytical disciplines (e.g. digestion, extraction, ICP, ICP/MS, titrimetric, colorimetric, GC, GC/MS, HPLC, microbiology, etc) from all sections of the laboratory are assessed in a year (for laboratories with fewer than 12 tests performed, the same tests will be audited more than once).
   b. The audits will assess SOP and method compliance.
   c. The audits will assess the use of sound analytical techniques and practices.
   d. The audits will assess the analyst(s) training and documentation of /proficiency.
   e. The audit will assess all aspects of the test being evaluated, including sample handling/preparation, calibration, sample batching/run sequences, standards, quality control, instrument operation/maintenance, data interpretation, data review/reporting, and applicable quality assurance.

3. Each laboratory will conduct two complete hardcopy data audits per quarter. These audits will focus on data validity, accuracy, and completeness. Data audits will be performed on hardcopy raw and reported data (or electronic version of) and on a 'Service Request basis'.
   a. The audits will be performed on data generated no earlier than three months prior to the audit.
   b. Service requests are to be chosen at random to encompass various analytical disciplines of the laboratory over the course of a year.
   c. The audit will assess the validity of the laboratory procedures used to generate the results reported, from sample receipt to analysis to data reporting, and the accuracy and completeness of the final report.
   d. The audit may be used as a convenient way to assess training documentation for the analysts who performed the analyses.

4. DoD report reviews will be conducted quarterly at the frequency required by the DoD QSM.

5. Electronic data auditing

    a. Each laboratory will conduct random screening of chromatographic data using Mint Miner software (where analytical software is compatible) every quarter on every instrument on data generated that quarter.
    b. Mint Miner software will be adequately configured in order to make screening effective.
    c. Using the screening results, data files will be selected for auditing from each instrument each quarter. Two sequences will be audited, one an initial calibration and one a typical sample analysis sequence. Test methods are to be chosen at random to encompass various methods performed.
    d. The audits will focus on calibration and QC data, including the evaluation of proper processing of files, interpretation of data, peak integrations, and comparison of raw electronic data to 'interpreted' and approved data.
    e. If screening results indicate significant potential problems, additional files should be inspected. The QA PM will conduct these added audits as needed.
    f. If Mint Miner software is not compatible with instrument software, auditing will be performed manually by the QA PM by auditing the data from two sequences per quarter, including one initial calibration sequence, per instrument.

6. As with any audit, additional auditing and investigation may be necessary based on the audits performed and magnitude of findings.

7. Each laboratory facility will have a written and approved standard operating procedure (SOP) for conducting their internal audits. The SOP will include detailed procedures for technical system audits, data audits, and electronic data audits as defined in this policy. In addition to meeting the standard CAS requirements for administrative SOPs, the SOP will include details of the audit processes, use of checklists, documentation, audit reporting, corrective action, and resolution of audit findings.

Lee Wolf, Corporate Director of Quality Assurance — Date: 5-5-09

Steve Vincent, President — Date: 5-5-09

Policy for Standards and Reagents Expiration Dates

September 2009
Effective September 28, 2009

The purpose of this policy is to state the standardized requirements for assigning expiration dates to standards and reagents used in the laboratories of Columbia Analytical Services. It is a requirement of NELAP Quality System standards, the DoD Quality System Manual (QSM), and ISO 17025 to have written protocols to ensure the use of standards and reagents of appropriate quality. Additionally, documentation of the expiration date of reagents and standards is required. This policy is intended to meet the requirements of NELAC, DOD, and ISO 17025.

This policy is applicable to all purchased and prepared standards and reagents used by the laboratory to generate reported data. This includes raw (neat) materials, stock, intermediate, working, and calibration standards and/or reagents. This does not include solvents and acids.

In general, the expiration date is the date after which a standard or reagent shall not be used. It is either the date assigned by the manufacturer, the date (duration) specified by the applicable reference method, or it is a date assigned by the laboratory under this policy.

General Policies:

1. All standard and reagent expiration dates/periods shall be listed in the applicable laboratory SOP.

2. When establishing an expiration date, the following hierarchy will be used:

   - If the cited analytical method specifies the expiration date/period, that date shall be used.
   - If the cited analytical method does not specify the expiration date/period, then the date assigned by the manufacturer will be used.
   - If the cited analytical method does not specify the expiration date/period, and an expiration date is not assigned by the manufacturer, then the laboratory will assign the expiration date according to the CAS Standardized Expiration Dates tables below.

CAS Expiration Dates for Reagents	
Chemical	Expiration Date
Purchased neat reagents	5 years after receipt
Inorganic reagent solutions	1 year from preparation or receipt
Organic reagent solutions	6 months from preparation or receipt

CAS Expiration Dates for Standards	
Chemical	Expiration Date
Purchased neat standards	5 years after receipt
Inorganic stock standard solutions	1 year from preparation or receipt
Inorganic secondary, intermediate, or working standard solutions	6 months from preparation or receipt
Purchased semivolatile organic stock standard solutions	1 year from receipt
Prepared semivolatile organics stock standards	1 year from preparation
Semivolatile organic secondary, intermediate, or working standard solutions	6 months from preparation or receipt
Purchased volatile organics stock standards – **unopened** ampules	1 year from receipt
Purchased volatile organics stock standards – **opened** ampules	≤2000 mg/L 1 month after opening >2000 mg/L 3 months after opening
Prepared volatile organics stock standards	1 year from preparation
All volatile organics secondary, intermediate, or working standards* * note: common 'gases' standards and standards used for calibration should not be older than 7 days	≤20 mg/L 7 day expiration date >20 and ≤200 mg/L 1 month expiration date >200 mg/L 3 month expiration date
Dioxin/Furan and PCB stock standards	5 years from receipt
Dioxin/Furan and PCB working standards	1 year from preparation or receipt
Derivatized (prepared) semivolatile organics standard solutions	1 year from date of derivatization

3. The expiration date of a prepared reagent or standard cannot exceed the expiration date of the starting material, with the exception of standards prepared via in-lab derivatization to yield a different compound. The expiration date of a reagent or standard cannot be extended by preparing a dilution of it. For example, a purchased standard has an expiration date of July 15, 2009. A standard prepared on February 20, 2009 from this purchased standard would ordinarily have an expiration date of six months (namely, 8/20/2009), but since the purchased standard expires before six months, the prepared standard would be assigned an expiration date of July 15, 2009.

4. A multicomponent prepared reagent or standard will be assigned an expiration date not to exceed the expiration date of any of the components' expiration date. For example, a prepared standard is made from purchased standard A (with an expiration date of August 5, 2009) and from purchased standard B (with an expiration date of December 15, 2009). Consequently, the prepared standard will have an expiration date of August 5, 2009.

5. The stability and concentration of the reagent or standard are to be taken into account when assigning the expiration date. Certain solutions, depending on use and storage, may have shorter usable life time than defined by the method, manufacturer, or this policy; and should be assigned expiration dates accordingly. Reagents and standards must be stored under conditions specified by the test method and outlined in the analytical SOP.

6. Expiration dates can be extended under the following conditions:
   - A new, replacement reagent or standard is not readily available from vendors and,
   - The cited analytical method does not specify the expiration date/period and,
   - The material has been stored under conditions specified by the analysis method and outlined in the analytical SOP and,
   - The material is not reactive, volatile, or prone to degradation under the specified storage conditions and,
   - The suitability of the material is verified by the laboratory as follows, under the same valid analysis conditions used for sample analysis, and meet the following criteria:

     a. For reagents:
        i. Perform a blank and LCS pair of analysis three times using three different subaliquots of the reagent.
        ii. Each LCS result must be within the specified control limits for the test.
        iii. The %RSD for the three LCS's must be <10%.
        iv. Each blank result must be < 1/2MRL for every compound to be reported from subsequent analysis.
     b. For standards:
        i. Analyze three separate dilutions of the standard at a concentration near the midpoint of the calibration range. (Note that standards below this concentration cannot be re-verified).
        ii. The average result must be within ± 5% of the original true value.
        iii. The %RSD for the three results must be <10%.

     If these conditions and criteria are met and documented, the material may be assigned a new expiration period the same as newly prepared material.

Lee Wolf, Corporate Director of Quality Assurance — Date: 9-10-09

Steve Vincent, President — Date: 9-15-09

Columbia Analytical Services

Policy for the Use of Accreditation Organization Names, Symbols, and Logos
September 2009
Effective October 1, 2009

The purpose of this policy is to state Columbia Analytical Services' (CAS) requirements and restrictions for the company use of the name, symbols, and logos of accreditation organizations. In general, the names, symbols, and logos used by these organizations are the property of the organization. Therefore, it is a policy that CAS will comply with the requirements and policies of the organizations that accredit our laboratories.

The NELAC Institute (TNI): The TNI Board of Directors approves and oversees the use of TNI logos and marks (TNI, NELAC, NELAP) by programs, members, and other entities. In consideration that CAS is a member of TNI, CAS will abide by the following TNI policy and be subject to the TNI Consequences of Misuse.

All persons and entities that use or reproduce TNI logos and marks:

1. *Shall restrict access to them by unauthorized parties.*
2. *Shall use them only for purposes and activities authorized by the TNI Board of Directors.*[a]
3. *Shall endeavor to avoid statements in relation to their use that the TNI Board of Directors may consider misleading or unauthorized.*
4. *May not imply endorsement or approval by TNI in communication media such as the Internet, documents, brochures, or advertising without the expressed consent of the TNI Board of Directors.*
5. *May not imply an association or partnership with TNI when such an arrangement has not been authorized by the TNI Board of Directors.*

[a] Authorized uses and activities are listed in the 2003 NELAC Standard, Section 6.8

American Association for Laboratory Accreditation (A2LA): CAS will comply with A2LA policy *P101 – Reference to A2LA Accredited Status – A2LA Advertising Policy*[b].

- CAS will only use the A2LA logo and symbol/phrase "A2LA Accredited" at individual CAS laboratory locations which have demonstrated to be in compliance with A2LA quality system requirements for the applicable A2LA accreditation program (e.g. Testing Laboratory).
- The "A2LA Accredited" symbol will not be used by a CAS laboratory that is not A2LA accredited and the symbol will not be used by a CAS laboratory that has only applied for accreditation.

- When promoting A2LA accreditation, CAS will follow the requirements of the A2LA policy.
- Where the "A2LA Accredited" symbol is used to endorse results on reports, it will always be accompanied by the A2LA certificate number and an indication of the type of laboratory (i.e., testing laboratory).

[b] The A2LA policy can be found at http://www.a2la.org/policies/A2LA_P101.pdf

International Organization for Standardization (ISO): ISO does not perform assessments and therefore is not a certification or accreditation organization. ISO is a standards development organization and compliance with an ISO standard does not imply ISO endorsement. ISO's statement on the use of the name and logo is listed below, and can be found at the following URL: http://www.iso.org/iso/support/name_and_logo.htm ISO has also provided a guide for how to publicize certification to an ISO standard: http://www.iso.org/iso/publicizing2005-en.pdf

Use of ISO's name®

Within the context of international standardization or related activities (such as consultancy, training or conformity assessment including certification) "ISO" (or "iso") is the short name of the International Organization for Standardization. The name is registered within this context as the sole property of ISO and the Organization will protect its name on behalf of all ISO's members - the national standards institutes of some 150 countries. In particular, ISO will not authorize the use of the name "ISO" (or "iso") by any organization other than its members in Internet domain names, names of Web sites, trademarks, companies / organizations, products, etc. Such use could mislead third parties into believing that the domain name / Web site / trademark / company / organization / product concerned represents ISO, or has been approved or authorized to act on behalf of ISO or belongs to ISO.

Therefore, ISO will take whatever actions it considers necessary to prevent the misuse of its name.

Use of ISO's logo®

The ISO logo is a registered trademark. Unless authorized by ISO, use of its logo is prohibited. Notably, ISO will not allow its logo to be used in connection with conformity assessment activities. These include the certification of management systems, products, services, materials or personnel, even when these certifications attest conformity to an ISO standard, such as one of the ISO 9000 or ISO 14000 series. Examples of unacceptable use of the ISO logo would include use on products, in publications, on Internet sites, in marketing materials, advertisements and company letterheads.

Allowing the ISO logo to be used would give the false impression that ISO carries out certification activities, or has approved or authorized the organization using its logo. These activities are not business functions of ISO.

ISO is not an auditor, assessor, registrar, or certifier of management systems, products, services, materials or personnel, nor does ISO endorse any such activities performed by other parties. ISO develops International Standards but does not operate any schemes for assessing conformance with them.

Therefore, ISO will take whatever actions it considers necessary to prevent the misuse of its logo.

The organizations specifically discussed in this policy do not comprise a complete list of organizations to which the policy applies. It is reiterated that, with regards to the use of names, symbols, and logos; it is a policy that CAS will comply with the policies of the organizations that accredit our laboratories.

Lee Wolf, Corporate Director of Quality Assurance — Date: 9-21-09

Steve Vincent, President — Date: 9-21-09

Policy for Conducting Research, Method Development, and Method Investigations

December 2009

Columbia Analytical Services (CAS) often develops test procedures internally by conducting research and development or method development based on published procedures. This type of testing may not fall under common laboratory regulations which describe benchmarks, or minimum requirements, for procedure development and implementation. Also, it may be necessary at certain times to conduct investigations into the quality of existing methods. Therefore, a policy is necessary to identify and establish those minimum requirements.

The purpose of this Policy is to identify the CAS requirements for performing internal research and subsequent method development, performing method development from published references, and performing investigations into method performance.

For the purpose of this policy, the following Definitions are provided:

Research and development (R&D) – The practice of independently evaluating analytical options and procedures and applying them to a sample analysis challenge; resulting in an internally developed analysis method. For this policy, R&D is limited to that performed by CAS personnel.

Method development – The practice of implementing a CAS analysis procedure based on published references.

Method investigation – For the purpose of this policy, this is defined as the evaluation of major changes in methodology outside the scope of published methods or SOPs. This is generally done to improve method performance or troubleshoot a significant analytical problem; and done outside of the routine maintenance, troubleshooting, and nonconformance/corrective action process.

The intent of this policy is to ensure that CAS R&D, method development, and method investigations are performed in an unbiased manner, ensure data integrity, use common scientific practices; and ensure that these activities are peer reviewed.

General Provisions

- When conducting any of the activities covered by this policy, employees will follow standard CAS procedures for maintaining documentation and analysis records.
- Initial and final review of statements, plans, and summaries will be done by two persons; the applicable Technical Director (TD) and the Laboratory Director (LD). If the TD is the LD, then a Peer will conduct the second review.
- Once development is concluded, the adoption of Standard Operating Procedures (SOPs), conducting personnel training, etc., will be done following routine CAS QA protocols.

Research and Development

When conducting research on new analyses and developing in-house procedures not based on reference methods or published methods, the research and development effort will include the following components:

1) There will be a written *Development Statement* detailing the intent of the research and development effort. This will state the purpose of the work, the resources and references expected to be used, the experimentation that will be performed, and the anticipated result. The following items will be included in the statement:
   a) Equipment to be used.
   b) Quality Control measures to be incorporated into the analysis.
   c) Method Performance (validation) measures to be taken and expectations.
2) There will be an initial internal review and acceptance of the statement by the Technical Director and the Laboratory Director.
3) The person leading a R&D effort will gather information, references, and resources as described in the Development Statement and document those resources.
4) The experimentation will be performed and documented.
5) Once data is collected, it will be interpreted objectively using common assessments of bias and precision. Tests for false negative and false positive results will be used as well as measurements of accuracy and precision.
6) The developer will draw conclusions, and if successful, summarize the results in a brief R&D summary.
7) The summary report will include a documented approval by the Technical Director and the Laboratory Director. The supporting data should be submitted with the report to facilitate the review.
8) Following approval, an SOP will be written for subsequent implementation.

Method Development

When developing and implementing new methods based on reference or published methods, the method development effort will include the following components:

Non-certified (nor certifiable) methods

1) There will be a written *Development Statement* detailing the method development effort. This will state the purpose of the work, the reference method, references expected to be used, the experimentation that will be performed, and the anticipated result. The following items will be included in the statement:
   a) The reference method being implemented and the application(s).
   b) Equipment to be used.
   c) Quality Control measures to be incorporated into the analysis.
   d) Method Performance (validation) measures to be taken and expectations.
   e) Modifications to the reference method.
2) There will be an initial internal review and acceptance of the statement by the applicable Technical Director and the Laboratory Director.

3) The experimentation will be performed and documented.
4) Once data is collected, it will be interpreted objectively using common assessments of bias and precision. Tests for false negative and false positive results will be used as well as measurements of accuracy and precision.
5) The developer will draw conclusions, and if successful, summarize the results in a brief method development summary.
6) The summary report will include a documented approval by the Technical Director and the Laboratory Director. The supporting data should be submitted with the report to facilitate the review.
7) Following approval, an SOP will be written for subsequent implementation on the stated applications.

Certified (certifiable) methods

1) There will be a written *Experimental Plan* detailing the method development effort. This will state the method being implemented, references expected to be used, the experimentation that will be performed, and the anticipated result. The following items will be included in the Plan:
   a) The reference method being implemented.
   b) Equipment to be used.
   c) Quality Control measures to be incorporated into the analysis.
   d) Method Performance (validation) measures to be taken and expectations. This will include method and certification requirements for accuracy and precision, sensitivity, selectivity, calibration/linear range, etc. For methods where NELAC accreditation is being pursued, the requirements of the NELAC Standard (2003 Standard, Quality Systems section 5, Appendix C.3) will be met.
   e) Modifications to the reference method.
2) There will be an initial internal review and acceptance of the Plan by the applicable Technical Director and the Laboratory Director.
3) The method will be set up and run following the procedural steps of the method and the Plan; and will be documented.
4) Once data is collected, it will be interpreted objectively using common assessments of bias and precision. Tests for false negative and false positive results will be used as well as measurements of accuracy and precision.
5) The developer will draw conclusions, and if the results meet the method performance criteria in the method and/or Experimental Plan, the results will be summarized in a brief method development summary.
6) The summary report will include a documented approval the Technical Director and the Laboratory Director. The supporting data should be submitted with the report to facilitate the review.
7) Following approval, an SOP will be written for subsequent implementation.

Method Investigations

1) There will be a written *Investigation Statement* detailing the method investigation effort. This will state the purpose of the investigation, the CAS procedure, the targeted problem, the experimentation that will be performed, and the desired improvement result. The following items will be included in the statement:
   a) The CAS procedure being investigated and the equipment used.
   b) A brief discussion of the problem, the solutions being investigated, and the impact on method compliance and data quality.
   c) The experimentation used to perform the investigation.
   d) The Method Performance (validation) measures that will be taken to re-establish conformity to QA/QC criteria.
2) There will be an initial internal review and acceptance of the statement by the applicable Technical Director and the Laboratory Director.
3) Once data is collected, it will be interpreted objectively using the assessments applicable to that analysis and CAS SOP.
4) The investigator will draw conclusions, and if the results meet the method performance criteria in the method and SOP, the results will be summarized in a brief method investigation summary.
5) The summary report will include a documented approval by the Technical Director and the Laboratory Director. The supporting data should be submitted with the report to facilitate the review.
6) Following approval, the CAS SOP will be revised to implement the changes to procedure.

Documentation

The developer or investigator will generate the written Development or Investigation statements, or Experimental Plan, and provide them for initial review prior to beginning experimentation and data collection. The initial review and acceptance of the Statement will be documented. The laboratory QA PM will keep this documentation on file.

The developer or investigator will generate the written summary report and validation package, and will submit supporting data for review. The approval of the development or investigation (and SOP changes) will be documented and the laboratory QA PM will keep this documentation on file.

Steve Vincent — 12-15-09

Steve Vincent, President/CEO — Date

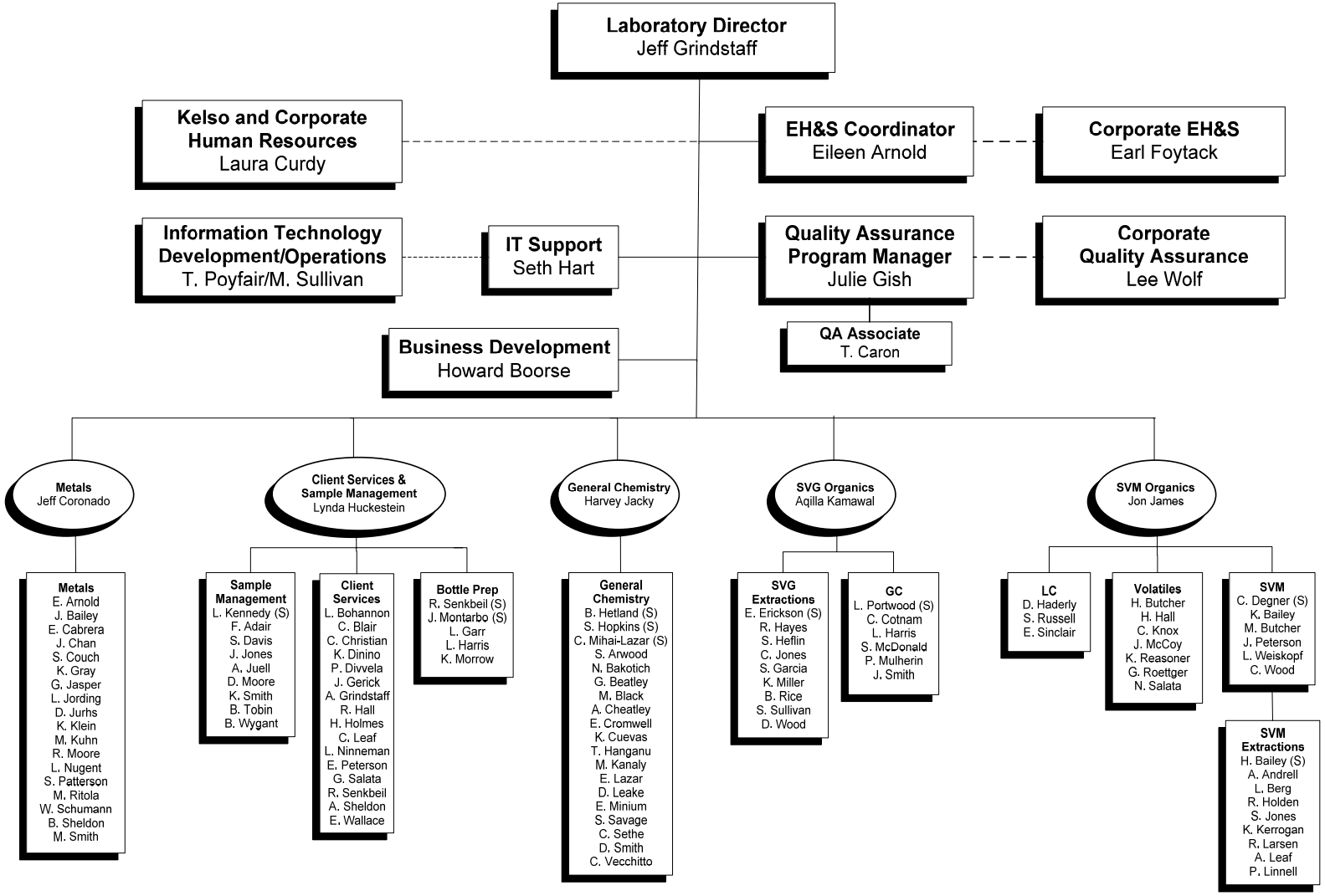
Lee Wolf — 12-15-09

Lee Wolf, Chief Quality/Ethics Officer — Date

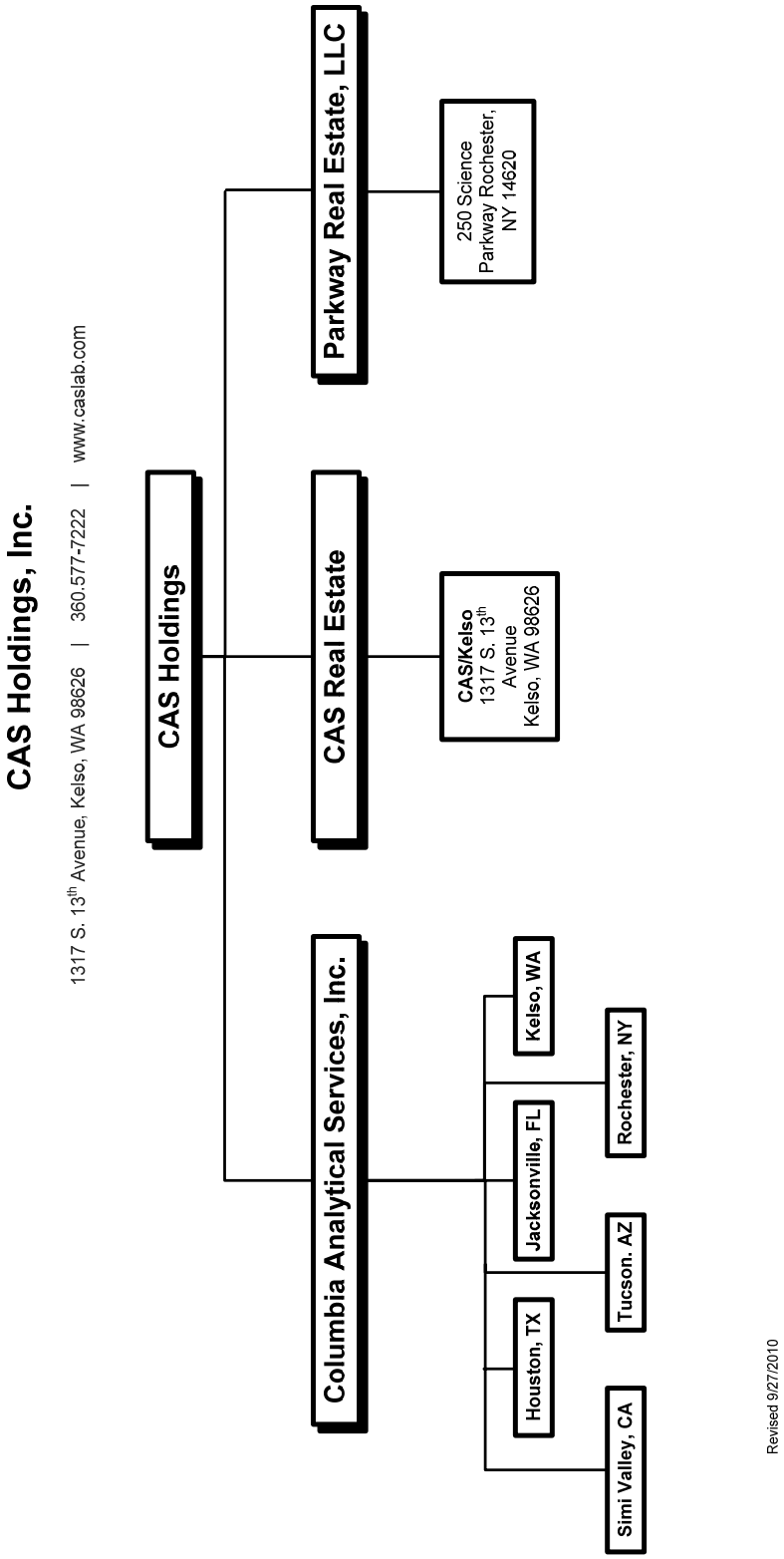
APPENDIX B

ORGANIZATIONAL CHARTS and RESUMES OF KEY PERSONNEL

Environmental and General Testing Division
Kelso, Washington
Laboratory Organization



9/27/2010



Revised 9/27/2010

JEFFERY A. GRINDSTAFF

1991 TO PRESENT

Columbia Analytical Services, Inc., 1317 South 13th Ave., Kelso, WA 98626 360.577.7222

Current Position

LABORATORY DIRECTOR, KELSO LABORATORY - 2010- to Present**.**

Responsibilities

Responsible for all phases of laboratory operations at the Kelso (WA) facility, including project planning, budgeting, and quality assurance. Primary duties include the direct management of the Kelso laboratory

Documentation of Demonstration of Capabilities is available for review.

Experience

Technical Manager III, Pharmaceutical, GC/MS VOA And Semi-VOA Laboratories, *Columbia Analytical Services, Inc., Kelso, Washington* **–** 1997-2010 Primary responsibilities include leadership of the Pharmaceutical, GC/MS VOA and Semi-VOA staff, management of method development, training, data review, tracking department workload, scheduling analyses. Responsible for ensuring data quality and timeliness. Also responsible for project management and coordination for pharmaceutical clients.

Manager, GC/MS VOA Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington,* 1994-1997. Responsible for supervision of GC/MS VOA staff, method development, training, data review, tracking department workload, scheduling analyses, and general maintenance and troubleshooting of GC/MS systems.

Scientist III, GC/MS VOA Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington,* 1991-1994. Responsibilities included scheduling workload, data review, instrument maintenance and troubleshooting, and personnel training and evaluation. Also responsible for supervision of extraction personnel and instrument analysts. Additional supervisory duties included report generation and data review for GC analyses. Responsibilities also included project management and customer service.

Chemist, *Enseco-CRL, Ventura, California,* 1990-1991. Established GC/MS department including inventory maintenance, preparation of state certification data packages, method development, SOPs, and extended data programs. Performed daily maintenance and troubleshooting of GC and GC/MS instrumentation. Scheduled and performed routine and non-routine VOA analyses.

GC/MS Chemist, VOA Laboratory *Coast-to-Coast Analytical Service, San Luis Obispo, California,* 1990-1991. Responsible for standard preparation for VOA analyses, instrument calibration, tuning, and maintenance. Also implemented and further developed EPA methods for quantitative analysis of pesticides and priority pollutants.

Education

Sampling and Testing of Raw Materials*, PTI International, 2004*.
Leadership Training, *Richard Rogers Group, 1996*
Mass Selective Detector Maintenance, *Hewlett Packard Education Center, 1993*
Interpretation of Mass Spectra I, *Hewlett-Packard Analytical Education Center,* 1992.
B.S., Chemistry, *California Polytechnic State University, San Luis Obispo, California,* 1989.
A.A., Liberal Arts, *Allan Hancock College, Santa Maria, California.* 1986

Publications/ Presentations

Mr. Grindstaff has a number of publications and presentations. For a list of these publications and presentations, please contact CAS.

Affiliations

American Chemical Society. 1989

JULIE GISH

1996 TO PRESENT

Columbia Analytical Services, Inc., 1317 South 13th Ave., Kelso, WA 98626 360.577.7222

Current Position

TECHNICAL MANAGER I, KELSO LAB QUALITY ASSURANCE MANAGER – 2008 to Present

Responsibilities

Responsible for the overall implementation of the laboratory QA program. Oversees implementation of Quality management systems including: Quality Assurance Manual, Certifications, SOP Control, Proficiency Testing (PT), Non-Conformity, Preventative Actions, Internal Auditing, Control Charting, Documentation of Training, and Metrology. Conducts employee QA training including orientations, sop, and ethics. Maintains state, agency and program certifications/accreditations. Acts as primary point of contact during laboratory audits coordinates audit responses and corrective actions.

Experience

Scientist IV, Semi-Volatile Mass Spectrometry Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington,* 2002-2008. Primary responsibilities were analysis, interpretation and report generation for semivolatile organics by GC/MS. Analyses included EPA 625, 8270, SIM, and other miscellaneous methodology.

Technical Manager I, Semi-Volatile GC Organics Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington,* 1999-2002. Primary responsibilities include supervision and oversight of semi-volatile GC department. This includes initiating new methods, staff training, workload management, and instrument maintenance/troubleshooting. Duties include departmental compliance with CAS QA and Safety policies. Responsible for analysis, interpretation and report generation for pesticides and PCB's by EPA Methods 608, 8080, 8081, 8082, EPA 8141A, Organotins, and CLP Pesticides.

Scientist III, Semi-Volatile Organics Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington,* 1996-1999. Primary responsibilities were analysis, interpretation and report generation for pesticides and PCB's by EPA Methods 608, 8080, 8081, 8082, and CLP-Pesticides. Secondary responsibilities include organics semi-volatile sample preparation.

Scientist, Volatile Organics Sample Preparation, *Employer's Overload, Longview, Washington – assigned to the Columbia Analytical Services, Inc., Kelso, Washington facility,* 1996. Primary duties included the preparation of water, soil, sediment and tissue samples using EPA Methods 3510, 3520, 3540, 3550, and 3545. Other duties were the further clean up of extracts using EPA Methods 3620 (Florsil), 3610 (Alumina), 3630 (Silica gel), 3650 (Acid/Base Partitioning), and 3660 (Sulfur).

Organics Chemist and GC/MS Chemist, *Coffey Laboratories, Portland, Oregon,* 1990-1996. Primary responsibilities included sample preparation and analysis for EPA FID, ECD, and HPLC using various EPA SW-846 and 500-series methods, as well as other methodology. Later, moved to GC/MS position which included sample preparation, analysis, and associated instrument maintenance for EPA Methods 625, 8027, and 525 BNA's.

QC Manager/QC Supervisor and Product Manager, Corn Products, *Frito-Lay, Inc., Vancouver, Washington,* 1982-1990. Manager of the QC department overseeing three supervisors and approximately 30 technicians. Responsible for department cost, accuracy, timeliness of data and safety performance. Later, responsible for production oversight of brand name snacks. Responsible for cost, quality and safety performance over three shifts. Managed four supervisors directly and approximately 60 employees indirectly.

Food Technologist, QA Department, *Kraft, Inc., Buena Park, California*, 1978-1981. Responsible for audits, formulations, finished product evaluation, batch reviews and technical support.

Education

MS, Food Science, Minor in Industrial Engineering, *Oregon State Univ. Corvallis, Oregon,* 1978.
BS, Food Science, Minor in Business Administration, *Utah State University, Logan, Utah,* 1975

Affiliations
Achievements

ASQ-American Society of Quality
TNI-The NELAC Institute
Quality Improvement Team Leader, Coffey Laboratories, Portland, Oregon. 1991
Methods Improvement Program, Coffey Laboratories, Portland, Oregon. Seminars on Development and Implementation 1990.
Statistical Process Control and Total Quality Management, Frito-Lay, Vancouver, Washington. Routine Training Classes 1986-1988.

JEFFREY A. CORONADO

1989 TO PRESENT

Columbia Analytical Services, Inc., 1317 South 13th Ave., Kelso, WA 98626 360.577.7222

Current Position	**TECHNICAL MANAGER IV, INORGANICS DEPARTMENT MANAGER –** 2001 to Present
Responsibilities	Oversee the operation of the Metals Group. Responsible for the quality and timeliness of the inorganic laboratories analytical reports, departmental budgets, workload coordination, method development efforts, cost-effectiveness, and resource allocation.
	Documentation of Demonstration of Capabilities is available for review.
Experience	**Metals Department Manager,** *Columbia Analytical Services, Inc., Kelso, Washington,* 1992-2001. Responsibilities included management of all aspects of the metal laboratory operation, including personnel training and evaluation, review of all metals data, and report generation. Also responsible for client service on a number of ongoing CAS accounts. Technical duties include primary analytical responsibility for trace level metals analysis by ICP/MS. Analyses range from routine water and soil analysis, to marine tissues, as well as industrial applications such as ultra-trace QA/QC work for various semiconductor clients. Also responsible for a number of specialized sample preparation techniques including trace metals in seawater by reductive precipitation, and arsenic and selenium speciation by ion-exchange chromatography. Developed methodology for performing mercury analysis at low part per trillion levels by cold vapor atomic fluorescence..
	Supervisor, GFAA Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington,* 1989-1992. Responsibilities included supervision of metals analysis by graphite furnace atomic absorption following SW-846 and EPA CLP methodologies. Duties include workload scheduling, data review, instrument maintenance, personnel training and evaluation.
Education	**Field Immunoassay Training Course**, *EnSys Inc*., 1995. **Winter Conference on Plasma Spectrochemistry**, *San Diego, California,* 1994. **ICP-MS Training Course**, *VG-Elemental*, 1992. **BS, Chemistry,** *Western Washington University, Bellingham, Washington,* 1988. **BA, Business Administration,** *Western Washington University, Bellingham, Washington,* 1985.

HARVEY L. JACKY

1999TO PRESENT

Columbia Analytical Services, Inc., 1317 South 13th Ave., Kelso, WA 98626 360.577.7222

Current Position

TECHNICAL MANAGER II – 2008 to Present

Responsibilities

Oversee the operation of the General Chemistry and Microbiology groups. Responsible for the quality and timeliness of the inorganic laboratories analytical reports, departmental budgets, workload coordination, method development efforts, cost-effectiveness, and resource allocation.

Documentation of Demonstration of Capabilities is available for review.

Experience

Project Manager III, *Columbia Analytical Services, Inc., Kelso, WA*, 1999-2008. Responsible for technical project management, ensuring overall data quality and compliance with customer requirements, and providing technical support to clients regarding laboratory application to projects. Additionally, acts as a consultant to clients regarding industrial/environmental compliance issues; serving as liaison between clients and regulatory agencies.

Director of Project Management, *Coffey Laboratories, Portland, Oregon*, 1997-1999. Responsible for technical project management. Communicated with clients to determine needs and expectations. Monitored laboratory production and ensured the timely completion of analytical projects. Technical consultant for clients regarding environmental compliance. Supervised and managed other members of the project management team. Served as a member of the senior management team for oversight of general operations, strategic planning, finances, and policy.

Project Manager/Chemist, *Coffey Laboratories, Portland, Oregon*, 1997-1999. Served as primary liaison between Coffey Laboratories and major clients. Ensured that work was completed in a timely manner and done to client specifications. Served as technical consultant regarding environmental chemistry, soil remediation, and waste water industrial compliance. Clients included the Oregon Department of Transportation, Hazmat Unit, Portland, Oregon; Raythion Demilitarization Co., Umatilla, Oregon; Hydroblast - Wastewater Evaporator Systems, Vancouver, Washington; and Union Pacific Railroad, Northwest Region, Klamath Falls, Oregon.

Technical Sales Representative, *Coffey Laboratories, Portland, Oregon*, 1995-1997. Responsible for marketing and sales, including actively prospecting for new potential clients. Additional responsibilities included procurement and preparation of all major project bids; ensuring that client expectations were met; and maintaining customer satisfaction. Served as consultant regarding industrial compliance issues, environmental remediation projects, and hazardous waste management.

Senior Chemist/Laboratory Chemical Hygiene Officer, *Coffey Laboratories, Portland, Oregon*, 1988-1995. Performed analytical tests including Anions by Ion Chromatography (EPA 300.0), PAHs by HPLC (EPA 8310), Cyanides (EPA 335), and other inorganic, wet chemistry, and organic analytical tests on a wide variety of sample matrices. Responsible for the initial quality assurance review of work performed, supervised and managed personnel. Developed and implemented Laboratory Chemical Hygiene Plan. Directed personnel in regards to safety issues and hazardous waste management. Served as consultant and teacher regarding analytical methodology, environmental compliance, and industrial hygiene.

Education

40-Hour Hazmat Certification, *PBS Environmental,* 1996.
Industrial Emergency Response, *SFSP Seminar,* 1991
BS, Zoology, *Oregon State University, Corvallis, Oregon,* 1988.
BS, General Science, *Oregon State University, Corvallis, Oregon,* 1988.
COURSEWORK, General Studies, *Linfield College, McMinnville, Oregon,* 1981-1982.

Publications/ Presentations

Biochemical and Physical Factors Involved in the Application and Measurement of a Soil Bioremediation System. Biogeochemistry, Portland State University, 1996

Affiliations

American Chemical Society, Member since 1988

AQILLA KAMAWAL

2002 TO PRESENT

Columbia Analytical Services, Inc., 1317 South 13th Ave., Kelso, WA 98626 360.577.7222

Current Position

TECHNICAL MANAGER II, Semivolatile Organics Department Manager– 2009 to Present

Responsibilities

Oversee the operation of the Semivolatile Organics Department. Responsible for the quality and timeliness of analytical reports, departmental budgets, workload coordination, method development efforts, cost-effectiveness, and resource allocation.

Documentation of Demonstration of Capabilities is available for review.

Experience

TECHNICAL MANAGER I, GC SEMI-VOA, *Columbia Analytical Services, Inc., Kelso, Washington,* 2007to 2009. Responsible for supervision of GC Semi-VOA staff, interfacing with Project Management Team, working with Extractions group, method development, training, data review, tracking department workload, scheduling analyses, and operation, maintenance and troubleshooting GC instrumentation. Also responsible for department adherence to strict QA/QC policies of the organization.

SCIENTIST III, GC SEMI-VOA, *Columbia Analytical Services, Inc., Kelso, Washington,* 2002 to 2007. Responsible for operation, maintenance, and troubleshooting of GC/ECD and GC/FPD instrumentation. Performed instrumental analysis and all stages of data review for tests performed in SVG. Also involved in problem-solving with Extractions group, training, and workload coordination.

Chemist II, Pesticide Laboratory, *Oregon Department of Agriculture, Portland, Oregon,* 2000-2002. Responsible for non-routine sample extraction and analysis of phenoxy herbicides, chlorinated acids, organochlorines, organophosphates, organonitrogens, sulfonyl ureas, carbamates, and other unclassified pesticides using a wide array of GC and LC instrumentation, including ECD, ELCD, FPD, AED, MS, and fluorescence detection. Also responsible for instrument maintenance, method development, data review, training, and assisting in workload coordination.

Chemist I, Pesticide Laboratory, *Oregon Department of Agriculture, Portland, Oregon,* 1999-2000. Performed sample extraction and analysis by GC and LC using FDA and EPA methodologies.

Research Technologist, *Shriners Hospital, Portland, Oregon,* 1995-1999. Worked with extracellular matrix proteins independently and under the supervision of/as assistant to post-doctoral associates. Protein isolation, purification, and characterization using the following techniques: cell culture, liquid chromatography (reverse-phase, ion-exchange, affinity), differential centrifugation, immunopreciptation, SDS-PAGE, immunoblotting, and ELISA assay.

Research Assistant/Thesis Student, *Reed College, Portland, Oregon,* 1994-1995. Reviewed literature, devised and conducted synthetic organic experiments, and analyzed results using NMR and IR instrumentation.

Education

BA, Chemistry, *Reed College, Portland, Oregon,* 1996.

JONATHAN H. "JON" JAMES
1991 TO PRESENT

Columbia Analytical Services, Inc., 1317 South 13th Ave., Kelso, WA 98626 360.577.7222

Current Position

Technical Manager II, VOA/MS, Semivolatile GC/MS and HPLC Department Manager, 2009-Present

Responsibilities

Oversee the operation of the Volatiles GC/MS, Semivolatile GC/MS and HPLC laboratories. Responsibilities include organizing and prioritizing workload, training and development of staff, working with PCs on client specific project requirements, departmental budgets, workload coordination, method development efforts and resource allocation. Responsible for the quality and timeliness of analytical reports. Other responsibilities include ensuring compliance with CAS QA protocols and assisting staff with troubleshooting equipment and procedural problems.

Documentation of Demonstration of Capabilities is available for review.

Experience

Technical Manager I, VOA and PHC/HPLC Laboratories, *Columbia Analytical Services, Inc., Kelso, Washington.* 2004-2009. Oversee daily operation of the Volatiles GC/MS and PHC/HPLC laboratories. Responsibilities include organizing and prioritizing workload, initiating process improvements, training and development of staff and working wit PCs on client specific project requirements. Responsible for analytical duties as listed below for Scientist IV.

Scientist IV, VOA Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington*, 1999-2004. Perform sample analysis and data review for EPA methods 524.2, 624 and 8260. Duties also include Project Management.

Scientist III/Project Chemist, Supervisor Pesticides GC Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington*, 1998-1999. Primary responsibilities included workload scheduling, data review, instrument maintenance and troubleshooting, and personnel training and evaluation. Also responsible for supervision of extraction personnel and instrument analysts.

Scientist III, Semi-volatile Gas Chromatography Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington*, 1996-1998. Primary responsibilities included analysis of samples using GC and HPLC techniques, report generation, data review, preparation of analytical standards, maintenance of instrumentation, Client Services and some Project Management. Routine duties included analysis of soil and water samples for pesticides, PCBs, CLP Pesticides, Explosives and PAHs using EPA methods.

Scientist II, Semi-volatile Gas Chromatography Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington*, 1994-1996. Primary responsibilities included analysis of samples using GC and HPLC techniques, report generation, data review, preparation of analytical standards, maintenance of instrumentation and client service/project management duties.

Laboratory Analyst III, Semi-volatile Gas Chromatography Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington*, 1992-1994. Primary responsibilities included analysis of samples by GC/ECD, GC/FID, GC/FPD, GC/NPD and HPLC techniques. Standard analytical methods performed were EPA method 515.1, 504, 8150, 8011, 8150M (for chlorinated phenols), 8310, and 8015.

Laboratory Analyst II, Organic Extractions Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington*, 1991-1992. Responsibilities included extraction of soil and water samples for various SVOCs, and TCLP extraction of SVOC and VOC compounds using TCLP equipment. Other duties included performing cleanup procedures, validation studies, MDL studies, and the training of employees in advanced extraction procedures and techniques.

Education

Introduction to LC Methods Development & Troubleshooting, *Hewlett-Packard, Tacoma, Washington,* 1995.
HPLC Maintenance Seminar, *Waters, Portland, Oregon,* 1994.
GC/HPLC Maintenance Seminar, *Hewlett-Packard, Olympia, Washington,* 1993.
Gas Chromatography Seminar, *Curtis Matheson Scientific, Kelso, Washington,* 1992.
HPLC Seminar, *Hewlett-Packard, Kelso, Washington,* 1991.
BA, Chemistry/Biology, *The Evergreen State College, Olympia, Washington,* 1991.
AA, Arts and Sciences, *Lower Columbia College, Longview, Washington,* 1990.

EILEEN M. ARNOLD

1987 TO PRESENT

Columbia Analytical Services, Inc., 1317 South 13th Ave., Kelso, WA 98626 360.577.7222

Current Position

SCIENTIST IV, METALS LABORATORY, KELSO HEALTH AND SAFTEY OFFICER – 1994 to Present

Responsibilities

Duties include the operation and maintenance of the Inductively Coupled Argon Plasma (ICAP) Emission Spectrometer. This involves digestion, instrumental analysis, and report generation for environmental samples using approved EPA techniques. Health and Safety Officer responsibilities included development and implementation of the Kelso Health and Safety program, including accident investigation and incident review, maintenance of all safety related equipment and documents, and performance of monthly safety audits.

Documentation of Demonstration of Capabilities is available for review.

Experience

Project Chemist, Client Services Group, Kelso Health and Safety Officer, *Columbia Analytical Services, Inc., Kelso, Washington,* 1992-1994. Duties included technical project management and customer service. Responsible for meeting the clients' needs of timely and appropriate analyses, and to act as liaison for all client-related activities within Columbia Analytical Services, Inc. Health and Safety Officer responsibilities included development and implementation of the Kelso Health and Safety program, including accident investigation and incident review, maintenance of all safety related equipment and documents, and performance of monthly safety audits.

Scientist IV, Metals Laboratory, Health and Safety Officer, *Columbia Analytical Services, Inc., Kelso, Washington, 1987-1992.* Duties include the operation and maintenance of the Inductively Coupled Argon Plasma (ICAP) Emission Spectrometer. This involves digestion, instrumental analysis, and report generation for environmental samples using approved EPA techniques. Health and Safety Officer responsibilities included development and implementation of the Kelso Health and Safety program, including accident investigation and incident review, maintenance of all safety related equipment and documents, and performance of monthly safety audits.

Chemist, *Dow Corning Corporation, Springfield, Oregon,* 1986-1987. Responsibilities included ICP and atomic absorption work in silicon manufacturing. Methods development for ICP analysis of minor impurities found in silicon.

Chemist, *Ametek, Inc., Harleysville, Pennsylvania,* 1982-1985. Responsibilities included product research and development chemist involved in production of thin-film semiconductors for use as solar cells. Work involved AA and SEM techniques.

Chemist, *Janbridge, Inc., Philadelphia, Pennsylvania*, 1978-1982. Responsibilities included maintaining electroplating process lines through wet chemical analysis techniques, and performed Quality Assurance testing on printed circuit boards.

Education

BA, Chemistry, *Immaculata College, Immaculata, Pennsylvania,* 1977.

Affiliations

American Chemical Society, Member since 1987.

LYNDA A. HUCKESTEIN

1989 TO PRESENT

Columbia Analytical Services, Inc., 1317 South 13th Ave., Kelso, WA 98626 360.577.7222

Current Position	**CLIENT SERVICES MANAGER IV** – 1998 to Present
Responsibilities	Management of the Client Services Departments: Project Management, Electronic Data Deliverables and Report Generation, and Sample Management. Personally responsible for approximately 1.5 million dollars of client work annually performing technical project management and client service. Provides technical and regulatory interpretation assistance, as well as project organization of work received by the laboratory.
	Documentation of Demonstration of Capabilities is available for review.
Experience	**Project Chemist,** *Columbia Analytical Service, Inc., Kelso, Washington,* 1992-1998. Primary responsibilities included technical project management and client service in areas of pulp & paper, marine services, mining, and DOD. Also responsible for providing technical and regulatory interpretation assistance as-well-as project organization to work received by the laboratory
	Project Chemist and Department Manager, General Chemistry Laboratory, *Columbia Analytical Services, Inc.,* 1989-1992. Responsible for management of the General Chemistry laboratory for routine wastewater, bioassay, and microbiological analyses. Also responsible for supervision of staff, data review, and reporting.
	Analyst III, *Columbia Analytical Services, Inc., Kelso, Washington*, 1989. Primary responsibilities included coliform testing, total recoverable petroleum hydrocarbon extractions and analysis, BODs, ammonias, and TKN, in addition to miscellaneous wet chemistry analyses.
	Microbiologist/Chemist, *Coffey Laboratories, Portland, Oregon,* 1983. Coliform analysis; water chemistry.
	Laboratory Assistant, *Oregon State University, Corvallis, Oregon,* 1983. Wheat spike dissection and tissue culture.
Education	**BS, Microbiology,** *Oregon State University, Corvallis, Oregon,* 1983.

JEFFREY D. CHRISTIAN
1989 TO PRESENT

Columbia Analytical Services, Inc., 1317 South 13th Ave., Kelso, WA 98626 360.577.7222

Current Position

CHIEF OPERATING OFFICER (COO) – 2010 to Present

Responsibilities

Responsible for oversight of operating units of Columbia Analytical Services, inc. with all Laboratory Directors reporting to the COO. Primary responsibilities include establishment of consistent quality, technical, and client service enhancements across the company, as well as the financial performance of the individual operating units. In addition, a significant role is to represent operations as a member of the Senior Management Team (SMT) consisting of the Chief Executive Officer, Chief Financial Officer, Chief Quality Officer, and the Director of Information Technology.

Experience

Vice President/Laboratory Director, Kelso Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington,* 1993-2010. Responsible for all phases of laboratory operations, including project planning, budgeting, and quality assurance.

Operations Manager, Kelso Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington,* 1992-1993. Responsibilities included directing the daily operation of the Kelso laboratory. Other responsibilities and duties included functioning as a technical consultant to clients, providing assistance in developing and planning analytical schemes to match client objectives, and writing and developing analytical procedures/methods. Also, served as Project Manager for State of Alaska Department of Environmental Conservation contract and Coordinator for EPA Special Analytical Services (SAS) contracts.

Project Chemist and Manager, Metals Analysis Laboratory, *Columbia Analytical Services, Kelso, Washington,* 1989-1992. Responsible for directing the daily operation of the Metals Laboratory, including the sample preparation, AAS, ICP-OES, and ICP-MS Laboratories.

Scientist, *Weyerhaeuser Technology Center, Federal Way, Washington,* 1986-1989. Responsibilities included supervising atomic spectroscopy laboratory which included flame and furnace AAS, ICP-OES, and sample preparation capabilities to handle a wide variety of sample types. Interfaced with internal and external clients to provide technical support. Wrote and developed analytical procedures/methods.

Lead Technician, Metals Lab, *Weyerhaeuser Technology Center, Federal Way, Washington*, 1981-1986. Responsibilities included primary ICP and AAS analyst for EPA-CLP contract work. Extensive experience in wide variety of environmental and product-related testing.

Research Assistant, *ITT Rayonier, Olympic Research Division, Shelton, Washington,* 1978-1981. Responsibilities included performing water quality tests, product-related analytical tests, corrosion tests (i.e., potentiometric polarization techniques), and operated pilot equipment specific to the pulp and paper industry.

Education

B.S., Chemistry, *Evergreen State College, Olympia, Washington,* 1993.
Coursework, *Pacific Lutheran University, Tacoma, Washington.* 1988-1989.
Coursework, *Tacoma Community College, Tacoma, Washington.* 1970-1971, 1988-1989.
CERTIFICATION, Chemistry, *L.H. Bates Technical, Tacoma, Washington,* 1976-1978.
Coursework, *Central Washington University, Ellensburg, Washington.* 1969-1970.
Numerous Training/Educational Activities via Conferences, Professional Seminars, and Factory Training, 1989-2010.

Publications/ Presentations

Mr. Christian has a number of publications and presentations. For a list of these publications and presentations, please contact CAS.

LEE E. WOLF

1988 TO PRESENT

Columbia Analytical Services, Inc., 1317 South 13th Ave., Kelso, WA 98626 360.577.7222

Current Position

QUALITY ASSURANCE DIRECTOR AND CHIEF QUALITY OFFICER – 2008 to Present

Responsibilities

Directing the overall corporate-wide quality systems and ethics programs for all CAS facilities. Responsible for ensuring that CAS quality systems and data integrity standards are implemented at all facilities. Act as liaison with government entities involving quality, technical and operational issues. Provide QA input and policy as needed for operations, development initiatives, special projects, planning, and information technology implementation. Provide assistance to QA Program Managers.

Experience

Technical Manager IV, Quality Assurance Program Manager, *Columbia Analytical Services, Inc., Kelso, Washington* **–** 2002 to 2008. As part of the management team, responsibilities included the overall management and implementation of the laboratory QA program. This included maintaining accreditations and certifications, and maintaining all necessary documents (QA Manual, SOPs, and QA records). Acted as primary point of contact during laboratory audits and provided audit responses and corrective actions. Coordinated performance audits (PE/PT testing) and conducted internal audits.

Scientist IV, Quality Assurance Program Manager, *Columbia Analytical Services, Inc., Kelso, Washington,* 1996-2002. Duties primarily as listed above.

Project Chemist/Principal Organic Scientist, *Columbia Analytical Services, Inc., Kelso, Washington,* 1994-1996. Responsibilities included GC and GC/MS method development and special projects coordination. Acts as technical advisor to the GC and GC/MS laboratories and GC/MS interpretation specialist and CLP organics specialist. Also responsible for Project Chemist functions, including management of projects for clients, identifying client needs, and preparation of data reports.

Semivolatile Organics Department Manager, *Columbia Analytical Services*, 1988-1994. Responsibilities included overall management of the department. Supervised GC/MS analyses, data review, reporting and related QA/QC functions. Responsible for supervision of staff, training, and scheduling. Beginning in 1992, responsibilities included being a Project Chemist for organics EPA-SAS and other clients. This involved scheduling projects for clients, identifying client requirements, and preparing data reports.

GC/MS Chemist, *U.S. Testing Co., Richland, Washington*, 1985-1988. Responsibilities included GC and GC/MS analysis of water and soil samples for volatiles and semivolatiles by EPA protocol, including Methods 8240, 8270 and CLP. Coordinated extraction and GC-GC/MS areas to manage sample/data flow through the lab. Also performed HPLC analysis and pesticide analysis by GC using EPA Methods.

Laboratory Assistant, *Eastern Washington University, Cheney, Washington,* 1985. Responsibilities included supervision and instruction of organic chemistry labs. Experience with GC and IR operation. Responsible for lab safety.

Education

Pharmaceutical Laboratory Control Systems, *Univ. of Wisconsin Short Course, Las Vegas,* 2004
Test Method Validation in Pharmaceutical Development and Production, *Univ. of Wisconsin Short Course, Las Vegas,* 2004
Documenting Your Quality System, *A2LA Short Course, Las Vegas, Nevada*, 1998.
Internal Laboratory Audits, *A2LA Short Course, Las Vegas, Nevada,* 1998.
Mass Spectra Interpretation, *ACS Short Course, Denver, Colorado*, 1992.
BS, Chemistry, *Eastern Washington University, Cheney, Washington,* 1985.

Publications/ Presentations

Selected Ion Monitoring: Issues for Method Development, Panel Discussion, Association of Official Analytical Chemists, (AOAC) Pacific Northwest Regional Meeting, 1995.

Method Enhancement Techniques for Achieving Low level Detection of Butyl Tin in Marine Sediments and Tissues, Association of Official Analytical Chemists (AOAC) Pacific Northwest Regional Meeting, 1994.

The Determination of Low-Level Concentrations of Polynuclear Aromatic Hydrocarbons (PAHs) in Soil and Water Using Gas Chromatography/Mass Spectroscopy Selected Ion Monitoring (GC/MS SIM), HazMat West, Long Beach, California, 1992.

Affiliations

American Chemical Society. American Society for Quality.

JAMES M. CARLSON

1999 TO PRESENT

Columbia Analytical Services, Inc., 1317 South 13th Ave., Kelso, WA 98632 360.577.7222

Current Position

PRESIDENT AND CHIEF EXECUTIVE OFFICER – 2010 to Present

Responsibilities

Responsible for overall management direction and coordination of all business activities, develops and implements business plans. Works closely with Branch Managers, and support staff, including Financial and Administration. Approves all policies, procedures, plans, and programs for the company and ensures their conformity with corporate guidelines and policies. Approves annual operating budgets for the branch offices and ensures operations perform within approved budget limits. Stays abreast of technological developments and trends, which could lead to new applications or markets. Maintains good client relations and actively pursues expansion of new clients and business lines in conjunction with regional and corporate marketing goals.

Experience

CHIEF OPERATING OFFICER (COO), *Columbian Analytical Services, Kelso, Washington,* 1999-2010. Responsible for oversight of operating units of Columbia Analytical Services, inc. with all Laboratory Directors reporting to the COO. Primary responsibilities include establishment of consistent quality, technical, and client service enhancements across the company, as well as the financial performance of the individual operating units. In addition, a significant role is to represent operations as a member of the Senior Management Team (SMT) consisting of the Chief Executive Officer, Chief Financial Officer, Chief Quality Officer, and the Director of Information Technology

Financial Services Manager, *BHP Coated Steel Corporation, Kalama, Washington,* 1997-1999. Developed and managed the financial accounting and services department for a two-plant facility with revenues exceeding $200 million. Supervised a staff of 11 and provided shared services for five organizations. Responsible for all internal and external financial reporting and audit requirements. Additional duties included supporting the general management team as relief CFO and acting as a meeting and process facilitator.

Finance and Administration Manager, *BHP Diamonds, Inc., Yellowknife, Northwest Territory, Canada,* 1993-1997. Developed and managed effective accounting, financial reporting, purchasing, and logistics systems for the start up of the BHP/Blackwater NWT Diamond Project in the high Arctic. Negotiated and administered contracts related to the supply of goods, services, and facilities for the construction and administration of the 100 person camp, including the development of HR, safety, and security systems. Participated in the general management team, including extensive public relations regarding the project's environmental and socioeconomic impacts. Participated in negotiations involving aboriginal, provincial, and the Canadian federal government.

Accounting and Administration Manager, *BHP Exploration, Herndon, Virginia,* 1992-1993. Controller and administration manager for BHP's world coal and industrial minerals programs. Oversight of 12 international office locations, including the 40-person office in Herndon, Virginia, and 30 international exploration and geophysical projects. Responsible for all aspects of office and accounting administration, including international and domestic staffing. Retained local external accounting and legal services in foreign locations and negotiated foreign labor agreements.

Senior Accountant, *BHP Western US Mining, Farmington, New Mexico,* 1989-1992. Responsible for general ledger, equipment, and fixed asset accounting for three coal mines with a combined annual revenue exceeding $300 million. Also responsible for administration of royalties, taxes, and land lease obligations with external entities, including governments, tribes, and individual landowners; preparation of monthly business reports; annual budgets; and ten-year forecasts. Trained developing accountants in major mining accounting and administration.

Management Trainee, *Financial Management Development Program, BHP Utah International, San Francisco, California,* 1986-1989. Performed three one-year training assignments within the BHP Minerals San Francisco office. One year of consolidation accounting, one year of exploration accounting, and one year of financial planning and analysis.

Education

Leading Organizational Change Program, *BHP, Kalama, Washington,* 1998.
Global Leadership Program 2, *BHP, Kota Kinabalu, Malaysia,* 1995.
Resident Management Course I, *BHP, Melbourne, Australia,* 1993.
BS, Business Administration/Accounting, *California State University, San Jose, California,* 1986.

APPENDIX C

MAJOR ANALYTICAL EQUIPMENT

GENERAL CHEMISTRY/WATER CHEMISTRY LABORATORY			
Equipment Description	**Year Acquired**	**Manufacturer or Laboratory Maintained (MM/LM)**	**# of Trained Operators**
Analytical Balances (10):			
Precisa and Mettler models	1988-2008	MM	13
Autoclave - Market Forge Sterilmatic	1988	LM	5
Autotitrator – Thermo Orion 500	2007	LM	3
Calorimeters (2):			
Parr 1241 EA Adiabatic	1987	LM	4
Parr 6300 Isoparabolic	2005	LM	4
Centrifuge - Damon/IEC Model K	1992	LM	13
Colony Counter - Quebec Darkfield	1988	LM	2
Conductivity Meters (2):			
YSI Model 3200	2004	LM	4
VWR	2001	LM	4
Digestion Systems (5):			
COD (4)	1987, 1989	LM	4
Kjeldahl, Lachat 46-place (1)	1999	LM	3
Dissolved Oxygen Meter - YSI Model 58 (3)	1987, 1988, 1991	LM	4
Distillation apparatus (Midi) - Easy Still (2)	1996, 2000	LM	5
Drying Ovens (9):	1990-2009		
Shel-Lab and VWR models		LM	13
Flash Point Testers (2):			
ERDCO Setaflash Tester	1991	LM	3
Petroleum Systems Services	2005	LM	3
Flow-Injection Analyzers (2):			
Bran-Leubbe	2002	LM	2
Lachat 8500	2007	LM	2
Ion Chromatographs (4)			
Dionex DX-120 with Peaknet Data System	1998	LM	3
Dionex ICS-2500 with Chromchem Data System	2002	LM	3
Dionex ICS-2000 with Chromchem Data System	2006	LM	3
Dionex ICS-1600 with Chromchem Data System	2009	LM	
Ion Selective Electrode Meters (5)			
Fisher Scientific Accument Model 50	1997	LM	4
Fisher Scientific Accument Model 25	1993	LM	4
Fisher Scientific Accument Model 20	2000	LM	4
Orion Model 920A	1990	LM	4
Corning pH/ion Meter Model 135	1992	LM	4
Microscope - Olympus	1988	LM	1
Muffle Furnace- Sybron Thermolyne Model F-A1730	1991	LM	13
pH Meters (2):			
Fisher Scientific Accument Model 20	1993	LM	5
Fisher Scientific Accument Model AR25	2005	LM	5

GENERAL CHEMISTRY/WATER CHEMISTRY LABORATORY (continued)			
Equipment Description	**Year Acquired**	**Manufacturer or Laboratory Maintained (MM/LM)**	**# of Trained Operators**
Shatter Box - GP 1000	1989	LM	5
Sieve Shakers (2):			
CE Tyler - Portable RX 24	1990	LM	5
WS Tyler - RX 86	1991	LM	5
Thomas-Wiley Laboratory Mill, Model 4	1989	LM	5
Total Organic Carbon (TOC) Analyzers (2)			
Coulemetrics Model 5012	1997	LM	3
Teledyne Tekmar Fusion 1	2009	LM	3
Total Organic Halogen (TOX) Analyzers (2):			
Mitsubishi TOX-100	2001	LM	2
Turbidimeter - Hach Model 2100N	1996	LM	5
UV-Visible Spectrophotometers (3):			
Hitachi 100-40 Single Beam	1986	LM	4
Beckman-Coulter DU520	2005	LM	4
Perkin Elmer Lambda 25	2008	LM	4
Vacuum Pumps (2):			
Welch Duo-Seal Model 1376	1990	LM	13
Busch R-5 Series Single Stage	1991	LM	13
Water Baths/Incubators (6):	1986 - 2009	LM	13
Various Fisher Scientific and VWR Models			

METALS LABORATORY			
Equipment Description	**Year Acquired**	**Manufacturer or Laboratory Maintained (MM/LM)**	**# of Trained Operators**
Analytical Balance (6)			
Mettler AE 200 analytical balance	1990	MM	12
Various Mettler, Sartorius, and Ohaus models (5)	1988	MM	12
Atomic Absorption Spectrophotometers (5):			
Varian SpectrAA Zeeman/220 AA (2)	2000	LM	2
CETAC Mercury Analyzer M-6000A	2000	LM	2
Perkin Elmer AAnalyst 200 Flame AA	2005	MM	2
CETAC Mercury Analyzer M-6100	2010	MM	2
Buck AA Spectrophotometer Model 205	2008	LM	1
Atomic Fluorescence Spectrophotometer			
Brooks-Rand Model III (2)	1996, 2005	LM	3
Leeman Mercury Analyzer (1)	2006	LM	2
Centrifuge - IEC Model Clinical Centrifuge	1990	LM	12
Drying Oven - VWR Model 1370F	1990	LM	12
Freeze Dryers (2) - Labconco	1992, 2006	LM	5
Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-AES) (3)			
Thermo Jarrell Ash Model 61E	1988	LM	4
Thermo Jarrell Ash, Model IRIS	2000	MM	4
Thermo Scientific Model iCAP 6500	2007	MM	3
Inductively Coupled Plasma Mass Spectrometers (ICP-MS):			
VG Excell	2001	MM	3
Thermo X-Series	2006	MM	2
Muffle Furnace - Thermolyne Furnatrol Model 53600 (2)	1991, 2005	LM	5
Shaker - Burrell Wrist Action Model 75	1990	LM	12
TCLP Extractors (3)	1989, 2002	LM	5

SEMIVOLATILE ORGANICS SAMPLE PREPARATION LABORATORY			
Equipment Description	**Year Acquired**	**Manufacturer or Laboratory Maintained (MM/LM)**	**# of Trained Operators**
Analytical Balance (4)			
Mettler PM480, AE166, BB300	1999 - 2005	MM	16
OHaus EP613	2006	MM	16
Centrifuge - Sorvall Model GLC-1	1988	LM	16
Drying Ovens (2)			
Fisher Model 655G	1991	LM	16
VWR Model 1305U	1999	LM	16
Evaporators (14):			
Organomation N-Evap (7)	1989-2006	LM	16
Organomation S-Evap (7)	1986-2006	LM	16
Zymark Turbovap (2)	1998-2000	LM	16
Extractor Heaters: Lab-Line Multi-Unit Models for Continuous Liquid-Liquid and Soxhlet Extractions (102)	1987-2007	LM	8
Solids Extractors:			
Sonic Bath VWR (2)	1991 -1994	LM	6
Sonic Horn (5)	1994	LM	6
Soxhtherm		LM	6
Gerhardt (2)	2000		
OI Analytical (6)	2008		
Extractors, TCLP (10):			
Millipore TCLP Zero Headspace Extractors (10)	1987-1992	LM	2
TCLP Extractor - Tumbler (12 position)	1989	LM	2
Gel Permeation Chromatography (GPC) (6)			
ABC single column (4)	1998, 1999, 2007	LM	4
J2 Scientific AccuPrep (2)	2005, 2010	LM	4
Muffle Furnace - 4	1994-2006	LM	4
Solid Phase Extractors (18) – Horizon SPE-Dex 4790	2003, 2006,2008	LM	4

GC SEMIVOLATILE ORGANICS INSTRUMENT LABORATORY			
Equipment Description	**Year Acquired**	**Manufacturer or Laboratory Maintained (MM/LM)**	**# of Trained Operators**
Chromatography Data Systems (12)			
HP Enviroquant (8)	1994-2003	LM	7
Thruput Target (4)	1998-2000	LM	4
Varian Saturn (1)	2003	LM	2
Gas Chromatographs (11):			
Hewlett-Packard 5890 GC with HP 7673 Autosampler and Dual ECD Detectors (4)	1990 – 1995	LM	7
Hewlett-Packard 5890 GC with HP 7673 Autosampler and Dual FPD Detectors	1991	LM	3
Agilent 6890 GC with Agilent 7683 Autosampler and Dual ECD Detectors (5)	2001, 2005, 2007	LM	7
Agilent 6890 GC with Agilent 7683 Autosampler and Dual FPD Detectors	2003	LM	3
Agilent 7890A Dual ECD Detectors Agilent 7683B autosampler	2008	LM	7
Hewlett-Packard 5890 GC with HP 7673 Autosampler and FID Detector	1995	LM	3
Agilent 6890 with Dual FID Detectors and Agilent 7873 Autosampler (3)	2001, 2005	LM	7
Agilent 6890N with Dual ECD and Agilent 7683 injector	2003	LM	2
Agilent 7890A with Dual ECD and Agilent 7683B injector	2008	LM	2
Varian Ion trap GC/MS:	2003	LM	2
Varian 3800 GC w/CP8400 autosampler	2006	LM	2
Varian Saturn 2100T mass spectrometer	2003	LM	2
Thremo Ion Trap ITQ-90C GC/MS w/TriPlus autosampler	2008	LM	2

GC/MS SEMIVOLATILE ORGANICS INSTRUMENT LABORATORY			
Equipment Description	**Year Acquired**	**Manufacturer or Laboratory Maintained (MM/LM)**	**# of Trained Operators**
Enviroquant Chromatography Data Systems (9)	1994-2003	LM	6
Gas Chromatograph: Hewlett-Packard 5890 with HP 7673 autosampler and FID Detector	1994	LM	6
Semivolatile GC/MS Systems (9):			
Agilent 6890/5973 with ATAS Optic2 LVI and HP 7673 Autosampler (2)	1997, 2001	LM	6
Agilent 5890/5970 and HP 7673 Autosampler	1990	LM	6
Agilent 5890/5970 with ATAS Optic2 LVI and HP 7673 Autosampler	1994	LM	6
Agilent 5890/5972 with ATAS Optic2 LVI and HP 7673 Autosampler (3)	1993, 1994, 1998	LM	6
Agilent 6890/5973 with ATAS Optic3 LVI and 7683 Autosampler	2004	LM	6
Agilent 6890/5973 with Agilent PTV Injector and 7683 Autosampler	2007	LM	6
Agilent7890A/5975C with Agilent 7693 Autosampler	2010	LM	6
Semivolatile GC/MS/MS – Waters Quattro Micro GC Micromass with Agilent 6890, Agilent PTV Injector, 7683B Autosampler	2008	MM	1

HPLC LABORATORY			
Equipment Description	**Year Acquired**	**Manufacturer or Laboratory Maintained (MM/LM)**	**# of Trained Operators**
Analytical Balance - Mettler BB240	1994	MM	4
Aspirator pump – GAST	2004	LM	4
Drying Oven - Fisher Model 630F	1991	LM	4
Evaporator – Turbo Vap	2009	LM	4
Centrifuge Marathon 21K	1996	LM	4
HP Enviroquant Chromatography Data Systems 4	1994-2002	LM	3
High-Performance Liquid Chromatographs (2): HP 1090M Series II with Diode Array UV Detector HP 1050/1100 Series with Fluorescence & Diode Array UV Detectors	 1999 2004	 LM LM	 2 2
High-Performance Liquid Chromatograph/Mass(2) Spectrometer - Thermo Electron TSQ Quantum LC/MS/MS and Autosampler API 5000 LC/MS/MS and SIL-20AC Autosampler	2005 2008	MM MM	2 2
Agilent 1100 HPLC w/post-column derivitization: UV/Fluoescence detectors Pickering PCX-5200 Post-column derivitization unit	2003 2003 2003	LM LM LM	2 2 2

VOLATILE ORGANICS LABORATORY			
Equipment Description	**Year Acquired**	**Manufacturer or Laboratory Maintained (MM/LM)**	**# of Trained Operators**
Analytical Balance - Mettler PE 160	1989	MM	5
Fisher Vortex Mixer	1989	LM	5
HP Enviroquant Chromatography Data Systems (10)	1994-2002	LM	5
Drying Ovens (2):			
Narco 420	1989	LM	5
VWR 1305 U	1991	LM	5
Sonic Water Bath - Branson Model 2200	1989	LM	5
Volatile GC/MS Systems (8):			
Agilent 5890/5970	1989	LM	5
Tekmar 3000 Purge and Trap Concentrator	1995	LM	5
Dynatech ARCHON 5100 Autosampler	1996	LM	5
Agilent 5890/5971	1991	LM	5
Tekmar 3000 Purge and Trap Concentrator	2001	LM	5
Dynatech ARCHON 5100 Autosampler	1995	LM	5
Agilent 5890/5972A	1993	LM	5
Tekmar 3000 Purge and Trap Concentrator	1995	LM	5
Dynatech ARCHON 5100 Autosampler	1996	LM	5
Agilent 6890/5973	2001	LM	5
Tekmar 3100 Purge and Trap Concentrator	2001	LM	5
Varian Archon Autosampler	2001	LM	5
Agilent 6890/5973	2005	LM	5
Tekmar Velocity Purge and Trap Concentrator	2005	LM	5
Tekmar Aquatech Autosampler	2005	LM	5
Agilent 6890/5973 (2)	2007	LM	5
Tekmar 3000 Purge and Trap Concentrator	2007	LM	5
Varian Archon 5100 Autosampler	2007	LM	5
Agilent 7980A/5975C	2010	LM	5
Teledyne Tekmar-Automx	2010	LM	5
Hewlett-Packard 5890 Series II with PID/PID/FID(2)	1991	LM	2
EST-ENCON Purge and Trap Concentrator	1991		
Dynatech Archon 5100 Autosampler	1992		

AUTOMATED DATA PROCESSING EQUIPMENT			
Equipment Description	**Year Acquired**	**Manufacturer or Laboratory Maintained (MM/LM)**	**# of Trained Operators**
1-WAN: LIMS Sample Manager using Oracle 10g & 11g DBMS running on Redhat Advanced Server 4.0 (Linux) platform connected/linked via both fiber and MPLS circuits.	1994-2007	LM	NA
1 - Network Server Pentium 4 class, 1 for Reporting and Data Acquisition running Windows 2003 SP2 Advanced Server, 1 for Applications running Windows 2003 Advanced Server SP2. Data acquisition capacity at 195 GB with redundant tape and disk arrays.	2004-2008	LM	NA
Approximately 80+ HP, Dell, Kyocera Laserjet printers (various types including models III, 4, 5, 8150, 4000, 4041, 4050, 4200 4250, 8150, 1720dn, W5300, 1300D, M4000)	1991 - 2010	LM	NA
Approximately 280 + Gateway/Dell PC/Workstations running Windows 2000/XP on LAN connected via 10BT/100BT and TCP/IP for LIMs Terminal Emulation	1993 - 2010	LM	NA
Microsoft Office 2003 Professional as the base application for all PC/Workstations. Some systems using Office 2000/97, Office 2007.	1996 - 2010	LM	NA
E-Mail with link to SMTP for internal/external messaging. Web mail via Outlook Web Access interface. Microsoft Outlook 2003.	1994 - 2006	LM	NA
Standard Excel (R) reporting platform application linked to LAN/WAN for data connectivity and EDD generation.	1996 - 2004	LM	NA
Standard Excel (R) reporting platform application linked to LAN/WAN for data connectivity and EDD generation.	1996 - 2004	LM	NA
Facsimile Machines - Brother 4750e; Brother 2920; Brother 1860	1991 - 2010	LM	NA
Copiers/Scanners: Konica BizHub 420 (1), BizHub 600 (1), BizHub 920 (2), BizHub Pro 1050 (3), BizHub Pro 1051 (1). All are accessible via LAN for network scanning.	2000 - 2010	LM	NA
Dot Matrix Panasonic KX-P1150	1991 - 2004	LM	NA
Thruput, MARRS, Stealth, Harold, Blackbird, EDDGE, CASLIMS reporting software systems.	1998 - 2004	LM	NA

NA: Not applicable. This equipment administered by IT staff but may be used by all staff.

APPENDIX D

DATA QUALIFIERS AND ACRONYMS

Inorganic Data Qualifiers

*	The result is an outlier. See case narrative.
#	The control limit criterion is not applicable. See case narrative.
B	The analyte was found in the associated method blank at a level that is significant relative to the sample result as defined by the DOD or NELAC standards.
E	The result is an estimate amount because the value exceeded the instrument calibration range.
J	The result is an estimated value that was detected outside the quantitation range.
U	The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL. *DOD-QSM 4.1 definition*: Analyte was not detected and is reported as less than the LOD or as defined by the project. The detection limit is adjusted for dilution.
i	The MRL/MDL or LOQ/LOD is elevated due to matrix interference.
X	See case narrative.
Q	See case narrative. One or more quality control criteria were outside the limits.

Metals Data Qualifiers

#	The control limit criterion is not applicable. See case narrative.
J	The result is an estimated value that was detected outside the quantitation range.
E	The percent difference for the serial dilution was greater than 10%, indicating possible matrix interference in the sample.
M	The duplicate injection precision was not met.
N	The Matrix Spike sample recovery is not within control limits. See case narrative.
S	The reported value was determined by the Method of Standard Additions (MSA).
U	The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL. *DOD-QSM 4.1 definition*: Analyte was not detected and is reported as less than the LOD or as defined by the project. The detection limit is adjusted for dilution.
W	The post-digestion spike for furnace AA analysis is out of control limits, while sample absorbance is less than 50% of spike absorbance.
i	The MRL/MDL or LOQ/LOD is elevated due to matrix interference.
X	See case narrative.
+	The correlation coefficient for the MSA is less than 0.995.
Q	See case narrative. One or more quality control criteria were outside the limits.

Organic Data Qualifiers

*	The result is an outlier. See case narrative.
#	The control limit criterion is not applicable. See case narrative.
A	A tentatively identified compound, a suspected aldol-condensation product.
B	The analyte was found in the associated method blank at a level that is significant relative to the sample result as defined by the DOD or NELAC standards.
C	The analyte was qualitatively confirmed using GC/MS techniques, pattern recognition, or by comparing to historical data.
D	The reported result is from a dilution.
E	The result is an estimate amount because the value exceeded the instrument calibration range.
J	The result is an estimated value that was detected outside the quantitation range.
N	The result is presumptive. The analyte was tentatively identified, but a confirmation analysis was not performed.
P	The GC or HPLC confirmation criterion was exceeded. The relative percent difference is greater than 40% between the two analytical results.
U	The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL. *DOD-QSM 4.1 definition*: Analyte was not detected and is reported as less than the LOD or as defined by the project. The detection limit is adjusted for dilution.
i	The MRL/MDL or LOQ/LOD is elevated due to a chromatographic interference.
X	See case narrative.
Q	See case narrative. One or more quality control criteria were outside the limits.

Additional Petroleum Hydrocarbon Specific Qualifiers

F	The chromatographic fingerprint of the sample matches the elution pattern of the calibration standard.
L	The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of lighter molecular weight constituents than the calibration standard.
H	The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of heavier molecular weight constituents than the calibration standard.
O	The chromatographic fingerprint of the sample resembles oil, but does not match the calibration standard.
Y	The chromatographic fingerprint of the sample resembles a petroleum product eluting in approximately the correct carbon range, but the elution pattern does not match the calibration standard.
Z	The chromatographic fingerprint does not resemble a petroleum product.

Acronyms

ASTM	American Society for Testing and Materials
A2LA	American Association for Laboratory Accreditation
CARB	California Air Resources Board
CAS Number	Chemical Abstract Service registry Number
CFC	Chlorofluorocarbon
CFU	Colony-Forming Unit
DEC	Department of Environmental Conservation
DEQ	Department of Environmental Quality
DHS	Department of Health Services
DOE	Department of Ecology
DOH	Department of Health
EPA	U. S. Environmental Protection Agency
ELAP	Environmental Laboratory Accreditation Program
GC	Gas Chromatography
GC/MS	Gas Chromatography/Mass Spectrometry
LUFT	Leaking Underground Fuel Tank
M	Modified
MCL	Maximum Contaminant Level is the highest permissible concentration of a substance allowed in drinking water as established by the USEPA.
MDL	Method Detection Limit
MPN	Most Probable Number
MRL	Method Reporting Limit
NA	Not Applicable
NC	Not Calculated
NCASI	National Council of the Paper Industry for Air and Stream Improvement
ND	Not Detected
NIOSH	National Institute for Occupational Safety and Health
PQL	Practical Quantitation Limit
RCRA	Resource Conservation and Recovery Act
SIM	Selected Ion Monitoring
TPH	Total Petroleum Hydrocarbons
tr	Trace level is the concentration of an analyte that is less than the PQL but greater than or equal to the MDL.

APPENDIX E

PREVENTIVE MAINTENANCE PROCEDURES

Instrument	Activity	Maint[a]	Frequency
Refrigerators and Coolers	Record temperatures	LM	Daily
	Clean coils	LM	Annually
	Check coolant	LM	Annually or if temperature outside limits
Vacuum Pumps	Clean and change pump oil	LM	Every month or as needed
Fume Hoods	Face velocity measured	LM	Quarterly
	Sash operation	LM	As needed
	Change filters	LM	Annually
	Inspect fan belts	LM	Annually
Ovens	Clean	LM	As needed or if temperature outside lim.
	Record temperatures	LM	Daily, when in use
Incubators	Record temperatures	LM	Daily, morning and evening
Water Baths	Record temperatures	LM	Daily, morning and evening
	Wash with disinfectant solution	LM	When water is murky, dirty, or when growth appears
Autoclave	Check sterility	LM	Every month
	Check temperature	LM	Every month
	Clean	LM	When mold or growth appears
	Calibrate thermometer	VM	Twice a year
Analytical Balances	Check alignment	LM	Before every use
	Verify calibration	LM	Daily
	Clean pans and compartment	LM	After every use
	Certified calibration	VM	Twice a year
Dissolved Oxygen Meter	Change membrane	LM	When fluctuations occur
pH probes	Condition probe	LM	When fluctuations occur
Fluoride ISE	Store in storage solution	LM	Between uses
Ammonia ISE	Store in storage solution	LM	Between uses
UV-visible Spectrophotometer	Wavelength check	VM	Twice a year

Total Organic Carbon Analyzers	Check IR zero	LM	Weekly
	Check digestion/condensation vessels	LM	Each use
	Clean digestion chamber	LM	Every 2000 hours, or as needed
	Clean permeation tube	LM	Every 2000 hours, or as needed
	Clean six-port valves	LM	Every 200 - 2000 hours, or as needed
	Clean sample pump	LM	Every 200 - 2000 hours, or as needed
	Clean carbon scrubber	LM	Every 200 - 2000 hours, or as needed
	Clean IR cell	LM	Every 2000 - 4000 hours, or as needed

Instrument	Activity	Maint[a]	Frequency
Total Organic Halogen Analyzers	Change cell electrolyte	LM	Daily
	Change electrode fluids	LM	Daily
	Change pyrolysis tube	LM	As needed
	Change inlet and outlet tubes	LM	As needed
	Change electrodes	LM	As needed
Flow Injection Analyzer	Check valve flares	LM	Each use
	Check valve ports	LM	Each use
	Check pump tubing	LM	Each use
	Check light counts	LM	Each use
	Check flow cell flares	LM	Quarterly
	Change bulb	LM	As needed
	Check manifold tubing	LM	Each use
	Check T's and connectors	LM	Each use
Ion Chromatographs	Change column	LM	Every six months or as needed
	Change valve port face & hex nut	LM	Every six months or as needed
	Clean valve slider	LM	Every six months or as needed
	Change tubing	LM	Annually or as needed
	Eluent pump	LM	Annually
Atomic Absorption Spectro-photometers - FAA and CVAA	Check gases	LM	Daily
	Clean burner head	LM	Daily
	Check aspiration tubing	LM	Daily

Instrument	Activity	Maint[a]	Frequency
Atomic Absorption Spectro-photometers - GFAA	Clean optics	LM	Every three months
	Empty waste container	LM	Weekly
	Check gases	LM	Daily
	Check argon dewar	LM	Daily
	Change graphite tube	LM	Daily, as needed
	Clean furnace windows	LM	Monthly
ICP - AES	Check argon dewar	LM	Daily
	Replace peristaltic pump tubing	LM	Daily
	Empty waste container	LM	Weekly
	Clean nebulizer, spray chamber, and torch	LM	Every two weeks
	Replace water filter	LM	Quarterly
	Replace vacuum air filters	LM	Monthly

Instrument	Activity	Maint[a]	Frequency
ICP - MS	Check argon dewar	LM	Daily
	Check water level in chiller	LM	Daily
	Complete instrument log	LM	Daily
	Replace peristaltic pump tubing	LM	Daily
	Clean sample and skimmer cones	LM	As needed
	Clean RF contact strip	LM	As needed
	Inspect nebulizer, spray chamber, and torch	LM	Clean as needed
	Clean lens stack/extraction lens	LM	As needed
	Check rotary pump oil	LM	Monthly
	Change rotary pump oil	LM	Every six months
Gel-Permeation Chromatographs	Clean and repack column	LM	As needed
	Backflush valves	LM	As needed
High Pressure Liquid Chromatographs	Backflush guard column	LM	As needed
	Backflush column	LM	As needed
	Change guard column	LM	As needed when back pressure too high
	Change column	LM	Annually or as needed
	Change in-line filters	LM	As needed
	Leak check	LM	After column maintenance
	Change pump seals	LM	As needed

Instrument	Activity	Maint[a]	Frequency
High Pressure Liquid Chromatographs	Change pump diaphragm	LM	Annually
	Clean flow cell	LM	As needed
	Fluorescence detector check	LM	Daily
	Diode array absorbance check	LM	Daily
Gas Chromatographs, Semivolatiles	Check gas supplies	LM	Daily, replace if pressure reaches 50psi
	Change in-line filters	LM	Quarterly or after 30 tanks of gas
	Change septum	LM	Daily
	Change injection port liner	LM	Weekly or as needed
	Clip first 6-12" of capillary column	LM	As needed
	Change guard column	LM	As needed
	Replace analytical column	LM	As needed when peak resolution fails
	Check system for gas leaks	LM	After changing columns and after any power failure
	Clean FID	LM	Weekly or as needed
	Clean ECD	LM	Quarterly or as needed
	Leak test ECD	LM	Annually

Instrument	Activity	Maint[a]	Frequency
Gas Chromatograph/Mass Spectrometers, Semivolatiles	Check gas supplies	LM	Daily, replace if pressure reaches 50psi
	Change in-line filters	LM	Annually or as needed
	Change septum	LM	Daily, when in use
	Change injection port liner	LM	Weekly or as needed
	Clip first 6-12" of capillary column	LM	As needed
	Change guard column	LM	As needed
	Replace analytical column	LM	As needed when peak resolution fails
	Clean source	LM	As needed when tuning problems
	Change pump oil	LM	As specified by service specifications
Purge and Trap Concentrators	Change trap	LM	Every four months or as needed
	Change transfer lines	LM	Every six months or as needed
	Clean purge vessel	LM	Daily
Gas Chromatographs, Volatiles	Check gas supplies	LM	Daily, replace when pressure reaches 50 psi
	Change in-line filters	LM	Quarterly or after 30 tanks of gas
	Change septum	LM	Daily
	Clip first 6-12" of capillary column	LM	As needed
	Change guard column	LM	As needed
	Replace analytical column	LM	As needed when peak resolution fails
	Check system for gas leaks	LM	After changing columns and after any power failure
	Clean PID lamp	LM	As needed
	Clean FID	LM	As needed
	Change ion exchange resin	LM	Every 60 days
	Replace nickel tubing	LM	Quarterly or as needed
Gas Chromatograph/Mass Spectrometers, Volatiles	Check gas supplies	LM	Daily, replace when pressure reaches 50 psi
	Change in-line filters	LM	Annually or as needed
	Change septum	LM	Daily
	Clip first foot of capillary column	LM	As needed
	Replace analytical column	LM	As needed when peak resolution fails
	Clean source	LM	As needed when tuning problems
	Change pump oil		As specified by service specifications

APPENDIX F

LABORATORY
STANDARD OPERATING PROCEDURES

Administrative SOP Kelso

SOP Title	FILE NAME
CHECKING VOLUMETRIC LABWARE	**ADM-VOLWARE**
CONTINGENCY PLAN FOR LABORATORY EQUIPMENT FAILURE	**ADM-ECP**
CONTROL CHARTING QUALITY CONTROL DATA	**ADM-CHRT**
DATA ARCHIVING	**ADM-ARCH**
DATA REPORTING AND REPORT GENERATION	**ADM-RG**
DEPARTMENT OF DEFENSE PROJECTS LABORATORY PRACTICES AND PROJECT MANAGEMENT	**ADM-DOD**
ELECTRONIC DATA BACKUP AND ARCHIVING	**ADM-EBACKUP**
INTERNAL QUALITY ASSURANCE AUDITS	**ADM-IAUD**
LABORATORY BALANCE MONITORING AND CALIBRATION	**ADM-BAL**
LABORATORY DATA REVIEW PROCESS	**ADM-DREV**
PROJECT MANAGEMENT	**ADM-PCM**
REAGENT LOGIN AND TRACKING	**ADM-RLT**
SUPPORT EQUIPMENT MONITORING AND CALIBRATION	**ADM-SEMC**
SAMPLE BATCHES	**ADM-BATCH**
SAMPLE MANAGEMENT SOPS	**FILE NAME**
BOTTLE ORDER PREPARATION AND SHIPPING	SMO-BORD
FOREIGN SOILS HANDLING TREATMENT	SMO-FSHT
SAMPLE DISPOSAL	SMO-SDIS
SAMPLE RECEIVING	SMO-GEN
SAMPLE TRACKING AND LABORATORY CHAIN OF CUSTODY	SMO-SCOC

Technical SOP - Kelso

COLIFORM, FECAL	BIO-9221FC
COLIFORM, TOTAL	BIO-9221TC
COLIFORM, FECAL (MEMBRANE FILTER PROCEDURE)	BIO-9222D
COLILERT® , COLILERT-18®, & COLISURE®	BIO-9223
FECAL STREPTOCOCCUS/ENTEROCOCCUS	BIO-9230B
ENTEROLERT	BIO-ENT
HEPTEROTROPHIC PLATE COUNT	BIO-HPC
MICROBIOLOGY QUALITY ASSURANCE AND QUALITY CONTROL	BIO-QAQC
SHEEN SCREEN/OIL DEGRADING MICROORGANISMS	BIO-SHEEN
SEPARATORY FUNNEL LIQUID-LIQUID EXTRACTION	EXT-3510
CONTINUOUS LIQUID - LIQUID EXTRACTION	EXT-3520
SOLID PHASE EXTRACTION	EXT-3535
SOXHLET EXTRACTION	EXT-3540
AUTOMATED SOXHLET EXTRACTION	EXT-3541
ULTRASONIC EXTRACTION	EXT-3550
WASTE DILUTION EXTRACTION	EXT-3580
SILICA GEL CLEANUP	EXT-3630
REMOVAL OF SULFUR USING COPPER	EXT-3660
REMOVAL OF SULFUR USING MERCURY	EXT-3660M
SULFURIC ACID CLEANUP	EXT-3665
CARBON CLEANUP	EXT-CARCU
DIAZOMETHANE PREPARATION	EXT-DIAZ
DMD SYNTHESIS	EXT-DMD
FLORISIL CLEANUP	EXT-FLOR
ORGANIC EXTRACTIONS GLASSWARE CLEANING	EXT-GC
PERCENT LIPIDS IN TISSUE	EXT-LIPID
EXTRACTION METHOD FOR ORGANOTINS IN SEDIMENTS, WATER, AND TISSUE	EXT-OSWT
PREPARATION OF REAGENTS AND BLANK MATRICES USED IN SEMIVOLATILE ORGANICS ANALYSIS	EXT-REAG
ADDITION OF SPIKES AND SURROGATES	EXT-SAS
SOLID PHASE DISPERSION IN TISSUES	EXT-SPD
MEASURING SAMPLE WEIGHTS AND VOLUMES FOR ORGANIC ANALYSIS	EXT-WVOL
FACILITY AND LABORATORY CLEANING	FAC-CLEAN
OPERATION AND MAINTENANCE OF LABORATORY REAGENT WATER SYSTEMS	FAC-WATER

Technical SOP - Kelso (CONT.)

FLASHPOINT DETERMINATION - SETAFLASH	GEN-1020
COLOR	GEN-110.2
TOTAL SOLIDS	GEN-160.3
SOLIDS, TOTAL VOLATILE AND PERCENT ASH IN SOIL AND SOLID SAMPLES	GEN-160.4
SETTEABLE SOLIDS	GEN-160.5
HALIDES, ADSORBABLE ORGANIC (AOX)	GEN-1650
ALKALINITY TOTAL	GEN-2320
HARDNESS, TOTAL	GEN-2340
DETERMINATION OF INORGANIC ANIONS IN DRINKING WATER BY ION CHROMATOGRAPHY	GEN-300.1
ACIDITY	GEN-305.2
PERCHLORATE BY ION CHROMATOGRAPHY	GEN-314.0
CHLORIDE (TITRIMETRIC, MERCURIC NITRATE)	GEN-325.3
CHLORINE, TOTAL/FREE RESIDUAL	GEN-330.4
TOTAL RESIDUAL CHLORINE - METHOD 330.5	GEN-330.5
AMMONIA BY FLOW INJECTION ANALYSIS	GEN-350.1
AMMONIA AS NITROGEN BY ION SPECIFIC ELECTRODE	GEN-350.3
NITRATE/NITRITE, NITRITE BY FLOW INJECTION ANALYSIS	GEN-353.2
NITRITE BY COLORIMETRIC PROCEDURE	GEN-354.1
PHOSPHORUS DETERMINATION USING COLORMETRIC PROCEDURE	GEN-365.3
DISSOLVED SILICA	GEN-370.1
GRAVIMETRIC SULFATE	GEN-375.3
PHENOLICS, TOTAL	GEN-420.1
MBAS	GEN-425.1
SULFIDE, METHYLENE BLUE	GEN-4500S2D
SULFIDE, TITRIMETRIC (IODINE)	GEN-4500S2F
HALOGENS TOTAL AS CHLORIDE BY BOMB COMBUSTION	GEN-5050
BIOCHEMICAL OXYGEN DEMAND	GEN-5210B
HALIDES, ADSORBABLE ORGANIC (AOX) - SM 5320B	GEN-5320B
TANNIN AND LIGNIN	GEN-5550
HALIDES, TOTAL ORGANIC (TOX)	GEN-9020
HALIDES, EXTRACTABLE ORGANIC (EOX)	GEN-9020M
TOTAL SULFIDES BY METHYLENE BLUE DETERMINATION	GEN-9030
TOTAL HALIDES BY OXIDATIVE COMBUSTION AND MICROCOULOMETRY	GEN-9076

Technical SOP - Kelso (CONT.)

CARBON, TOTAL ORGANIC IN SOIL	GEN-ASTM
AUTOFLUFF	GEN-AUTOFLU
SULFIDES, ACIDS VOLATILE	GEN-AVS
HEAT OF COMBUSTION	GEN-BTU
CHLOROPHYLL-a BY COLORIMETRY	GEN-CHLOR
TOTAL CYANIDES AND CYANIDES AMENABLE TO CHLORINATION	GEN-CN
CYANIDE, WEAK ACID DISSOCIABLE	GEN-CNWAD
CHEMICAL OXYGEN DEMAND	GEN-COD
CONDUCTIVITY IN WATER AND WASTES	GEN-COND
CORROSIVITY TOWARDS STEEL	GEN-CORR
HEXAVALENT CHROMIUM - COLORIMETRIC	GEN-CR6
CARBONATE (CO3) BY EVOLUTION AND COLUMETRIC TITRATION	GEN-D513-82M
SULFIDE, SOLUBLE DETERMINATION OF SOLUBLE SULFIDE IN SEDIMENT	GEN-DIS.S2
BULK DENSITY OF SOLID WASTE FRACTIONS	GEN-E1109
FDA EXTRACTABLES	GEN-FDAEX
FERROUS IRON IN WATER	GEN-FeII
FLUORIDE BY ION SELECTIVE ELECTRODE	GEN-FISE
FORMALDEHYDE COLORIMETRIC DETERMINATION	GEN-FORM
HYDROGEN HALIDES BY ION CHROMATOGTRAPHY (METHOD 26)	GEN-HA26
MERCURY IN COAL SAMPLE PREPARATION BY PARR BOMB COMBUSTION	GEN-HGPREP
HYDAZINE IN WATER USING COLORIMETRIC PROCEDURE	GEN-HYD
TOTAL SULFUR FOR ION CHROMATOGRAPHY	GEN-ICS
ION CHROMATOGRAPHY	GEN-IONC
COLOR, NCASI	GEN-NCAS
NITROCELLULOSE IN SOIL	GEN-NCEL
OXYGEN CONSUMPTION RATE	GEN-O2RATE
CARBON, TOTAL ORGANIC DETERMINATION (WALKELY BLACK METHOD)	GEN-OSU
Ph IN SOIL AND SOLIDS	GEN-Phs
Ph IN WATER	GEN-Phw
PARTICLE SIZE DETERMINATION - ASTM PROCEDURE	GEN-PSASTM
PARTICLE SIZE DETERMINATION	GEN-PSP
SULFIDES, REACTIVE	GEN-RS
TOTAL SULFIDE BY PSEP	GEN-S2PS
SULFITE	GEN-SO3
SPECIFIC GRAVITY	GEN-SPGRAV
SUBSAMPLING AND COMPOSITING OF SAMPLES	GEN-SUBS

Technical SOP - Kelso (CONT.)

SOLIDS, TOTAL DISSOLVED (TDS)	GEN-TDS
THIOCYANATE	GEN-THIOCN
NITROGEN, TOTAL AND SOLUBLE KJELDAHL	GEN-TKN
TOTAL ORGANIC CARBON IN WATER	GEN-TOC
SOLIDS, TOTAL SUSPENDED (TSS)	GEN-TSS
TURBIDITY MEASUREMENT	GEN-TURB
ULTIMATE BOD	GEN-UBOD
GLASSWASHING FOR INORGANIC ANALYSES	GEN-WASH
PHARMACEUTICALS, PERSONAL CARE PRODUCTS AND ENDOCRINE DISRUPTING COMPOUNDS IN WATER BY HPLC/TANDEM MASS SPECTROMETRY (HPLC/MS/MS)	LCP-1694
ALDEHYDES BY HPLC	LCP-8315
Quantitative Determination of Carbamate Pesticides by High Performance Liquid Chromatography/Tandam Mass Spectrometry (HPLC/MS/MS)	LCP-8321
NITROAROMATICS AND NITRAMINES BY HIGH PERFORMANCE LIQUID CHROMATOGRAPHY(HPLC)	LCP-8330B
Acrylamide by High Performance Liquid Chromatography/tandem mass spectrometry (HPLC/ms/ms)..	LCP-ACRYL
QUANTITATIVE DETERMINATION OF AFLATOXINS By High Performance Liquid Chromatography/tandem mass spectrometry (HPLC/ms/ms)	LCP-AFLA
Dioctyl sulfosuccinate by High Performance Liquid Chromatography/tandem mass spectrometry (HPLC/ms/ms)..	LCP-DOS
QUANTITATION OF NITROAROMATICS AND NITRAMINES IN WATER, SOIL, AND TISSUE BY LIQUID CHROMATOGRAPHY AND TANDEM MASS SPECTROMETRY (LC-MS/MS)	LCP-LCMS4
NITROGUANIDINE BY HIGH PERFORMANCE LIQUID CHROMATOGRAPHY	LCP-NITG
QUANTITATION OF NITROPHENOLS IN SOILS BY LIQUID CHROMATOGRAPHYAND TANDEM MASS SPECTORMETRY (LC-MS/MS)	LCP-NITRO
ORGANIC ACIDS IN AQUEOUS MATRICES BY HPLC	LCP-OALC
QUANTITATIVE DETERMINATION OF OPTICAL BRIGHTENER 220 By High Performance Liquid Chromatography (HPLC)	LCP-OPBr
PERFLUORINATED COMPOUNDS BY HPLC/MS/MS	LCP-PFC

Technical SOP - Kelso (CONT.)

METHYL MERCURY IN SOIL AND SEDIMENT BY ATOMIC FLUORESCENCE SPECTROMETRY	MET-1630S
METHYL MERCURY IN TISSUE BY ATOMIC FLUORESCENCE SPECTROMETRY	MET-1630T
METHYL MERCURY IN WATER BY ATOMIC FLUORESCENCE SPECTROMETRY	MET-1630W
MERCURY IN WATER BY OXIDATION, PURGE&TRAP, AND COLD VAPOR ATOMIC FLUORES. SPECTROMETRY	MET-1631
DETERMINATION OF ARSENIC SPECIES BY HYDRIDE GENERATION CRYOGENIC TRAPPING GAS CHROMATOGRAPY ATOMIC ABSORPTION SPECTROPOTOMETRY	MET-1632
MERCURY IN WATER	MET-245.1
METALS DIGESTION	MET-3005A
METALS DIGESTION	MET-3010A
METALS DIGESTION	MET-3020A
METALS DIGESTION	MET-3050
CLOSED VESSEL OIL DIGESTION	MET-3051M
DETERMINATION OF METALS & TRACE ELEMENTS BY INDUCTIVELY COUPLED PLASMA-MS (METHOD 6020)	MET-6020
ARSENIC BY BOROHYDRIDE REDUCTION ATOMIC ABSORPTION	MET-7062
METALS DIGESTION	MET-7195
MERCURY IN LIQUID WASTE	MET-7470A
MERCURY IN SOLID OR SEMISOLID WASTE	MET-7471A/B
SELENIUM BY BOROHYDRIDE REDUCTION ATOMIC ABSORPTION	MET-7742
SAMPLE PREPARATION OF AQUEOUS SAMPLES BY "CLEAN" TECHNIQUES	MET-ACT
BIOACCESSIBILITY OF METALS IN SOIL AND SOLID WASTE	MET-BIOACC
METALS DIGESTION	MET-DIG
SAMPLE FILTRATION FOR METALS ANALYSIS	MET-FILT
METALS LABORATORY GLASSWARE CLEANING	MET-GC
DETERMINATION OF TRACE METALS BY GRAPHITE FURNACE ATOMIC ABSORPTION SPECTROMETRY (GFAA)	MET-GFAA
DETERMINATION OF METALS AND TRACE ELEMENTS BY ICP/AES	MET-ICP
DETERMINATION OF METALS & TRACE ELEMENTS BY INDUCTIVELY COUPLED PLASMA-MS (METHOD 200.8)	MET-ICP.MS
MULTIPLE EXTRACTION PROCEDURE	MET-MEP
TRACE METALS IN WATER BY PRECONCENTRATION USING REDUCTIVE PRECIPITATION FOLLOWED BY ICP-MS	MET-RPMS
METALS AND SEMIVOLATILES SPLP EXTRACTION (EPA METHOD 1312)	MET-SPLP
WASTE EXTRACTION TEST (WET) PROCEDURE (STLC) for NONVOLATILE and SEMIVOLATILE PARAMETERS	MET-STLC

Technical SOP - Kelso (CONT.)

METALS AND SEMIVOLATILES TCLP EXTRACTION (EPA METHOD 1311)	MET-TCLP
SAMPLE PREPARATION OF BIOLOGICAL TISSUES FOR METALS ANALYSIS BY GFAA, ICP-OES, AND ICP-MS	MET-TDIG
TISSUE SAMPLE PREPARATION	MET-TISP
GRAVIMETRIC DETERMINATION OF HEAXANE EXTRACTABLE MATERIAL (1664)	PET-1664
ANALYSIS OF WATER AND SOLID SAMPLES FOR ALIPHATIC HYDROCARBONS	PET-ALIPHAT
GASOLINE RANGE ORGANICS BY GAS CHROMATOGRAPHY	PET-GRO
ANALYSIS OF WATER, SOLIDS AND SOLUBLE WASTE SAMPLES FOR SEMI-VOLATILE FUEL HYDROCARBONS	PET-SVF
ANALYSIS OF WATER AND SOLIDS SAMPLES FOR TOTAL PETROLEUM HYDROCARBONS	PET-TPH
ANALYSIS OF SOLID AND AQUEOUS SAMPLES FOR STATE OF WISCONSIN DIESEL RANGE ORGANICS	PHC-WIDRO
BOTTLE ORDER PREPARATION AND SHIPPING	SMO-BORD
FOREIGN SOILS HANDLING TREATMENT	SMO-FSHT
SAMPLE RECEIVING	SMO-GEN
SAMPLE TRACKING AND INTERNAL CHAIN OF CUSTODY	SMO-SCOC
SAMPLE DISPOSAL	SMO-SDIS
CHLORINATED PHENOLICS BY IN-SITU ACETYLATION AND GC/MS	SOC-1653A
GEL PERMEATION CHROMATOGRAPHY	SOC-3640A
ACETAMIDE HERBICIDE DEGRADATES IN DRINKING WATER BY SPE AND HPLC/MS/MS	SOC-535
ORGANOCHLORINE PESTICIDES AND PCBs (METHOD 608)	SOC-608
SEMIVOLATILE ORGANIC COMPOUNDS BY GC/MS	SOC-625
GLYCOLS	SOC-8015M
ORGANOCHLORINE PESTICIDES BY GAS CHROMATOGRAPHY: CAPILLARY COLUMN TECHNIQUE	SOC-8081
PCBS AS AROCLORS	SOC-8082Ar
CONGENER-SPECIFIC DETERMINATION OF PCBS BY GC/ECD	SOC-8082C
DETERMINATION OF NITROGEN OR PHOSPHORUS CONTAINING PESTICIDES	SOC-8141
CHLORINATED HERBICIDES	SOC-8151
CHLORINATED PHENOLS METHOD 8151 MODIFIED	SOC-8151M
SEMIVOLATILE ORGANIC COMPOUNDS BY GC/MS	SOC-8270C
SEMIVOLATILE ORGANIC COMPOUNDS BY GC/MS - METHOD 8270D	SOC-8270D
SEMIVOLATILE ORGANIC COMPOUNDS BY GC/MS - LOW LEVEL PROCEDURE	SOC-8270L
POLYNUCLEAR AROMATIC HYDROCARBONS BY GAS CHROMATOGRAPHY/MASS SPECTROMETRY SIM	SOC-8270P
SEMIVOLATILE ORGANIC COMPOUNDS BY GC/MS SELECTED ION MONITORING	SOC-8270S

Technical SOP - Kelso (CONT.)

POLYNUCLEAR AROMATIC HYDROCARBONS BY HPLC	SOC-8310
NITROAROMATICS AND NITRAMINES BY HIGH PERFORMANCE LIQUID CHROMATOGRAPHY	SOC-8330
NITROGLYCERIN AND PETN BY HIGH PERFORMANCE LIQUID CHROMATOGRAPHY	SOC-8332
RESIN AND FATTY ACIDS BY GC/MS - NCASI METHOD 85.02 MODIFIED	SOC-85.02
METHANOL IN PROCESS LIQUIDS AND STATIONARY SOURCE EMISSIONS	SOC-9403
HAZARDOUS AIR POLLUTANTS (HAPS) IN PULP AND PAPER INDUSTRY CONDENSATES	SOC-9901
HAPS AND OTHER COMPOUNDS IN IMPINGER/CANISTER SAMPLES FROM WOOD PRODUCTS FACILITIES	SOC-9902
BUTYLTINS	SOC-BUTYL
CALIBRATION OF INSTRUMENTS FOR ORGANICS CHROMATOGRAPHIC ANALYSES	SOC-CAL
CONFIRMATION PROCEDURE FOR GC AND HPLC ANALYSES	SOC-CONF
CPSC PHTHALATES BY GC/MS SELECTIVE ION MONITORING	SOC-CPSC
DIMP	SOC-DIMP
TOTAL OLEANOLIC ACID SAPONINS IN WATER BY ACID HYDROLYSIS AND HPLC/MS/MS	SOC-LCMS3
MONOCHLOROACETIC ACID BY GC-ECD	SOC-MCA
NONYLPHENOLS ISOMERS AND NONYLPHENOL ETHOXYLATES	SOC-NONYL
DETERMINATION OF OTTO FUEL II IN WATER	SOC-OTTO
CHLORINATED PESTICIDES BY GC/MS/MS, EPA METHOD 1699 MODIFIED	SOC-PESTMS2
PICRIC ACID AND PICRAMIC ACID BY HPLC	SOC-PICRIC
POLYBROMINATED DIPHENYL ETHERS (PBDEs) AND POLYBROMINATED BIPHENYLS (PBBs) BY GC/MS	SOC-ROHS
SEMI-VOLATILE ORGANICS SCREENING	SOC-SCR

Technical SOP - Kelso (CONT.)

1,2-DIBROMOETHANE, 1,2-DIBROMO-3-CHLOROPROPANE, AND 1,2,3-TCP BY GC	SVD-504
ORGANOCHLORINE PESTICIDES AND PCBS IN DRINKING WATER	SVD-508_1
CHLORINATED HEBICIDES IN DRINKING WATER	SVD-515.4
N-NITROSAMINES BY GC/MS/MS	SVD-521
SEMIVOLATILE ORGANIC COMPOUNDS BY GC/MS (METHOD 525.2)	SVD-525
SELECTED PESTICIDES AND FLAME RETARDANTS IN DRINKING WATER BY GC/MS (EPA METHOD 527)	SVD-527
DETERMINATION OF EXPLOSIVES AND RELATED COMPOUNDS IN DRINKING WATER BY GC/MS	SVD-529
CARBAMATES AND CARBAMOYLOXIMES IN WATER BY POST-COLUMN DERIVITIZATION HPLC	SVD-531 -1
GLYPHOSATE IN DRINKING WATER BY HPLC	SVD-547
ENDOTHALL IN DRINKING WATER BY GC/MS	SVD-548
DIQUAT AND PARAQUAT BY HPLC	SVD-549
HALOACETIC ACIDS IN DRINKING WATER	SVD-552
PURGE AND TRAP FOR AQUEOUS SAMPLES	VOC-5030
PURGE AND TRAP/EXTRACTION FOR VOC IN SOIL AND WASTE SAMPLES , CLOSED SYSTEM	VOC-5035
VOLATILE ORGANIC COMPOUNDS BY GC/MS	VOC-524.2
AROMATIC VOLATILE ORGANICS (BTEX) BY GC - METHOD 602	VOC-602BTEX
VOLATILE ORGANIC COMPOUNDS BY GC/MS	VOC-624
AROMATIC VOLATILE ORGANICS (BTEX) BY GC - METHOD 8021	VOC-8021BTEX
VOLATILE ORGANIC COMPOUNDS BY GC/MS	VOC-8260
VOLATILE ORGANIC COMPOUNDS BY GC/MS SELECTIVE ION MONITORING	VOC-8260S
VOA STORAGE BLANKS	VOC-BLAN
SAMPLE SCREENING FOR VOLATILE ORGANIC COMPOUNDS IN SOIL, WATER AND MISC. MATRICES	VOC-BVOC
ZERO HEADSPACE EXTRACTION (EPA METHOD 1311)	VOC-ZHE

APPENDIX G

List of Laboratory Certifications and Accreditations

Federal and National Programs

- The TNI (The NELAC Institute) National Environmental Laboratory Accreditation Program (NELAP) Accredited Drinking Water, Non-Potable Water, Solid & Hazardous Waste, and Biological Tissue Laboratory
- ANSI-ASQ National Accreditation Board/ACLASS ISO 17025:2005
- DoD- ELAP Environmental Laboratory Accreditation Program
- U.S. EPA Region 8
  Approved Drinking Water Laboratory

State and Local Programs

- State of Alaska, Department of Environmental Conservation
  UST Laboratory, Lab I.D. UST040
- State of Arizona, Department of Health Services
  License No. AZ0339
- State of Arkansas, Department of Environmental Quality
  Certified Environmental Laboratory, Lab I.D. 88-0637
- State of California, Department of Health Services, Environmental Laboratory Accreditation Program
  Certification No. 2286
- State of Florida, Department of Health
  Primary NELAP Accreditation No. E87412
- State of Georgia, Department of Natural Resources
  Certified Drinking Water Laboratory
- State of Hawaii, Department of Health
  Certified Drinking Water Laboratory
- State of Idaho, Department of Health and Welfare
  Certified Drinking Water Laboratory
- State of Indiana, Department of Health
  Certified Drinking Water Laboratory, Lab I.D. C-WA-01
- State of Louisiana, Department of Environmental Quality
  Accredited Environmental Laboratory, Lab I.D. 3016
- State of Louisiana, Department of Health and Hospitals
  Accredited Drinking Water Laboratory, Lab I.D. LA080001
- State of Maine, Department of Human Services
  Certified Environmental Laboratory, Lab I.D. WA0035
- State of Michigan, Department of Environmental Quality
  Certified Drinking Water Laboratory, Lab I.D. 9949

State and Local Programs (continued)

- State of Minnesota, Department of Health
  Certified Environmental Laboratory, Lab I.D. 053-999-368
- State of Montana, Department of Health and Environmental Sciences
  Certified Drinking Water Laboratory, Lab I.D. 0047
- State of Nevada, Division of Environmental Protection
  Certified Drinking Water Laboratory, Lab I.D. WA35
- State of New Jersey, Department of Environmental Protection
  Accredited Environmental Laboratory, Lab I.D. WA005
- State of New Mexico, Environment Department
  Certified Drinking Water Laboratory
- State of North Carolina, Department of Environment and Natural Resources
  Certified Environmental Laboratory, Lab I.D. 605
- State of Oklahoma, Department of Environmental Quality
  General Water Quality/Sludge Testing, Lab I.D. 9801
- State of Oregon, ORELAP Laboratory Accreditation Program
  Accredited Environmental Laboratory, Lab I.D. WA200001
- State of South Carolina, Department of Health and Environmental Control
  Certified Environmental Laboratory, Lab I.D. 61002
- State of Washington, Department of Ecology, Environmental Laboratory Accreditation Program
  Accreditation No. C1203
- State of Wisconsin, Department of Natural Resources
  Accredited Environmental Laboratory, Lab I.D. 998386840

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Solid and Chemical Materials Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
139	EPA 9030/9034	Sulfide	Accredited	7/17/2003	NELAP	FL
215	NWTPH-Dx	Diesel range organics (DRO)	Accredited	10/8/2001	NELAP	FL
217	NWTPH-Gx	Gasoline range organics (GRO)	Accredited	10/8/2001	NELAP	FL
218	NWTPH-HCID	Total Petroleum Hydrocarbons (TPH)	Accredited	10/8/2001	NELAP	FL
1349	CASW SOC-BUTYL, Rev. 8, 7/31/07 / GC-FPD	Dibutyltin	Accredited	12/1/2009	NELAP	FL
1349	CASW SOC-BUTYL, Rev. 8, 7/31/07 / GC-FPD	Monobutyltin	Accredited	12/1/2009	NELAP	FL
1349	CASW SOC-BUTYL, Rev. 8, 7/31/07 / GC-FPD	Tetrabutyltin	Accredited	12/1/2009	NELAP	FL
1349	CASW SOC-BUTYL, Rev. 8, 7/31/07 / GC-FPD	Tributyltin	Accredited	12/1/2009	NELAP	FL
1350	CASW SOC-8151M, Rev. 9, 7/20/09 / GC-ECD	2,3,4,5-Tetrachlorophenol	Accredited	12/1/2009	NELAP	FL
1350	CASW SOC-8151M, Rev. 9, 7/20/09 / GC-ECD	2,3,5,6-Tetrachlorophenol	Accredited	12/1/2009	NELAP	FL
1351	CASW SOC-PESTMS2, Rev. 1, 3/9/09 / GC-MS-MS	2,4'-DDD	Accredited	12/1/2009	NELAP	FL
1351	CASW SOC-PESTMS2, Rev. 1, 3/9/09 / GC-MS-MS	2,4'-DDE	Accredited	12/1/2009	NELAP	FL
1351	CASW SOC-PESTMS2, Rev. 1, 3/9/09 / GC-MS-MS	2,4'-DDT	Accredited	12/1/2009	NELAP	FL
1351	CASW SOC-PESTMS2, Rev. 1, 3/9/09 / GC-MS-MS	Chlorpyrifos	Accredited	12/1/2009	NELAP	FL
1351	CASW SOC-PESTMS2, Rev. 1, 3/9/09 / GC-MS-MS	Isodrin	Accredited	12/1/2009	NELAP	FL
1351	CASW SOC-PESTMS2, Rev. 1, 3/9/09 / GC-MS-MS	Mirex	Accredited	12/1/2009	NELAP	FL
1351	CASW SOC-PESTMS2, Rev. 1, 3/9/09 / GC-MS-MS	Oxychlordane	Accredited	12/1/2009	NELAP	FL
1351	CASW SOC-PESTMS2, Rev. 1, 3/9/09 / GC-MS-MS	trans-Nonachlor	Accredited	12/1/2009	NELAP	FL
1352	CASW LCP-8321, Rev. 0, 7/20/09 / HPLC-MS-MS	3-Hydroxycarbofuran	Accredited	12/1/2009	NELAP	FL
1352	CASW LCP-8321, Rev. 0, 7/20/09 / HPLC-MS-MS	Aldicarb (Temik)	Accredited	12/1/2009	NELAP	FL
1352	CASW LCP-8321, Rev. 0, 7/20/09 / HPLC-MS-MS	Aldicarb sulfone	Accredited	12/1/2009	NELAP	FL
1352	CASW LCP-8321, Rev. 0, 7/20/09 / HPLC-MS-MS	Aldicarb sulfoxide	Accredited	12/1/2009	NELAP	FL
1352	CASW LCP-8321, Rev. 0, 7/20/09 / HPLC-MS-MS	Carbaryl (Sevin)	Accredited	12/1/2009	NELAP	FL
1352	CASW LCP-8321, Rev. 0, 7/20/09 / HPLC-MS-MS	Carbofuran (Furadan)	Accredited	12/1/2009	NELAP	FL
1352	CASW LCP-8321, Rev. 0, 7/20/09 / HPLC-MS-MS	Methiocarb (Mesurol)	Accredited	12/1/2009	NELAP	FL
1352	CASW LCP-8321, Rev. 0, 7/20/09 / HPLC-MS-MS	Methomyl (Lannate)	Accredited	12/1/2009	NELAP	FL
1352	CASW LCP-8321, Rev. 0, 7/20/09 / HPLC-MS-MS	Oxamyl	Accredited	12/1/2009	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Solid and Chemical Materials Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
1352	CASW LCP-8321, Rev. 0, 7/20/09 / HPLC-MS-MS	Propoxur (Baygon)	Accredited	12/1/2009	NELAP	FL
10009800	EPA 160.3	Residue-total	Accredited	10/8/2007	NELAP	FL
10053006	EPA 300.0	Chloride	Accredited	2/17/2006	NELAP	FL
10053006	EPA 300.0	Fluoride	Accredited	2/17/2006	NELAP	FL
10053006	EPA 300.0	Sulfate	Accredited	2/17/2006	NELAP	FL
10055400	EPA 314.0	Perchlorate	Accredited	12/1/2009	NELAP	FL
10063204	EPA 350.1	Ammonia as N	Accredited	10/8/2007	NELAP	FL
10067206	EPA 353.2	Nitrate as N	Accredited	10/8/2007	NELAP	FL
10067206	EPA 353.2	Nitrite as N	Accredited	10/8/2007	NELAP	FL
10067206	EPA 353.2	Total nitrate-nitrite	Accredited	10/8/2007	NELAP	FL
10070607	EPA 365.3	Orthophosphate as P	Accredited	10/8/2007	NELAP	FL
10070607	EPA 365.3	Phosphorus, total	Accredited	10/8/2007	NELAP	FL
10116800	EPA 1020	Ignitability	Accredited	10/8/2001	NELAP	FL
10118000	EPA 1110	Corrosivity toward steel	Accredited	10/8/2001	NELAP	FL
10118806	EPA 1311	Toxicity Characteristic Leaching Procedure	Accredited	10/8/2001	NELAP	FL
10119003	EPA 1312	Synthetic Precipitation Leaching Procedure	Accredited	7/17/2003	NELAP	FL
10122608	EPA 1630	Methyl mercury	Accredited	10/8/2007	NELAP	FL
10122802	EPA 1631	Mercury	Accredited	10/8/2007	NELAP	FL
10127603	EPA 1664A	Oil & Grease	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Aluminum	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Antimony	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Arsenic	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Barium	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Beryllium	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Boron	Accredited	10/8/2007	NELAP	FL
10155201	EPA 6010	Cadmium	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Calcium	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Solid and Chemical Materials Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10155201	EPA 6010	Chromium	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Cobalt	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Copper	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Iron	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Lead	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Magnesium	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Manganese	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Molybdenum	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Nickel	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Potassium	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Selenium	Accredited	7/17/2003	NELAP	FL
10155201	EPA 6010	Silver	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Sodium	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Strontium	Accredited	10/8/2007	NELAP	FL
10155201	EPA 6010	Thallium	Accredited	7/17/2003	NELAP	FL
10155201	EPA 6010	Tin	Accredited	10/8/2007	NELAP	FL
10155201	EPA 6010	Vanadium	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Zinc	Accredited	10/8/2001	NELAP	FL
10156000	EPA 6020	Aluminum	Accredited	10/8/2001	NELAP	FL
10156000	EPA 6020	Antimony	Accredited	10/8/2001	NELAP	FL
10156000	EPA 6020	Arsenic	Accredited	10/8/2001	NELAP	FL
10156000	EPA 6020	Barium	Accredited	10/8/2001	NELAP	FL
10156000	EPA 6020	Beryllium	Accredited	10/8/2001	NELAP	FL
10156000	EPA 6020	Cadmium	Accredited	10/8/2001	NELAP	FL
10156000	EPA 6020	Chromium	Accredited	10/8/2001	NELAP	FL
10156000	EPA 6020	Cobalt	Accredited	10/8/2001	NELAP	FL
10156000	EPA 6020	Copper	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Solid and Chemical Materials Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10156000	EPA 6020	Lead	Accredited	10/8/2001	NELAP	FL
10156000	EPA 6020	Manganese	Accredited	10/8/2001	NELAP	FL
10156000	EPA 6020	Molybdenum	Accredited	10/8/2007	NELAP	FL
10156000	EPA 6020	Nickel	Accredited	10/8/2001	NELAP	FL
10156000	EPA 6020	Selenium	Accredited	10/8/2007	NELAP	FL
10156000	EPA 6020	Silver	Accredited	10/8/2001	NELAP	FL
10156000	EPA 6020	Strontium	Accredited	10/8/2007	NELAP	FL
10156000	EPA 6020	Thallium	Accredited	10/8/2001	NELAP	FL
10156000	EPA 6020	Vanadium	Accredited	10/8/2007	NELAP	FL
10156000	EPA 6020	Zinc	Accredited	10/8/2001	NELAP	FL
10158608	EPA 7060	Arsenic	Accredited	10/8/2001	NELAP	FL
10159407	EPA 7062	Arsenic	Accredited	10/8/2007	NELAP	FL
10162206	EPA 7196	Chromium VI	Accredited	10/8/2001	NELAP	FL
10164600	EPA 7421	Lead	Accredited	10/8/2001	NELAP	FL
10166004	EPA 7471	Mercury	Accredited	10/8/2001	NELAP	FL
10168602	EPA 7740	Selenium	Accredited	10/8/2001	NELAP	FL
10169207	EPA 7742	Selenium	Accredited	7/17/2003	NELAP	FL
10170602	EPA 7841	Thallium	Accredited	10/8/2001	NELAP	FL
10173203	EPA 8015	Diesel range organics (DRO)	Accredited	7/17/2003	NELAP	FL
10173203	EPA 8015	Ethylene glycol	Accredited	10/8/2001	NELAP	FL
10173203	EPA 8015	Gasoline range organics (GRO)	Accredited	7/17/2003	NELAP	FL
10174400	EPA 8021	Benzene	Accredited	10/8/2001	NELAP	FL
10174400	EPA 8021	Ethylbenzene	Accredited	10/8/2001	NELAP	FL
10174400	EPA 8021	Toluene	Accredited	10/8/2001	NELAP	FL
10174400	EPA 8021	Xylene (total)	Accredited	10/8/2001	NELAP	FL
10178402	EPA 8081	4,4'-DDD	Accredited	10/8/2001	NELAP	FL
10178402	EPA 8081	4,4'-DDE	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Solid and Chemical Materials Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10178402	EPA 8081	4,4'-DDT	Accredited	10/8/2001	NELAP	FL
10178402	EPA 8081	Aldrin	Accredited	10/8/2001	NELAP	FL
10178402	EPA 8081	alpha-BHC (alpha-Hexachlorocyclohexane)	Accredited	10/8/2001	NELAP	FL
10178402	EPA 8081	alpha-Chlordane	Accredited	7/17/2003	NELAP	FL
10178402	EPA 8081	beta-BHC (beta-Hexachlorocyclohexane)	Accredited	10/8/2001	NELAP	FL
10178402	EPA 8081	Chlordane (tech.)	Accredited	10/8/2001	NELAP	FL
10178402	EPA 8081	delta-BHC	Accredited	10/8/2001	NELAP	FL
10178402	EPA 8081	Dieldrin	Accredited	10/8/2001	NELAP	FL
10178402	EPA 8081	Endosulfan I	Accredited	10/8/2001	NELAP	FL
10178402	EPA 8081	Endosulfan II	Accredited	10/8/2001	NELAP	FL
10178402	EPA 8081	Endosulfan sulfate	Accredited	10/8/2001	NELAP	FL
10178402	EPA 8081	Endrin	Accredited	10/8/2001	NELAP	FL
10178402	EPA 8081	Endrin aldehyde	Accredited	10/8/2001	NELAP	FL
10178402	EPA 8081	Endrin ketone	Accredited	10/8/2007	NELAP	FL
10178402	EPA 8081	gamma-BHC (Lindane, gamma-Hexachlorocyclohexane)	Accredited	10/8/2001	NELAP	FL
10178402	EPA 8081	gamma-Chlordane	Accredited	7/17/2003	NELAP	FL
10178402	EPA 8081	Heptachlor	Accredited	10/8/2001	NELAP	FL
10178402	EPA 8081	Heptachlor epoxide	Accredited	10/8/2001	NELAP	FL
10178402	EPA 8081	Methoxychlor	Accredited	10/8/2001	NELAP	FL
10178402	EPA 8081	Toxaphene (Chlorinated camphene)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (BZ 206)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	2,2',3,3',4,4',5-Heptachlorobiphenyl (BZ 170)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	2,2',3,4,4',5,5'-Heptachlorobiphenyl (BZ 180)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	2,2',3,4,4',5',6-Heptachlorobiphenyl (BZ 183)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	2,2',3,4,4',5'-Hexachlorobiphenyl (BZ 138)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	2,2',3,4',5,5',6-Heptachlorobiphenyl (BZ 187)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	2,2',3,4,5,5'-Hexachlorobiphenyl (BZ 141)	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Solid and Chemical Materials Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10179007	EPA 8082	2,2',3,4,5'-Pentachlorobiphenyl (BZ 87)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	2,2',3,5,5',6-Hexachlorobiphenyl (BZ 151)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	2,2',3,5'-Tetrachlorobiphenyl (BZ 44)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	2,2',4,4',5,5'-Hexachlorobiphenyl (BZ 153)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	2,2',4,5,5'-Pentachlorobiphenyl (BZ 101)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	2,2',5,5'-Tetrachlorobiphenyl (BZ 52)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	2,2',5-Trichlorobiphenyl (BZ 18)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	2,3,3',4',6-Pentachlorobiphenyl (BZ 110)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	2,3',4,4'-Tetrachlorobiphenyl (BZ 66)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	2,3-Dichlorobiphenyl (BZ 5)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	2,4',5-Trichlorobiphenyl (BZ 31)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	2-Chlorobiphenyl (BZ 1)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	Aroclor-1016 (PCB-1016)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	Aroclor-1221 (PCB-1221)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	Aroclor-1232 (PCB-1232)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	Aroclor-1242 (PCB-1242)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	Aroclor-1248 (PCB-1248)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	Aroclor-1254 (PCB-1254)	Accredited	10/8/2001	NELAP	FL
10179007	EPA 8082	Aroclor-1260 (PCB-1260)	Accredited	10/8/2001	NELAP	FL
10181803	EPA 8141	Azinphos-methyl (Guthion)	Accredited	10/8/2001	NELAP	FL
10181803	EPA 8141	Bolstar (Sulprofos)	Accredited	10/8/2001	NELAP	FL
10181803	EPA 8141	Chlorpyrifos	Accredited	10/8/2001	NELAP	FL
10181803	EPA 8141	Coumaphos	Accredited	10/8/2001	NELAP	FL
10181803	EPA 8141	Demeton-o	Accredited	10/8/2001	NELAP	FL
10181803	EPA 8141	Demeton-s	Accredited	7/17/2003	NELAP	FL
10181803	EPA 8141	Diazinon	Accredited	10/8/2001	NELAP	FL
10181803	EPA 8141	Dichlorovos (DDVP, Dichlorvos)	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Solid and Chemical Materials Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10181803	EPA 8141	Dimethoate	Accredited	7/17/2003	NELAP	FL
10181803	EPA 8141	Disulfoton	Accredited	10/8/2001	NELAP	FL
10181803	EPA 8141	EPN	Accredited	7/17/2003	NELAP	FL
10181803	EPA 8141	Ethoprop	Accredited	10/8/2001	NELAP	FL
10181803	EPA 8141	Fensulfothion	Accredited	10/8/2001	NELAP	FL
10181803	EPA 8141	Fenthion	Accredited	10/8/2001	NELAP	FL
10181803	EPA 8141	Malathion	Accredited	10/8/2001	NELAP	FL
10181803	EPA 8141	Merphos	Accredited	10/8/2001	NELAP	FL
10181803	EPA 8141	Methyl parathion (Parathion, methyl)	Accredited	10/8/2001	NELAP	FL
10181803	EPA 8141	Mevinphos	Accredited	10/8/2001	NELAP	FL
10181803	EPA 8141	Parathion, ethyl	Accredited	10/8/2001	NELAP	FL
10181803	EPA 8141	Phorate	Accredited	10/8/2001	NELAP	FL
10181803	EPA 8141	Ronnel	Accredited	10/8/2001	NELAP	FL
10181803	EPA 8141	Stirofos	Accredited	10/8/2001	NELAP	FL
10181803	EPA 8141	Sulfotepp	Accredited	7/17/2003	NELAP	FL
10181803	EPA 8141	Tokuthion (Prothiophos)	Accredited	10/8/2001	NELAP	FL
10181803	EPA 8141	Trichloronate	Accredited	10/8/2001	NELAP	FL
10183003	EPA 8151	2,4,5-T	Accredited	10/8/2001	NELAP	FL
10183003	EPA 8151	2,4-D	Accredited	10/8/2001	NELAP	FL
10183003	EPA 8151	2,4-DB	Accredited	10/8/2001	NELAP	FL
10183003	EPA 8151	Dalapon	Accredited	10/8/2001	NELAP	FL
10183003	EPA 8151	Dicamba	Accredited	10/8/2001	NELAP	FL
10183003	EPA 8151	Dichloroprop (Dichlorprop)	Accredited	10/8/2001	NELAP	FL
10183003	EPA 8151	Dinoseb (2-sec-butyl-4,6-dinitrophenol, DNBP)	Accredited	10/8/2001	NELAP	FL
10183003	EPA 8151	MCPA	Accredited	10/8/2001	NELAP	FL
10183003	EPA 8151	MCPP	Accredited	10/8/2001	NELAP	FL
10183003	EPA 8151	Silvex (2,4,5-TP)	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Solid and Chemical Materials Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10184404	EPA 8260	1,1,1,2-Tetrachloroethane	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	1,1,1-Trichloroethane	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	1,1,2,2-Tetrachloroethane	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	1,1,2-Trichloroethane	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	1,1-Dichloroethane	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	1,1-Dichloroethylene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	1,1-Dichloropropene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	1,2,3-Trichlorobenzene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	1,2,3-Trichloropropane	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	1,2,4-Trichlorobenzene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	1,2,4-Trimethylbenzene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	1,2-Dibromo-3-chloropropane (DBCP)	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	1,2-Dibromoethane (EDB, Ethylene dibromide)	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	1,2-Dichlorobenzene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	1,2-Dichloroethane	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	1,2-Dichloropropane	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	1,3,5-Trimethylbenzene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	1,3-Dichlorobenzene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	1,3-Dichloropropane	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	1,4-Dichlorobenzene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	1-Chlorohexane	Accredited	7/17/2003	NELAP	FL
10184404	EPA 8260	2,2-Dichloropropane	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	2-Butanone (Methyl ethyl ketone, MEK)	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	2-Chloroethyl vinyl ether	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	2-Chlorotoluene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	2-Hexanone	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	2-Nitropropane	Accredited	7/17/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Solid and Chemical Materials Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10184404	EPA 8260	4-Chlorotoluene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	4-Methyl-2-pentanone (MIBK)	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Acetone	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Acetonitrile	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Acrolein (Propenal)	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Acrylonitrile	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Allyl chloride (3-Chloropropene)	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Benzene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Bromobenzene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Bromochloromethane	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Bromodichloromethane	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Bromoform	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Carbon disulfide	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Carbon tetrachloride	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Chlorobenzene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Chloroethane	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Chloroform	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Chloroprene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	cis-1,2-Dichloroethylene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	cis-1,3-Dichloropropene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	cis-1,4-Dichloro-2-butene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Dibromochloromethane	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Dibromomethane	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Dichlorodifluoromethane	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Diethyl ether	Accredited	7/17/2003	NELAP	FL
10184404	EPA 8260	Ethyl acetate	Accredited	7/17/2003	NELAP	FL
10184404	EPA 8260	Ethyl methacrylate	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Solid and Chemical Materials Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10184404	EPA 8260	Ethylbenzene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Hexachlorobutadiene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Iodomethane (Methyl iodide)	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Isobutyl alcohol (2-Methyl-1-propanol)	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Isopropylbenzene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Methacrylonitrile	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Methyl bromide (Bromomethane)	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Methyl chloride (Chloromethane)	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Methyl methacrylate	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Methyl tert-butyl ether (MTBE)	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Methylene chloride	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Naphthalene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	n-Butylbenzene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	n-Propylbenzene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	p-Dioxane	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	p-Isopropyltoluene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Propionitrile (Ethyl cyanide)	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	sec-Butylbenzene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Styrene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	tert-Butyl alcohol	Accredited	7/17/2003	NELAP	FL
10184404	EPA 8260	tert-Butylbenzene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Tetrachloroethylene (Perchloroethylene)	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Toluene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	trans-1,2-Dichloroethylene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	trans-1,3-Dichloropropylene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	trans-1,4-Dichloro-2-butene	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Trichloroethene (Trichloroethylene)	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Solid and Chemical Materials Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10184404	EPA 8260	Trichlorofluoromethane	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Vinyl acetate	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Vinyl chloride	Accredited	10/8/2001	NELAP	FL
10184404	EPA 8260	Xylene (total)	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	1,2,4,5-Tetrachlorobenzene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	1,2,4-Trichlorobenzene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	1,2-Dichlorobenzene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	1,2-Diphenylhydrazine	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	1,3,5-Trinitrobenzene (1,3,5-TNB)	Accredited	7/17/2003	NELAP	FL
10185203	EPA 8270	1,3-Dichlorobenzene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	1,3-Dinitrobenzene (1,3-DNB)	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	1,4-Dichlorobenzene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	1,4-Naphthoquinone	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	1,4-Phenylenediamine	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	1-Chloronaphthalene	Accredited	7/17/2003	NELAP	FL
10185203	EPA 8270	1-Naphthylamine	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	2,3,4,6-Tetrachlorophenol	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	2,4,5-Trichlorophenol	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	2,4,6-Trichlorophenol	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	2,4-Dichlorophenol	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	2,4-Dimethylphenol	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	2,4-Dinitrophenol	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	2,4-Dinitrotoluene (2,4-DNT)	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	2,6-Dichlorophenol	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	2,6-Dinitrotoluene (2,6-DNT)	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	2-Acetylaminofluorene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	2-Chloronaphthalene	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Solid and Chemical Materials Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10185203	EPA 8270	2-Chlorophenol	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	2-Methyl-4,6-dinitrophenol	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	2-Methylnaphthalene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	2-Methylphenol (o-Cresol)	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	2-Naphthylamine	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	2-Nitroaniline	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	2-Nitrophenol	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	2-Picoline (2-Methylpyridine)	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	3,3'-Dichlorobenzidine	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	3,3'-Dimethylbenzidine	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	3-Methylcholanthrene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	3-Methylphenol (m-Cresol)	Accredited	7/17/2003	NELAP	FL
10185203	EPA 8270	3-Nitroaniline	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	4-Aminobiphenyl	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	4-Bromophenyl phenyl ether	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	4-Chloro-3-methylphenol	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	4-Chloroaniline	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	4-Chlorophenyl phenylether	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	4-Dimethyl aminoazobenzene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	4-Methylphenol (p-Cresol)	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	4-Nitroaniline	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	4-Nitrophenol	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	5-Nitro-o-toluidine	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	7,12-Dimethylbenz(a) anthracene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	a-a-Dimethylphenethylamine	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Acenaphthene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Acenaphthylene	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Solid and Chemical Materials Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10185203	EPA 8270	Acetophenone	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Aniline	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Anthracene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Aramite	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Benzo(a)anthracene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Benzo(a)pyrene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Benzo(b)fluoranthene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Benzo(g,h,i)perylene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Benzo(k)fluoranthene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Benzoic acid	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Benzyl alcohol	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	bis(2-Chloroethoxy)methane	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	bis(2-Chloroethyl) ether	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	bis(2-Chloroisopropyl) ether (2,2'-Oxybis(1-chloropropane))	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	bis(2-Ethylhexyl) phthalate (DEHP)	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Butyl benzyl phthalate	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Carbazole	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Chlorobenzilate	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Chrysene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Diallate	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Dibenz(a,h)anthracene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Dibenzofuran	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Diethyl phthalate	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Dimethoate	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Dimethyl phthalate	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Di-n-butyl phthalate	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Di-n-octyl phthalate	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Solid and Chemical Materials Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10185203	EPA 8270	Dinoseb (2-sec-butyl-4,6-dinitrophenol, DNBP)	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Disulfoton	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Ethyl methanesulfonate	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Famphur	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Fluoranthene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Fluorene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Hexachlorobenzene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Hexachlorobutadiene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Hexachlorocyclopentadiene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Hexachloroethane	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Hexachlorophene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Hexachloropropene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Indeno(1,2,3-cd)pyrene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Isodrin	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Isophorone	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Isosafrole	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Kepone	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Methapyrilene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Methyl methanesulfonate	Accredited	7/17/2003	NELAP	FL
10185203	EPA 8270	Methyl parathion (Parathion, methyl)	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Naphthalene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Nitrobenzene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Nitroquinoline-1-oxide	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	n-Nitrosodiethylamine	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	n-Nitrosodimethylamine	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	n-Nitroso-di-n-butylamine	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	n-Nitrosodi-n-propylamine	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Solid and Chemical Materials Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10185203	EPA 8270	n-Nitrosodiphenylamine	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	n-Nitrosomethylethylamine	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	n-Nitrosomorpholine	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	n-Nitrosopiperidine	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	n-Nitrosopyrrolidine	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	o,o,o-Triethyl phosphorothioate	Accredited	7/17/2003	NELAP	FL
10185203	EPA 8270	o-Toluidine	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Parathion, ethyl	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Pentachlorobenzene	Accredited	7/17/2003	NELAP	FL
10185203	EPA 8270	Pentachloronitrobenzene (Quintozene)	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Pentachlorophenol	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Phenacetin	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Phenanthrene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Phenol	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Phorate	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Pronamide (Kerb)	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Pyrene	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Pyridine	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Safrole	Accredited	10/8/2001	NELAP	FL
10185203	EPA 8270	Thionazin (Zinophos)	Accredited	10/8/2001	NELAP	FL
10187607	EPA 8310	Acenaphthene	Accredited	10/8/2001	NELAP	FL
10187607	EPA 8310	Acenaphthylene	Accredited	10/8/2001	NELAP	FL
10187607	EPA 8310	Anthracene	Accredited	10/8/2001	NELAP	FL
10187607	EPA 8310	Benzo(a)anthracene	Accredited	10/8/2001	NELAP	FL
10187607	EPA 8310	Benzo(a)pyrene	Accredited	10/8/2001	NELAP	FL
10187607	EPA 8310	Benzo(b)fluoranthene	Accredited	10/8/2001	NELAP	FL
10187607	EPA 8310	Benzo(g,h,i)perylene	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Solid and Chemical Materials Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10187607	EPA 8310	Benzo(k)fluoranthene	Accredited	10/8/2001	NELAP	FL
10187607	EPA 8310	Chrysene	Accredited	10/8/2001	NELAP	FL
10187607	EPA 8310	Dibenz(a,h)anthracene	Accredited	10/8/2001	NELAP	FL
10187607	EPA 8310	Fluoranthene	Accredited	10/8/2001	NELAP	FL
10187607	EPA 8310	Fluorene	Accredited	10/8/2001	NELAP	FL
10187607	EPA 8310	Indeno(1,2,3-cd)pyrene	Accredited	10/8/2001	NELAP	FL
10187607	EPA 8310	Naphthalene	Accredited	10/8/2001	NELAP	FL
10187607	EPA 8310	Phenanthrene	Accredited	10/8/2001	NELAP	FL
10187607	EPA 8310	Pyrene	Accredited	10/8/2001	NELAP	FL
10187801	EPA 8315	Formaldehyde	Accredited	10/8/2001	NELAP	FL
10189807	EPA 8330	1,3,5-Trinitrobenzene (1,3,5-TNB)	Accredited	10/8/2001	NELAP	FL
10189807	EPA 8330	1,3-Dinitrobenzene (1,3-DNB)	Accredited	10/8/2001	NELAP	FL
10189807	EPA 8330	2,4,6-Trinitrotoluene (2,4,6-TNT)	Accredited	10/8/2001	NELAP	FL
10189807	EPA 8330	2,4-Dinitrotoluene (2,4-DNT)	Accredited	10/8/2001	NELAP	FL
10189807	EPA 8330	2,6-Dinitrotoluene (2,6-DNT)	Accredited	10/8/2001	NELAP	FL
10189807	EPA 8330	2-Amino-4,6-dinitrotoluene (2-am-dnt)	Accredited	10/8/2001	NELAP	FL
10189807	EPA 8330	2-Nitrotoluene	Accredited	10/8/2001	NELAP	FL
10189807	EPA 8330	3,5-Dinitroaniline	Accredited	12/1/2009	NELAP	FL
10189807	EPA 8330	3-Nitrotoluene	Accredited	10/8/2001	NELAP	FL
10189807	EPA 8330	4-Amino-2,6-dinitrotoluene (4-am-dnt)	Accredited	10/8/2001	NELAP	FL
10189807	EPA 8330	4-Nitrotoluene	Accredited	10/8/2001	NELAP	FL
10189807	EPA 8330	Nitrobenzene	Accredited	10/8/2001	NELAP	FL
10189807	EPA 8330	Nitroglycerin	Accredited	12/1/2009	NELAP	FL
10189807	EPA 8330	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	Accredited	10/8/2001	NELAP	FL
10189807	EPA 8330	Pentaerythritoltetranitrate (PETN)	Accredited	12/1/2009	NELAP	FL
10189807	EPA 8330	RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine)	Accredited	10/8/2001	NELAP	FL
10189807	EPA 8330	Tetryl (methyl-2,4,6-trinitrophenylnitramine)	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Solid and Chemical Materials Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10193201	EPA 9012	Total cyanide	Accredited	12/23/2005	NELAP	FL
10194000	EPA 9020	Total organic halides (TOX)	Accredited	10/8/2001	NELAP	FL
10196802	EPA 9040	pH	Accredited	10/8/2001	NELAP	FL
10197805	EPA 9045	pH	Accredited	7/17/2003	NELAP	FL
10199005	EPA 9056	Chloride	Accredited	7/17/2003	NELAP	FL
10199005	EPA 9056	Fluoride	Accredited	7/17/2003	NELAP	FL
10199005	EPA 9056	Nitrate	Accredited	7/17/2003	NELAP	FL
10199005	EPA 9056	Nitrite	Accredited	7/17/2003	NELAP	FL
10199005	EPA 9056	Sulfate	Accredited	7/17/2003	NELAP	FL
10200201	EPA 9060	Total organic carbon	Accredited	10/8/2001	NELAP	FL
10201204	EPA 9071	Oil & Grease	Accredited	10/8/2001	NELAP	FL

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
144	NCASI 99.01	Methanol	Accredited	10/8/2001	NELAP	FL
168	ENTEROLERT	Enterococci	Accredited	12/1/2009	NELAP	FL
215	NWTPH-Dx	Diesel range organics (DRO)	Accredited	7/1/2003	NELAP	FL
217	NWTPH-Gx	Gasoline range organics (GRO)	Accredited	7/1/2003	NELAP	FL
218	NWTPH-HCID	Total Petroleum Hydrocarbons (TPH)	Accredited	7/1/2003	NELAP	FL
657	NCASI DI/MEOH-94.03	Methanol	Accredited	10/8/2001	NELAP	FL
680	SM 4500 Cl- C	Chloride	Accredited	4/11/2007	NELAP	FL
725	SM 9223 B	Escherichia coli	Accredited	10/8/2007	NELAP	FL
725	SM 9223 B	Total coliforms	Accredited	10/8/2007	NELAP	FL
804	SM 4500-S F (20th/21st Ed.)	Sulfide	Accredited	4/11/2007	NELAP	FL
834	SM 9223 B /QUANTI-TRAY	Enterococci	Accredited	10/8/2007	NELAP	FL
834	SM 9223 B /QUANTI-TRAY	Escherichia coli	Accredited	10/8/2007	NELAP	FL
834	SM 9223 B /QUANTI-TRAY	Total coliforms	Accredited	10/8/2007	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
1239	SM 4500-NH3 E (19th, 20th, 21st Ed.)/ISE	Ammonia as N	Accredited	10/8/2007	NELAP	FL
1349	CASW SOC-BUTYL, Rev. 8, 7/31/07 / GC-FPD	Dibutyltin	Accredited	12/1/2009	NELAP	FL
1349	CASW SOC-BUTYL, Rev. 8, 7/31/07 / GC-FPD	Monobutyltin	Accredited	12/1/2009	NELAP	FL
1349	CASW SOC-BUTYL, Rev. 8, 7/31/07 / GC-FPD	Tetrabutyltin	Accredited	12/1/2009	NELAP	FL
1349	CASW SOC-BUTYL, Rev. 8, 7/31/07 / GC-FPD	Tributyltin	Accredited	12/1/2009	NELAP	FL
1350	CASW SOC-8151M, Rev. 9, 7/20/09 / GC-ECD	2,3,4,5-Tetrachlorophenol	Accredited	12/1/2009	NELAP	FL
1350	CASW SOC-8151M, Rev. 9, 7/20/09 / GC-ECD	2,3,5,6-Tetrachlorophenol	Accredited	12/1/2009	NELAP	FL
1351	CASW SOC-PESTMS2, Rev. 1, 3/9/09 / GC-MS-MS	2,4'-DDD	Accredited	12/1/2009	NELAP	FL
1351	CASW SOC-PESTMS2, Rev. 1, 3/9/09 / GC-MS-MS	2,4'-DDE	Accredited	12/1/2009	NELAP	FL
1351	CASW SOC-PESTMS2, Rev. 1, 3/9/09 / GC-MS-MS	2,4'-DDT	Accredited	12/1/2009	NELAP	FL
1351	CASW SOC-PESTMS2, Rev. 1, 3/9/09 / GC-MS-MS	Chlorpyrifos	Accredited	12/1/2009	NELAP	FL
1351	CASW SOC-PESTMS2, Rev. 1, 3/9/09 / GC-MS-MS	Isodrin	Accredited	12/1/2009	NELAP	FL
1351	CASW SOC-PESTMS2, Rev. 1, 3/9/09 / GC-MS-MS	Mirex	Accredited	12/1/2009	NELAP	FL
1351	CASW SOC-PESTMS2, Rev. 1, 3/9/09 / GC-MS-MS	Oxychlordane	Accredited	12/1/2009	NELAP	FL
1351	CASW SOC-PESTMS2, Rev. 1, 3/9/09 / GC-MS-MS	trans-Nonachlor	Accredited	12/1/2009	NELAP	FL
10005400	EPA 110.2	Color	Accredited	10/8/2001	NELAP	FL
10006209	EPA 120.1	Conductivity	Accredited	10/8/2001	NELAP	FL
10007008	EPA 130.2	Hardness	Accredited	10/8/2001	NELAP	FL
10008205	EPA 150.1	pH	Accredited	10/8/2001	NELAP	FL
10009004	EPA 160.1	Residue-filterable (TDS)	Accredited	10/8/2001	NELAP	FL
10009402	EPA 160.2	Residue-nonfilterable (TSS)	Accredited	10/8/2001	NELAP	FL
10009800	EPA 160.3	Residue-total	Accredited	10/8/2001	NELAP	FL
10010205	EPA 160.4	Residue-volatile	Accredited	10/8/2001	NELAP	FL
10010603	EPA 160.5	Residue-settleable	Accredited	10/8/2001	NELAP	FL
10011402	EPA 180.1	Turbidity	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Aluminum	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Antimony	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10013408	EPA 200.7	Arsenic	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Barium	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Beryllium	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Boron	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Cadmium	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Calcium	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Chromium	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Cobalt	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Copper	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Hardness (calc.)	Accredited	10/8/2007	NELAP	FL
10013408	EPA 200.7	Iron	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Lead	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Magnesium	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Manganese	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Molybdenum	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Nickel	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Potassium	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Selenium	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Silica as SiO2	Accredited	10/8/2007	NELAP	FL
10013408	EPA 200.7	Silver	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Sodium	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Strontium	Accredited	10/8/2007	NELAP	FL
10013408	EPA 200.7	Thallium	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Tin	Accredited	7/17/2003	NELAP	FL
10013408	EPA 200.7	Titanium	Accredited	7/17/2003	NELAP	FL
10013408	EPA 200.7	Total hardness as CaCO3	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Vanadium	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10013408	EPA 200.7	Zinc	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Aluminum	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Antimony	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Arsenic	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Barium	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Beryllium	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Cadmium	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Chromium	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Cobalt	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Copper	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Lead	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Manganese	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Molybdenum	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Nickel	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Selenium	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Silver	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Thallium	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Uranium	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Vanadium	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Zinc	Accredited	10/8/2001	NELAP	FL
10015006	EPA 200.9	Arsenic	Accredited	10/8/2001	NELAP	FL
10015006	EPA 200.9	Lead	Accredited	10/8/2001	NELAP	FL
10015006	EPA 200.9	Selenium	Accredited	10/8/2001	NELAP	FL
10015006	EPA 200.9	Thallium	Accredited	10/8/2001	NELAP	FL
10036201	EPA 245.1	Mercury	Accredited	10/8/2001	NELAP	FL
10053006	EPA 300.0	Bromide	Accredited	10/8/2001	NELAP	FL
10053006	EPA 300.0	Chloride	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10053006	EPA 300.0	Fluoride	Accredited	10/8/2001	NELAP	FL
10053006	EPA 300.0	Nitrate as N	Accredited	10/8/2001	NELAP	FL
10053006	EPA 300.0	Nitrite as N	Accredited	10/8/2001	NELAP	FL
10053006	EPA 300.0	Sulfate	Accredited	10/8/2001	NELAP	FL
10054601	EPA 310.1	Alkalinity as CaCO3	Accredited	10/8/2001	NELAP	FL
10055400	EPA 314.0	Perchlorate	Accredited	12/1/2009	NELAP	FL
10057406	EPA 325.3	Chloride	Accredited	10/8/2001	NELAP	FL
10059004	EPA 330.4	Residual free chlorine	Accredited	10/8/2001	NELAP	FL
10059800	EPA 335.1	Amenable cyanide	Accredited	10/8/2001	NELAP	FL
10061208	EPA 335.4	Total cyanide	Accredited	7/17/2003	NELAP	FL
10062007	EPA 340.2	Fluoride	Accredited	10/8/2001	NELAP	FL
10063204	EPA 350.1	Ammonia as N	Accredited	10/8/2001	NELAP	FL
10064207	EPA 350.3	Ammonia as N	Accredited	10/8/2001	NELAP	FL
10066009	EPA 351.4	Kjeldahl nitrogen - total	Accredited	10/8/2001	NELAP	FL
10067206	EPA 353.2	Nitrate as N	Accredited	7/17/2003	NELAP	FL
10067206	EPA 353.2	Nitrate-nitrite	Accredited	10/8/2001	NELAP	FL
10067206	EPA 353.2	Nitrite as N	Accredited	7/17/2003	NELAP	FL
10070607	EPA 365.3	Orthophosphate as P	Accredited	10/8/2001	NELAP	FL
10070607	EPA 365.3	Phosphorus, total	Accredited	10/8/2001	NELAP	FL
10074007	EPA 376.1	Sulfide	Accredited	10/8/2001	NELAP	FL
10075408	EPA 405.1	Biochemical oxygen demand	Accredited	10/8/2001	NELAP	FL
10075806	EPA 410.1	Chemical oxygen demand	Accredited	10/8/2001	NELAP	FL
10078203	EPA 415.1	Total organic carbon	Accredited	10/8/2001	NELAP	FL
10079206	EPA 420.1	Total phenolics	Accredited	10/8/2001	NELAP	FL
10103603	EPA 608	4,4'-DDD	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	4,4'-DDE	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	4,4'-DDT	Accredited	7/17/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10103603	EPA 608	Aldrin	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	alpha-BHC (alpha-Hexachlorocyclohexane)	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	Aroclor-1016 (PCB-1016)	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	Aroclor-1221 (PCB-1221)	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	Aroclor-1232 (PCB-1232)	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	Aroclor-1242 (PCB-1242)	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	Aroclor-1248 (PCB-1248)	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	Aroclor-1254 (PCB-1254)	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	Aroclor-1260 (PCB-1260)	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	beta-BHC (beta-Hexachlorocyclohexane)	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	Chlordane (tech.)	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	delta-BHC	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	Dieldrin	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	Endosulfan I	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	Endosulfan II	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	Endosulfan sulfate	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	Endrin	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	Endrin aldehyde	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	gamma-BHC (Lindane, gamma-Hexachlorocyclohexane)	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	Heptachlor	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	Heptachlor epoxide	Accredited	7/17/2003	NELAP	FL
10103603	EPA 608	Toxaphene (Chlorinated camphene)	Accredited	7/17/2003	NELAP	FL
10107207	EPA 624	1,1,1-Trichloroethane	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	1,1,2,2-Tetrachloroethane	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	1,1,2-Trichloroethane	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	1,1-Dichloroethane	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	1,1-Dichloroethylene	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10107207	EPA 624	1,2-Dichlorobenzene	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	1,2-Dichloroethane	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	1,2-Dichloropropane	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	1,3-Dichlorobenzene	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	1,4-Dichlorobenzene	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	2-Chloroethyl vinyl ether	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	Acrolein (Propenal)	Accredited	7/17/2003	NELAP	FL
10107207	EPA 624	Acrylonitrile	Accredited	7/17/2003	NELAP	FL
10107207	EPA 624	Benzene	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	Bromodichloromethane	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	Bromoform	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	Carbon tetrachloride	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	Chlorobenzene	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	Chloroethane	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	Chloroform	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	cis-1,3-Dichloropropene	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	Dibromochloromethane	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	Ethylbenzene	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	Methyl bromide (Bromomethane)	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	Methyl chloride (Chloromethane)	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	Methylene chloride	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	Tetrachloroethylene (Perchloroethylene)	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	Toluene	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	trans-1,2-Dichloroethylene	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	trans-1,3-Dichloropropylene	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	Trichloroethene (Trichloroethylene)	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	Trichlorofluoromethane	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10107207	EPA 624	Vinyl chloride	Accredited	10/8/2001	NELAP	FL
10107207	EPA 624	Xylene (total)	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	1,2,4-Trichlorobenzene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	1,2-Dichlorobenzene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	1,3-Dichlorobenzene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	1,4-Dichlorobenzene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	2,4,6-Trichlorophenol	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	2,4-Dichlorophenol	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	2,4-Dimethylphenol	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	2,4-Dinitrophenol	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	2,4-Dinitrotoluene (2,4-DNT)	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	2,6-Dinitrotoluene (2,6-DNT)	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	2-Chloronaphthalene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	2-Chlorophenol	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	2-Methyl-4,6-dinitrophenol	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	2-Nitrophenol	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	3,3'-Dichlorobenzidine	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	4-Bromophenyl phenyl ether	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	4-Chloro-3-methylphenol	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	4-Chlorophenyl phenylether	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	4-Nitrophenol	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Acenaphthene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Acenaphthylene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Anthracene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Benzidine	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Benzo(a)anthracene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Benzo(a)pyrene	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10107401	EPA 625	Benzo(b)fluoranthene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Benzo(g,h,i)perylene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Benzo(k)fluoranthene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	bis(2-Chloroethoxy)methane	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	bis(2-Chloroethyl) ether	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	bis(2-Chloroisopropyl) ether (2,2'-Oxybis(1-chloropropane))	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	bis(2-Ethylhexyl) phthalate (DEHP)	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Butyl benzyl phthalate	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Chrysene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Dibenz(a,h)anthracene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Diethyl phthalate	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Dimethyl phthalate	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Di-n-butyl phthalate	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Di-n-octyl phthalate	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Fluoranthene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Fluorene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Hexachlorobenzene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Hexachlorobutadiene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Hexachlorocyclopentadiene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Hexachloroethane	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Indeno(1,2,3-cd)pyrene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Isophorone	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Naphthalene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Nitrobenzene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	n-Nitrosodimethylamine	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	n-Nitrosodi-n-propylamine	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	n-Nitrosodiphenylamine	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10107401	EPA 625	Pentachlorophenol	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Phenanthrene	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Phenol	Accredited	10/8/2001	NELAP	FL
10107401	EPA 625	Pyrene	Accredited	10/8/2001	NELAP	FL
10116800	EPA 1020	Ignitability	Accredited	7/1/2003	NELAP	FL
10122608	EPA 1630	Methyl mercury	Accredited	10/8/2007	NELAP	FL
10122802	EPA 1631	Mercury	Accredited	10/8/2001	NELAP	FL
10124808	EPA 1650	Adsorbable organic halogens (AOX)	Accredited	10/8/2001	NELAP	FL
10125403	EPA 1653	2,3,4,6-Tetrachlorophenol	Accredited	10/8/2001	NELAP	FL
10125403	EPA 1653	2,4,5-Trichlorophenol	Accredited	10/8/2001	NELAP	FL
10125403	EPA 1653	2,4,6-Trichlorophenol	Accredited	10/8/2001	NELAP	FL
10125403	EPA 1653	3,4,5-Trichlorocatechol	Accredited	10/8/2001	NELAP	FL
10125403	EPA 1653	3,4,5-Trichloroguaiacol	Accredited	10/8/2001	NELAP	FL
10125403	EPA 1653	3,4,6-Trichlorocatechol	Accredited	10/8/2001	NELAP	FL
10125403	EPA 1653	3,4,6-Trichloroguaiacol	Accredited	10/8/2001	NELAP	FL
10125403	EPA 1653	4,5,6-Trichloroguaiacol	Accredited	10/8/2001	NELAP	FL
10125403	EPA 1653	Pentachlorophenol	Accredited	10/8/2001	NELAP	FL
10125403	EPA 1653	Tetrachlorocatechol	Accredited	10/8/2001	NELAP	FL
10125403	EPA 1653	Tetrachloroguaiacol	Accredited	10/8/2001	NELAP	FL
10125403	EPA 1653	Trichlorosyringol	Accredited	10/8/2001	NELAP	FL
10127603	EPA 1664A	Oil & Grease	Accredited	10/8/2001	NELAP	FL
10127603	EPA 1664A	Total Petroleum Hydrocarbons (TPH)	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Aluminum	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Antimony	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Arsenic	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Barium	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Beryllium	Accredited	7/1/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10155201	EPA 6010	Boron	Accredited	10/8/2007	NELAP	FL
10155201	EPA 6010	Cadmium	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Calcium	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Chromium	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Cobalt	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Copper	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Iron	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Lead	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Magnesium	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Manganese	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Molybdenum	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Nickel	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Potassium	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Selenium	Accredited	10/8/2001	NELAP	FL
10155201	EPA 6010	Silver	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Sodium	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Thallium	Accredited	10/8/2007	NELAP	FL
10155201	EPA 6010	Tin	Accredited	10/8/2007	NELAP	FL
10155201	EPA 6010	Titanium	Accredited	10/8/2007	NELAP	FL
10155201	EPA 6010	Vanadium	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Zinc	Accredited	10/8/2001	NELAP	FL
10156000	EPA 6020	Aluminum	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Antimony	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Arsenic	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Barium	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Beryllium	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Cadmium	Accredited	7/1/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10156000	EPA 6020	Chromium	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Cobalt	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Copper	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Lead	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Manganese	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Molybdenum	Accredited	10/8/2007	NELAP	FL
10156000	EPA 6020	Nickel	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Selenium	Accredited	10/8/2007	NELAP	FL
10156000	EPA 6020	Silver	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Thallium	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Vanadium	Accredited	10/8/2007	NELAP	FL
10156000	EPA 6020	Zinc	Accredited	7/1/2003	NELAP	FL
10158608	EPA 7060	Arsenic	Accredited	10/8/2001	NELAP	FL
10159407	EPA 7062	Arsenic	Accredited	10/8/2007	NELAP	FL
10161805	EPA 7191	Chromium	Accredited	10/8/2007	NELAP	FL
10162002	EPA 7195	Chromium VI	Accredited	7/1/2003	NELAP	FL
10162206	EPA 7196	Chromium VI	Accredited	7/1/2003	NELAP	FL
10164600	EPA 7421	Lead	Accredited	10/8/2001	NELAP	FL
10165603	EPA 7470	Mercury	Accredited	10/8/2001	NELAP	FL
10168602	EPA 7740	Selenium	Accredited	10/8/2001	NELAP	FL
10169207	EPA 7742	Selenium	Accredited	7/17/2003	NELAP	FL
10170602	EPA 7841	Thallium	Accredited	7/1/2003	NELAP	FL
10173203	EPA 8015	Diesel range organics (DRO)	Accredited	7/28/2003	NELAP	FL
10173203	EPA 8015	Ethanol	Accredited	7/1/2003	NELAP	FL
10173203	EPA 8015	Ethylene glycol	Accredited	7/1/2003	NELAP	FL
10173203	EPA 8015	Gasoline range organics (GRO)	Accredited	7/17/2003	NELAP	FL
10173203	EPA 8015	Total Petroleum Hydrocarbons (TPH)	Accredited	7/1/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10174400	EPA 8021	Benzene	Accredited	7/1/2003	NELAP	FL
10174400	EPA 8021	Ethylbenzene	Accredited	7/1/2003	NELAP	FL
10174400	EPA 8021	Toluene	Accredited	7/1/2003	NELAP	FL
10174400	EPA 8021	Xylene (total)	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	4,4'-DDD	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	4,4'-DDE	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	4,4'-DDT	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Aldrin	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	alpha-BHC (alpha-Hexachlorocyclohexane)	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	alpha-Chlordane	Accredited	12/23/2005	NELAP	FL
10178402	EPA 8081	beta-BHC (beta-Hexachlorocyclohexane)	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Chlordane (tech.)	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	delta-BHC	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Dieldrin	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Endosulfan I	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Endosulfan II	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Endosulfan sulfate	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Endrin	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Endrin aldehyde	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Endrin ketone	Accredited	10/8/2007	NELAP	FL
10178402	EPA 8081	gamma-BHC (Lindane, gamma-Hexachlorocyclohexane)	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	gamma-Chlordane	Accredited	12/23/2005	NELAP	FL
10178402	EPA 8081	Heptachlor	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Heptachlor epoxide	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Methoxychlor	Accredited	7/17/2003	NELAP	FL
10178402	EPA 8081	Toxaphene (Chlorinated camphene)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (BZ 206)	Accredited	7/1/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10179007	EPA 8082	2,2',3,3',4,4',5-Heptachlorobiphenyl (BZ 170)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',3,4,4',5,5'-Heptachlorobiphenyl (BZ 180)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',3,4,4',5',6-Heptachlorobiphenyl (BZ 183)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',3,4,4',5'-Hexachlorobiphenyl (BZ 138)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',3,4',5,5',6-Heptachlorobiphenyl (BZ 187)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',3,4,5,5'-Hexachlorobiphenyl (BZ 141)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',3,4,5'-Pentachlorobiphenyl (BZ 87)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',3,5,5',6-Hexachlorobiphenyl (BZ 151)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',3,5'-Tetrachlorobiphenyl (BZ 44)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',4,4',5,5'-Hexachlorobiphenyl (BZ 153)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',4,5,5'-Pentachlorobiphenyl (BZ 101)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',5,5'-Tetrachlorobiphenyl (BZ 52)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',5-Trichlorobiphenyl (BZ 18)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,3,3',4',6-Pentachlorobiphenyl (BZ 110)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,3',4,4'-Tetrachlorobiphenyl (BZ 66)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,3-Dichlorobiphenyl (BZ 5)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,4',5-Trichlorobiphenyl (BZ 31)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2-Chlorobiphenyl (BZ 1)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	Aroclor-1016 (PCB-1016)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	Aroclor-1221 (PCB-1221)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	Aroclor-1232 (PCB-1232)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	Aroclor-1242 (PCB-1242)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	Aroclor-1248 (PCB-1248)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	Aroclor-1254 (PCB-1254)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	Aroclor-1260 (PCB-1260)	Accredited	7/1/2003	NELAP	FL
10181803	EPA 8141	Azinphos-methyl (Guthion)	Accredited	7/1/2003	NELAP	FL
10181803	EPA 8141	Bolstar (Sulprofos)	Accredited	7/1/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10181803	EPA 8141	Chlorpyrifos	Accredited	7/1/2003	NELAP	FL
10181803	EPA 8141	Coumaphos	Accredited	7/1/2003	NELAP	FL
10181803	EPA 8141	Demeton-o	Accredited	7/1/2003	NELAP	FL
10181803	EPA 8141	Diazinon	Accredited	7/1/2003	NELAP	FL
10181803	EPA 8141	Dichlorovos (DDVP, Dichlorvos)	Accredited	7/1/2003	NELAP	FL
10181803	EPA 8141	Disulfoton	Accredited	7/1/2003	NELAP	FL
10181803	EPA 8141	Ethoprop	Accredited	7/1/2003	NELAP	FL
10181803	EPA 8141	Fensulfothion	Accredited	7/1/2003	NELAP	FL
10181803	EPA 8141	Fenthion	Accredited	7/1/2003	NELAP	FL
10181803	EPA 8141	Malathion	Accredited	7/1/2003	NELAP	FL
10181803	EPA 8141	Merphos	Accredited	7/1/2003	NELAP	FL
10181803	EPA 8141	Methyl parathion (Parathion, methyl)	Accredited	7/1/2003	NELAP	FL
10181803	EPA 8141	Mevinphos	Accredited	7/1/2003	NELAP	FL
10181803	EPA 8141	Parathion, ethyl	Accredited	7/1/2003	NELAP	FL
10181803	EPA 8141	Phorate	Accredited	7/1/2003	NELAP	FL
10181803	EPA 8141	Ronnel	Accredited	7/1/2003	NELAP	FL
10181803	EPA 8141	Stirofos	Accredited	7/1/2003	NELAP	FL
10181803	EPA 8141	Tokuthion (Prothiophos)	Accredited	7/1/2003	NELAP	FL
10181803	EPA 8141	Trichloronate	Accredited	7/1/2003	NELAP	FL
10183003	EPA 8151	2,4,5-T	Accredited	7/1/2003	NELAP	FL
10183003	EPA 8151	2,4-D	Accredited	7/1/2003	NELAP	FL
10183003	EPA 8151	2,4-DB	Accredited	7/1/2003	NELAP	FL
10183003	EPA 8151	Dalapon	Accredited	7/1/2003	NELAP	FL
10183003	EPA 8151	Dicamba	Accredited	7/1/2003	NELAP	FL
10183003	EPA 8151	Dichloroprop (Dichlorprop)	Accredited	7/1/2003	NELAP	FL
10183003	EPA 8151	Dinoseb (2-sec-butyl-4,6-dinitrophenol, DNBP)	Accredited	7/1/2003	NELAP	FL
10183003	EPA 8151	MCPA	Accredited	7/1/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10183003	EPA 8151	MCPP	Accredited	7/1/2003	NELAP	FL
10183003	EPA 8151	Silvex (2,4,5-TP)	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	1,1,1,2-Tetrachloroethane	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	1,1,1-Trichloroethane	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	1,1,2,2-Tetrachloroethane	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	1,1,2-Trichloroethane	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	1,1-Dichloroethane	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	1,1-Dichloroethylene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	1,1-Dichloropropene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	1,2,3-Trichlorobenzene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	1,2,3-Trichloropropane	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	1,2,4-Trichlorobenzene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	1,2,4-Trimethylbenzene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	1,2-Dibromo-3-chloropropane (DBCP)	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	1,2-Dibromoethane (EDB, Ethylene dibromide)	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	1,2-Dichlorobenzene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	1,2-Dichloroethane	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	1,2-Dichloropropane	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	1,3,5-Trimethylbenzene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	1,3-Dichlorobenzene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	1,3-Dichloropropane	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	1,4-Dichlorobenzene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	1,4-Dioxane (1,4-Diethyleneoxide)	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	2,2-Dichloropropane	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	2-Butanone (Methyl ethyl ketone, MEK)	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	2-Chloroethyl vinyl ether	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	2-Chlorotoluene	Accredited	7/1/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10184404	EPA 8260	2-Hexanone	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	4-Chlorotoluene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	4-Methyl-2-pentanone (MIBK)	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Acetone	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Acetonitrile	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Acrolein (Propenal)	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Acrylonitrile	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Allyl chloride (3-Chloropropene)	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Benzene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Bromobenzene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Bromochloromethane	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Bromodichloromethane	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Bromoform	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Carbon disulfide	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Carbon tetrachloride	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Chlorobenzene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Chloroethane	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Chloroform	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Chloroprene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	cis-1,2-Dichloroethylene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	cis-1,3-Dichloropropene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	cis-1,4-Dichloro-2-butene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Dibromochloromethane	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Dibromomethane	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Dichlorodifluoromethane	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Ethyl methacrylate	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Ethylbenzene	Accredited	7/1/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10184404	EPA 8260	Hexachlorobutadiene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Iodomethane (Methyl iodide)	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Isobutyl alcohol (2-Methyl-1-propanol)	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Isopropylbenzene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Methacrylonitrile	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Methyl bromide (Bromomethane)	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Methyl chloride (Chloromethane)	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Methyl methacrylate	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Methyl tert-butyl ether (MTBE)	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Methylene chloride	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Naphthalene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	n-Butylbenzene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	n-Propylbenzene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	p-Isopropyltoluene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Propionitrile (Ethyl cyanide)	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	sec-Butylbenzene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Styrene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	tert-Butylbenzene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Tetrachloroethylene (Perchloroethylene)	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Toluene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	trans-1,2-Dichloroethylene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	trans-1,3-Dichloropropylene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	trans-1,4-Dichloro-2-butene	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Trichloroethene (Trichloroethylene)	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Trichlorofluoromethane	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Vinyl acetate	Accredited	7/1/2003	NELAP	FL
10184404	EPA 8260	Vinyl chloride	Accredited	7/1/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10184404	EPA 8260	Xylene (total)	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	1,2,4,5-Tetrachlorobenzene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	1,2,4-Trichlorobenzene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	1,2-Dichlorobenzene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	1,2-Diphenylhydrazine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	1,3-Dichlorobenzene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	1,3-Dinitrobenzene (1,3-DNB)	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	1,4-Dichlorobenzene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	1,4-Naphthoquinone	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	1,4-Phenylenediamine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	1-Naphthylamine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2,3,4,6-Tetrachlorophenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2,4,5-Trichlorophenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2,4,6-Trichlorophenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2,4-Dichlorophenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2,4-Dimethylphenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2,4-Dinitrophenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2,4-Dinitrotoluene (2,4-DNT)	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2,6-Dichlorophenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2,6-Dinitrotoluene (2,6-DNT)	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2-Acetylaminofluorene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2-Chloronaphthalene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2-Chlorophenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2-Methyl-4,6-dinitrophenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2-Methylnaphthalene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2-Methylphenol (o-Cresol)	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2-Naphthylamine	Accredited	7/1/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10185203	EPA 8270	2-Nitroaniline	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2-Nitrophenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2-Picoline (2-Methylpyridine)	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	3,3'-Dichlorobenzidine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	3,3'-Dimethylbenzidine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	3-Methylcholanthrene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	3-Nitroaniline	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	4-Aminobiphenyl	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	4-Bromophenyl phenyl ether	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	4-Chloro-3-methylphenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	4-Chloroaniline	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	4-Chlorophenyl phenylether	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	4-Dimethyl aminoazobenzene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	4-Methylphenol (p-Cresol)	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	4-Nitroaniline	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	4-Nitrophenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	5-Nitro-o-toluidine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	7,12-Dimethylbenz(a) anthracene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	a-a-Dimethylphenethylamine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Acenaphthene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Acenaphthylene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Acetophenone	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Aniline	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Anthracene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Aramite	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Benzo(a)anthracene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Benzo(a)pyrene	Accredited	7/1/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10185203	EPA 8270	Benzo(b)fluoranthene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Benzo(g,h,i)perylene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Benzo(k)fluoranthene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Benzoic acid	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Benzyl alcohol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	bis(2-Chloroethoxy)methane	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	bis(2-Chloroethyl) ether	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	bis(2-Chloroisopropyl) ether (2,2'-Oxybis(1-chloropropane))	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	bis(2-Ethylhexyl) phthalate (DEHP)	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Butyl benzyl phthalate	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Carbazole	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Chlorobenzilate	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Chrysene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Diallate	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Dibenz(a,h)anthracene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Dibenzofuran	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Diethyl phthalate	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Dimethoate	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Dimethyl phthalate	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Di-n-butyl phthalate	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Di-n-octyl phthalate	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Dinoseb (2-sec-butyl-4,6-dinitrophenol, DNBP)	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Disulfoton	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Ethyl methanesulfonate	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Famphur	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Fluoranthene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Fluorene	Accredited	7/1/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10185203	EPA 8270	Hexachlorobenzene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Hexachlorobutadiene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Hexachlorocyclopentadiene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Hexachloroethane	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Hexachlorophene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Hexachloropropene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Indeno(1,2,3-cd)pyrene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Isodrin	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Isophorone	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Isosafrole	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Kepone	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Methapyrilene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Methyl parathion (Parathion, methyl)	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Naphthalene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Nitrobenzene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Nitroquinoline-1-oxide	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	n-Nitrosodiethylamine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	n-Nitrosodimethylamine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	n-Nitroso-di-n-butylamine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	n-Nitrosodi-n-propylamine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	n-Nitrosodiphenylamine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	n-Nitrosomethylethylamine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	n-Nitrosomorpholine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	n-Nitrosopiperidine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	n-Nitrosopyrrolidine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	o-Toluidine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Parathion, ethyl	Accredited	7/1/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10185203	EPA 8270	Pentachloronitrobenzene (Quintozene)	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Pentachlorophenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Phenacetin	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Phenanthrene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Phenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Phorate	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Pronamide (Kerb)	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Pyrene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Pyridine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Safrole	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Thionazin (Zinophos)	Accredited	7/1/2003	NELAP	FL
10187607	EPA 8310	Acenaphthene	Accredited	7/1/2003	NELAP	FL
10187607	EPA 8310	Acenaphthylene	Accredited	7/1/2003	NELAP	FL
10187607	EPA 8310	Anthracene	Accredited	7/1/2003	NELAP	FL
10187607	EPA 8310	Benzo(a)anthracene	Accredited	7/1/2003	NELAP	FL
10187607	EPA 8310	Benzo(a)pyrene	Accredited	7/1/2003	NELAP	FL
10187607	EPA 8310	Benzo(b)fluoranthene	Accredited	7/1/2003	NELAP	FL
10187607	EPA 8310	Benzo(g,h,i)perylene	Accredited	7/1/2003	NELAP	FL
10187607	EPA 8310	Benzo(k)fluoranthene	Accredited	7/1/2003	NELAP	FL
10187607	EPA 8310	Chrysene	Accredited	7/1/2003	NELAP	FL
10187607	EPA 8310	Dibenz(a,h)anthracene	Accredited	7/1/2003	NELAP	FL
10187607	EPA 8310	Fluoranthene	Accredited	7/1/2003	NELAP	FL
10187607	EPA 8310	Fluorene	Accredited	7/1/2003	NELAP	FL
10187607	EPA 8310	Indeno(1,2,3-cd)pyrene	Accredited	7/1/2003	NELAP	FL
10187607	EPA 8310	Naphthalene	Accredited	7/1/2003	NELAP	FL
10187607	EPA 8310	Phenanthrene	Accredited	7/1/2003	NELAP	FL
10187607	EPA 8310	Pyrene	Accredited	7/1/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10187801	EPA 8315	Formaldehyde	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	1,3,5-Trinitrobenzene (1,3,5-TNB)	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	1,3-Dinitrobenzene (1,3-DNB)	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	2,4,6-Trinitrotoluene (2,4,6-TNT)	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	2,4-Dinitrotoluene (2,4-DNT)	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	2,6-Dinitrotoluene (2,6-DNT)	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	2-Amino-4,6-dinitrotoluene (2-am-dnt)	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	2-Nitrotoluene	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	3,5-Dinitroaniline	Accredited	12/1/2009	NELAP	FL
10189807	EPA 8330	3-Nitrotoluene	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	4-Amino-2,6-dinitrotoluene (4-am-dnt)	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	4-Nitrotoluene	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	Nitrobenzene	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	Nitroglycerin	Accredited	12/1/2009	NELAP	FL
10189807	EPA 8330	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	Pentaerythritoltetranitrate (PETN)	Accredited	12/1/2009	NELAP	FL
10189807	EPA 8330	RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine)	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	Tetryl (methyl-2,4,6-trinitrophenylnitramine)	Accredited	7/1/2003	NELAP	FL
10193201	EPA 9012	Total cyanide	Accredited	12/23/2005	NELAP	FL
10194000	EPA 9020	Total organic halides (TOX)	Accredited	7/1/2003	NELAP	FL
10196802	EPA 9040	pH	Accredited	7/1/2003	NELAP	FL
10200201	EPA 9060	Total organic carbon	Accredited	7/1/2003	NELAP	FL
20001803	SM 2120 B	Color	Accredited	4/11/2007	NELAP	FL
20002806	SM 2310 B (4A)	Acidity, as CaCO3	Accredited	4/11/2007	NELAP	FL
20003003	SM 2320 B	Alkalinity as CaCO3	Accredited	4/11/2007	NELAP	FL
20003605	SM 2340 C	Hardness	Accredited	4/11/2007	NELAP	FL
20004404	SM 2540 C	Residue-filterable (TDS)	Accredited	4/11/2007	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Non-Potable Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
20004608	SM 2540 B	Residue-total	Accredited	4/11/2007	NELAP	FL
20004802	SM 2540 D	Residue-nonfilterable (TSS)	Accredited	4/11/2007	NELAP	FL
20005009	SM 2540 F	Residue-settleable	Accredited	4/11/2007	NELAP	FL
20012800	SM 4500 F-C	Fluoride	Accredited	4/11/2007	NELAP	FL
20015003	SM 4500-Cl F	Total residual chlorine	Accredited	4/11/2007	NELAP	FL
20016404	SM 4500-H+-B	pH	Accredited	4/11/2007	NELAP	FL
20021607	SM 4500-CN G	Amenable cyanide	Accredited	4/11/2007	NELAP	FL
20023205	SM 4500-NH3 G	Ammonia as N	Accredited	4/11/2007	NELAP	FL
20025405	SM 4500-O G	Oxygen, dissolved	Accredited	4/11/2007	NELAP	FL
20026806	SM 4500-SO3 B	Sulfite-SO3	Accredited	4/11/2007	NELAP	FL
20027401	SM 5210 B	Biochemical oxygen demand	Accredited	4/11/2007	NELAP	FL
20027605	SM 5220 C	Chemical oxygen demand	Accredited	4/11/2007	NELAP	FL
20028200	SM 5310 C	Total organic carbon	Accredited	4/11/2007	NELAP	FL
20029009	SM 5540 C	Surfactants - MBAS	Accredited	4/11/2007	NELAP	FL
20029203	SM 5550 B	Tannin & Lignin	Accredited	10/8/2007	NELAP	FL
20035807	SM 9221 B	Total coliforms	Accredited	10/8/2001	NELAP	FL
20036208	SM 9221 E	Fecal coliforms	Accredited	10/8/2001	NELAP	FL
20037803	SM 9230 B	Fecal streptococci	Accredited	12/1/2009	NELAP	FL
30016605	ASTM D3590-89A	Kjeldahl nitrogen	Accredited	4/11/2007	NELAP	FL

Drinking Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
725	SM 9223 B	Escherichia coli	Accredited	10/8/2001	NELAP	FL
725	SM 9223 B	Total coliforms	Accredited	10/8/2001	NELAP	FL
884	EPA 515.4	2,4,5-T	Accredited	7/17/2003	NELAP	FL
884	EPA 515.4	2,4-D	Accredited	7/17/2003	NELAP	FL
884	EPA 515.4	Acifluorfen	Accredited	7/17/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Drinking Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
884	EPA 515.4	Dalapon	Accredited	7/17/2003	NELAP	FL
884	EPA 515.4	DCPA di acid degradate	Accredited	7/17/2003	NELAP	FL
884	EPA 515.4	DCPA mono acid degradate	Accredited	7/17/2003	NELAP	FL
884	EPA 515.4	Dicamba	Accredited	7/17/2003	NELAP	FL
884	EPA 515.4	Dinoseb (2-sec-butyl-4,6-dinitrophenol, DNBP)	Accredited	7/17/2003	NELAP	FL
884	EPA 515.4	Pentachlorophenol	Accredited	7/17/2003	NELAP	FL
884	EPA 515.4	Picloram	Accredited	7/17/2003	NELAP	FL
884	EPA 515.4	Silvex (2,4,5-TP)	Accredited	7/17/2003	NELAP	FL
10008205	EPA 150.1	pH	Accredited	10/8/2001	NELAP	FL
10011402	EPA 180.1	Turbidity	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Aluminum	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Barium	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Beryllium	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Boron	Accredited	10/8/2007	NELAP	FL
10013408	EPA 200.7	Cadmium	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Calcium	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Chromium	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Copper	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Iron	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Magnesium	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Manganese	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Molybdenum	Accredited	10/8/2007	NELAP	FL
10013408	EPA 200.7	Nickel	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Potassium	Accredited	10/8/2007	NELAP	FL
10013408	EPA 200.7	Silica as SiO2	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Silver	Accredited	10/8/2001	NELAP	FL
10013408	EPA 200.7	Sodium	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Drinking Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10013408	EPA 200.7	Vanadium	Accredited	10/8/2007	NELAP	FL
10013408	EPA 200.7	Zinc	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Aluminum	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Antimony	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Arsenic	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Barium	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Beryllium	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Cadmium	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Chromium	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Copper	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Lead	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Manganese	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Nickel	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Selenium	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Silver	Accredited	10/8/2001	NELAP	FL
10014401	EPA 200.8	Thallium	Accredited	11/18/2004	NELAP	FL
10014401	EPA 200.8	Zinc	Accredited	10/8/2001	NELAP	FL
10015006	EPA 200.9	Antimony	Accredited	10/8/2001	NELAP	FL
10015006	EPA 200.9	Arsenic	Accredited	10/8/2001	NELAP	FL
10015006	EPA 200.9	Copper	Accredited	10/8/2001	NELAP	FL
10015006	EPA 200.9	Lead	Accredited	10/8/2001	NELAP	FL
10015006	EPA 200.9	Selenium	Accredited	10/8/2001	NELAP	FL
10015006	EPA 200.9	Thallium	Accredited	10/8/2001	NELAP	FL
10036201	EPA 245.1	Mercury	Accredited	10/8/2001	NELAP	FL
10053006	EPA 300.0	Chloride	Accredited	10/8/2001	NELAP	FL
10053006	EPA 300.0	Fluoride	Accredited	10/8/2001	NELAP	FL
10053006	EPA 300.0	Nitrate	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Drinking Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10053006	EPA 300.0	Nitrite	Accredited	10/8/2001	NELAP	FL
10053006	EPA 300.0	Sulfate	Accredited	10/8/2001	NELAP	FL
10053006	EPA 300.0	Total nitrate-nitrite	Accredited	10/8/2001	NELAP	FL
10053404	EPA 300.1	Bromate	Accredited	7/17/2003	NELAP	FL
10053404	EPA 300.1	Bromide	Accredited	7/17/2003	NELAP	FL
10053404	EPA 300.1	Chlorate	Accredited	12/23/2005	NELAP	FL
10053404	EPA 300.1	Chlorite	Accredited	7/17/2003	NELAP	FL
10055400	EPA 314.0	Perchlorate	Accredited	7/17/2003	NELAP	FL
10061208	EPA 335.4	Cyanide	Accredited	10/8/2001	NELAP	FL
10067206	EPA 353.2	Nitrate	Accredited	10/8/2001	NELAP	FL
10067206	EPA 353.2	Nitrite	Accredited	10/8/2001	NELAP	FL
10067206	EPA 353.2	Total nitrate-nitrite	Accredited	10/8/2001	NELAP	FL
10082607	EPA 504.1	1,2,3-Trichloropropane	Accredited	7/17/2003	NELAP	FL
10082607	EPA 504.1	1,2-Dibromo-3-chloropropane (DBCP)	Accredited	7/17/2003	NELAP	FL
10082607	EPA 504.1	1,2-Dibromoethane (EDB, Ethylene dibromide)	Accredited	7/17/2003	NELAP	FL
10086007	EPA 508.1	4,4'-DDD	Accredited	7/17/2003	NELAP	FL
10086007	EPA 508.1	4,4'-DDE	Accredited	7/17/2003	NELAP	FL
10086007	EPA 508.1	4,4'-DDT	Accredited	7/17/2003	NELAP	FL
10086007	EPA 508.1	Aldrin	Accredited	7/17/2003	NELAP	FL
10086007	EPA 508.1	Chlordane (tech.)	Accredited	7/17/2003	NELAP	FL
10086007	EPA 508.1	Dieldrin	Accredited	7/17/2003	NELAP	FL
10086007	EPA 508.1	Endrin	Accredited	7/17/2003	NELAP	FL
10086007	EPA 508.1	gamma-BHC (Lindane, gamma-Hexachlorocyclohexane)	Accredited	7/17/2003	NELAP	FL
10086007	EPA 508.1	Heptachlor	Accredited	7/17/2003	NELAP	FL
10086007	EPA 508.1	Heptachlor epoxide	Accredited	7/17/2003	NELAP	FL
10086007	EPA 508.1	Methoxychlor	Accredited	7/17/2003	NELAP	FL
10086007	EPA 508.1	PCBs	Accredited	7/17/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Drinking Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10086007	EPA 508.1	Toxaphene (Chlorinated camphene)	Accredited	7/17/2003	NELAP	FL
10088605	EPA 524.2	1,1,1,2-Tetrachloroethane	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	1,1,1-Trichloroethane	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	1,1,2,2-Tetrachloroethane	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	1,1,2-Trichloroethane	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	1,1-Dichloroethane	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	1,1-Dichloroethylene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	1,1-Dichloropropene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	1,2,3-Trichlorobenzene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	1,2,3-Trichloropropane	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	1,2,4-Trichlorobenzene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	1,2,4-Trimethylbenzene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	1,2-Dichlorobenzene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	1,2-Dichloroethane	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	1,2-Dichloropropane	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	1,3,5-Trimethylbenzene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	1,3-Dichlorobenzene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	1,3-Dichloropropane	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	1,4-Dichlorobenzene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	2,2-Dichloropropane	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	2-Chlorotoluene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	4-Chlorotoluene	Accredited	7/17/2003	NELAP	FL
10088605	EPA 524.2	4-Isopropyltoluene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Benzene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Bromobenzene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Bromochloromethane	Accredited	7/17/2003	NELAP	FL
10088605	EPA 524.2	Bromodichloromethane	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Drinking Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10088605	EPA 524.2	Bromoform	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Carbon tetrachloride	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Chlorobenzene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Chloroethane	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Chloroform	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	cis-1,2-Dichloroethylene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	cis-1,3-Dichloropropene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Dibromochloromethane	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Dibromomethane	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Dichlorodifluoromethane	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Dichloromethane (DCM, Methylene chloride)	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Ethylbenzene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Hexachlorobutadiene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Isopropylbenzene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Methyl bromide (Bromomethane)	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Methyl chloride (Chloromethane)	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Methyl tert-butyl ether (MTBE)	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Naphthalene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	n-Butylbenzene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	n-Propylbenzene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	sec-Butylbenzene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Styrene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	tert-Butylbenzene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Tetrachloroethylene (Perchloroethylene)	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Toluene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Total trihalomethanes	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	trans-1,2-Dichloroethylene	Accredited	10/8/2001	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Drinking Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10088605	EPA 524.2	trans-1,3-Dichloropropylene	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Trichloroethene (Trichloroethylene)	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Trichlorofluoromethane	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Vinyl chloride	Accredited	10/8/2001	NELAP	FL
10088605	EPA 524.2	Xylene (total)	Accredited	10/8/2001	NELAP	FL
10089608	EPA 525.2	2,4-Dinitrotoluene (2,4-DNT)	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	2,6-Dinitrotoluene (2,6-DNT)	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	4,4'-DDD	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	4,4'-DDE	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	4,4'-DDT	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Acetochlor	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Alachlor	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Aldrin	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Atrazine	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Benzo(a)pyrene	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	bis(2-Ethylhexyl) phthalate (DEHP)	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Butachlor	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Butyl benzyl phthalate	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Dacthal (DCPA)	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Di(2-ethylhexyl)adipate	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Dieldrin	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Diethyl phthalate	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Dimethyl phthalate	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Di-n-butyl phthalate	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Di-n-octyl phthalate	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Endrin	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	EPTC (Eptam, s-ethyl-dipropyl thio carbamate)	Accredited	7/17/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Drinking Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10089608	EPA 525.2	gamma-BHC (Lindane, gamma-Hexachlorocyclohexane)	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Heptachlor	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Heptachlor epoxide	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Hexachlorobenzene	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Hexachlorocyclopentadiene	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Isophorone	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Methoxychlor	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Metolachlor	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Metribuzin	Accredited	4/20/2009	NELAP	FL
10089608	EPA 525.2	Molinate	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Propachlor (Ramrod)	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Simazine	Accredited	7/17/2003	NELAP	FL
10089608	EPA 525.2	Terbacil	Accredited	7/17/2003	NELAP	FL
10090809	EPA 531.1	3-Hydroxycarbofuran	Accredited	7/17/2003	NELAP	FL
10090809	EPA 531.1	Aldicarb (Temik)	Accredited	7/17/2003	NELAP	FL
10090809	EPA 531.1	Aldicarb sulfone	Accredited	7/17/2003	NELAP	FL
10090809	EPA 531.1	Aldicarb sulfoxide	Accredited	7/17/2003	NELAP	FL
10090809	EPA 531.1	Carbaryl (Sevin)	Accredited	7/17/2003	NELAP	FL
10090809	EPA 531.1	Carbofuran (Furadan)	Accredited	7/17/2003	NELAP	FL
10090809	EPA 531.1	Methiocarb (Mesurol)	Accredited	12/1/2009	NELAP	FL
10090809	EPA 531.1	Methomyl (Lannate)	Accredited	7/17/2003	NELAP	FL
10090809	EPA 531.1	Oxamyl	Accredited	7/17/2003	NELAP	FL
10091802	EPA 547	Glyphosate	Accredited	7/17/2003	NELAP	FL
10092601	EPA 548.1	Endothall	Accredited	7/17/2003	NELAP	FL
10093206	EPA 549.2	Diquat	Accredited	7/17/2003	NELAP	FL
10093206	EPA 549.2	Paraquat	Accredited	12/23/2005	NELAP	FL
10095600	EPA 552.2	Bromoacetic acid	Accredited	7/17/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Drinking Water Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10095600	EPA 552.2	Bromochloroacetic acid	Accredited	7/17/2003	NELAP	FL
10095600	EPA 552.2	Chloroacetic acid	Accredited	7/17/2003	NELAP	FL
10095600	EPA 552.2	Dibromoacetic acid	Accredited	7/17/2003	NELAP	FL
10095600	EPA 552.2	Dichloroacetic acid	Accredited	7/17/2003	NELAP	FL
10095600	EPA 552.2	Total haloacetic acids (HAA5)	Accredited	7/17/2003	NELAP	FL
10095600	EPA 552.2	Trichloroacetic acid	Accredited	7/17/2003	NELAP	FL
20001803	SM 2120 B	Color	Accredited	7/17/2003	NELAP	FL
20003003	SM 2320 B	Alkalinity as CaCO3	Accredited	10/8/2001	NELAP	FL
20003401	SM 2340 B	Hardness	Accredited	10/8/2007	NELAP	FL
20003809	SM 2510 B	Conductivity	Accredited	10/8/2001	NELAP	FL
20004404	SM 2540 C	Total dissolved solids	Accredited	10/8/2001	NELAP	FL
20012800	SM 4500 F-C	Fluoride	Accredited	10/8/2001	NELAP	FL
20016404	SM 4500-H+-B	pH	Accredited	4/11/2007	NELAP	FL
20025803	SM 4500-P E	Orthophosphate as P	Accredited	12/1/2009	NELAP	FL
20028200	SM 5310 C	Total organic carbon	Accredited	4/11/2007	NELAP	FL
20035205	SM 9215 B	Heterotrophic plate count	Accredited	7/17/2003	NELAP	FL

Biological Tissue Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
1349	CASW SOC-BUTYL, Rev. 8, 7/31/07 / GC-FPD	Dibutyltin	Accredited	12/1/2009	NELAP	FL
1349	CASW SOC-BUTYL, Rev. 8, 7/31/07 / GC-FPD	Monobutyltin	Accredited	12/1/2009	NELAP	FL
1349	CASW SOC-BUTYL, Rev. 8, 7/31/07 / GC-FPD	Tetrabutyltin	Accredited	12/1/2009	NELAP	FL
1349	CASW SOC-BUTYL, Rev. 8, 7/31/07 / GC-FPD	Tributyltin	Accredited	12/1/2009	NELAP	FL
10122802	EPA 1631	Mercury	Accredited	10/8/2007	NELAP	FL
10155201	EPA 6010	Aluminum	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Antimony	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Arsenic	Accredited	7/1/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Biological Tissue Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10155201	EPA 6010	Barium	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Beryllium	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Boron	Accredited	10/8/2007	NELAP	FL
10155201	EPA 6010	Cadmium	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Chromium	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Cobalt	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Copper	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Iron	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Lead	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Manganese	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Molybdenum	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Nickel	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Selenium	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Silver	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Tin	Accredited	10/8/2007	NELAP	FL
10155201	EPA 6010	Vanadium	Accredited	7/1/2003	NELAP	FL
10155201	EPA 6010	Zinc	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Aluminum	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Antimony	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Arsenic	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Barium	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Beryllium	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Cadmium	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Chromium	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Cobalt	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Copper	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Lead	Accredited	7/1/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Biological Tissue Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10156000	EPA 6020	Manganese	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Molybdenum	Accredited	10/8/2007	NELAP	FL
10156000	EPA 6020	Nickel	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Selenium	Accredited	10/8/2007	NELAP	FL
10156000	EPA 6020	Silver	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Thallium	Accredited	7/1/2003	NELAP	FL
10156000	EPA 6020	Vanadium	Accredited	10/8/2007	NELAP	FL
10156000	EPA 6020	Zinc	Accredited	7/1/2003	NELAP	FL
10158608	EPA 7060	Arsenic	Accredited	7/1/2003	NELAP	FL
10161805	EPA 7191	Chromium	Accredited	10/8/2007	NELAP	FL
10162206	EPA 7196	Chromium VI	Accredited	7/1/2003	NELAP	FL
10164600	EPA 7421	Lead	Accredited	7/1/2003	NELAP	FL
10166004	EPA 7471	Mercury	Accredited	7/1/2003	NELAP	FL
10168602	EPA 7740	Selenium	Accredited	7/1/2003	NELAP	FL
10169207	EPA 7742	Selenium	Accredited	7/1/2003	NELAP	FL
10170602	EPA 7841	Thallium	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	4,4'-DDD	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	4,4'-DDE	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	4,4'-DDT	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Aldrin	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	alpha-BHC (alpha-Hexachlorocyclohexane)	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	alpha-Chlordane	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	beta-BHC (beta-Hexachlorocyclohexane)	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Chlordane (tech.)	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	delta-BHC	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Dieldrin	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Endosulfan I	Accredited	7/1/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Biological Tissue Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10178402	EPA 8081	Endosulfan II	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Endosulfan sulfate	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Endrin	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Endrin aldehyde	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Endrin ketone	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	gamma-BHC (Lindane, gamma-Hexachlorocyclohexane)	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	gamma-Chlordane	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Heptachlor	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Heptachlor epoxide	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Methoxychlor	Accredited	7/1/2003	NELAP	FL
10178402	EPA 8081	Toxaphene (Chlorinated camphene)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (BZ 206)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',3,3',4,4',5-Heptachlorobiphenyl (BZ 170)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',3,4,4',5,5'-Heptachlorobiphenyl (BZ 180)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',3,4,4',5',6-Heptachlorobiphenyl (BZ 183)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',3,4,4',5'-Hexachlorobiphenyl (BZ 138)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',3,4',5,5',6-Heptachlorobiphenyl (BZ 187)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',3,4,5,5'-Hexachlorobiphenyl (BZ 141)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',3,4,5'-Pentachlorobiphenyl (BZ 87)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',3,5,5',6-Hexachlorobiphenyl (BZ 151)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',3,5'-Tetrachlorobiphenyl (BZ 44)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',4,4',5,5'-Hexachlorobiphenyl (BZ 153)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',4,5,5'-Pentachlorobiphenyl (BZ 101)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',5,5'-Tetrachlorobiphenyl (BZ 52)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,2',5-Trichlorobiphenyl (BZ 18)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,3,3',4',6-Pentachlorobiphenyl (BZ 110)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,3',4,4'-Tetrachlorobiphenyl (BZ 66)	Accredited	7/1/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Biological Tissue Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10179007	EPA 8082	2,3-Dichlorobiphenyl (BZ 5)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2,4',5-Trichlorobiphenyl (BZ 31)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	2-Chlorobiphenyl (BZ 1)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	Aroclor-1016 (PCB-1016)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	Aroclor-1221 (PCB-1221)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	Aroclor-1232 (PCB-1232)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	Aroclor-1242 (PCB-1242)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	Aroclor-1248 (PCB-1248)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	Aroclor-1254 (PCB-1254)	Accredited	7/1/2003	NELAP	FL
10179007	EPA 8082	Aroclor-1260 (PCB-1260)	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	1,2,4-Trichlorobenzene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	1,2-Dichlorobenzene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	1,2-Diphenylhydrazine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	1,3-Dichlorobenzene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	1,3-Dinitrobenzene (1,3-DNB)	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	1,4-Dichlorobenzene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2,4,5-Trichlorophenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2,4,6-Trichlorophenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2,4-Dichlorophenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2,4-Dimethylphenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2,4-Dinitrophenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2,4-Dinitrotoluene (2,4-DNT)	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2,6-Dinitrotoluene (2,6-DNT)	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2-Chloronaphthalene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2-Chlorophenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2-Methyl-4,6-dinitrophenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2-Methylnaphthalene	Accredited	7/1/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Biological Tissue Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10185203	EPA 8270	2-Methylphenol (o-Cresol)	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2-Nitroaniline	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	2-Nitrophenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	3,3'-Dichlorobenzidine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	3-Nitroaniline	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	4-Bromophenyl phenyl ether	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	4-Chloro-3-methylphenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	4-Chloroaniline	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	4-Chlorophenyl phenylether	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	4-Methylphenol (p-Cresol)	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	4-Nitroaniline	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	4-Nitrophenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Acenaphthene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Acenaphthylene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Aniline	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Anthracene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Benzo(a)anthracene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Benzo(a)pyrene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Benzo(b)fluoranthene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Benzo(g,h,i)perylene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Benzo(k)fluoranthene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Benzoic acid	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Benzyl alcohol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	bis(2-Chloroethoxy)methane	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	bis(2-Chloroethyl) ether	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	bis(2-Chloroisopropyl) ether (2,2'-Oxybis(1-chloropropane))	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	bis(2-Ethylhexyl) phthalate (DEHP)	Accredited	7/1/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Biological Tissue Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10185203	EPA 8270	Butyl benzyl phthalate	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Carbazole	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Chrysene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Dibenz(a,h)anthracene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Dibenzofuran	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Diethyl phthalate	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Dimethyl phthalate	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Di-n-butyl phthalate	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Di-n-octyl phthalate	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Fluoranthene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Fluorene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Hexachlorobenzene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Hexachlorobutadiene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Hexachlorocyclopentadiene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Hexachloroethane	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Indeno(1,2,3-cd)pyrene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Isophorone	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Naphthalene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Nitrobenzene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	n-Nitrosodimethylamine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	n-Nitrosodi-n-propylamine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	n-Nitrosodiphenylamine	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Pentachlorophenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Phenanthrene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Phenol	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Pyrene	Accredited	7/1/2003	NELAP	FL
10185203	EPA 8270	Pyridine	Accredited	7/1/2003	NELAP	FL

Laboratory Scope of Accreditation

Organization

E87412 **(360) 577-7222**
Columbia Analytical Services, Inc. - WA
1317 South 13th Avenue
Kelso, WA 98626

Biological Tissue Certification

Method Code	Method Ref	Analyte	Status	Date Effective	Type	AA
10189807	EPA 8330	1,3,5-Trinitrobenzene (1,3,5-TNB)	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	1,3-Dinitrobenzene (1,3-DNB)	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	2,4,6-Trinitrotoluene (2,4,6-TNT)	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	2,4-Dinitrotoluene (2,4-DNT)	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	2,6-Dinitrotoluene (2,6-DNT)	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	2-Amino-4,6-dinitrotoluene (2-am-dnt)	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	2-Nitrotoluene	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	3,5-Dinitroaniline	Accredited	12/1/2009	NELAP	FL
10189807	EPA 8330	3-Nitrotoluene	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	4-Amino-2,6-dinitrotoluene (4-am-dnt)	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	4-Nitrotoluene	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	Nitrobenzene	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	Nitroglycerin	Accredited	12/1/2009	NELAP	FL
10189807	EPA 8330	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	Pentaerythritoltetranitrate (PETN)	Accredited	12/1/2009	NELAP	FL
10189807	EPA 8330	RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine)	Accredited	7/1/2003	NELAP	FL
10189807	EPA 8330	Tetryl (methyl-2,4,6-trinitrophenylnitramine)	Accredited	7/1/2003	NELAP	FL
10193201	EPA 9012	Total cyanide	Accredited	12/23/2005	NELAP	FL

QUALITY ASSURANCE MANUAL

Columbia Analytical Services, Inc.

19408 Park Row Blvd., Suite 320
Houston, Texas 77084
(713) 266-1599
Effective Date: September 17th, 2010

Approved by:

Laboratory Director: _____ 9/1/10
Name Date

NON-CONTROLLED COPY

Quality Assurance Program Manager: _____ 09/01/10
Name Date

Technical Director: _____ 09/01/10
Name Date

© Columbia Analytical Services, Inc. 2010

DOCUMENT CONTROL

NUMBER: _____

Initials: _____ Date: _____

1.0 TABLE OF CONTENTS

Section	Heading	Page
-	Title Page with Provision Signatures	1
1.0	Table of Contents	2
2.0	Introduction and Company Quality Assurance Policy	4
3.0	Program Description	5
4.0	Professional Conduct, Data Integrity, and Ethics	12
5.0	Organization and Responsibilities	15
6.0	Information Management	18
7.0	Sample Management	20
8.0	Analytical Procedures	27
9.0	Calibration Procedures	30
10.0	Quality Control	33
11.0	Data Processing, Validation, and Reporting	40
12.0	Performance and System Audits	47
13.0	Preventive Maintenance	49
14.0	Corrective and Preventive Action	51
15.0	Quality Assurance Reports and Management Review	53
16.0	Personnel Training	54
17.0	References for Quality Systems, External Documents, Manuals, Standards, and Analytical Procedures	58

NON-CONTROLLED COPY

Tables Page

Table 5-1 Summary of Technical Experience and Qualifications 17
Table 7-1 Sample Preservation and Holding Times 24
Table 11-1 Descriptions of Data Deliverables 46

Figures Page

Figure 3-1 Relationships of Quality Management Systems 6
Figure 3-2 Columbia Analytical/Houston Laboratory Floor Plan 11
Figure 7-1 Chain of Custody Form 25
Figure 7-2 Cooler Receipt and Preservation Check Form 26
Figure 14-1 Corrective Action Report 52
Figure 16-1 Initial Demonstration of Proficiency Requirements 57

NON CONTROLLED COPY

Appendices

Appendix A List of QA Program Documents and Standard Operating Procedures
Appendix B Organizational Chart and Resumes of Key Personnel
Appendix C Major Analytical Equipment
Appendix D Data Qualifiers and Acronyms
Appendix E Preventive Maintenance Procedures
Appendix F Laboratory SOP List
Appendix G Certifications, Accreditations, and Primary NELAP Accredited Methods

2.0 INTRODUCTION AND COMPANY QUALITY ASSURANCE POLICY

Columbia Analytical Services, Inc. (CAS) is an employee-owned professional analytical services laboratory which performs chemical and microbiological analyses on a wide variety of sample matrices, including drinking water, groundwater, surface water, wastewater, soil, sludge, sediment, tissue, industrial and hazardous waste, air, and other material. Columbia Analytical operates a network of laboratory facilites located in Arizona, California, Florida, New York, Texas, and Washington.

We recognize that quality assurance requires a commitment to quality by everyone in the organization - individually, within each operating unit, and throughout the entire laboratory. Laboratory management is committed to ensuring the effectiveness of its quality systems and to ensure that all tests are carried out in accordance to customer requirements. Key elements of this commitment are set forth in the Columbia Analytical Services, Inc. Quality and Ethics Policy Statement, March 2009 (Appendix A) and in this Quality Assurance Manual (QAM). Columbia Analytical Services, Inc. is committed to operate in accordance with these requirements and those of regulatory agencies, accrediting authorities, and certifying organizations.

NON-CONTROLLED COPY

Quality Management Systems are established, implemented and maintained by management. Policies and procedures are established in order to meet requirements of accreditation bodies and applicable programs, such as the Department of Defense (DoD) Environmental Laboratory Accreditation Program, as well as client's quality objectives. Systems are designed so that there will be sufficient Quality Assurance (QA) activities conducted in the laboratory to ensure that all analytical data generated and processed will be scientifically sound, legally defensible, of known and documented quality, and will accurately reflect the material being tested. Quality Systems are applicable to all fields of testing in which the laboratory is involved.

Quality Control (QC) procedures are used to continually assess performance of the laboratory and quality systems. Columbia Analytical maintains control of analytical results by adhering to written standard operating procedures (SOPs), using analytical control parameters with all analyses, and by observing sample custody requirements. All analytical results are calculated and reported in units consistent with project specifications to allow comparability of data.

This QAM is applicable to the facility listed on the title page. The information in this QAM has been organized according to requirements found in the National Environmental Laboratory Accreditation Program (NELAP) Quality Systems Standards (2003 and 2009), the EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5, USEPA, 2001; and *General Requirements for the Competence of Testing and Calibration Laboratories*, ISO/IEC 17025:2005.

3.0 PROGRAM DESCRIPTION

The purpose of the QA program at Columbia Analytical is to ensure that our clients are provided with analytical data that is scientifically sound, legally defensible, and of known and documented quality. The concept of Quality Assurance can be extended, and is expressed in the mission statement of Columbia Analytical:

> "The mission of Columbia Analytical Services, Inc. is to provide high quality, cost-effective, and timely professional testing services to our customers. We recognize that our success as a company is based on our ability to maintain customer satisfaction. To do this requires constant attention to customer needs, maintenance of state-of-the-art testing capabilities and successful management of our most important asset - our people - in a way that encourages professional growth, personal development and company commitment."

3.1 Quality Management Systems

NON-CONTROLLED COPY

In support of this mission, the laboratory has developed a Quality Management System to ensure all products and services meet our client's needs. The system is implemented and maintained by the Quality Assurance Program Manager (QA PM) with corporate oversight by the Chief Quality Officer (CQO). These systems are based upon ISO 17025:2005 standards, upon which fundamental programs (NELAC 2003, 2009 and DoD QSM) are based. Implementation and documentation against these standards are communicated in corporate policy statements, this QAM, and SOPs. Actual procedures, actions and documentation are defined in both administrative and technical SOPs. Figure 3-1 shows the relationships of the quality systems and associated documentation. Quality systems include:

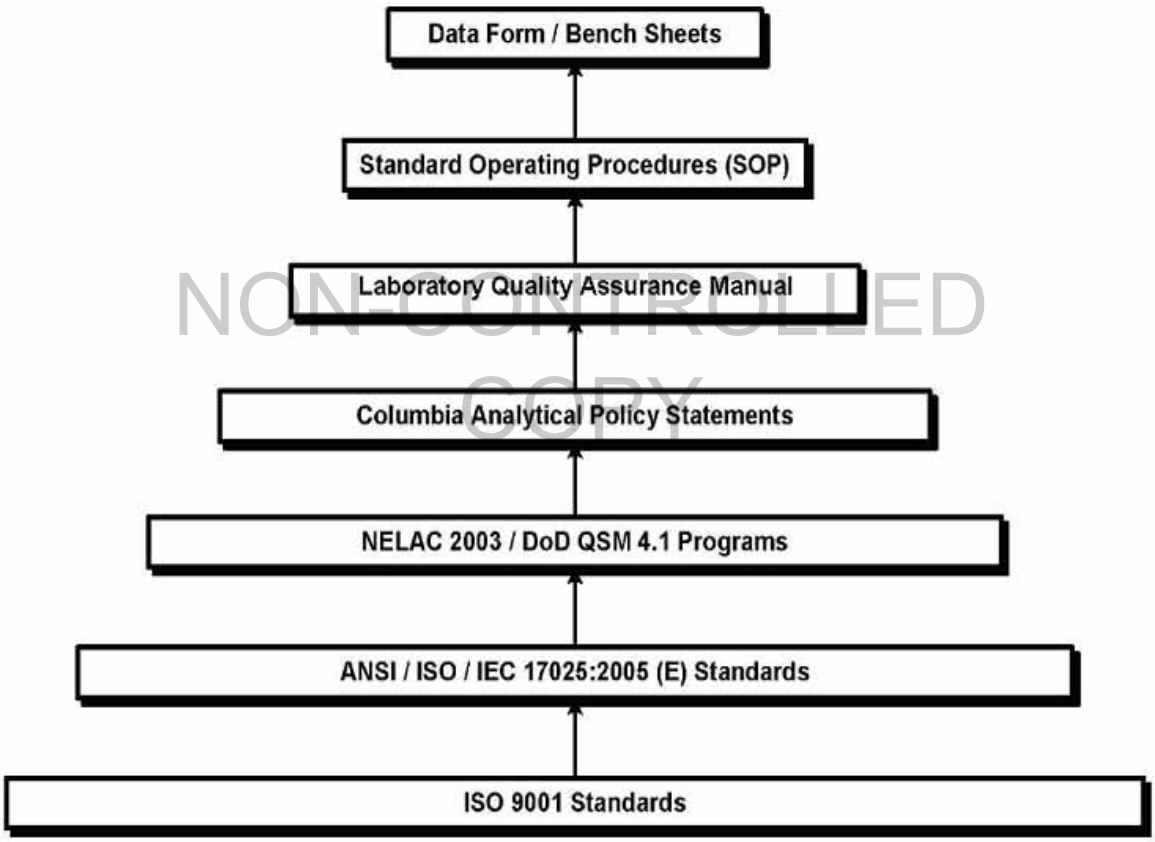
- Standard Operating Procedures
- Sample Management and Chain of Custody procedures
- Statistical Control Charting
- Standards Traceability
- Ethics Training
- Document Control
- Corrective Action Program
- Management Reviews
- Demonstration of Capability

The effectiveness of the quality system is assessed in several ways, including:

- Internal and External Audits covering all aspects of the organization
- Annual Management Reviews
- Analysis of Customer Feedback
- Internal and External Proficiency Testing

Figure 3-1

Relationships of Quality Management Systems and Documentation



NON-CONTROLLED COPY

3.2 Facilities, Equipment, and Security

Columbia Analytical features 12,000 square feet of laboratory and administrative workspace. The laboratory has been designed and constructed to provide safeguards against cross-contamination of samples and is arranged according to work function, which enhances the efficiency of analytical operations. The ventilation system has been specially designed to meet the needs of the analyses performed in each work space. Also, Columbia Analytical minimizes laboratory contamination sources by employing janitorial and maintenance staff to ensure that good housekeeping and facilities maintenance are performed. In addition, the segregated laboratory areas are designed for safe and efficient handling of a variety of sample types. These specialized areas (and access restrictions) include:

- Shipping and Receiving/Purchasing
- Sample Management Office, including controlled-access sample storage areas
- Semi-volatile Organics Sample Preparation Laboratory
- High Resolution Gas Chromatography/High Resolution Mass Spectrometry Laboratory
- Laboratory Management, Client Service, Report Generation and Administration
- Data Archival, Data Review and support functions areas
- Information Technology (IT) and LIMS

In addition, the designated areas for sample receiving, refrigerated sample storage, dedicated sample container preparation and shipping provide for the efficient and safe handling of a variety of sample types. Figure 3-2 shows the facility floor plan. The laboratory is equipped with state-of-the-art analytical and administrative support equipment. The equipment and instrumentation are appropriate for the procedures in use. Appendix C lists the major equipment, illustrating the laboratory's overall capabilities and depth.

NON CONTROLLED COPY

3.3 Technical Elements of the Quality Assurance Program

The laboratory's technical procedures are based upon procedures published by various agencies or organizations (See Section 17). The Quality Assurance Program provides to the laboratory organization, procedures, and policies by which the laboratory operates. The necessary certifications and approvals administered by external agencies are maintained by the QA department. This includes method approvals and audit administration. In addition, internal audits are performed to assess compliance with policies and procedures. SOPs are maintained for technical and administrative functions. A document control system is used for SOPs, as well as laboratory notebooks, and this QA Manual. A list of QA Program documents is provided in Appendix A and SOPs in Apppendix F.

Acceptable calibration procedures are defined in the SOP for each test procedure. Calibration procedures for other laboratory equipment (balances, thermometers, etc.) are also defined. Quality Control (QC) procedures are used to monitor the testing performed. Each analytical procedure has associated QC requirements to be achieved in order to demonstrate data quality. The use of method detection limit studies, control charting, technical training and preventive maintenance procedures further ensure the quality of data produced. Proficiency Testing (PT) samples are used as an external means of monitoring the quality and proficiency of the laboratory.

PT samples are obtained from qualified vendors and are performed on a regular basis. In addition to method proficiency, documentation of analyst training is performed to ensure proficiency and competency of laboratory analysts and technicians. Sample handling and custody procedures are defined in SOPs. Procedures are also in place to monitor the sample storage areas. The technical elements of the QA program are discussed in further detail in later sections of this QA manual.

3.4 Operational Assessments and Service to the Client

The laboratory uses a number of systems to assess its daily operations. In addition to the routine quality control (QC) measurements, the senior laboratory management examines a number of other indicators to assess the overall ability of the laboratory to successfully perform analyses for its clients including; on-time performance, customer complaints, training reports and non-conformity reports. A frequent, routine assessment must also be made of the laboratory's facilities and resources in anticipation of accepting an additional or increased workload.

Columbia Analytical utilizes a number of different methods to ensure that adequate resources are available for service demands. Senior staff meetings, tracking of outstanding proposals and an accurate, current synopsis of incoming work all assist the senior staff in properly allocating sufficient resources. All Requests for Proposal (RFP) documents are reviewed by the Project Manager and appropriate managerial staff to identify any project specific requirements that differ from the standard practices of the laboratory. Any requirements that cannot be met are noted and communicated to the client, as well as requesting the client to provide any project specific Quality Assurance Project Plans (QAPPs) if available. Status/production meetings are also conducted regularly with the laboratory and Project Managers to inform the staff of the status of incoming work, future projects, or project requirements.

NON-CONTROLLED COPY

When a customer requests a modification to an SOP, policy, or standard specification the Project Manager will discuss the proposed deviation with the Laboratory Director and department manager to obtain approval for the deviation. The QA PM may also be involved. All project-specific requirements must be on-file and with the service request upon logging in the samples. The modification or deviation must be documented. A Project-Specific Communication Form, or similar, may be used to document such deviations.

The laboratory shall afford clients cooperation to clarify the client's request and to monitor the laboratory's performance in relation to the work performed, provided that the laboratory ensures confidentiality to other clients. The laboratory maintains and documents timely communication with the client for the purposes of seeking feedback and clarifying customer requests. Feedback is used and analyzed to improve the quality of services. The *SOP for Handling Customer Feedback* (ADM-FDBK) is in place for these events.

3.5 Document Control and Records

Procedures for control and maintenance of documents are described in the *SOP for Document Control* (ADM-DOC_CTRL). The requirements of the SOP apply to all laboratory logbooks (standards, maintenance, run logbooks, etc), certificates of analysis, SOPs, QAMs, quality assurance project plans (QAPPs), Environmental Health & Safety (EHS) manuals, and other controlled Columbia Analytical documents.

Each controlled copy of a controlled document will be released only after a document control number is assigned and the recipient is recorded on a document distribution list. Filing and distribution is performed by the QA PM, or designee, and ensure that only the most current version of the document is distributed and in use. A document control number is assigned to logbooks. Completed logbooks that are no longer in use are archived in a master logbook file. Logbook entries are standardized following the *SOP for Making Entries into Logbooks and onto Benchsheets* (ADM-DATANTRY). The entries made into laboratory logbooks are reviewed and approved at a regular interval (quarterly).

A records system is used which ensures all laboratory records (including raw data, reports, and supporting records) are retained and available. The archiving system is described in the *SOP for Data Archiving* (ADM-ARCH).

NON-CONTROLLED COPY

3.6 Subcontracting

Analytical services are subcontracted when the laboratory needs to balance workload or when the requested analyses are not performed by the laboratory. Subcontracting is only done with the knowledge and approval of the client and to qualified laboratories. Subcontracting to another Columbia Analytical laboratory is preferred over external-laboratory subcontracting. Further, subcontracting is done using capable and qualified laboratories. Established procedures are used to qualify external subcontract laboratories. These procedures are described in the *SOP for Qualification of Subcontract Laboratories* (ADM-SUBLAB). The Corporate Quality Assurance staff is responsible for maintaining a list of qualified subcontract laboratories.

3.7 Procurement

The quality level of reagents and materials (grade, traceability, etc.) required is specified in analytical SOPs. Department supervisors ensure that the proper materials are purchased. Inspection and verification of material ordered is performed at the time of receipt by receiving personnel. The receiving staff labels the material with the date received. Expiration dates are assigned as appropriate for the material. Storage conditions and expiration dates are specified in the analytical SOP. The corporate Policy for Standards and Reagents Expiration Dates provides default expiration requirements. Supplies and services that are critical in maintaining the quality of laboratory testing are procured from pre-approved vendors. The policy and procedure for purchasing and procurement are described in the *SOP for Purchasing and Approval of Vendors* (ADM-PUR). Also, refer to section 9.4 for a discussion of reference materials.

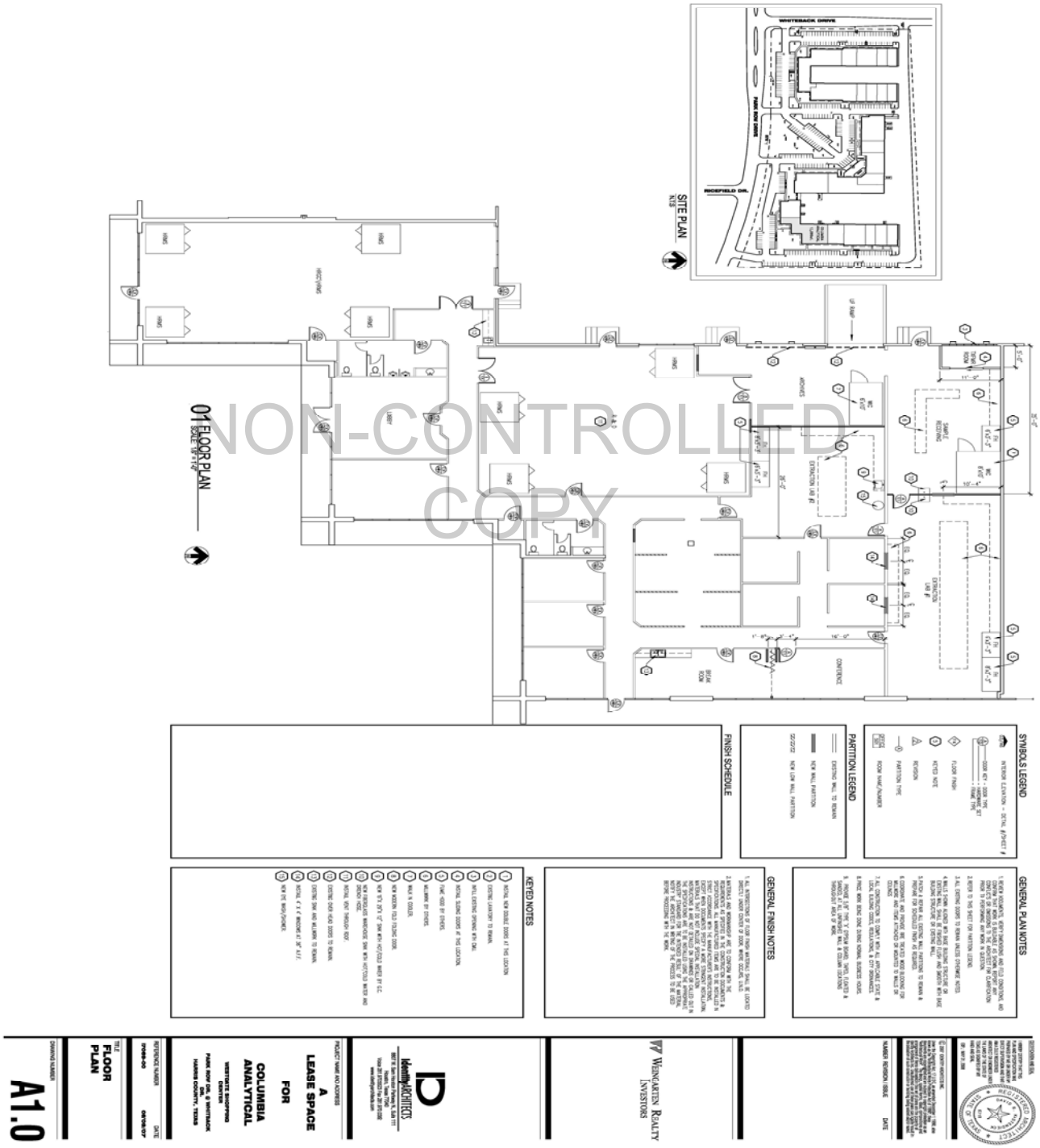
Receipt procedures include technical review of the purchase order/request to verify that what was received is identical to the item ordered. The laboratory checks new lots of reagents for unacceptable levels of contamination prior to use in sample preservation, sample preparation, and sample analysis by following the *SOP for Checking New Lots of Chemicals for Contamination* (ADM-CTMN).

3.8 Review of Requests, Tenders and Contracts (Procedures for Accepting New Work)

Requests for new work are reviewed prior to signing any contracts or otherwise agreeing to perform the work. The specific methods to be used are agreed upon between the laboratory and the client. A capability review is performed to determine if the laboratory has or needs to obtain certification to perform the work, to determine if the laboratory has the resources (personnel, equipment, materials, capacity, skills, expertise) to perform the work, and if the laboratory is able to meet the client's required reporting and QC limits. The results of this review are communicated to the client and any potential conflict, deficiency, lack of appropriate accreditation status, or concerns of the ability to complete the client's work are resolved. Any differences between the request or tender and the contract shall be resolved before any work commences. The client should be notified at this time if work is expected to be subcontracted. Each contract shall be acceptable both to the laboratory and the client. Records are maintained of pertinent discussions with a client relating to the client's requirements or the results of the work. If a contract needs to be amended after work has commenced, the contract review process is repeated and any amendments are communicated to all affected personnel. Changes in accreditation status affecting ongoing projects must be reported to the client.

NON-CONTROLLED COPY

Figure 3-2
Columbia Analytical/Houston Laboratory Floor Plan



NON-CONTROLLED COPY

4.0 PROFESSIONAL CONDUCT, DATA INTEGRITY, AND ETHICS

One of the most important aspects of the success of CAS is the emphasis placed on the integrity of the data provided and the services rendered. This success is reliant on both the professional conduct of all employees within CAS as well as established laboratory practices. All personnel involved with environmental testing and calibration activities must familiarize themselves with the quality documentation and implement the policies and procedures in their work.

4.1 Professional Conduct

To promote quality, CAS requires certain standards of conduct and ethical performance among employees. The following examples of documented CAS policy are representative of these standards, and are not intended to be limiting or all-inclusive:

- Under no circumstances is the willful act of fraudulent manipulation of analytical data condoned. Such acts are to be reported immediately to senior management for appropriate corrective action.
- Unless specifically required in writing by a client, alteration, deviation or omission of written contractual requirements is not permitted. Such changes must be in writing and approved by senior management.
- Falsification of data in any form will not be tolerated. While much analytical data is subject to professional judgment and interpretation, outright falsification, whenever observed or discovered, will be documented, and appropriate remedies and punitive measures will be taken toward those individuals responsible.
- It is the responsibility of all Columbia Analytical employees to safeguard sensitive company information, client data, records, and information; and matters of national security concern should they arise. The nature of our business and the well being of our company and of our clients is dependent upon protecting and maintaining proprietary company/client information. All information, data, and reports (except that in the public domain) collected or assembled on behalf of a client is treated as confidential. Information may not be given to third parties without the consent of the client. Unauthorized release of confidential information about the company or its clients is taken seriously and is subject to formal disciplinary action. All employees sign a confidentiality agreement upon hire to protect the company and client's confidentiality and proprietary rights.

NON-CONTROLLED COPY

4.2 Prevention and Detection of Improper, Unethical or Illegal Actions

It is the intention of CAS to proactively prevent and/or detect any improper, unethical or illegal action conducted within the laboratory. This is performed by the implementation of a program designed for not only the detection but also prevention. Prevention consists of educating all laboratory personnel in their roles and duties as employees, company policies, inappropriate practices, and their corresponding implications as described here.

In addition to education, appropriate and inappropriate practices are included in SOPs such as manual integration, data review and specific method procedures. Electronic and hardcopy data audits are performed regularly, including periodic audits of chromatographic electronic data. Requirements are described in the Policy for Internal Quality Assurance Audits and details are listed in laboratory admininstrative SOPs. All aspects of this program are documented and retained on file according to the company policy on record retention.

The CAS Employee Handbook also contains information on the CAS ethics and data integrity program, including mechanisms for reporting and seeking advice on ethical decisions.

4.3 Laboratory Data Integrity and Ethics Training

Each employee receives in-depth (approximately 6-8 hour) core Data Integrity/Ethics Training. New employees are given a QA and Ethics orientation within the first month of hire, followed by the the core training within 1 year of hire. On an ongoing basis, all employees receive semi-annual ethics refresher training. Topics covered are documented in writing and all training is documented. It is the responsibility of the QA PM to ensure that the training is conducted as described.

Key topics covered are the organizational mission and its relationship to the critical need for honesty and full disclosure in all analytical reporting, how and when to report data integrity issues and record keeping. Training includes discussion regarding all data integrity procedures, data integrity training documentation, in-depth data monitoring and data integrity procedure documentation.

NON CONTROLLED COPY

Trainees are required to understand that any infractions of the laboratory data integrity procedures will result in a detailed investigation that could lead to very serious consequences including immediate termination, or civil/criminal prosecution.

The training session includes many concepts and topics, numerous examples of improper actions (defined by DoD as deviations from contract-specified or method-specified analytical practices and may be intentional or unintentional), legal and liability implications (company and personal), causes, prevention, awareness, and reporting mechanisms.

4.4 Management and Employee Commitment

Columbia Analytical makes every attempt to ensure that employees are free from any commercial, financial, or other undue pressures that might affect their quality of work. Related policies are described in the CAS Employee Handbook. This includes:

- CAS Open Door Policy (CAS Employee Handbook) – Employees are encouraged to bring any work related problems or concerns to the attention of local management or their Human Resources representative. However, depending on the extent or sensitivity of the concern, employees are encouraged to directly contact any member of upper management.

- CAS Corporate Ethics Point Program – An anonymous and confidential reporting system available to all employees that is used to communicate misconduct and other concerns. The program shall help minimize negative morale, promote a positive work place, and encourage reporting suspected misconduct without retribution. Associated upper management is notified and the investigations are documented.
- Use of flexible work hours. Within reason and as approved by supervisors, employees are allowed flexible work hours in order to help ease schedule pressures which could impact decision-making and work quality.
- Operational and project scheduling assessments are continually made to ensure that project planning is performed and that adequate resources are available during anticipated periods of increased workloads. Procedures for subcontracting work are established, and within the Columbia Analytical laboratory network additional capacity is typically available for subcontracting, if necessary.
- Gifts and Favors (CAS Employee Handbook) – To avoid possible conflict of interest implications, employees do not receive unusual gifts or favors to, nor accept such gifts or favors from, persons outside the Company who are, or may be, in any way concerned with the projects on which the Company is professionally engaged.

All employees are required to sign and adhere to the requirements set forth in the Columbia Analytical *Confidentiality and Conflicts of Interest Employee Agreement* and the Columbia Analytical *Commitment to Excellence in Data Quality* (see Appendix A).

NON CONTROLLED COPY

5.0 ORGANIZATION AND RESPONSIBILITIES

The Columbia Analytical/Houston staff, consisting of approximately 16 employees, includes chemists, technicians and support personnel. They represent diverse educational backgrounds and experience, and provide the comprehensive skills that the laboratory requires. During seasonal workload increases, additional temporary employees may be hired to perform specific tasks.

CAS is committed to providing an environment that encourages excellence. All employees share the responsibility for maintaining and improving the quality of our analytical services. The responsibilities of key personnel within the laboratory are described below. Table 5-1 lists the Columbia Analytical/Houston personnel assigned to these key positions. Managerial staff members are provided the authority and resources needed to perform their duties. An organizational chart of the laboratory, as well as the resumes of these key personnel, can be found in Appendix B.

- The role of the **Laboratory Director** is to provide technical, operational, and administrative leadership through planning, allocation and management of personnel and equipment resources. The Laboratory Director provides leadership and support for the QA program and is responsible for overall laboratory efficiency and the financial performance of the Houston facility. The Laboratory Director has the authority to stop work in response to quality problems. The Laboratory Director also provides resources for implementation of the QA program, reviews and approves this QA Manual, reviews and approves standard operating procedures (SOPs), and provides support for business development by identifying and developing new markets through continuing support of the management of existing client activities.

NON-CONTROLLED COPY

- The responsibility of the **Quality Assurance Program Manager** (QA PM) is to oversee implementation of the quality program and to coordinate QA activities within the laboratory. The QA PM is responsible for ensuring compliance with NELAC standards (and ISO, DoD QSM, etc. as applicable). The QA PM works with laboratory staff to establish effective quality control and assessment plans and has the authority to stop work in response to quality problems. The QA PM is responsible for maintaining the QA Manual and performing an annual review of it; reviewing and approving SOPs and ensuring the annual review of each SOP; maintaining QA records such as metrological records, archived logbooks, PT study results, etc.; document control; conducting PT sample studies; approving nonconformity and corrective action reports; maintaining the laboratory's certifications and approvals; performing internal QA audits; preparing QA activity reports; etc. The QA PM reports directly to the Laboratory Director and also works closely with the Chief Quality Officer. It is important to note that when evaluating data, the QA PM does so in an objective manner and free of outside, or managerial, influence.

  The Chief Quality Officer (CQO) is responsible for the overall QA program at all the Columbia Analytical laboratories. The CQO is responsible for oversight of QA PMs regulatory compliance efforts (NELAC, ISO, DoD, etc). The CQO performs annual internal audits at each laboratory; maintains a database of laboratory certification/accreditation programs; approves company-wide SOPs; maintains a database of approved subcontract laboratories; provides assistance to the laboratory QA staff and laboratory managers; prepares a quarterly QA activity report; etc.

- In the case of absence of the Laboratory Director or QA PM, deputies are assigned to act in that role. Default deputies for these positions are the Technical Director (for the Laboratory Director) and the CQO or Technical Director (for the QA PM).

- The **Environmental Health and Safety Officer** (EH&S) is responsible for the administration of the laboratory health and safety policies. This includes the formulation and implementation of safety policies, the supervision of new-employee safety training, the review of accidents, incidents and prevention plans, the monitoring of hazardous waste disposal and the conducting of departmental safety inspections. The EH&S officer is also designated as the Chemical Hygiene Officer. The EH&S Officer has a dotted-line reporting responsibility to Columbia Analytical's EH&S Director.

- The **Project Manager** is a scientist assigned to each client to act as a technical liaison between the client and the laboratory. The project chemist is responsible for ensuring that the analyses performed by the laboratory meet all project, contract, and regulatory-specific requirements. This entails coordinating with the Columbia Analytical laboratory and administrative staff to ensure that client-specific needs are understood and that the services Columbia Analytical provides are properly executed and satisfy the requirements of the client.

- The Analytical Laboratory is divided into operational units based upon specific disciplines. Each department is responsible for establishing, maintaining and documenting a quality control program based upon the unique requirements within the department. Each **Department Manager and Supervisor** has the responsibility to ensure that quality control functions are carried out as planned, and to guarantee the production of high quality data. Department managers and bench-level supervisors have the responsibility to monitor the day-to-day operations to ensure that productivity and data quality objectives are met. Each department manager has the authority to stop work in response to quality problems in their area. Analysts have the responsibility to carry out testing according to prescribed methods, SOPs, and quality control guidelines particular to the laboratory in which he/she is working.

- The **Sample Management Office** plays a key role in the laboratory QA program by maintaining documentation for all samples received by the laboratory. The sample management office staff is also responsible for the proper disposal of samples after analysis.

- **Information Technology** (IT) staff are responsible for the administration of the Laboratory Information Management System (LIMS) and other necessary support services. Other functions of the IT staff include laboratory network maintenance, IT systems development and implementation, education of analytical staff in the use of scientific software, Electronic Data Deliverable (EDD) generation, and data back-up, archival and integrity operations.

NON CONTROLLED COPY

Table 5-1
Summary of Technical Experience and Qualifications

Personnel	Years of Experience	Project Role
Xiangqiu 'Sam' Liang, M.S.	20	Laboratory Director, HRMS Operator
Andrew Biddle, B.S.	4	Quality Assurance Program Manager, Environmental Health and Safety Officer
Lan Le, Ph.D.	21	Technical Director, HRMS Operator, Human Resources
Arthi Kodur, M.S.	3	HRMS Analyst – SMO/Extractions Department Supervisor
Michael Cosson, B.S.	4	HRMS Analyst – Data Review, Data Processing, and Assembly Department Supervisor
Darren Biles, B.S.	5	Project Management, IT Support, HRMS Operator
Nicole Brown, B.S.	3	Project Management
Mike Sullivan, B.S.	10	Information Technology
Jeff Christian, B.S.	31	Chief Operations Officer
Lee Wolf, B.S.	25	Chief Quality Officer/Quality Assurance Director
Jim Carlson, B.S.	24	President/CEO

NON-CONTROLLED COPY

6.0 INFORMATION MANAGEMENT

The generation, compilation, reporting, and archiving of electronic data is a critical component of laboratory operations. In order to generate data of known and acceptable quality, the quality assurance systems and quality control practices for electronic data systems must be complete and comprehensive and in keeping with the overall quality assurance objectives of the organization. CAS management provides the tools and resources to implement electronic data systems and establishes information technology standards and policies. Appendix C lists major computing equipment.

6.1 Software Quality Assurance Plan

Columbia Analytical has defined practices for assuring the quality of the computer software used throughout all laboratory operations to generate, compile, report, and store electronic data. These practices are described in the *CAS Software Quality Assurance Plan* (SQAP). The purpose of the SQAP is to describe the policies and practices for the procurement, configuration management, development, validation and verification, data security, maintenance, and use of computer software. The policies and practices described in the plan apply to purchased computer software as well as to internally developed computer software. Key components of this plan are policies for software validation and control.

NON CONTROLLED COPY

6.2 IT Support

The local Columbia Analytical Information Technology (IT) department is established to provide technical support for all computing systems. The IT department staff continually monitors the performance and output of operating systems. The IT department oversees routine system maintenance and data backups to ensure the integrity of all electronic data. A software inventory is maintained. Additional IT responsibilities are described in the SQAP.

In addition to the local IT department, Columbia Analytical Corporate IT provides support for network-wide systems. Columbia Analytical also has personnel assigned to information management duties such as development and implementation of reporting systems; data acquisition, and Electronic Data Deliverable (EDD) generation.

6.3 Information Management Systems

Columbia Analytical has various systems in place to address specific data management needs. The Columbia Analytical Laboratory Information Management System (LIMS) is used to manage sample information and invoicing. Access is controlled by password. This system defines sample identification, analysis specifications, and provides a means of sample tracking. This system is used during sample login to generate the internal service request. Included on the service request is a summary of client information, sample identification, required analyses, work instructions, deliverable requirements. The LIMS is used to track the status of a sample and is important in maintaining internal chain of custody.

Where possible, instrument data acquired locally is immediately moved to a server (Microsoft Windows2003® domain). This provides a reliable, easily maintained, high-volume acquisition and storage system for electronic data files. With password entry, users may access the system from many available computer stations, improving efficiency and flexibility. The server is also used for data reporting, EDD generation, and administrative functions. Access to these systems is controlled by password. A standardized EDI (electronic data interchange) format is used as a reporting platform, providing functionality and flexibility for end users. With a common standardized communication platform, the EDI provides data reporting in a variety of hardcopy and electronic deliverable formats, including Staged Electronic Data Deliverable (SEDD) format.

6.4 Backup and Security

Columbia Analytical laboratory data is either acquired directly to the centralized acquisition server or acquired locally and then transferred to the server. All data is eventually moved to the centralized data acquisition server for reporting and archiving. Differential backups are performed on all file server information once per day, Sunday through Thursday. Full backups are performed each Friday night. Tapes are physically stored with IT Support and every other full backup is securely stored offsite.

Access to sample information and data is on a need-to-know basis. Access is restricted to the person's areas of responsibility. Passwords are required on all systems. No direct external, non-Columbia Analytical access is allowed to any of our network systems.

NON-CONTROLLED COPY

The external e-mail system and Internet access is established via a single gateway to discourage unauthorized entry. Columbia Analytical uses a closed system for company e-mail. Files, such as electronic deliverables, are sent through the external e-mail system only via a trusted agent. The external messaging system operates through a single secure gateway. Email attachments sent in and out of the gateway are subject to a virus scan. Because the Internet is not regulated, we use a limited access approach to provide a firewall for added security. Virus screening is performed continuously on all network systems.

7.0 SAMPLE MANAGEMENT

7.1 Sampling and Sample Preservation

The quality of analytical results is highly dependent upon the quality of the procedures used to collect, preserve and store samples. Columbia Analytical recommends that clients follow sampling guidelines described in 40 CFR 136, 40 CFR 141, USEPA SW-846, and state-specific sampling guidelines, if applicable. Sampling factors that must be taken into account to ensure accurate, defensible analytical results include:

- Amount of sample taken
- Type of container used
- Type of sample preservation
- Sample storage time
- Proper custodial documentation

NON-CONTROLLED COPY

Columbia Analytical uses the sample preservation, container, and holding-time recommendations published in a number of documents. The primary documents of reference are: USEPA SW-846, Third Edition and Updates I, II, IIA, IIB, III, IV for hazardous waste samples; USEPA 600/4-79-020, 600/4-91-010, 600/4-82-057, 600/R-93/100, 600/4-88-039, 600/R-94-111, and Supplements; EPA 40CFR parts 136 and 141; and *Standard Methods for the Examination of Water and Wastewater* for water and wastewater samples (see Section 18 for complete citations). The container, preservation and holding time information for these references is summarized in Table 7-1 for soil, water, and drinking water. The current EPA CLP Statement of Work should be referred to for CLP procedures. Where allowed by project sampling and analysis protocols (such as Puget Sound Protocols) the holding time for sediment, soil, and tissue samples may be extended for a defined period when stored frozen at -20°C.

Columbia Analytical routinely provides sample containers for our clients. Containers are purchased as precleaned to a level 1 status, and conform to the requirements for samples established by the USEPA. Certificates of analysis for the sample containers are available to clients if requested. Our sample kits typically consist of foam-lined, precleaned shipping coolers, (cleaned inside and out with appropriate cleaner, rinsed thoroughly and air-dried), specially prepared and labeled sample containers individually wrapped in protective material, chain-of-custody (COC) forms, and custody seals. Container labels and custody seals are provided for each container.

Figure 7-1 shows the chain-of-custody form routinely used at Columbia Analytical and included with sample kits. For large sample container shipments, the containers may be shipped in their original boxes. Such shipments will consist of several boxes of labeled sample containers and sufficient materials (bubble wrap, COC forms, custody seals, shipping coolers, etc.) to allow the sampling personnel to process the sample containers and return them to Columbia Analytical.

If any returning shipping cooler exhibits an odor or other abnormality after receipt and subsequent decontamination by laboratory personnel, a second, more vigorous decontamination process is employed. Containers exhibiting an odor or abnormality after the second decontamination process are promptly and properly discarded. Columbia Analytical keeps client-specific shipping requirements on file and utilizes major transportation carriers to guarantee that sample shipping requirements (same-day, overnight, etc.) are met.

When Columbia Analytical ships environmental samples to other laboratories for analysis each sample bottle is wrapped in protective material and placed in a plastic bag (preferably Ziploc®) to avoid any possible cross-contamination of samples during shipping. The sample management office (SMO) follows formalized procedures (SMO-WET) for maintaining the samples' chain of custody, packaging and shipment. Wet ice is the only temperature preservative used by Columbia Analytical, unless otherwise specified by the client or receiving laboratory.

NON-CONTROLLED COPY

7.2 Sample Receipt and Handling

Standard Operating Procedures (SMO-WET) are established for the receiving of samples into the laboratory. These procedures ensure that samples are received and properly logged into the laboratory, and that all associated documentation, including chain of custody forms, is complete and consistent with the samples received.

Once samples are delivered to the Columbia Analytical sample management office (SMO), a Cooler Receipt and Preservation Check Form (CRF - see Figure 7-2 for an example) is used to assess the shipping cooler and its contents as received by the laboratory personnel. Verification of sample integrity includes the following activities:

- Assessment of custody seal presence/absence, location and signature;
- Temperature of sample containers upon receipt;
- Chain of custody documents properly used (entries in ink, signature present, etc.);
- Sample containers checked for integrity (broken, leaking, etc.);
- Sample is clearly marked and dated (bottle labels complete with required information);
- Appropriate containers (size, type) are received for the requested analyses;
- The minimum amount of sample material is provided for the analysis.
- Sample container labels and/or tags agree with chain of custody entries (identification, required analyses, etc.); and
- Assessment of proper sample preservation (if inadequate, corrective action is employed).

Samples are logged into a Laboratory Information Management System (LIMS). Any anomalies or discrepancies observed during the initial assessment are recorded on the CRF and COC documents. Potential problems with a sample shipment are addressed by contacting the client and discussing the pertinent issues. When the Project Manager and client have reached a satisfactory resolution, the login process may continue and analysis may begin. During the login process, each sample container is given a unique laboratory code and a service request form is generated. The LIMS generates a Service Request that contains client information, sample descriptions, sample matrix information, required analyses, sample collection dates, analysis due dates and other pertinent information. The service request is reviewed by the appropriate Project Manager for accuracy, completeness, and consistency of requested analyses and for client project objectives.

Samples are stored as per method requirements until they undergo analysis, unless otherwise specified, using various refrigerators or freezers, or designated secure areas. Columbia Analytical has two walk-in cold storage units which house the majority of sample containers received at the laboratory. Columbia Analytical also has three sub-zero freezers capable of storing samples at -20° C primarily used for tissue and sediment samples requiring specialized storage conditions. The temperature of each sample storage unit is monitored daily and the data recorded in a bound logbook.

NON-CONTROLLED COPY

Columbia Analytical adheres to the method-prescribed or project-specified holding times for all analyses. The sampling date and time are entered into the LIMS system at the time of sample receipt and login. Analysts then monitor holding times by obtaining analysis-specific reports from the LIMS. These reports provide holding time information on all samples for the analysis, calculated from the sampling date and the holding time requirement. To document holding time compliance, the date and time analyzed is printed or written on the analytical raw data.

Unless other arrangements have been made in advance, upon completion of all analyses and submittal of the final report, aqueous, soil, and tissue samples are retained for 30 days. Extracts are stored for up to one year. Upon expiration of these time limits, the samples are either returned to the client or disposed of according to approved disposal practices. All samples are characterized according to hazardous/non-hazardous waste criteria and are segregated accordingly. All hazardous waste samples are disposed of according to formal procedures outlined in the *CAS Environmental Health and Safety Manual.* All waste produced at the laboratory, including the laboratory's own various hazardous waste streams, is treated in accordance with applicable local and Federal laws. Documentation is maintained for each sample from initial receipt through final disposal to ensure that an accurate history of the sample from "cradle to grave" is available.

7.3 Sample Custody

Sample custody transfer at the time of sample receipt is documented using chain-of-custody (COC) forms accompanying the samples. During sample receipt, it is also noted if custody seals were present. This is described in the SOP for *Sample Receiving* (SMO-WET). Figure 7-1 is a copy of the chain-of-custody form routinely used at Columbia Analytical.

Facility security and access is important in maintaining the integrity of samples received at Columbia Analytical/Houston. Access to the laboratory facility is limited by use of locked exterior doors, except for the reception and side office areas, which are manned during business hours and locked at all other times. The Columbia Analytical facility is equipped with an alarm system and Columbia Analytical employs a private security firm to provide nighttime and weekend security.

A barcoding system is used to document internal sample custody. Each person removing or returning samples from/to sample storage while performing analyses is required to document this custody transfer. The system uniquely identifies the sample container and provides an electronic record of the custody of each sample. For sample extracts the analyst documents custody of the sample extract by signing on the custody record that they have accepted custody.

7.4 Project Setup

The analytical method(s) used for sample analysis are chosen based on the client's requirements. Unless specified otherwise, the most recent versions of reference methods are used. For SW-846 methods, some projects may require the most recent *promulgated* version, and some projects may require the most recent *published* version. The Project Manager will ensure that the correct method version is used. LIMS codes are chosen to identify the analysis method used for analysis. The Project Manager ensures that the correct methods are selected for analysis, deliverable requirements are identified, and due dates are specified on the service request. To communicate and specify project-specific requirements, a service request form is utilized.

NON CONTROLLED COPY

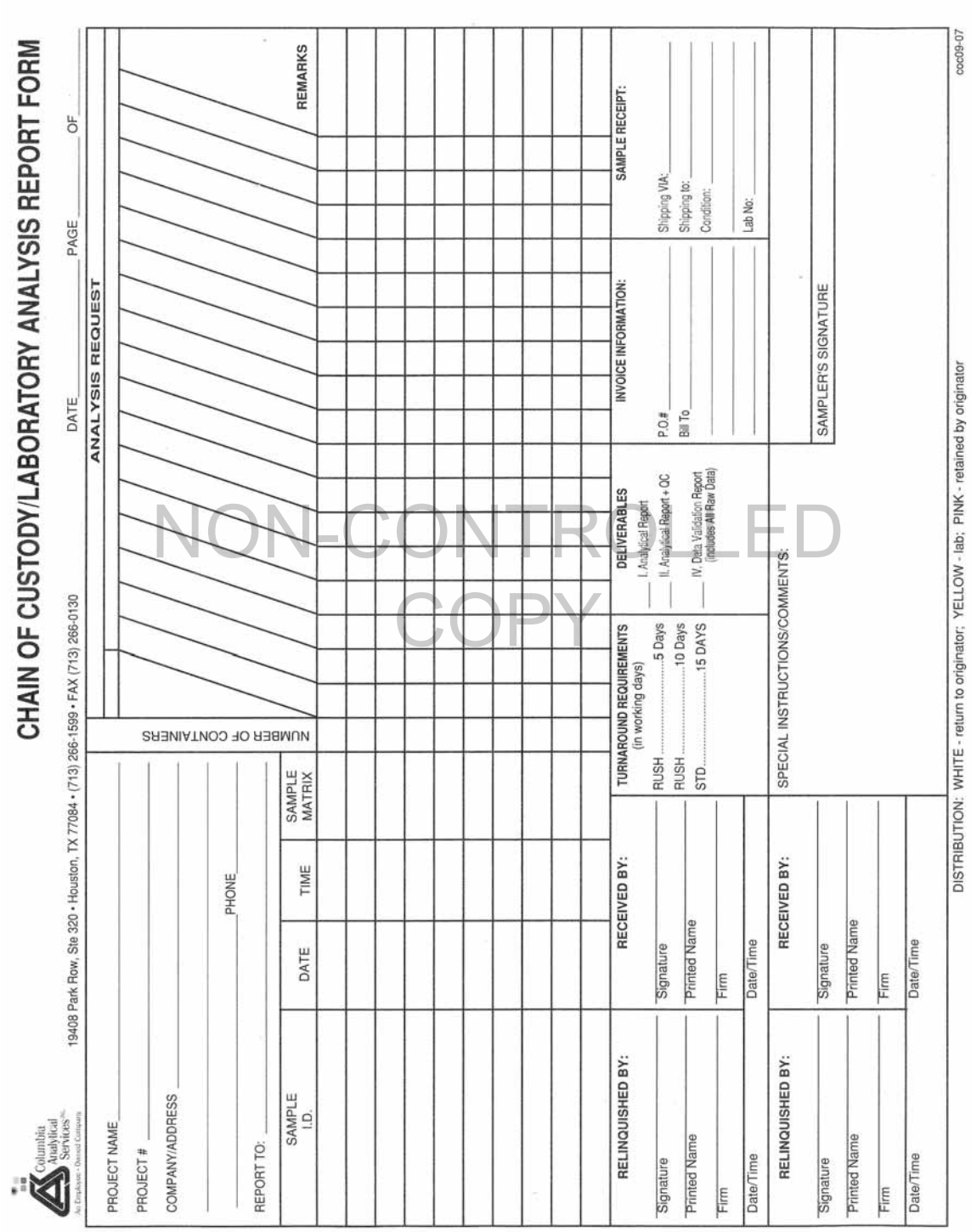
Table 7-1
Sample Preservation and Holding Times

DETERMINATION	MATRIX[a, b]	CONTAINER[c]	PRESERVATION[d]	MAXIMUM HOLDING TIME[e]
Dioxins/Furans by EPA 8290	W	G	4°C	30 days
Dioxins/Furans by EPA 8280A	W	G	4°C	30 days
Dioxins/Furans by EPA 8290	S	G	4°C	30 days, 1 year if frozen
Dioxins/Furans by EPA 8280A	S	G	4°C	30 days, 1 year if frozen
Dioxins/Furans by EPA 1613B	W, DW	G	0-4°C	1 year
Dioxins/Furans by EPA 1613B	S	G	-20°C to -10°C	1 year
Dioxins/Furans by EPA 23	A	XAD	0-6°C	30 days
Dioxins/Furans by EPA 1613B	T	G	-20°C to -10°C	1 year
Dioxins/Furans by EPA 8290	T	G	-20°C to -10°C	30 days
Dioxins/Furans by EPA TO-9A	A	PUF	<4°C	7 days
Polychlorinated Biphenyls (PCBs) by EPA 1668	W	G	<6°C	1 year
Polychlorinated Biphenyls (PCBs) by EPA 1668	S	G	-20°C to -10°C	1 year
Polychlorinated Biphenyls (PCBs) by EPA 1668	T	G	-20°C to -10°C	1 year
Polychlorinated Biphenyls (PCBs) by CARB[f] 428	A	XAD	Ambient	45 days
Polycyclic Aromatic Hydrocarbons (PAHs) by CARB[f] 429	A	XAD	<4°C	21 days
Pesticides by EPA 1699	W	G	<6°C	7 days
Pesticides by EPA 1699	S	G	-20°C to -10°C	1 year

NON-CONTROLLED COPY

a A = Air, DW = Drinking Water, S = Soil or Sediment, T = Tissue, W = Water
b Amount of sample required: DW, W = 2x1L; S, T = 50g; A = contents of 1 trap
c G = Glass, PUF = Polyurethane foam plug, XAD = XAD filled glass trap
d NELAC §5.5.8.4(a)(1) – For samples with a specified storage temperature of 4°C, storage at a temperature above the freezing point of water to 6°C shall be acceptable.
e Holding times listed for samples only. Extract holding times can be found in referenced technical methods.
f CARB = California Air Resource Board

Figure 7-1
Chain of Custody Form



CHAIN OF CUSTODY/LABORATORY ANALYSIS REPORT FORM

Columbia Analytical Services™ An Exclusive Chemical Company

19408 Park Row, Ste 320 • Houston, TX 77084 • (713) 266-1599 • FAX (713) 266-0130

DATE ____ PAGE ____ OF ____

PROJECT NAME ____
PROJECT # ____
COMPANY/ADDRESS ____
____ PHONE ____
REPORT TO: ____

SAMPLE I.D.	DATE	TIME	SAMPLE MATRIX	NUMBER OF CONTAINERS	ANALYSIS REQUEST	REMARKS

RELINQUISHED BY:	RECEIVED BY:
Signature	Signature
Printed Name	Printed Name
Firm	Firm
Date/Time	Date/Time

RELINQUISHED BY:	RECEIVED BY:
Signature	Signature
Printed Name	Printed Name
Firm	Firm
Date/Time	Date/Time

TURNAROUND REQUIREMENTS (in working days)
RUSH .....5 Days
RUSH .....10 Days
STD.....15 DAYS

DELIVERABLES
___ I. Analytical Report
___ II. Analytical Report + QC
___ IV. Data Validation Report (includes All Raw Data)

SPECIAL INSTRUCTIONS/COMMENTS:

INVOICE INFORMATION:
P.O.# ____
Bill To ____

SAMPLE RECEIPT:
Shipping VIA: ____
Shipping to: ____
Condition: ____
Lab No: ____

SAMPLER'S SIGNATURE

DISTRIBUTION: WHITE - return to originator; YELLOW - lab; PINK - retained by originator

coc09-07

NON-CONTROLLED COPY

Figure 7-2
Cooler Receipt and Preservation Form

Reset Form

Print Form

Columbia Analytical Services, Inc.
Cooler Receipt Form

Client/Project:_____ Service Request: _____

Received:_____ Opened (Date/Time): _____ By:_____

1. Samples were received via? ☐*US Mail* ☐*Fedex* ☐*UPS* ☐*DHL* ☐*Courier* ☐*Hand Delivered*
2. Samples were received in: (circle) ☐*Cooler* ☐*Box* ☐ *Other*_____ ☐*NA*
3. Were custody seals present on coolers? ☐Y ☐N If yes, how many and where?_____
   If present, were custody seals intact? ☐Y ☐N If present, were they signed and dated? ☐Y ☐N
4. Is shipper's air-bill filed? ☐NA ☐Y ☐N If not, record air bill number:_____
5. Temperature of cooler(s) upon receipt (°C): _____ _____ _____ _____
6. If applicable, list Chain of Custody numbers: _____ _____ _____ _____
7. Were custody papers properly filled out (ink, signed, etc.)? ☐NA ☐Y ☐N
8. Packing material used: ☐*Inserts* ☐*Bubble Wrap* ☐*Blue Ice* ☐*Wet Ice* ☐*Sleeves* ☐*Other*_____
9. Were the correct types of bottles used for the tests indicated? ☐Y ☐N
   Did all bottles arrive in good condition (i.e. unbroken, out of temp.)? *Indicate in the table below.* ☐Y ☐N

NON-CONTROLLED COPY

Sample ID	Bottle Count	Bottle Type	Out of Temp	Broken	Initials
			☐	☐	
			☐	☐	
			☐	☐	
			☐	☐	
			☐	☐	
			☐	☐	
			☐	☐	

10. Were all bottle labels complete (i.e. analysis, ID, etc.)? ☐Y ☐N
    Did all bottle labels and tags agree with custody papers? *Indicate in the table below.* ☐Y ☐N

Sample ID on Bottle	Sample ID on COC		Sample ID on Bottle	Sample ID on COC

11. Additional notes, discrepancies, and resolutions:

_____

_____

_____

CRF_r092109.pdf

Page 1 of: ☐1 ☐2

8.0 ANALYTICAL PROCEDURES

Columbia Analytical employs methods and analytical procedures from a variety of external sources. The primary method references are: USEPA SW-846, Third Edition and Updates I, II, IIA, IIB, III, IVA, IVB, and online updates for hazardous waste samples, and USEPA 600/4-79-020, 600/4-91-010, 600/4-82-057, 600/R-93/100, 600/4-88-039, 600/R-94-111, EPA 40CFR parts 136 and 141, and Supplements; and *Standard Methods for the Examination of Water and Wastewater* for water and wastewater samples. Complete citations for these references can be found in Section 17.0. Other published procedures, such as state-specific methods, program-specific methods (such as Puget Sound Protocols), or in-house methods may be used. Several factors are involved with the selection of analytical methods to be used in the laboratory. These include the method detection limit, the concentration of the analyte being measured, method selectivity, accuracy and precision of the method, the type of sample being analyzed, and the regulatory compliance objectives. The implementation of methods by Columbia Analytical is described in SOPs specific to each method. A list of NELAP-accredited methods is given in Appendix G. Further details are described below.

8.1 Standard Operating Procedures (SOPs) and Laboratory Notebooks.

NON-CONTROLLED COPY

Columbia Analytical maintains SOPs for use in both technical and administrative functions. SOPs are written following standardized format and content requirements as described in the *SOP for Preparation of Standard Operating Procedures* (ADM-SOP). Each SOP is reviewed and approved by a minimum of two managers (the Laboratory Director and/or Department Manager and the Quality Assurance Program Manager). All SOPs undergo a documented annual review to make sure current practices are described. The QA PM maintains a comprehensive list of current SOPs. The document control process ensures that only the most currently prepared version of an SOP is being used. The QA Manual, QAPPs, SOPs, standards preparation logbooks, maintenance logbooks, et al., are controlled documents. The procedures for document control are described in the *SOP for Document Control* (ADM-DOC_CTRL). In addition to SOPs, each laboratory department maintains a current file, accessible to all laboratory staff, of the current methodology used to perform analyses. Laboratory notebook entries are standardized following the guidelines in the *SOP for Making Entries into Logbooks and onto Benchsheets* (ADM-DATANTRY). Entries made into laboratory notebooks are reviewed and approved by the appropriate supervisor at a regular interval.

8.2 Deviation from Standard Operating Procedures

When a customer requests a modification to an SOP (such as a change in reporting limit, addition or deletion of target analyte(s), etc.), the project chemist handling that project must discuss the proposed deviation with the department manager in charge of the analysis and obtain their approval to accept the project. The project chemist is responsible for documenting the approved or allowed deviation from the SOP by placing a detailed description of the deviation attached to the quotation or in the project file and also providing an appropriate comment on the service request when the samples are received.

For circumstances when a deviation or departure from company policies or procedures involving any non-technical function is found necessary, approval must be obtained from the appropriate supervisor, manager, the laboratory director, or other level of authority. Frequent departure from policy is not encouraged. However, if frequent departure from any policy is noted, the laboratory director will address the possible need for a change in policy.

8.3 Modified Procedures

Columbia Analytical strives to perform published methods as described in the referenced documents. If there is a material deviation from the published method, the method is cited as a "Modified" method in the analytical report. Modifications to the published methods are listed in the standard operating procedure. Standard operating procedures are available to analysts and are also available to our clients for review, especially those for "Modified" methods. Client approval is obtained for the use of "Modified" methods prior to the performance of the analysis.

8.4 Analytical Batch

The basic unit for analytical quality control is the analytical batch. The definition that Columbia Analytical has adopted for the analytical batch is listed below. The overriding principle for describing an analytical batch is that all the samples in a batch, both field samples and quality control samples are to be handled exactly the same way, and all of the data from each analysis is to be manipulated in exactly the same manner. The minimum requirements of an analytical batch are:

NON-CONTROLLED COPY

1) The number of (field) samples in a batch is not to exceed 20.
2) All (field) samples in a batch are of the same matrix.
3) The QC samples to be processed with the (field) samples include:
   a) Method Blank (a.k.a. Laboratory Reagent Blank)

      Function: Determination of laboratory contamination.

   b) Laboratory Control Sample

      Function: Assessment of method performance

   c) Matrix Spiked (field) Sample (a.k.a. Laboratory Fortified Sample Matrix)*

      Function: Assessment of matrix bias

   d) Duplicate Matrix Spiked (field) Sample or Duplicate (field) Sample (a.k.a. Laboratory Duplicate)*

      Function: Assessment of batch precision

   * A sample identified as a field blank, an equipment blank, or a trip blank is not to be matrix spiked or duplicated.
4) A single lot of reagents is used to process the batch of samples.

5) Each operation within the analysis is performed by a single analyst, technician, chemist, or by a team of analysts/technicians/chemists.

6) Samples are analyzed in a continuous manner over a timeframe not to exceed 24-hours between the start of processing of the first and last sample of the batch.

7) (Field) samples are assigned to batches commencing at the time that sample processing begins. For analysis of organic constituents, it begins when the samples are extracted.

8) The QC samples are to be analyzed in conjunction with the associated field samples prepared with them. However, for tests which have a separate sample preparation step that defines a batch (extraction, etc.), the QC samples in the batch do not require analysis each time a field sample within the preparation batch is analyzed (multiple instrument sequences to analyze all field samples in the batch need not include re-analyses of the QC samples).

9) The batch is to be assigned a unique identification number that can be used to correlate the QC samples with the field samples.

10) Batch QC refers to the QC samples that are analyzed in a batch of (field) samples.

11) Project-specific requirements may be exceptions. If project, program, or method requirements are more stringent than these laboratory minimum requirements, then the project, program, or method requirements will take precedence. However, if the project, program, or method requirements are less stringent than these laboratory minimum requirements, these laboratory minimum requirements will take precedence.

NON-CONTROLLED COPY

8.5 Specialized Procedures

Columbia Analytical not only strives to provide results that are scientifically sound, legally defensible, and of known and documented quality; but also strives to provide the best solution to analytical challenges. Procedures using specialized instrumentation and methodology have been developed to improve sensitivity (provide lower detection limits), selectivity (minimize interferences while maintaining sensitivity), and overall data quality for low concentration applications.

8.6 Sample Cleanup

Columbia Analytical commonly employs several cleanup procedures to minimize known common interferences prior to analysis. EPA methods (3620, 3630, 3640, 3660, and 3665) for cleanup of sample extracts for organics analysis are routinely used to minimize or eliminate interferences that may adversely affect sample results and data usability.

9.0 CALIBRATION PROCEDURES

All equipment and instruments used at Columbia Analytical are operated, maintained and calibrated according to the manufacturer's guidelines and recommendations, as well as to criteria set forth in the applicable analytical methodology. Operation and calibration are performed by personnel who have been properly trained in these procedures. Documentation of calibration information is maintained in appropriate reference files. Brief descriptions of the calibration procedures for our major laboratory equipment and instruments are described below. Calibration verification is performed according to the applicable analytical methodology. Calibration verification procedures and criteria are listed in laboratory Standard Operating Procedures. Documentation of calibration verification is maintained in appropriate reference files. Records are maintained to provide traceability of reference materials.

Laboratory support equipment (thermometers, balances, and weights) are routinely verified on an annual basis by a vendor accredited to A2LA or ISO/IEC 17025:2005 International Standards. All analytical measurements generated at Columbia Analytical are performed using materials and/or processes that are traceable to a reference material. Metrology equipment (analytical balances, thermometers, etc.) is calibrated using reference materials traceable to the National Institute of Standards and Technology (NIST). These primary reference materials are themselves recertified on an annual basis. Vendors used for metrology support are required to verify compliance to International Standards by supplying the laboratory with a copy of their scope of accreditation.

NON-CONTROLLED COPY

Equipment subjected to overloading or mishandling, or has been shown by verification to be defective; is taken out of service until it is repaired. The equipment is placed back in service only after verifying, by calibration, that the equipment performs satisfactorily.

9.1 Temperature Control Devices

Temperatures are monitored and recorded for all of the temperature-regulating support equipment such as sample refrigerators, freezers, ovens, and standards refrigerators. Bound record books are kept which contain daily-recorded temperatures, identification and location of equipment, acceptance criteria and the initials of the technician who performed the checks. The procedure for performing these measurements is provided in the *SOP for the Calibration Check of Measuring Devices* (WET-DALCYK). The SOP also includes the use of acceptance criteria and correction factors.

Where the operating temperature is specified as a test condition (such as ovens) the temperature is recorded on the raw data. All thermometers are identified according to serial number, and the calibration is checked annually against a National Institute of Standards and Technology (NIST) certified thermometer. The NIST thermometer is recertified by a vendor accredited to A2LA or ISO/IEC 17025:2005 International Standard on an annual basis.

9.2 Analytical Balances

The calibration of each analytical balance is checked by the user each day of use with three Class S or S-1 weights, which assess the accuracy of the balance at low, mid-level and high levels bracketing the working range. Records are kept which contain the recorded measurements, identification of the balance, acceptance criteria, and the initials of user who performed the check. The procedure for performing these measurements and use of acceptance criteria is described in WET-DALCYK. The weights are recertified using NIST traceable standards by an accredited metrology organization on an annual basis.

As needed, the balances are recalibrated using the manufacturers recommended operating procedures. Analytical balances are serviced on an annual basis by an accredited metrology organization.

9.3 Water Purification System

Columbia Analytical/Houston purchases drinking water for the preparation of standards and reagents. This purchased water meets specifications for ASTM Type 1 water and is free of contamination of the analytical target compounds.

9.4 Source and Preparation of Standards and Reference Materials

NON-CONTROLLED COPY

Consumable reference materials routinely purchased by the laboratories (e.g., analytical standards) are purchased from nationally recognized, reputable vendors. All vendors have fulfilled the requirements for ISO 9001 certification and/or are accredited by A2LA. Columbia Analytical relies on a primary vendor for the majority of its analytical supplies. Consumable primary stock standards are obtained from certified commercial sources or from sources referenced in a specific method. Cambridge Isotope Laboratories (CIL), Wellington Laboratories, and AccuStandard are examples of the vendors used. Reference material information is recorded in the appropriate logbook(s) and materials are stored under conditions that provide maximum protection against deterioration and contamination. The logbook entry includes such information as an assigned logbook identification code, the source of the material (i.e. vendor identification), solvent (if applicable) and concentration of analyte(s), reference to the certificate of analysis and an assigned expiration date. The date that the standard is received in the laboratory is marked on the container. When the reference material is used for the first time, the date of usage and the initials of the analyst are also recorded on the container.

Stock solutions and calibration standard solutions are prepared fresh as often as necessary according to their stability. All standard solutions are properly labeled as to analyte concentration, solvent, date, preparer, and expiration date; these entries are also recorded in the appropriate notebook(s) following the *SOP for Making Entries into Logbooks and onto Benchsheets* (ADM-DATANTRY). Prior to sample analysis, all calibration reference materials are verified with a second, independent source of the material (see section 11.3.5).

9.5 High Resolution GC/MS Systems

All HRGC/HRMS instruments are calibrated at a minimum of five different concentration levels for the analytes of interest (unless specified otherwise) using procedures outlined in Standard Operating Procedures and/or appropriate USEPA method citations. All reference materials

used for this function are vendor-certified standards. Calibration verification is performed at method-specified intervals following the procedures in the SOP and reference method. For isotope dilution procedures, the internal standard response(s) and labeled compound recovery must meet method criteria. Method-specific instrument tuning is regularly checked using perfluorokerosene (PFK). Mass spectral peaks for the tuning compounds must conform both in mass numbers and in relative intensity criteria before analyses can proceed.

9.6 Pipets

The calibration of pipets and autopipettors used to make critical-volume measurements is verified following WET-DALCYK. Both accuracy and precision verifications are performed, at intervals applicable to the pipet and use. The results of all calibration verifications are recorded in bound logbooks.

NON-CONTROLLED
COPY

10.0 QUALITY CONTROL

A primary focus of Columbia Analytical's QA Program is to ensure the accuracy, precision and comparability of all analytical results. Prior to using a procedure for the analysis on field samples, acceptable method performance is established by performing demonstration of capability analyses. Performance characteristics are established by performing method detection limit studies and assessing accuracy and precision according to the reference method. Columbia Analytical has established Quality Control (QC) objectives for precision and accuracy that are used to determine the acceptability of the data that is generated. These QC limits are either specified in the test methodology or are statistically derived based on the laboratory's historical data. Quality Control objectives are defined below.

10.1 Quality Control Objectives

10.1.1 Demonstration of Capability - A demonstration of capability (DOC) is made prior to using any new test method or when a technician is new to the method. This demonstration is made following regulatory, accreditation, or method specified procedures. In general, this demonstration does not test the performance of the method in real world samples, but in the applicable clean matrix free of target analytes and interferences.

NON CONTROLLED COPY

A quality control sample material may be obtained from an outside source or may be prepared in the laboratory. The analyte(s) is (are) diluted in a volume of clean matrix (for analytes which do not lend themselves to spiking, e.g., TSS, the demonstration of capability may be performed using quality control samples). Where specified, the method-required concentration levels are used. Four aliquots are prepared and analyzed according to the test procedure. The mean recovery and standard deviations are calculated and compared to the corresponding acceptance criteria for precision and accuracy in the test method or laboratory-generated acceptance criteria (if there are not established mandatory criteria). All parameters must meet the acceptance criteria. Where spike levels are not specified, actual Laboratory Control Sample results may be used to meet this requirement, provided acceptance criteria is met.

10.1.2 Accuracy - Accuracy is a measure of the closeness of an individual measurement (or an average of multiple measurements) to the true or expected value. Accuracy is determined by calculating the mean value of results from ongoing analyses of laboratory-fortified blanks, reference materials, and standard solutions. In addition, laboratory-fortified (i.e. matrix-spiked) samples are also measured; this indicates the accuracy or bias in the actual sample matrix. Accuracy is expressed as percent recovery (% REC.) of the measured value, relative to the true or expected value. If a measurement process produces results whose mean is not the true or expected value, the process is said to be biased. Bias is the systematic error either inherent in a method of analysis (e.g., extraction efficiencies) or caused by an artifact of the measurement system (e.g., contamination).

Columbia Analytical utilizes several quality control measures to eliminate analytical bias, including systematic analysis of method blanks, laboratory control samples and independent calibration verification standards. Because bias can be positive or negative, and because several types of bias can occur simultaneously, only the net, or total, bias can be evaluated in a measurement.

10.1.3 Precision - Precision is the ability of an analytical method or instrument to reproduce its own measurement. It is a measure of the variability, or random error, in sampling, sample handling and in laboratory analysis. The American Society of Testing and Materials (ASTM) recognizes two levels of precision: repeatability - the random error associated with measurements made by a single test operator on identical aliquots of test material in a given laboratory, with the same apparatus, under constant operating conditions, and reproducibility - the random error associated with measurements made by different test operators, in different laboratories, using the same method but different equipment to analyze identical samples of test material.

"Within-batch" precision is measured using replicate sample or QC analyses and is expressed as the relative percent difference (RPD) between the measurements. The "batch-to-batch" precision is determined from the variance observed in the analysis of standard solutions or laboratory control samples from multiple analytical batches.

NON-CONTROLLED COPY

10.1.4 Control Limits - The control limits for accuracy and precision originate from two different sources. For analyses having enough QC data, control limits are calculated at the 99% confidence limits. For analyses not having enough QC data, or where the method is prescriptive, control limits are taken from the method on which the procedure is based. If the method does not have stated control limits, then control limits are assigned method-default or reasonable values. Control limits are updated periodically when new statistical limits are generated for the appropriate surrogate, laboratory control sample, and matrix spike compounds (typically once a year) or when method prescribed limits change. The updated limits are reviewed by the QA PM. The new control limits replace the previous limits and data is assessed using the new values. Current acceptance limits for accuracy and precision are available from the laboratory. For inorganics, the precision limit values listed are for laboratory duplicates. For organics, the precision limit values listed are for duplicate laboratory control samples or duplicate matrix spike analyses. Procedures forestablishing control limits are found in the *SOP for Control Limits* (ADM-CTRL_LIM).

10.1.5 Representativeness - Representativeness is the degree to which the field sample, being properly preserved, free of contamination, and analyzed within holding time, represents the overall sample site or material. This can be extended to the sample itself, in that representativeness is the degree to which the subsample that is analyzed represents the entire field sample submitted for analysis. Columbia Analytical has sample handling procedures to ensure that the sample used for analysis is representative of the entire sample. These include the *SOP for Subsampling and Compositing Aqueous and Soil Samples* (WET-SSMP) and the *SOP for Tissue Preparation* (WET-TISP). Further, analytical SOPs specify appropriate sample handling and sample sizes to further ensure the sample aliquot that is analyzed is representative in entire sample.

10.1.6 Comparability – Comparability expresses the confidence with which one data set can be compared to another and is directly affected by data quality (accuracy and precision) and sample handling (sampling, preservation, etc). Only data of known quality can be compared. The objective is to generate data of known quality with the highest level of comparability, completeness, and usability. This is achieved by employing the quality controls listed below and standard operating procedures for the handling and analysis of all samples. Data is reported in units specified by the client and using Columbia Analytical or project-specified data qualifiers.

10.2 Method Detection Limits, Method Reporting Limits, and Limits of Detection/Quantitation

Method Detection Limits (MDL) for methods performed at Columbia Analytical/Houston are determined during initial method set up and if any significant changes are made. If an MDL study is not performed annually, the established MDL is verified by performing a limit of detection (LOD) verification on every instrument used in the analysis. The MDLs are determined by following the *SOP for Performing Method Detection Limits Studies and Establishing Limits of Detection and Quantitation* (ADM-MDL), which is based on the procedure in 40 CFR Part 136, Appendix B. As required by NELAP and DoD protocols, the validity of MDLs is verified using LOD verification samples.

The Method Reporting Limit (MRL) is the lowest amount of an analyte in a sample that can be quantitatively determined with stated, acceptable precision and accuracy under stated analytical conditions (i.e. limit of quantitation - LOQ). LOQ are analyzed on an annual basis and cannot be lower than the lowest calibration standard. Current MDLs and MRLs are available from the laboratory.

NON-CONTROLLED COPY

10.3 Quality Control Procedures

The specific types, frequencies, and processes for quality control sample analysis are described in detail in method-specific standard operating procedures and listed below. These sample types and frequencies have been adopted for each method and a definition of each type of QC sample is provided below.

10.3.1 Method Blank (a.k.a. Laboratory Reagent Blank)

The method blank is an analyte-free matrix (water, soil, etc.) subjected to the entire analytical process. When analyte-free soil is not available, anhydrous sodium sulfate, organic-free sand, or an acceptable substitute is used. The method blank is analyzed to demonstrate that the analytical system itself does not introduce contamination. The method blank results should be below the Method Reporting Limit (MRL) or, if required for DoD projects, < ½ MRL for the analyte(s) being tested. Otherwise, corrective action must be taken. A method blank is included with the analysis of every sample preparation batch, every 20 samples, or as stated in the method, whichever is more frequent.

10.3.2 Calibration Blanks

For some methods, calibration blanks are prepared along with calibration standards in order to create a calibration curve. Calibration blanks are free of the analyte of interest and, where applicable, provide the zero point of the calibration curve. Additional project-specific requirements may also apply to calibration blanks.

10.3.3 Continuing Calibration Blanks

Continuing calibration blanks (CCBs) are solutions of either analyte-free water, reagent, or solvent that are analyzed in order to verify the system is contamination-free when CCV standards are analyzed. The frequency of CCB analysis is either once every ten samples or as indicated in the method, whichever is greater. Additional project-specific requirements may also apply to continuing calibration blanks.

10.3.4 Calibration Standards

Calibration standards are solutions of known concentration prepared from primary standard or stock standard materials. Calibration standards are used to calibrate the instrument response with respect to analyte concentration. Standards are analyzed in accordance with the requirements stated in the particular method being used.

NON-CONTROLLED COPY

10.3.5 Initial (or Independent) Calibration Verification Standards

Initial (or independent) calibration verification standards (ICVs) are standards that are analyzed *after* calibration but *prior to* sample analysis, in order to verify the validity and accuracy of the standards used in for calibration. Once it is determined that there is no defect or error in the calibration standard(s), standards are considered valid and may be used for subsequent calibrations and quantitative determinations (as expiration dates and methods allow). The ICV standards are prepared from materials obtained from a source independent of that used for preparing the calibration standards ("second-source"). ICVs are also analyzed in accordance with method-specific requirements.

10.3.6 Continuing Calibration Verification Standards

Continuing calibration verification standards (CCVs) are midrange standards that are analyzed in order to verify that the calibration of the analytical system is still acceptable. The frequency of CCV analysis is either once every ten samples, or as indicated in the method.

10.3.7 Internal Standards

Internal standards are known amounts of specific compounds that are added to each sample prior to instrument analysis. Internal standards are generally used for GC/MS and ICP-MS procedures to correct sample results that have been affected by changes in instrument conditions or changes caused by matrix effects. The requirements for evaluation of internal standards are specified in each method and SOP.

10.3.8 Labeled Standards

Labeled standards are organic compounds which are similar in chemical composition and chromatographic behavior to the analytes of interest, but which are not normally found in environmental samples. Depending on the analytical method, one or more of these compounds is added to method blanks, calibration and check standards, and samples (including duplicates, matrix spike samples, duplicate matrix spike samples and laboratory control samples) prior to extraction and analysis in order to monitor the method performance on each sample. The percent recovery is calculated for each labeled standard, and the recovery is a measurement of the overall method performance.

Recovery (%) = (M/T) x 100

Where: M = The measured concentration of analyte,
T = The theoretical concentration of analyte added.

10.3.9 Laboratory Control Samples

NON-CONTROLLED COPY

The laboratory control sample (LCS) is an aliquot of analyte-free water or analyte-free solid (or anhydrous sodium sulfate or equivalent) to which known amounts of the method analyte(s) is (are) added. A reference material of known matrix type, containing certified amounts of target analytes, may also be used as an LCS. An LCS is prepared and analyzed at a minimum frequency of one LCS per 20 samples, with every analytical batch or as stated in the method, whichever is more frequent. The LCS sample is prepared and analyzed in exactly the same manner as the field samples.

The percent recovery of the target analytes in the LCS is compared to established control limits and assists in determining whether the methodology is in control and whether the laboratory is capable of making accurate and precise measurements at the required reporting limit. Comparison of batch-to-batch LCS analyses enables the laboratory to evaluate batch-to-batch precision and accuracy.

Recovery (%) = (M/T) x 100

Where: M = The measured concentration of analyte,
T = The theoretical concentration of analyte added.

10.3.10 Laboratory Fortified Blanks - LFB

A laboratory blank fortified at the MRL used to verify the minimum reporting limit. The LFB is carried through the entire extraction and analytical procedure. A LFB is required with every batch of drinking water samples.

10.3.11 Matrix Spikes (a.k.a. Laboratory Fortified Sample Matrix)

Matrix spiked samples are aliquots of samples to which a known amount of the target analyte (or analytes) is (are) added. The samples are then prepared and analyzed in the same analytical batch, and in exactly the same manner as are routine samples. For the appropriate methods, matrix spiked samples are prepared and analyzed and at a minimum frequency of one spiked sample (and one duplicate spiked sample, if appropriate) per twenty samples. The spike recovery measures the effects of interferences caused by the sample matrix and reflects the accuracy of the method for the particular matrix in question. Spike recoveries are calculated as follows:

$$Recovery\ (\%) = (S - A) \times 100 \div T$$

Where: S = The observed concentration of analyte in the spiked sample,
A = The analyte concentration in the original sample, and
T = The theoretical concentration of analyte added to the spiked sample.

NON CONTROLLED COPY

10.3.12 Laboratory Duplicates and Duplicate Matrix Spikes

Duplicates are additional replicates of samples that are subjected to the same preparation and analytical scheme as the original sample. Depending on the method of analysis, either a duplicate analysis (and/or a matrix spiked sample) or a matrix spiked sample and duplicate matrix spiked sample (MS/DMS) are analyzed. The relative percent difference between duplicate analyses or between an MS and DMS is a measure of the precision for a given method and analytical batch. The relative percent difference (RPD) for these analyses is calculated as follows:

$$Relative\ Percent\ Difference\ (RPD) = (S1 - S2) \times 100 \div S_{ave}$$

Where S1 and S2 = The observed concentrations of analyte in the sample and its duplicate, or in the matrix spike and its duplicate matrix spike, and

S_{ave} = The average of observed analyte concentrations in the sample and its duplicate, or in the matrix spike and its duplicate matrix spike.

Depending on the method of analysis, either duplicates (and/or matrix spikes) or MS/DMS analyses are performed at a minimum frequency of one set per 20 samples. If an insufficient quantity of sample is available to perform a laboratory duplicate or duplicate matrix spikes, duplicate LCSs will be prepared and analyzed.

10.3.13 Interference Check Samples

An interference check sample (ICS) is a solution containing both interfering and analyte elements of known concentration that can be analyzed to verify background and interelement correction factors in metals analyses. The ICS is prepared to contain known concentrations (method or program specific) of elements that will provide an adequate test of the correction factors. The ICS is analyzed at the beginning and end of an analytical run or at a method-specified frequency. Results must meet method criteria and any project-specific criteria.

10.3.14 Post Digestion Spikes

Post digestion spikes are samples prepared for metals analyses that have an analyte spike added to determine if matrix effects may be a factor in the results. The spike addition should produce a method-specified minimum concentration above the method reporting limit. A post digestion spike is analyzed with each batch of samples and recovery criteria are specified for each method.

10.3.15 Control Charting

NON-CONTROLLED COPY

The generation of control charts is routinely performed at Columbia Analytical. Surrogate, Matrix Spike and LCS recoveries are all monitored and charted. In addition, the laboratory also monitors the Relative Percent Difference (RPD) measurement of precision. Control charts are available to each individual laboratory unit to monitor the data generated in its facility using control charts that have been programmed to identify various trends in the analytical results. If trends in the data are perceived, various means of corrective action may then be employed in order to prevent future problems with the analytical system(s). Finally, data quality reports using control charts are generated for specific clients and projects pursuant to contract requirements.

10.3.16 Glassware Washing

Glassware washing and maintenance play a crucial role in the daily operation of a laboratory. The glassware used at Columbia Analytical undergoes a rigorous cleansing procedure prior to every usage. A number of SOPs have been generated that outline the various procedures used at Columbia Analytical; each is specific to the end-use of the equipment as well as to the overall analytical requirements of the project. In addition, other equipment that may be routinely used at the laboratory is also cleaned following instructions in the appropriate SOP.

11.0 DATA PROCESSING, VALIDATION, AND REPORTING

Columbia Analytical reports the analytical data produced in its laboratories to the client via the certified analytical report. This report includes a transmittal letter, a case narrative, client project information, specific test results, quality control data, chain of custody information, and any other project-specific support documentation. The following procedures describe our data reduction, validation and reporting procedures.

11.1 Data Reduction and Review

Results are generated by the analyst who performs the analysis and works up the data. All data is initially reviewed and processed by analysts using appropriate methods (e.g., chromatographic software, instrument printouts, hand calculation, etc.). Equations used for calculation of results are found in the applicable analytical SOPs. The resulting data set is either manually entered (e.g., titrimetric or microbiological data) into an electronic report form or is electronically transferred into the report from the software used to process the original data set (e.g., chromatographic software). Once the complete data set has been transferred into the proper electronic report form(s), it is then printed. The resulting hardcopy version of the electronic report is then reviewed by the analyst for accuracy. Once the primary analyst has checked the data for accuracy and acceptability, the hardcopy is forwarded to the supervisor or second qualified analyst, who reviews the data for errors. Where calculations are not performed using a validated software system, the reviewer rechecks a minimum of 10% of the calculations. When the entire data set has been found to be acceptable, a final copy of the report is printed and signed by the laboratory supervisor, departmental manager or designated laboratory staff. The entire data package is then placed into the appropriate service request file, and an electronic copy of the final data package is forwarded to the appropriate personnel for archival. Data review procedures are described in the *SOP for HRMS Data Review and Reporting* (HMS-DATAREV).

NON CONTROLLED COPY

Policies and procedures for manual editing of data are established. The analyst making the change must initial and date the edited data entry, without obliteration of the original entry. The policies and procedures are described in the *SOP for Making Entries into Logbooks and onto Benchsheets* (ADM-DATANTRY).

Policies and procedures for electronic manual integration of chromatographic data are established. The analyst performing the integration must document the integration change by printing both the “before” and “after” integrations and including them in the raw data records. The policies and procedures are described in the *SOP for Manual Integration of Chromatographic Peaks* (ADM-INT).

11.2 Confirmation Analysis

11.2.1 Gas Chromatographic and Liquid Chromatographic Analyses

For gas chromatographic (GC) and liquid chromatographic (LC) analyses, all positive results are confirmed by a second column, a second detector, a second wavelength (HPLC/UV), or by GC/MS analysis, unless exempted by one of the following situations:

- The analyte of interest produces a chromatogram containing multiple peaks exhibiting a characteristic pattern, which matches appropriate standards. This is limited to petroleum hydrocarbon analyses (e.g., gasoline and diesel) and does not include polychlorinated biphenyls.
- The sample meets all of the following requirements:
    1. All samples (liquid or solid) come from the same source (e.g., groundwater samples from the same well) for continuous monitoring. Samples of the same matrix from the same site, but from different sources (e.g., different sampling locations) are not exempt.
    2. All analytes have been previously analyzed in sample(s) from the same source, identified and confirmed by a second column or by GC/MS. The chromatogram is largely unchanged from the one for which confirmation was carried out. The documents indicating previous confirmation must be available for review.

NON-CONTROLLED COPY

11.2.2 Confirmation Data

Confirmation data will be provided as specified in the method. Identification criteria for GC, LC or GC/MS methods are summarized below:

- GC and LC Methods
    1. The analyte must fall within plus or minus three times the standard deviation (established for the analyte/column) of the retention time of the daily midpoint standard in order to be qualitatively identified. The retention-time windows will be established and documented, as specified in the appropriate Standard Operating Procedure (SOP).
    2. When sample results are confirmed by two dissimilar columns or detectors, the agreement between quantitative results must be evaluated. The relative percent difference between the two results is calculated and evaluated against SOP and/or method criteria.
- GC/MS Methods - Two criteria are used to verify identification:
    1. Elution of the analyte in the sample will occur at the same relative retention time (RRT) as that of the analyte in the standard.
    2. The mass spectrum of the analyte in the sample must, in the opinion of a qualified analyst or the department manager, correspond to the spectrum of the analyte in the standard or the current GC/MS reference library.

11.3 Data Review and Validation of Results

The integrity of the data generated is assessed through the evaluation of the sample results, calibrations, and QC samples (method blanks, laboratory control samples, sample duplicates, matrix spikes, trip blanks, etc.). A brief description of the evaluation of these analyses is described below, with details listed in applicable SOPs. The criteria for evaluation of QC samples are listed within each method-specific SOP. Other data evaluation measures may include (as necessary) a check of the accuracy check of the QC standards and a check of the system sensitivity. Data transcriptions and calculations are also reviewed.

Note: Within the scope of this document, all possible data assessment requirements for various project protocols cannot be included in the listing below. This listing gives a general description of data evaluation practices used in the laboratory in compliance with NELAP Quality Systems requirements. Additional requirements exist for certain programs, such as projects under the DoD QSM protocols, and project-specific QAPPs.

- Method Calibration – Following the analysis of calibration blanks and standards according to the applicable SOP the calibration correlation coefficient, average response factor, etc. is calculated and compared to specified criteria. If the calibration meets criteria analysis may continue. If the calibration fails, any problems are isolated and corrected and the calibration standards reanalyzed.
- Continuing Calibration Verification (CCV or VER) – Following the analysis of the CCV standard the percent difference is calculated and compared to specified criteria or the concentration result is compared to specific criteria. If the CCV meets the criteria analysis may continue. If the CCV fails, routine corrective action is performed and documented and a 2nd CCV is analyzed. If this CCV meets criteria, analysis may continue, including any reanalysis of samples that were associated with a failing CCV. If the routine corrective action failed to produce an immediate CCV within criteria, then either acceptable performance is demonstrated (after additional corrective action) with two consecutive calibration verifications or a new initial calibration is performed.
- Method Blank – Results for the method blank are calculated as performed for samples. If results are less than the MRL (<½ MRL for DoD projects), the blank may be reported. If not, associated sample results are evaluated to determine the impact of the blank result. If possible, the source of the contamination is determined. If the contamination has affected sample results the blank and samples are reanalyzed. If positive blank results are reported, the blank (and sample) results are flagged with an appropriate flag, qualifier, or footnote.

NON-CONTROLLED COPY

- Sample Results (Organic) – For HRGC/HRMS analyses, it is verified that the analysis was within the prescribed tune window. If not, the sample is reanalyzed. Following sample analysis and calculations (including any dilutions made) peak integrations, ion abundance ratios, and retention times are evaluated to confirm qualitative identification. Internal standard responses and labeled standard recoveries are evaluated against specified criteria. Results outside of the calibration range are diluted to within the calibration range. Results for 2,3,7,8-Tetrachlorodibenzofuran are confirmed on a second dissimilar column. If obvious matrix interferences are present, additional cleanup of the sample using appropriate procedures may be necessary and the sample is reanalyzed. When dilutions are performed the MRL is elevated accordingly and qualified. Efforts are made to meet the project MRL's including additional cleanup.
- Labeled Standard Results (Organic) – The percent recovery of each labeled standard is compared to specified control limits. If recoveries are acceptable, the results are reported. If recoveries do not fall within control limits, the sample matrix is evaluated. When matrix interferences are present or documented, the results are reported with a qualifier that matrix interferences are present. If no matrix interferences are present and there is no cause for the outlier, the sample is reprepared and reanalyzed. However, if the recovery is above the upper control limit with non-detected target analytes, the sample may be reported. All labeled standard recovery outliers are appropriately qualified on the report.
- Duplicate Sample and/or Duplicate Matrix Spike Results – The RPD is calculated and compared to the specified control limits. If the RPD is within the control limits the result is reported. If not, an evaluation of the sample is made to verify that a homogenous sample was used. Despite the use of homogenizing procedures prior to sample preparation or analysis, the sample may not be homogenous or duplicate sample containers may not have been sampled consistently. If non-homogenous, the result is reported with a qualifier about the homogeneity of the sample. Also, the results are compared to the MRL. If the results are less than five times the MRL, the results are reported with a qualifier that the high RPD is due to the results being near the MRL. If the sample is homogenous and results above five times the MRL, the samples and duplicates are reanalyzed. If re-analysis also produces out-of-control results, the results are reported with an appropriate qualifier.
- Laboratory Control Sample Results – The LCS percent recovery is calculated and compared to specified control limits. If the recovery is within control limits, the analysis is in control and results may be reported. If not, this indicates that the analysis is not in control. Samples associated with the 'out of control' LCS, shall be considered suspect and the samples re-extracted or re-analyzed or the data reported with the appropriate qualifiers. For analysis where a large number of analytes are in the LCS, it becomes more likely that some analytes (marginal exceedences) will be outside the control limits. The procedure described in the 2003 NELAC standards, Appendix D.1.1.2.1 are used to determine if the LCS is effective in validating the analytical system and the associated samples.

NON-CONTROLLED COPY

- Matrix Spike Results – The MS percent recovery is calculated and compared to specified control limits. If the recovery is within control limits the results are reported. If not, and the LCS is within control limits, this indicates that the matrix potentially biases analyte recovery. It is verified that the spike level is at least five times the background level. If not, the results are reported with a qualifier that the background level is too high for accurate recovery determination. If matrix interferences are present or results indicate a potential problem with sample preparation, steps may be taken to improve results; such as performing any additional cleanups, dilution and reanalysis, or re-preparation and reanalysis. Results that do not meet acceptance limits are reported with an appropriate qualifier.

11.4 Data Reporting

When an analyst determines that a data package has met the data quality objectives (and/or any client-specific data quality objectives) of the method and has qualified any anomalies in a clear, acceptable fashion, the data package is reviewed by a trained chemist. Prior to release of the report to the client, the Project Manager reviews and approves the entire report for completeness and to ensure that any and all client-specified objectives were successfully achieved. The original raw data, along with a copy of the final report, is filed in project files by service request number for archiving. Columbia Analytical maintains control of analytical results by adhering to standard operating procedures and by observing sample custody requirements. All data are calculated and reported in units consistent with project specifications, to enable easy comparison of data from report to report.

NON-CONTROLLED COPY

To the extent possible, samples shall be reported only if all QC measures are acceptable. If a QC measure is found to be out of control, and the data is to be reported, all samples associated with the failed quality control measure shall be reported with the appropriate data qualifier(s). The *SOP for HRMS Data Review and Reporting* addresses the flagging and qualification of data. The Columbia Analytical-defined data qualifiers, state-specific data qualifiers, or project-defined data qualifiers are used depending on project requirements. A case narrative may be written by the Project Manager to explain problems with a specific analysis or sample, etc.

For subcontracted analyses, the Project Manager verifies that the report received from the subcontractor is complete. This includes checking that the correct analyses were performed, the analyses were performed for each sample as requested, a report is provided for each analysis, and the report is signed. The Project Manager accepts the report if all verification items are complete. Acceptance is demonstrated by forwarding the report to the client.

11.5 Documentation

Columbia Analytical maintains a records system which ensures that all laboratory records of analysis data retained and available. Analysis data is retained for five years from the report date unless contractual terms or regulations specify a longer retention time. The archiving system is described in the *SOP for Report and Data Archiving* (HOU-ARCH).

11.5.1 Documentation and Archiving of Sample Analysis Data

The archiving system includes the following items for each set of analyses performed:

- Benchsheets describing sample preparation (if appropriate) and analysis;
- Instrument parameters (or reference to the data acquisition method);
- Sample analysis sequence;
- Instrument printouts, including chromatograms and peak integration reports for all samples, standards, blanks, spikes and reruns;
- Logbook ID number for the appropriate standards;
- Copies of report sheets submitted to the work request file; and
- Copies of Nonconformity and Corrective Action Reports, if necessary.

Individual sets of analyses are identified by analysis date and service request number. Since many analyses are performed with computer-based data systems, the final sample concentrations can be automatically calculated. If additional calculations are needed, they are written on the integration report or securely stapled to the chromatogram, if done on a separate sheet.

For organics analysis, data applicable to all analyses within the batch, such as HRGC/HRMS tunes, CCVs, batch QC, and analysis sequences; are kept using a separate documentation system. This system is used to archive data on a batch-specific basis and is segregated according to the date of analysis. This system also includes results for the most recent calibration curves, as well as method validation results.

NON-CONTROLLED COPY

11.6 Deliverables

In order to meet individual project needs, Columbia Analytical provides several levels of analytical reports. Standard specifications for each level of deliverable are described in Table 11-1. Variations may be provided based on client or project specifications. This includes (but is not limited to) the following specialized deliverables:

- ADEC – Alaska Department of Conservation specified data package
- ACOE/HTRW – Army Corps of Engineers specified data package and reporting requirements (HTRW, CERP, FUDS, etc.)
- AFCEE – Air Force Center for Environmental Excellence project-specific reporting

When requested, Columbia Analytical provides Electronic Data Deliverables (EDDs) in the format specified by client need or project specification. Columbia Analytical is capable of generating EDDs with many different formats and specifications. The EDD is prepared by report production staff using the electronic version of the laboratory report to minimize transcription errors. User guides and EDD specification outlines are used in preparing the EDD. The EDD is reviewed and compared to the hard-copy report for accuracy.

Table 11-1
Descriptions of Columbia Analytical Standard Data Deliverables*

Tier I. Routine Certified Analytical Report (CAR) includes the following:

1. Transmittal letter
2. Chain of custody documents and sample/cooler receipt documentation
3. Sample analytical results
4. Method blank results
5. Surrogate recovery results and acceptance criteria for applicable organic methods
6. Dates of sample preparation and analysis for all tests
7. Case narrative - **optional**

Tier II. In addition to the Tier I Deliverables, this CAR includes the following:

1. Matrix spike result(s) with calculated recovery and including associated acceptance criteria
2. Duplicate or duplicate matrix spike result(s) (as appropriate to method), with calculated relative percent difference
3. Laboratory Control Sample result(s) with calculated recovery and including associated acceptance criteria
4. Case narrative - **optional**

NON-CONTROLLED COPY

Tier III. Data Validation Package. In addition to the Tier II Deliverables, this CAR includes the following:

1. Case narrative - **required**
2. Summary forms for all associated QC and Calibration parameters, with associated control criteria/acceptance limits

Note: Other summary forms specified in QAPPs or project/program protocols, or those related to specialized analyses such as HRGC/MS will be included.

Tier IV. Full Data Validation Package.

1. All raw data associated with the sample analysis, including but not limited to:
   a. Preparation and analysis bench sheets and instrument printouts,
   b. For organics analyses, all applicable chromatograms, spectral, confirmation, and manual integration raw data. For GC/MS this includes tuning results, mass spectra of all positive hits, and the results and spectra of TIC compounds when requested.
   c. QC data,
   d. Calibration data (initial, verification, continuing, etc),
   e. Calibration blanks or instrument blanks (as appropriate to method).
2. If a project QAPP or program protocol applies, the report will be presented as required by the QAPP.

*The tier levels listed describe standard Columbia Analytical deliverable levels for all laboratory locations. Columbia Analytical/Houston routinely provides only Tier II or Tier IV deliverables.

12.0 PERFORMANCE AND SYSTEM AUDITS

Quality audits are an essential part of Columbia Analytical/Houston's quality assurance program. There are two types of audits used at the facility: System Audits are conducted to qualitatively evaluate the operational details of the QA program, while Performance Audits are conducted by analyzing proficiency testing samples in order to quantitatively evaluate the outputs of the various measurement systems.

12.1 System Audits

The system audit examines the presence and appropriateness of laboratory systems. External system audits of Columbia Analytical/Houston are conducted regularly by various regulatory agencies and clients. Appendix G lists the certification and accreditation programs in which Columbia Analytical/Houston participates. Copies of these certificates may be found in the laboratory front lobby. Programs and certifications are added as required. Additionally, internal system audits of Columbia Analytical/Houston are conducted regularly under the direction of the Quality Assurance Program Manager. The internal audit procedures are described in the *SOP for Conducting Internal Quality Assurance Audits* (QA-AUDIT). The internal audits are performed as follows:

NON CONTROLLED COPY

- Comprehensive lab-wide system audit – performed annually. This audit is conducted such that systems, technical operations, hardcopy data, and electronic data are assessed.
- Technical/method audits – minimum of 3 per quarter
- Hardcopy report audits – minimum of 2 per quarter.
- Chromatographic electronic data audits – each applicable instrument per quarter.

All audit findings, and corrective actions are documented. The results of each audit are reported to the Laboratory Director and Department Managers for review. Any deficiencies identified are summarized in the audit report. Managers must respond with corrective actions correcting the deficiency within a defined timeframe. Should problems impacting data quality be found during an internal audit, any client whose data is adversely impacted will be given written notification within the corrective action period (if not already provided).

Electronic data audits may be performed in conjunction with hardcopy data audits. The electronic audits focus on organic chromatographic data and include an examination of audit trails, peak integrations, calibration practices, GCMS tuning data, peak response data, use of appropriate files, and other components of the analysis. The audit also verifies that the electronic data supports the hardcopy reported data.

Additional internal audits or data evaluations may be performed as needed to address any potential data integrity issues that may arise.

12.2 Performance Audits

Columbia Analytical/Houston also participates in the analysis of interlaboratory proficiency testing (PT) samples. Participation in PT studies is performed on a regular basis and is designed to evaluate all analytical areas of the laboratory. General procedures for these analyses are described in the SOP for *Proficiency Sample Testing Analysis* (ADM-PTS). Columbia Analytical routinely participates in the following studies:

- Water Pollution (WP) and additional water parameters, 2 per year.
- Water Supply (WS) PT studies, 2 per year.
- Hazardous Waste/Soil PT studies, 2 per year.
- Other studies as required for specific certifications, accreditations, or validations.

PT samples are processed by entering them into the LIMS system as samples (assigned Service Request, due date, testing requirements, etc.) and are processed the same as field samples. The laboratory sections handle samples the same as field samples, performing the analyses following method requirements and performing data review. The laboratory sections submit results to the QA Program Manager for subsequent reporting to the appropriate agencies or study provider. Results of the performance evaluation samples and audits are reviewed by the QA PM, Laboratory Director, the laboratory staff, and the Chief Quality Officer. For any results outside acceptance criteria, the analysis data is reviewed to identify a root cause for the deficiency, and corrective action is taken and documented through nonconformance (NCAR) procedures.

NON-CONTROLLED COPY

13.0 PREVENTIVE MAINTENANCE

Preventive maintenance is a crucial element of the Quality Assurance program. Instruments at Columbia Analytical (e.g. HRGC/HRMS systems, analytical balances, etc.) are maintained under commercial service contracts or by qualified, in-house personnel. All instruments are operated and maintained according to the instrument operating manuals. All routine and special maintenance activities pertaining to the instruments are recorded in instrument maintenance logbooks. The maintenance logbooks used at Columbia Analytical contain extensive information about the instruments used at the laboratory.

An initial demonstration of analytical control is required on every instrument used at Columbia Analytical before it maybe used for sample analysis. If an instrument is modified or repaired, a return to analytical control is required before subsequent sample analyses can occur. When an instrument is acquired at the laboratory, the following information is noted in a bound maintenance notebook specifically associated with the new equipment:

- The equipment's serial number;
- Date the equipment was received;
- Date the equipment was placed into service;
- Condition of equipment when received (new, used, reconditioned, etc.); and
- Prior history of damage, malfunction, modification or repair (if known).

NON-CONTROLLED COPY

Preventive maintenance procedures, frequencies, etc. are available for each instrument used at Columbia Analytical. They may be found in the various SOPs for routine methods performed on an instrument and may also be found in the operating or maintenance manuals provided with the equipment at the time of purchase.

Responsibility for ensuring that routine maintenance is performed lies with the department supervisor. The supervisor may perform the maintenance or assign the maintenance task to a qualified bench level analyst who routinely operates the equipment. In the case of non-routine repair of capital equipment, the department supervisor is responsible for providing the repair, either by performing the repair themselves with manufacturer guidance or by acquiring on-site manufacturer repair. Each laboratory department maintains a critical parts inventory. The parts inventories include the items needed to perform necessary preventive maintenance procedures.

This inventory or "parts list" also includes the items needed to perform any other routine maintenance and certain in-house non-routine repairs. When performing maintenance on an instrument (whether preventive or corrective), additional information about the problem, attempted repairs, etc. is also recorded in the notebook. Typical logbook entries include the following information:

- Details and symptoms of the problem;
- Repairs and/or maintenance performed;
- Description and/or part number of replaced parts;
- Source(s) of the replaced parts;
- Analyst's signature and date; and
- Demonstration of return to analytical control.

See the table in Appendix E for a list of preventive maintenance activities and frequency for each instrument.

NON-CONTROLLED
COPY

14.0 CORRECTIVE AND PREVENTIVE ACTION

The laboratory takes all appropriate steps necessary to ensure all sample results are reported with acceptable quality control results. When sample results do not conform to established quality control procedures, responsible management will evaluate the significance of the nonconforming work and take corrective action to address the nonconformance.

Nonconforming events such as errors, deficiencies, deviations from SOP, proficiency (PT) failure or results that fall outside of established QC limits are documented using a *Nonconformity and Corrective Action Report* form (See Figure 14-1). The procedure and responsibilities for addressing nonconforming work is defined in the *SOP for Corrective Action* (ADM-CA). Nonconformances are reported to the client using various means (voice, email, narrative, etc). When a nonconformance occurs that casts doubt on the validity of the test results or additional client instructions are needed, the Project Manager notifies the client the same business day that the nonconformance is confirmed and reported. The QA PM reviews each problem, ensuring that appropriate corrective action has been taken by the appropriate personnel. The Nonconformity and Corrective Action Report (NCAR) is filed in the associated service request file and a copy is kept by the QA PM. The QA PM periodically reviews all NCARs looking for chronic, systematic problems that need more in-depth investigation and alternative corrective action consideration. In addition, the appropriate Project Manager is promptly notified of any problems in order to inform the client and proceed with any action the client may want to initiate.

NON-CONTROLLED COPY

If a quality control measure is found to be out of control, and the data is to be reported, all samples associated with the failed quality control measure shall be reported with the appropriate data qualifier(s). Failure to meet established analytical controls, such as the quality control objectives, prompts corrective action. Corrective action may take several forms and may involve a review of the calculations, a check of the instrument maintenance and operation, a review of analytical technique and methodology, and reanalysis of quality control and field samples. If a potential problem develops that cannot be solved directly by the responsible analyst, the supervisor, team leader, the department manager, and/or the QA PM may examine and pursue alternative solutions. In addition, the appropriate Project Manager is notified in order to ascertain if the client needs to be notified.

Part of the corrective action process involves determining the root cause. Identifying the root cause of a nonconformance can be difficult, but important for implementing effective corrective action. Root cause principles are used to determine assignable causes, which leads to corrective action taken to prevent recurrence. Various preventive action processes are used for eliminating a potential problem or averting a problem before it occurs. This is explained in the *SOP for Preventive Action* (ADM-PA).

In addition to internal communication of data issues, the laboratory also maintains a system for dealing with customer complaints. The person who initially receives the feedback (typically the Project Manager) is responsible for documenting the complaint. If the Project Manager is unable to satisfy the customer, the complaint is brought to the attention of the Laboratory Director or QA PM for final resolution. The complaint and resolution are documented. The procedure is described in the *SOP for Handling Customer Feedback* (ADM-FDBK).

Figure 14-1

Nonconformity and Corrective Action Report

NCAR No: *Assigned by QA*

PROCEDURE (SOP or METHOD): EVENT DATE: _____

EVENT:
- ☐ Missed Holding Time
- ☐ Method Blank Contamination
- ☐ Equipment Failure
- ☐ SOP Deviation
- ☐ QC Failure
- ☐ Login Error
- ☐ Unacceptable PT Sample Result
- ☐ Other (describe):
- ☐ Lab Error (spilled sample, spiking error, etc.)
- ☐ Project Management Error

INCLUDE NUMBER OF SAMPLES / PROJECTS / CUSTOMERS / SYSTEMS AFFECTED

DETAILED DESCRIPTION

ORIGINATOR: _____ DATE: _____

PROJECT MANAGER(S): _____ NOTIFIED BY: _____ DATE: _____

ROOT CAUSE OF NON-CONFORMITY (POTENTIAL CAUSES COULD BE TRAINING, COMMUNICATION, SPECIFICATIONS, EQUIPMENT, KNOWLEDGE)

What is the cause of the error or finding:

NON-CONTROLLED COPY

CORRECTIVE ACTION AND OUTCOME

Re-establishment of conformity must be demonstrated and documented. Describe the steps that were taken, or are planned to be taken, to correct the particular Nonconformity and prevent its reoccurrence. Include Project Manager Instructions here.

Is the data to be flagged in the Analytical Report with an appropriate qualifier? ☐ **No** ☐ **Yes**

APPROVAL AND NOTIFICATION

Supervisor Verification and Approval of Corrective Action _____ Date: _____
Comments:

QA PM Verification and Approval of Corrective Action _____ Date: _____
Comments:

Project Manager Verification and Approval of Corrective Action _____ Date: _____
Comments:

Customer Notified by ☐ Telephone ☐ Fax ☐ E-mail ☐ Narrative ☐ Not notified

(Attach record or cite reference where record is located.)

15.0 QUALITY ASSURANCE REPORTS AND MANAGEMENT REVIEW

Quality assurance requires an active, ongoing commitment by Columbia Analytical personnel at all levels of the organization. Communication and feedback mechanisms are designed so that analysts, supervisors and managers are aware of QA issues in the laboratory. Analysts performing routine testing are responsible for generating a data quality narrative or data review document with every analytical batch processed. This report also allows the analyst to provide appropriate notes and/or a narrative if problems were encountered with the analyses. A Nonconformity and Corrective Action Report (NCAR) (see Section 14.0) may also be attached to the data prior to review. Supervisors or qualified analysts review all of the completed analytical batches to ensure that all QC criteria have been examined and any deficiencies noted and addressed.

It is the responsibility of each laboratory unit to provide the Project Manager with a final report of the data, accompanied by signature approval. Footnotes and/or narrative notes must accompany any data package if problems were encountered that require further explanation to the client. Each data package is submitted to the appropriate Project Manager, who in turn reviews the entire collection of analytical data for completeness and to ensure that any and all client-specified objectives were successfully achieved. A case narrative is written by the Project Manager to explain any unusual problems with a specific analysis or sample, etc.

NON-CONTROLLED COPY

The QA PM provides overview support to the Project Managers as required (e.g., contractually specified, etc.). The QA PM is also responsible for the oversight of all internal and external audits, for all proficiency testing sample and analysis programs, and for all laboratory certification/accreditation responsibilities. The QA PM provides the Laboratory Director with quarterly reports that summarize the various QA/QC activities that occurred during the previous quarter. The report addresses such topics as the following:

- Status, schedule, and results of internal and external audits;
- Status, schedule, and results of internal and external proficiency testing studies;
- Status of certifications, accreditations, and approvals;
- Status of QA Manual and SOP review and revision;
- Status of MDL studies;
- Discussion of QC problems in the laboratory;
- Discussion of corrective action program issues;
- Status of staff training and qualification; and
- Other topics as appropriate.

An annual management review of the quality and testing systems is perfomed as described in the *SOP for Managerial Reviews of the Laboratory's Quality Systems and Testing Activities* (ADM-MGMTRVW). This is done to identify any necessary changes or improvements to the quality system or quality assurance policies. This review is documented in a Managerial Review of the Laboratory's Quality Systems and Testing Activities and sent to senior management.

16.0 PERSONNEL TRAINING

Technical position descriptions are available for all employees, regardless of position or level of seniority. These documents are maintained by the Human Resources personnel and are available for review. In order to assess the technical capabilities and qualifications of a potential employee, all candidates for employment at Columbia Analytical are evaluated, in part, against the appropriate technical description.

Training begins the first day of employment at Columbia Analytical when the company policies are presented and discussed. Safety and QA/QC requirements are integral parts of all technical SOPs and, consequently, are integral parts of all training processes at Columbia Analytical. Safety training begins with the reading of the *Environmental Health and Safety Manual.* Employees are also required to attend periodic safety meetings where additional safety training may be performed by the Environmental, Health and Safety Officer.

Employees are responsible for complying with the requirements of the QA Manual and QA/QC requirements associated with their function(s). Quality Systems training begins with Quality Assurance orientation for new employees and reading the Quality Assurance Manual. During the employee's first year, the employee attends Core Ethics training and learns about Columbia Analytical Services quality systems. Each employee participates in annual Ethics Refresher training, which is part of the Columbia Analytical Improper Practices Prevention Program.

NON-CONTROLLED COPY

Columbia Analytical also encourages its personnel to continue to learn and develop new skills that will enhance their performance and value to the Company. Ongoing training occurs for all employees through a variety of mechanisms. The corporate, company-wide training and development program, external and internal technical seminars and training courses, and laboratory-specific training exercises are all used to provide employees with professional growth opportunities.

All technical training is documented and records are maintained in the QA department. Training requirements and its documentation are described in the *SOP for Documentation of Training.* (ADM-TRANDOC). A training plan is developed whenever an employee starts a new procedure or new position. The training plan includes a description of the step-by-step process for training an employee and for initial demonstration of capability. Where the analyst performs the entire procedure, a generic training plan may be used.

16.1 Initial Demonstration of Capability (IDOC)

Training in analytical procedures typically begins with the reading of the Standard Operating Procedure (SOP) for the method. Hands-on training begins with the observation of an experienced analyst performing the method, followed by the trainee performing the method under close supervision, and culminating with independent performance of the method on quality control samples. Successful completion of the applicable Demonstration of Capability analysis qualifies the analyst to perform the method independently. Demonstration of Capability is performed by one of the following:

- Successful completion of an Initial Precision and Recovery (IPR) study (required where mandated by the method).
- Analysis of four consecutive Laboratory Control Samples, with acceptable accuracy and precision.
- Where spiking is not possible but QC standards are used ("non-spiked" Laboratory Control Samples), analysis of four consecutive Laboratory Control Samples with acceptable accuracy and precision.
- Where one of the three above is not possible, special requirements are as follows:
    - Total Settleable Solids: Successful single-blind PT sample analysis and duplicate results with RPD<10%.
    - Color: Four consecutive prepared LCSs with acceptable accuracy and precision of <10% RSD.
    - Physical Tests (Grain size, Corrosivity to Steel, etc.): Supervisor acknowledgement of training and approval.

NON-CONTROLLED COPY

A flowchart identifying the Demonstration of Proficiency requirements is given in Figure 16-1. The flowchart identifies allowed approaches to assessing Demonstration of Capability when a four-replicate study is not mandated by the method, when spiking is not an option, or when QC samples are not readily available.

16.2 Continuing Demonstration of Proficiency

A periodic demonstration of proficiency is required to maintain continuing qualification. Continuing Demonstration of Proficiency is required each year, and may be performed one of the following ways:

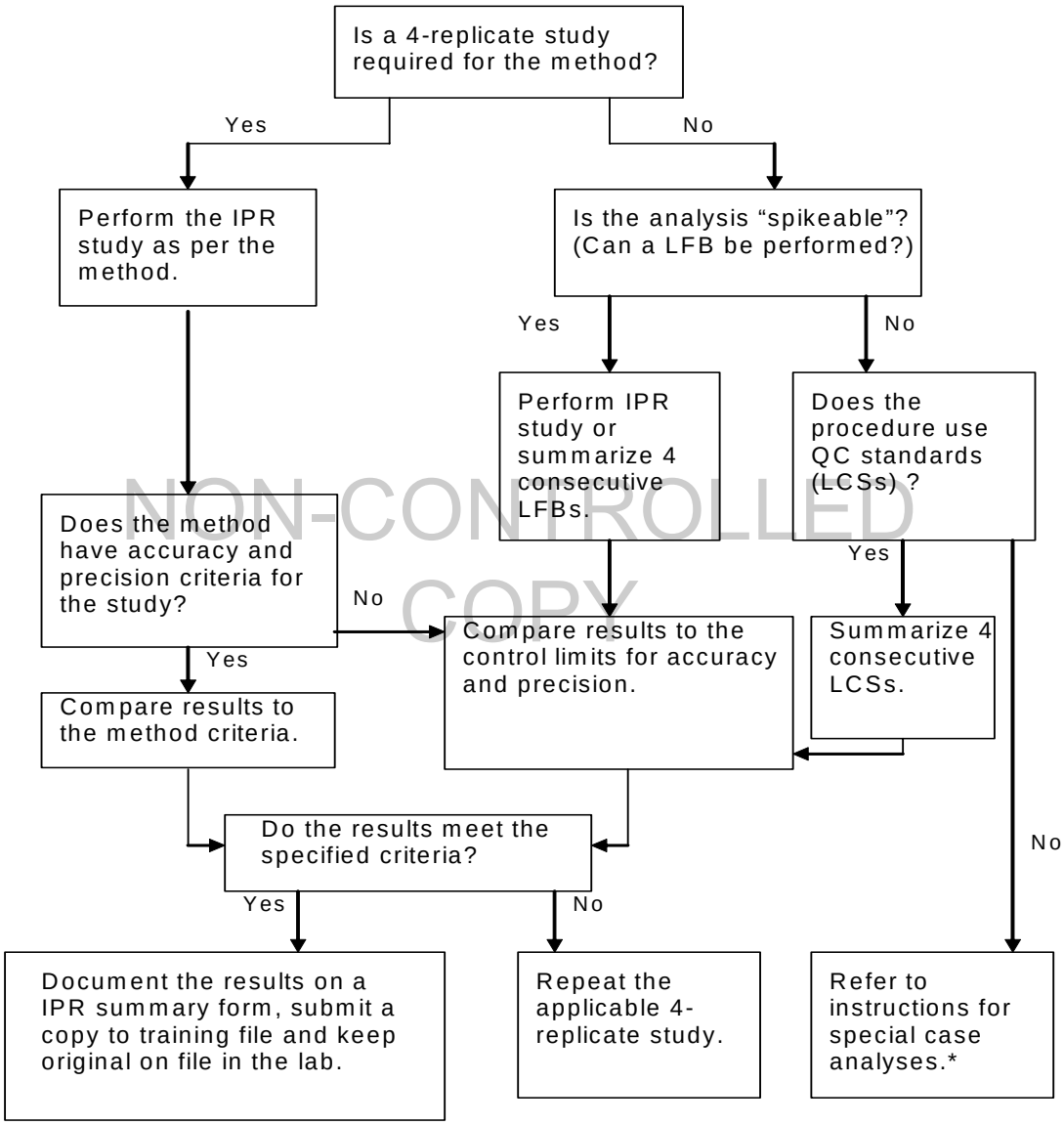
- Successful performance on external (independent) single-blind sample analyses using the test method, or a similar test method using the same technology, i.e. PT sample or QC sample blind to the analyst.
- Performing Initial Demonstration of Capability as described above, with acceptable levels of precision and accuracy.
- Analysis of at least four consecutive LCSs with acceptable levels of accuracy and precision from in-control analytical batches.
- If the above cannot be performed, analysis of authentic samples with results statistically indistinguishable from those obtained by another trained analyst.
- For methods for which PT samples are not available and a spiked analysis (LFB, MDL, etc.) is not possible, analysis of field samples that have been analyzed by another analyst with statistically indistinguishable results.

16.3 Documentation of Training

Records are maintained to indicate the employee has the necessary training, education, and experience to perform their functions. Information of previously acquired skills and abilities for a new employee is maintained in Human Resources personnel files and Columbia Analytical resumes. QA maintains a database to record the various technical skills and training acquired while employed by Columbia Analytical. Information includes the employee's name, a description of the skill including the appropriate method and SOP reference, the mechanism used to document proficiency, and the date the training was completed. General procedures for documenting technical training are described in the *SOP for Documentation of Training* (ADM-TRANDOC).

NON-CONTROLLED
COPY

Figure 16-1
Initial Demonstration of Capability Requirements[a]



NON-CONTROLLED COPY

[a] For IDOC IPR or LFB studies, "second-source" reference materials are used, as per NELAP requirements
* Refer to the *SOP for Documentation of Training* (ADM-TRANDOC) for details.

17.0 REFERENCES FOR QUALITY SYSTEMS, EXTERNAL DOCUMENTS, MANUALS, STANDARDS, AND ANALYTICAL PROCEDURES

The analytical methods used at Columbia Analytical generally depend upon the end-use of the data. Since most of our work involves the analysis of environmental samples for regulatory purposes, specified federal and/or state testing methodologies are used and followed closely. Typical methods used at Columbia Analytical are taken from the following references:

- National Environmental Laboratory Accreditation Program (NELAP), 2003 Quality Standards.
- National Environmental Laboratory Accreditation Program (NELAP), 2009 TNI Quality Standards.
- American National Standard *General requirements for the competence of testing and calibration laboratories,* ANSI/ISO/IEC 17025:2005(E)
- *Department of Defense Quality Systems Manual for Environmental Laboratories*, Final Version 3 (January 2006).
- *DoD Quality Systems Manual for Environmental Laboratories,* Version 4.1, 4/22/2009
- *Good Automated Laboratory Practices, Principles and Guidance to Regulations For Ensuring Data Integrity In Automated Laboratory Operations*, EPA 2185 (August 1995).
- *Manual for the Certification of Laboratories Analyzing Drinking Water*, 4th Edition, EPA 815-B-97-001 (March 1997).
- *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, SW-846, Third Edition, (September 1986) and Updates I (July 1992), II (September 1994), IIA (August 1993), IIB (January 1995), III (December 1996), Final Update IV (February 2007), and updates posted online at http://www.epa.gov/epaoswer/hazwaste/test/sw846.htm. See Chapters 1, 2, 3, and 4.
- *Methods for Chemical Analysis of Water and Wastes*, EPA-600/4-79-020, (Revised March 1983).
- *Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater*, EPA 600/4-82-057 (July 1982) and 40 CFR Part 136, Appendix A.
- *Methods for the Determination of Organic Compounds in Drinking Water*, EPA/600/4-88/039 (December 1988) and Supplements.
- *Standard Methods for the Examination of Water and Wastewater*, 18th Edition (1992); 19th Edition (1995), 20th Edition (1998). See Introduction in Part 1000.
- 40 CFR Part 136, Guidelines for Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act.
- 40 CFR Part 141, National Primary Drinking Water Regulations.
- Annual Book of ASTM Standards, Part 31, Water.

NON CONTROLLED COPY

- EPA Contract Laboratory Program, Statement of Work for Analysis of Chlorinated Dibenzo-p-dioxins (CDDs) and Chlorinated Dibenzofurans (CDFs), SOW Nos. DLM02.0 and DLM02.2.
- EPA Contract Laboratory Program, Statement of Work for Analysis of Chlorinated Biphenyl Congeners (CBC), SOW Nos. CBC01.0 and CBC01.2.
- *U. S. EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, EPA-540/R-94/012 (February 1993).
- *U. S. EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, EPA-540/R-94/013 (February 1994).
- *U. S. EPA Contract Laboratory Program National Functional Guidelines for Dioxin/Furan Data Review,* EPA-540/R-05/001 (September 2005).
- National Institute for Occupational Safety and Health (NIOSH) *Manual of Analytical Methods*, Third Edition (August 1987); Fourth Edition (August 1994).
- *Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound*, for USEPA and USACE (March 1986), with revisions through April 1997.
- *Identification and Listing of Hazardous Waste,* California Code of Regulations, Title 22, Division 4.5, Chapter 11.
- *Analytical Methods for the Determination of Pollutants in Pulp and Paper Industry Wastewater*, EPA 821-R-93-017 (October 1993).
- *Analytical Methods for the Determination of Pollutants in Pharmaceutical Manufacturing Industry Wastewaters*, EPA 821-B-98-016 (July 1998).
- National Council of the Pulp and Paper Industry for Air and Stream Improvement (NCASI).

NON-CONTROLLED COPY

NON-CONTROLLED COPY

APPENDIX A

LIST OF QA PROGRAM DOCUMENTS AND STANDARD OPERATING PROCEDURES

Columbia Analytical Quality and Ethics Policy Statement

CAS Quality and Ethics Policy Statement
March 2009

Columbia Analytical Services (CAS) vision is simple. We strive to be the best in everything we do. This includes ethics and professional practice where CAS is committed to the highest standards of ethical behavior and quality of its analytical testing.

Unethical behavior carries a heavy price - one that we do not want to bear. This includes loss of reputation, loss of business, civil and criminal penalties, and government and customer sanctions.

CAS is committed to excellence and superior performance in everything we do. We will not sacrifice our ethical principles in order to achieve business success. This means we will always strive to conduct business honestly and with integrity. We will always follow and obey the law of the land in which we are operating our business. We will always follow, to the best of our ability, standard operating procedures, rules and regulations that apply to our industry and specifically to our laboratory operations. Our customers, employees, suppliers and communities that we serve expect and deserve nothing less than the highest standards of conduct and compliance.

NON-CONTROLLED COPY

The following are the critical elements of the Quality and Ethics program at CAS.

- The Executive Management and Board of Directors of CAS sponsor and support the Quality and Ethics program through their personal commitment and by providing the necessary resources to promote this program throughout the organization.
- Chief Quality and Ethics Officer. The position is responsible for the quality and ethics program, ensures that appropriate resources are provided, reviews and recommends changes in the program, and resolves ethical and quality issues brought to management attention. This Officer reports directly to the Board of Directors Audit Committee on quality and ethics.
- Core Values. The CAS Statement of Core Values was developed internally with input from the entire company. We are committed to ensuring the integrity and quality of data, and meeting the needs of our clients, while conducting business with high ethical standards. We hold strong to the core values of Honor, Truth, and Fairness. We are committed to these values and rely on them when confronted by difficult choices.
- Ethical Code of Conduct. As a member of the American Council of Independent Laboratories (ACIL) and part of the laboratory industry, CAS subscribes to and supports the core values and ethical codes established by this industry organization.

Columbia Analytical Quality and Ethics Policy Statement (cont.)

Columbia Analytical Services™

- CAS Code of Conduct. CAS requires its employees to be introduced to and to sign the "CAS Commitment to Excellence in Data Quality" statement and to comply with standards outlined in Section 6, Employee Conduct, of our Employee Handbook. All personnel concerned with analytical testing activities within the laboratory are required to acquaint themselves with the quality documentation and to implement these policies and procedures in their work.
- Open Door Policy. Employees have the right and obligation for open communications to ask questions, seek guidance, and report incorrect practices and wrong doing without fear of retribution. As described in the CAS Open Door Policy; CAS believes in using the chain-of-command channels for this dialogue. However, if there is fear or a concern that using this approach is not appropriate, employees are free to take their concerns to the President, the Director of Human Resources, the Chief Administrative Officer, the Chief Quality Officer, or the company Ombudsman. Employees may do so without fear of retribution.
- Ombudsman Program. CAS has implemented an external ombudsman/hotline program through EthicsPoint, a phone and internet-based reporting system, to enhance communication and empower employees to promote safety, security, and ethical behavior. Employees can file a report anonymously to address issues in the workplace and to cultivate a positive work environment.
- Internal Audits. Policies are established to ensure that internal systems and data audits are conducted periodically in addition to external agency and client audits. The data audits include a detailed in-depth review of hardcopy data and electronic data to ensure compliance with the CAS Quality program and on-going data integrity.
- NELAP Accreditation. CAS management is committed to compliance with the NELAP standards. CAS maintains NELAP accreditation and as such includes quality systems documented in QA Manuals, documented procedures in Standard Operating Procedures (SOPS) and policies, and documented training for demonstration of capabilities.
- Ethics Training. CAS has the obligation to provide training to its employees with respect to company policies concerning business conduct. This includes introductory training on this, and related policies, at the time of hire; in-depth "core" training within one year of hire, and on-going refresher training on a semi-annual basis.

NON-CONTROLLED COPY

The CAS Quality and Ethics Program has been in place for several years. However, this is a "living" program that will change and improve as the company grows and changes.

Steve Vincent, President/CEO — Date: 3-19-09

Lee Wolf, Chief Quality/Ethics Officer — Date: 3-19-09

Columbia Analytical/Houston Approved Signatories

The following Columbia Analytical/Houston employees are authorized to issue certified analytical reports and sign other critical documents (such as QAPPs, other program protocols, etc.) In the event that these individuals are not available, an assigned designee or the Chief Operating Officer may approve these documents.

Employee:	Position:
Xiangqiu Liang	Laboratory Director
Lan Le	Technical Director
Andrew Biddle	Quality Assurance Program Manager
Darren Biles	Project Manager
Nicole Brown	Project Manager
Michael Cosson	Data Review, Data Processing, and Assembly Department Supervisor
Arthi Kodur	SMO/Extractions Department Supervisor

NON-CONTROLLED
COPY

Columbia Analytical/Houston QA Program Documents

Quality Assurance Manual	08/20/10
Software Quality Assurance Plan	07/11/05
Columbia Analytical/Houston Certification List	Houston Certification List FY11.doc
Columbia Analytical/Houston MDL Tracking Spreadsheet	QA Log.xls
Technical Training Summary Database	QA Log.xls
Approved Signatories List	AppSignatories.pdf
Personnel Resumes/Qualifications	Corporate HR Department
Personnel Job Descriptions	Corporate HR Department
Data Quality Objectives Spreadsheets	Quality Assurance Department
Master Logbook of Laboratory Logbooks	Quality Assurance Department
Standard Operating Procedure Database	QA Log.xls

NON-CONTROLLED
COPY

Columbia Analytical Job Descriptions

Analyst I

Entry level analyst position within the laboratory. Employee performs routine tasks in the lab under close supervision or by following detailed instructions. Progressively learning methods and procedures commonly used. Entry level skills performed at this level include titrations, gravimetric, and volumetric measurements, and routine small instrument use. Duties performed are routine in nature with a limited number of alternatives available. Work is closely supervised and reviewed.

Analyst II

Analyst at this position is progressively developing a proficiency performing a variety of analyses including instrumental and wet chemistry techniques. He/she has a mastery of the basic laboratory skills and has the ability to work with moderate supervision following project assignment. Able to identify problems and take corrective action on own work within the range of alternatives available.

Analyst III

Analyst at this position is progressively developing a proficiency performing a variety of analysPosition requires a complete level of knowledge and understanding in a specific application of laboratory principles and practices. An analyst at this level should be proficient in applicable scientific procedures and techniques to independently conduct tests or experiments for scientific projects as assigned and provide initial analyses of results for the supervisor.
Performs non-routine assignments of substantial variety and complexity under general supervisory direction. Receives objectives and technical advice from supervisor of project scientist. Compiles data and computes results on a variety of scientific procedures and techniques according to standard operation procedures. May assist in the training of junior analysts and technical assistants.es including instrumental and wet chemistry techniques. He/she has a mastery of the basic laboratory skills and has the ability to work with moderate supervision following project assignment. Able to identify problems and take corrective action on own work within the range of alternatives available.

NON-CONTROLLED COPY

Senior Analyst

Position requires an advanced level of knowledge and understanding of vocational field containing recognized formal principles and practices, complete knowledge in multiple fields, or full competence in a specialized skill or field encompassing the major business function of the Company. Examples of such skill areas would include gas chromatography, mass spectrometry, emissions spectrometry, AA, TOC, and TOX.
Position may direct work of other analyst, as lead analyst on an on-going basis, or as a project analyst on a project basis.
Performs non-routine and complex technical assignments involving responsibility for planning and conducting a complete project of limited scope or a portion of a larger and more diverse project.
Requires well-developed interpersonal skills in training junior analysts and assisting scientists with assigned tasks.

Columbia Analytical Job Descriptions (cont.)

Scientist I

As an entry-level scientist, the focus is on developing basic laboratory skills, learning routine tests, and using some instrumentation. Progressively learning and utilizing entry level applications of specialized methods, techniques, and instrumentation, including AA, IPC, and GC. Performs competently with entry-level scientific instrumentation and methods and is responsible for data interpretation, quality control, and reporting of own work. May prepare, or assist in preparing, standard operating procedures, and specifications for process and test. Handles routine maintenance and troubleshooting of instrumentation. Develops quality assurance skills, supervisory responsibilities, technical report writing, and project managements skills. May assist in training of analysts and technical assistants, and instruct lower level staff on routine project set-ups. Will assist the supervisor and/or senior scientists in setting up more complex procedures.
Requires moderately close supervision by experienced staff.

Scientist II

Performs work requiring the application of a specialized field of chemical analysis and ingenuity in the independent evaluation, selection, and adaptation of standard methods and techniques. Progressively learning and utilizing intermediate applications of specialized methods techniques. Performs competently with entry-level scientific instrumentation and methods and is responsible for data interpretation, quality control, and reporting of own work. Prepares standard operating procedures and specifications for process and test. Handles routine maintenance and troubleshooting of instrumentation.
Progressively developing quality assurance and project management skills, becoming involved with more complex analytical systems, technical report writing, and possible client interface. May assist in training of analyst and technical assistants, and instruct lower level staff on more complex project set-ups. Will assist the supervisor and/or senior scientists in setting up more complex procedures.
Works independently with only moderate supervision by experienced staff.

NON-CONTROLLED COPY

Scientist III

Performs work requiring the application of a specialized field of chemical analysis and ingenuity in the independent evaluation, selection, and adaptation of standard methods and techniques. Progressively learning and utilizing intermediate applications of specialized methods techniques. Performs competentlyPerforms work requiring the application of a specialized field of chemical analysis and ingenuity in the independent evaluation, selection, and adaptation of standard methods and techniques. May have expertise in several areas of analytical chemistry or have specific skills in a highly specialized, technical operation, such as GC/MS or metals analysis. Performs competently with intermediate to advanced interments and methods and is responsible for data interpretation, quality control and reporting of own work. Prepares standard operating procedures and specifications for process and test. Handles routine maintenance and troubleshooting of instrumentation.

Columbia Analytical Job Descriptions (cont.)

Progressively developing quality assurance skills, supervisory responsibilities, and project management skills, becoming involved with more complex analytical systems, technical report writing, and client interface. May assist in training of analysts and technical assistants, and instruct lower level staff on more complex project set-ups. Will assist the supervisor and/or senior scientists in setting up more complex procedures.
May serve as a team leader, or back up supervisor, overseeing three to eight employees. As such, will be responsible for ensuring conformance to company policies and applicable laws and regulations. Responsibilities may include interviewing, selecting and training employees; planning, assigning and directing work; evaluating performance; rewarding and disciplining employees; and addressing complaints and resolving problems. May be asked to perform other duties of a similar nature or level of responsibility.
Works independently, with only moderate supervision by experienced staff. with entry-level scientific instrumentation and methods and is responsible for data interpretation, quality control, and reporting of own work. Prepares standard operating procedures and specifications for process and test. Handles routine maintenance and troubleshooting of instrumentation.
Progressively developing quality assurance and project management skills, becoming involved with more complex analytical systems, technical report writing, and possible client interface. May assist in training of analyst and technical assistants, and instruct lower level staff on more complex project set-ups. Will assist the supervisor and/or senior scientists in setting up more complex procedures.
Works independently with only moderate supervision by experienced staff.

NON-CONTROLLED COPY

Scientist IV

Typically viewed as the department or laboratory technical specialist for particular area of expertise. At this level, the laboratory scientist's career path begins to fork in two directions. Those exhibiting both the desire and ability for management will enter the management track, while those whose strength and interests lie more in the scientific realm will follow this one. There may, however, be lateral movement between the two tracks.
A senior level scientist performs work requiring the application of a specialized field of chemical analysis and ingenuity in the independent evaluation, selection, and adaptation of standard methods and techniques. Performs competently with complex instruments and methods and is responsible for data interpretation, quality control and reporting of own work. Plans, conducts, and supervises (as a lead) complex analyses requiring advanced instrumentation such as IPC/MS, GC/MS, and GC. Handles routine and advanced maintenance and troubleshooting of instrumentation.
Works comfortably with complex analytical systems, technical report writing, and client interface. Assists in training of staff scientist, analysts and technical assistants, and instructing entry level staff on more complex project set ups. Will assist the supervisor and/or other senior scientists in setting up more complex procedures. Serves as technical advisor for teams and projects. May be asked to perform other duties of a similar nature or level of responsibility. May present formal technical training seminars to both clients and staff.
Works independently, under little supervision.

Columbia Analytical Job Descriptions (cont.)

Project Manager

A project manager is an individual who works with customers to determine their analytical needs, coordinates with CAS laboratory and administrative staff to ensure that these needs are understood, and ensures that the service CAS provides adequately meets these defined needs.

1. Client Responsibilities
   - Establish a working relationship with client.
   - Identify clients analytical needs and how the lab can address these needs.
   - Plan analytical program to meet these needs.
   - Keep client informed of progress of work.
   - Report findings and results back to client.
   - Communicate client concerns/issues to lab management.
   - Keep client informed of new developments and lab services.
   - Provides quotations and job specifications for specific work.
2. Project Responsibilities
   - Work with client and lab to define project specifications.
   - Communicate project schedule to lab.
   - Work with Sample Management to ensure proper type and number containers are provided.
   - Review incoming work to ensure work requests are properly specified according to project requirements.
   - Track as required projects through the lab keeping client and lab personnel appraised of progress.
   - Prepare, review, and approve invoices for specific work orders.
3. Reporting and QA/QC Responsibilities
   - Ensure consistent reporting formats for clients.
   - Review reported data against historical results for consistency.
   - Responsible for meeting QA objectives for specified projects.
   - Approves certified analytical reports.
   - Brings problems or issues relative to work to the QA Coordinator, Lab Operations, or Lab Management for study and resolution.
   - At times may be involved with QAP development.
   - May participate in specific marketing activities (i.e., trade show booths), if appropriate.
   - Identifies and communicates to management on new marketing opportunities and other issues.
   - Works closely with SMO, Lab Operations, QA/QC, and administrative staff to keep everyone informed as appropriate on client issues and projects.

NON-CONTROLLED COPY

Columbia Analytical Job Descriptions (cont.)

Business Development Manager

Responsible for supporting the marketing efforts of a region's upper management, sales force, and technical staff. Accountable for the quality and timeliness of all work produced and for coordinating client development efforts with other branch offices. Establishes and maintains contact with smaller clients to market the company's services. Creates client awareness of company services and their applications. Develops and maintains a staff client orientation through training and team-building exercises. Conducts local market research, coordinates and recommends marketing strategies, identifies target markets, and is responsible for consolidating marketing plans into the branch business development plan. Budgets and controls annual business development expenditures while reviewing and approving branch activities and budgets to minimize redundancy and waste.
Prepares and updates an accurate Business Portfolio Analysis and Client Market Profile by branch. Coordinates and assists in developing strategic and tactical marketing plans for the region as well as for other local operations. Prepares standardized market information collection, distribution and utilization formats, and procedures for regional marketing staff use. Also conducts market analysis.

Quality Assurance Program Manager

NON-CONTROLLED COPY

Accountable for the conduct of the Quality Assurance (QA) program for a branch laboratory. Is generally responsible for all branch laboratory QA activities and maintaining QA related documents. Accountable for obtaining and maintaining certifications and accreditations and maintaining laboratory proficiency testing programs.
Responsible for the overall coordination of the laboratory QA program and for ensuring that quality objectives established by management, certification programs, and project plans are met. Responsible for Quality Assurance functions including the Quality Assurance Manual, documentation of certifications, documenting standard operating procedures, and maintaining proficiency testing records. Oversees balance calibration and sample storage temperature control. Maintains certifications/accreditations for regulatory agencies and client certification or approval programs. Acts as primary point of contact during laboratory audits and coordinates the audit schedule with laboratory and audit staff. Provides audit responses and initiates any changes in procedures resulting from an audit. Coordinates the analysts of proficiency testing samples required for certification/accreditation programs. Reports and reviews result s for these analyses. Conducts informal audits and makes recommendations for corrective action. Provides technical assistance to laboratory staff on QA/QC issues, project feasibility, and methods interpretation/development. Receives operational supervision from the Laboratory Direction; may receive general administrative supervision and guidance from the Corporate Chief Quality Officer.

Columbia Analytical Job Descriptions (cont.)

Technical Director

Accountable for timely performance and quality of work assigned, and may be responsible for the work of a small department, including profit and loss responsibility for the unit. Under minimal direction, plans and manages all activities relating to specific laboratory operations or may operate within a key functional area such as client services. Assist in identifying project opportunities, developing proposals, and developing and maintaining client relationships. Manages administration and project schedules, provides technical consultation services to project teams, government agencies, and clients. Responsible for quality control of laboratory work including final review of all reports for specific area of responsibility or as required. Assures that work is being performed using appropriate technology. Attends trade shows and gives marketing and client presentations as required. Encourages and directs development and application of state-of-the-art methodologies and techniques.

Personnel responsibilities include coordination of unit workloads, conducting employee performance reviews, recommending personnel changes, additions, and participation in recruiting process. Marketing responsibilities may include attending trade shows and professional conferences, authoring technical papers, and contacting existing clients and new clients to market company's capabilities.

Has high level role in data evaluation and report responsibility. Supervises, trains and develops scientists, supervisors, analysts, and technician assistants. Monitors work load and project flow through self or assigned team leaders. Monitors adherence to corporate safety plans and policies. High level client and regulatory agency contact. Participation in internal and external meetings involving project strategy and major technical issues. Monitors and reviews budget and schedule status of projects with supervisors. High financial responsibility for profit and loss considerations. Works with regional senior management in short- and long-range planning, e.g., staff requirements, primary areas of technical development, marketing program. May be asked to perform other duties of a similar nature or level of responsibility.

NON-CONTROLLED COPY

Laboratory Director

Accountable for the growth and profitability of a medium-sized branch office. Is generally responsible for all branch office staff, client relations, and marketing. Accountable for the quality and timeliness of all work produced and for coordinating work efforts with other branch offices.

Responsible for all operations within assigned region, including personnel, scheduling, coordination of daily project field and office activities. Supervised operations normally include SMO, facilities, administration, laboratory operations, and related activities. Maintains close working relationships with clients and staff and plays a key role in conflict resolution.

Directs and monitors the activities of the branch office through the appropriate supervisors, technical and administrative managers. Formulates and recommends to the Regional Regional Managers and/or President policies, procedures, plans and programs for the branch office that are commensurate with the overall objective of the region. Formulates and recommends to the Regional Regional Managers and/or President an annual operating budget for the branch office and conducts operations within approved budget limits.

Columbia Analytical Job Descriptions (cont.)

Reviews and approves organizational and key staffing assignments within the branch office. Directs periodic status reviews of major projects to ensure that technical and quality standards are being met and that the performance is within budget and schedule. Participates, as required, in project and management reviews of proposals, reports, and client contract negotiations, including final pricing of proposals. Provides counsel and information about the project's feasibility.

Responsible for branch office programs and procedures, including staff planning and development, personnel administration, and compliance with corporate policies and procedures. Stays abreast of technological developments and trends which could lead to new applications or markets, Responsible for maintaining proper and timely controls over all branch office work, ensuring that billability targets and overall profitability goals are met. Maintains good client relations and actively pursues expansion of new clients and business lines in conjunction with regional and corporate marketing goals.

Receives operational supervision from the Regional Managers and/or President; may receive general administrative supervision and guidance from the regional CAO.

NON-CONTROLLED
COPY

Columbia Analytical/Corporate Quality Assurance Program Documents

SOP Title	SOP Code	Rev	SOP Date	Date of Last Review
SOP for Checking New Lots of Chemicals for Contamination	ADM-CTMN	4	1/26/09	1/13/10
SOP for Control Limits	ADM-CTRL_LIM	7	12/14/09	12/16/09
SOP for Corrective Action	ADM-CA	6	9/15/09	9/21/09
SOP for Data Recall	ADM-DATARECALL	0	9/21/07	11/16/09
SOP for Document Control	ADM-DOC_CTRL	8	9/15/09	9/21/09
SOP for Documentation of Training	ADM-TRANDOC	11	12/17/09	12/17/09
SOP for Estimation of Uncertainty of Measurements	ADM-UNCERT	5	9/15/09	9/15/09
SOP for Handling Customer Feedback	ADM-FDBK	5	12/14/09	12/17/09
SOP for Making Entries into Logbooks and onto Benchsheets	ADM-DATANTRY	8	9/8/09	9/9/09
SOP for Managerial Review of the Laboratory's Quality Systems and Testing Activities	ADM-MGMTRVW	3	12/10/09	12/16/09
SOP for Manual Integration of Chromatographic Peaks	ADM-INT	3	8/28/07	11/16/09
SOP for Performing Method Detection Limit Studies and Establishing Limits of Detection and Quantitation	ADM-MDL	9	9/8/09	9/9/09
SOP for Preparation of Electronic-data for Organic Analyses for Electronic-data Audits	ADM-E_DATA	3	8/29/07	11/16/09
SOP for Preparation of SOPs	ADM-SOP	9	12/14/09	12/16/09
SOP for Preventive Action	ADM-PA	1	12/14/09	12/16/09
SOP for Proficiency Testing Sample Analysis	ADM-PTS	2	9/14/09	9/15/09
SOP for Purchasing and Approval of Vendors	ADM-PUR	4	10/15/09	10/19/09
SOP for Qualification of Subcontract Laboratories	ADM_SUBLAB	5	9/15/09	9/21/09
SOP for Significant Figures	ADM-SIGFIG	8	1/28/09	1/13/10

NON-CONTROLLED COPY

Columbia Analytical/Corporate Quality Assurance Program Documents (cont.)

Policy Title	Policy Date	Date Approved	Date Effective
CAS Quality and Ethics Policy Statement	March 2009	3/19/09	3/19/09
Policy for Data Review and Validation	May 2009	5/5/09	7/1/09
Policy for Internal Quality Assurance Audits	May 2009	5/5/09	7/1/09
Policy for Standards and Reagents Expiration Dates	September 2009	9/15/09	9/28/09
Policy for Use of Accreditation Organization's Name, Symbols, and Logos	September 2009	9/21/09	10/1/09
Policy for Conducting Research, Method Development, and Method Investigations	December 2009	12/15/09	12/17/09

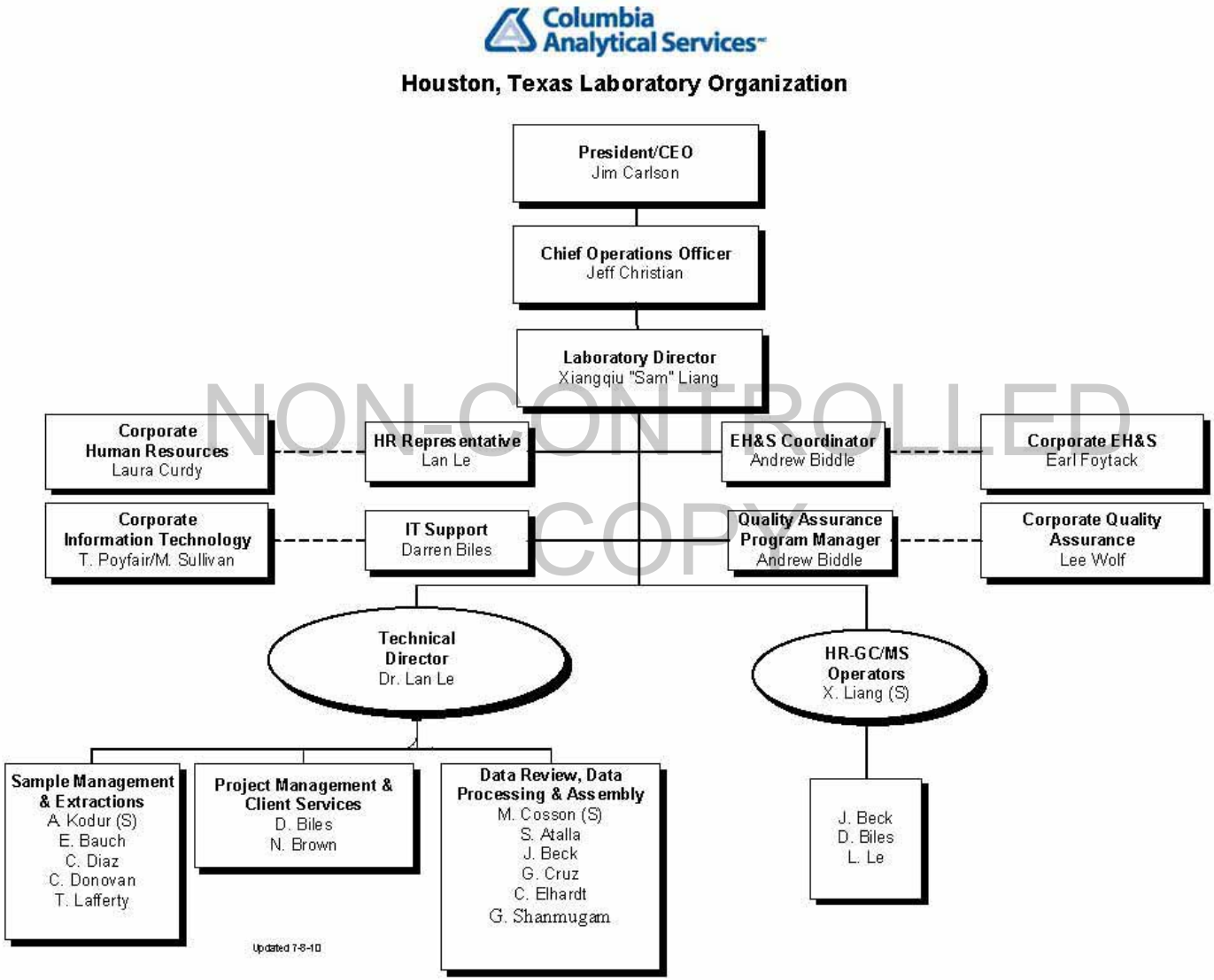
NON-CONTROLLED COPY

NON-CONTROLLED
COPY

APPENDIX B

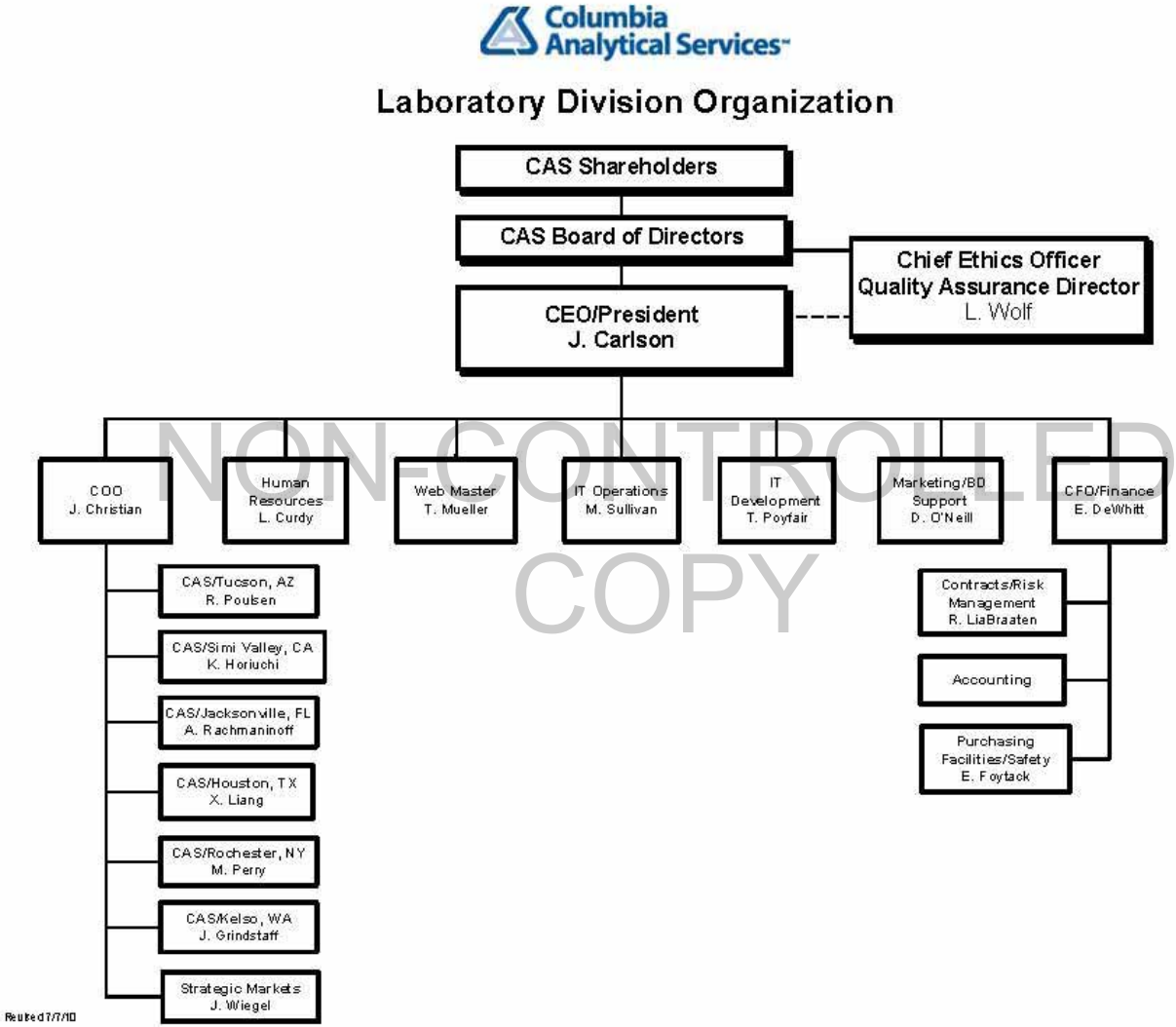
Organizational Chart and Resumes of Key Personnel

Columbia Analytical/Houston Organizational Chart



NON-CONTROLLED COPY

Columbia Analytical Laboratory Division Organizational Chart



NON-CONTROLLED COPY

Columbia Analytical Resumes for Key Personnel

ANDREW BIDDLE

2006 TO PRESENT

Columbia Analytical Services, Inc., 19408 Park Row, Ste. 320, Houston, TX 77084 800.434.6946

Current Position	**Quality Assurance Program Manager** – 2008 to Present
Responsibilities	As quality Assurance Program Manager, lead CAS/Houston's Quality Assurance/Quality Control Program. Responsible for reviewing, approving and controlling the quality systems of Columbia Analytical Services' HRMS laboratory. Facilitate the review and changes to laboratory SOPs and the QA Manual. Document training through DoCs and attestations. Manage PE samples and document adherence to standard operating procedures. Review analytical data, perform internal audits and assure compliance with external audit findings. Maintain state and federal certifications. Facilitate Quality Assurance and Ethics training. Prepare quarterly and annual quality reports to senior management. Facilitate managerial review of the Houston laboratory's Quality Assurance Program. **Documentation of Demonstration of Capabilities is available for review.**
Experience	**Scientist II**, *Columbia Analytical Services, Inc. Houston, Texas*, 2008. Extractions Supervisor. Duties primarily as listed below. **Scientist I**, *Columbia Analytical Services, Inc. Houston, Texas,* 2007-2008. Extractions Supervisor. Oversee operations in Extraction Laboratory and SMO. Primary responsibilities include sample login, extraction, cleanup, and final concentration. Aid in continuous improvement of existing methods and development of new methods. Perform non-routine and complex technical assignments. Ensure compliance with NELAC (and other accrediting authorities.) **Analyst II**, *Columbia Analytical Services, Inc., Houston, Texas,* 2006-2007. Extractions. Primary responsibilities include sample log in, extraction, clean up, and final concentration.
Education	**BS, Astrophysics,** *Rice University, Houston, Texas*, 2006.
Publications/ Presentations	
Affiliations	**Member, American Society for Quality**

NON-CONTROLLED COPY

Columbia Analytical Resumes for Key Personnel (cont.)

MICHAEL COSSON

2007 TO PRESENT

Columbia Analytical Services, Inc., 19408 Park Row, Ste. 320, Houston, TX 77084 800.434.6946

Current Position	**Group Leader, Data Processing and Reporting** – 2009 to Present
Responsibilities	Oversee operations in the processing and reporting group. Troubleshoot data reporting issues, schedule daily tasks, and meet reporting production schedules. Train new staff in the reviewing and reporting criteria for HRGC/HRMS data production, LIMS and OpusQuan. Review and process HRMS data for method and reporting compliance, assemble data packages according to project data quality objectives, assure data quality criteria meet project specifications, archive calibration data, prepare reports and case narratives, upload data into LIMS and prepare electronic data deliverables (EDDs).
	Documentation of Demonstration of Capabilities is available for review
Experience	**Scientist I,** *Columbia Analytical Services, Inc.., Houston, TX,* 2007 – 2009. Review and process HRMS data for method and reporting compliance, assemble data packages according to project data quality objectives, assure data quality criteria meet project specifications, archive calibration data, prepare reports and case narratives, upload data into LIMS and prepare electronic data deliverables (EDDs).
	Analyst III, *Columbia Analytical Services, Inc.., Houston, TX,* 2007. Responsible for reviewing reports and meeting production goals, assembling data packages, uploading data into LIMS, reviewing and archiving data calibration folders and preparing project-specific forms or data summaries. Also responsible for training new staff in the review and reporting criteria for HRMS data production.
	Laboratory Analyst, *Philip Reclamation Services, Houston, TX*, 2006-2007. Responsible for interpreting manifests, checking in samples, and performing chemical analysis of samples. Also responsible for updating waste management systems and checking for discrepancies. Served as laboratory safety committee representative.
Education	**Bachelor of Science in Biochemistry**. Florida State University, Tallahassee, Florida, 2007.
	Associate of Arts in Liberal Arts. Pensacola Junior College, Pensacola, Florida, 2003.

NON-CONTROLLED COPY

Columbia Analytical Resumes for Key Personnel (cont.)

ARTHI KODUR

2008 TO PRESENT

Columbia Analytical Services, Inc., 19408 Park Row, Ste. 320, Houston, TX 77084 800.434.694

Current Position	**Scientist I** – 2008 to Present
Responsibilities	**Group Leader, Extraction Laboratory**, *Columbia Analytical Services, Inc., Houston, Texas*, 2008. Oversee operations in Extraction Laboratory and SMO. Primary responsibilities include sample login, extraction, cleanup, and final concentration. Schedule daily tasks for extraction analysts. Run Methods 1668A, 1613B, 8280, 8290, TO-9A and 23. Aid in continuous improvement of existing methods and development of new methods. Perform non-routine and complex technical assignments.
	Documentation of Demonstration of Capabilities is available for review.
Experience	**Analyst III**, *Columbia Analytical Services, Inc., Houston, Texas*, 2007-08. Run Methods 1668A, 1613B, 8280, 8290, TO-9A and 23. Perform extractions, sulfuric acid clean up, silica gel column clean up, and blow downs/transfers. Receive and log arriving samples into CAS LIMS. Prepare and ship client bottle kit orders.
	Science Instructor, *Yancy Life, Stafford, TX*, 2008. Educate children from pre K-5th grade on basic science.
	Lab Technician, *Genetic Profiles Corporation, San Diego, CA*, 2005-2006. Acce specimens, extraction, PCR, gel electrophoresis and gel analysis.
Education	**MFS, Forensic Science**, *National University, San Diego, California*, 2007.
	BS, Genetics, *Texas A & M University, College Station, Texas*, 2005.

NON-CONTROLLED COPY

Columbia Analytical Resumes for Key Personnel (cont.)

LAN LE

2008 TO PRESENT

Columbia Analytical Services, Inc., 19408 Park Row, Ste. 320, Houston, TX 77084 800.434.6946

Current Position	**TECHNICAL MANAGER II** – 2008 to Present
Responsibilities	Manages and coordinates sample/data production, data quality, staff development and training, new method development and provides technical oversight to entire operations. Monitors adherence to corporate and local policies and procedures.
	Documentation of Demonstration of Capabilities is available for review.
Experience	**GC/MS Supervisor**, *Southern Petroleum Labs, Houston, Texas*, 1993-2008. Supervise staff of 13 scientist and technicians, oversee data collection and validation, manage calibration and maintenance of analytical instrument systems, method development, perform training, and interface with project management personnel in support of technical solutions for clients.
	Organic Supervisor, *Core Laboratories, Houston, Texas*, 1991-1993. Responsible for the Organics Laboratory including both GC/MS and GC analyses. Method interpretation and implementation. Supervised and performed both volatile and semivolatile organics determinations. Used HP-RTE data systems for data interpretation, quantitation, and reporting. Performed instrument maintenance and troubleshooting on HP 5970 GC/MS systems, autosamplers, integrators, and related analytical equipment.
	GC/MS Analyst, *MBA Laboratories, Houston, Texas*, 1988-1990. Performed environmental GC/MS analyses samples in accordance with EPA protocols using an HP 5970 GC/MS with an HP-1000 RTE data system.
	Contract Chemist, *Shell Development Company, Houston, Texas*, 1987-1988. Performed research in a group that developed an expert system for analyzing spectra obtained from a variety of samples, including polymers and heavy oils, which had undergone neutron irradiation.
	Contract Chemist, *Exxon Research & Engineering Company, Baytown, Texas*, 1989-1987. Worked in a research group that developed and expert system for data interpretation for GC/MS hydrocarbon analyses, including naphthas and kerosene.
	Chemistry Researcher, *University of Houston, Chemistry Department, Houston, Texas*, 1983-1987. Developed and authored a Reversed Phase-HPLC method on neutral surfactants. Studied varying HPLC gradients and performance factors.
	Water Chemist, *City of New Orleans, New Orleans, Louisiana*, 1981-1982. Performed a variety of wet bench and GC analyses on water and wastewater samples.
Education	**PhD, Chemistry**, *University of Houston, Houston, Texas*, 1987.
	BS, Chemical Engineering, *Kansas State University, Manhattan, Kansas*, 1981.
Publications/ Presentations	*Expert Systems for the Analytical Laboratory,* Demonchy, A.R.; Aretteig, J.R.; Le, L., and Deming, S.N., Analytical Chemistry, 60, 1355A, 1988.

NON-CONTROLLED COPY

Columbia Analytical Resumes for Key Personnel (cont.)

XIANGQIU LIANG

2000 TO PRESENT

Columbia Analytical Services, Inc., 19408 Park Row, Ste. 320, Houston, TX 77084 800.434.6946

Current Position	**LABORATORY DIRECTOR** – 2000 to Present
Responsibilities	Laboratory Director. Managing HR-GCMS instrumentation, sample/data production, data quality, staff development and training, computers, new method development, profitability of the laboratory and sustain the business growth.
	Documentation of Demonstration of Capabilities is available for review.
Experience	**Senior Chemist**, *Southwest Lab of Oklahoma, Broken Arrow, OK*, 1993-2000. Responsibilities included production of data and development of methods for HRMS and LRMS- dioxins and furans, PAHs and PCBs. Also trained staff, coordinated activities with other laboratory departments, maintained the analytical instrumentation and the networked computer system (DECNET and LIMS).
	Analytical Laboratory Supervisor, *Triangle Labs, Sugarland, TX*, 1990-1993. Responsibilities included supervision of the production delivery schedules and maintenance of production instrumentation. Laboratory production activities included adhering to established data quality systems and preparing data packages for validation by a third-party assessor.
	VAX Operator, *Canata Computer Center, University of Houston, TX*, 1988-1990. Responsibilities included network maintenance. Also responsible for archiving data according to established procedures.
	Research Assistant, *University of Houston, TX*, 1987-1990. Responsibilities included project and grant assistance during graduate study program. Gained technical expertise using a VG-70SEQ HRMS.
Education	**MS, Chemistry**, *University of Houston, TX.* 1990.
Publications/ Presentations	*Fast-Atom Bombardment Tandem Mass Spectrometry of (Polypyridyl)Ruthenium (II) Complexes.* Inorganic Chemistry, Volume 30, No. 4, 1991.
	Collusion-Induced Reaction of Coordinately Unsaturated Dimanese Carbonyl Cluster Fragment Ions and Alkyl Halides in the Gaseous Phase, American Society of Mass Spectrometry, June 3-8, 1990, Tucson, AZ, 1991.
Affiliations	American Society of Mass Spectrometry

NON-CONTROLLED COPY

Columbia Analytical Resumes for Key Personnel (cont.)

JAMES M. CARLSON

1999 TO PRESENT

Columbia Analytical Services, Inc., 1317 South 13th Ave., Kelso, WA 98632 360.577.7222

Current Position

PRESIDENT AND CHIEF EXECUTIVE OFFICER – 2010 to Present

Responsibilities

Responsible for overall management direction and coordination of all business activities, develops and implements business plans. Works closely with Branch Managers, and support staff, including Financial and Administration. Approves all policies, procedures, plans, and programs for the company and ensures their conformity with corporate guidelines and policies. Approves annual operating budgets for the branch offices and ensures operations perform within approved budget limits. Stays abreast of technological developments and trends, which could lead to new applications or markets. Maintains good client relations and actively pursues expansion of new clients and business lines in conjunction with regional and corporate marketing goals.

Experience

CHIEF OPERATING OFFICER (COO), *Columbian Analytical Services, Kelso, Washington,* 1999-2010. Responsible for oversight of operating units of Columbia Analytical Services, inc. with all Laboratory Directors reporting to the COO. Primary responsibilities include establishment of consistent quality, technical, and client service enhancements across the company, as well as the financial performance of the individual operating units. In addition, a significant role is to represent operations as a member of the Senior Management Team (SMT) consisting of the Chief Executive Officer, Chief Financial Officer, Chief Quality Officer, and the Director of Information Technology

NON CONTROLLED COPY

Financial Services Manager, *BHP Coated Steel Corporation, Kalama, Washington,* 1997-1999. Developed and managed the financial accounting and services department for a two-plant facility with revenues exceeding $200 million. Supervised a staff of 11 and provided shared services for five organizations. Responsible for all internal and external financial reporting and audit requirements. Additional duties included supporting the general management team as relief CFO and acting as a meeting and process facilitator.

Finance and Administration Manager, *BHP Diamonds, Inc., Yellowknife, Northwest Territory, Canada,* 1993-1997. Developed and managed effective accounting, financial reporting, purchasing, and logistics systems for the start up of the BHP/Blackwater NWT Diamond Project in the high Arctic. Negotiated and administered contracts related to the supply of goods, services, and facilities for the construction and administration of the 100 person camp, including the development of HR, safety, and security systems. Participated in the general management team, including extensive public relations regarding the project's environmental and socioeconomic impacts. Participated in negotiations involving aboriginal, provincial, and the Canadian federal government.

Accounting and Administration Manager, *BHP Exploration, Herndon, Virginia,* 1992-1993. Controller and administration manager for BHP's world coal and industrial minerals programs. Oversight of 12 international office locations, including the 40-person office in Herndon, Virginia, and 30 international exploration and geophysical projects. Responsible for all aspects of office and accounting administration, including international and domestic staffing. Retained local external accounting and legal services in foreign locations and negotiated foreign labor agreements.

Senior Accountant, *BHP Western US Mining, Farmington, New Mexico,* 1989-1992. Responsible for general ledger, equipment, and fixed asset accounting for three coal mines with a combined annual revenue exceeding $300 million. Also responsible for administration of royalties, taxes, and land lease obligations with external entities, including governments, tribes, and individual landowners; preparation of monthly business reports; annual budgets; and ten-year forecasts. Trained developing accountants in major mining accounting and administration.

Management Trainee, *Financial Management Development Program, BHP Utah International, San Francisco, California,* 1986-1989. Performed three one-year training assignments within the BHP Minerals San Francisco office. One year of consolidation accounting, one year of exploration accounting, and one year of financial planning and analysis.

Education

Leading Organizational Change Program, *BHP, Kalama, Washington,* 1998.
Global Leadership Program 2, *BHP, Kota Kinabalu, Malaysia,* 1995.
Resident Management Course I, *BHP, Melbourne, Australia,* 1993.
BS, Business Administration/Accounting, *California State University, San Jose, California,* 1986.

Columbia Analytical Resumes for Key Personnel (cont.)

JEFFREY D. CHRISTIAN

1989 TO PRESENT

Columbia Analytical Services, Inc., 1317 South 13th Ave., Kelso, WA 98626 360.577.7222

Current Position

CHIEF OPERATING OFFICER (COO) – 2010 to Present

Responsibilities

Responsible for oversight of operating units of Columbia Analytical Services, inc. with all Laboratory Directors reporting to the COO. Primary responsibilities include establishment of consistent quality, technical, and client service enhancements across the company, as well as the financial performance of the individual operating units. In addition, a significant role is to represent operations as a member of the Senior Management Team (SMT) consisting of the Chief Executive Officer, Chief Financial Officer, Chief Quality Officer, and the Director of Information Technology.

Experience

Vice President/Laboratory Director, Kelso Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington,* 1993-2010. Responsible for all phases of laboratory operations, including project planning, budgeting, and quality assurance.

Operations Manager, Kelso Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington,* 1992-1993. Responsibilities included directing the daily operation of the Kelso laboratory. Other responsibilities and duties included functioning as a technical consultant to clients, providing assistance in developing and planning analytical schemes to match client objectives, and writing and developing analytical procedures/methods. Also, served as Project Manager for State of Alaska Department of Environmental Conservation contract and Coordinator for EPA Special Analytical Services (SAS) contracts.

NON CONTROLLED COPY

Project Chemist and Manager, Metals Analysis Laboratory, *Columbia Analytical Services, Kelso, Washington,* 1989-1992. Responsible for directing the daily operation of the Metals Laboratory, including the sample preparation, AAS, ICP-OES, and ICP-MS Laboratories.

Scientist, *Weyerhaeuser Technology Center, Federal Way, Washington,* 1986-1989. Responsibilities included supervising atomic spectroscopy laboratory which included flame and furnace AAS, ICP-OES, and sample preparation capabilities to handle a wide variety of sample types. Interfaced with internal and external clients to provide technical support. Wrote and developed analytical procedures/methods.

Lead Technician, Metals Lab, *Weyerhaeuser Technology Center, Federal Way, Washington*, 1981-1986. Responsibilities included primary ICP and AAS analyst for EPA-CLP contract work. Extensive experience in wide variety of environmental and product-related testing.

Research Assistant, *ITT Rayonier, Olympic Research Division, Shelton, Washington,* 1978-1981. Responsibilities included performing water quality tests, product-related analytical tests, corrosion tests (i.e., potentiometric polarization techniques), and operated pilot equipment specific to the pulp and paper industry.

Education

B.S., Chemistry, *Evergreen State College, Olympia, Washington,* 1993.
Coursework, *Pacific Lutheran University, Tacoma, Washington.* 1988-1989.
Coursework, *Tacoma Community College, Tacoma, Washington.* 1970-1971, 1988-1989.
CERTIFICATION, Chemistry, *L.H. Bates Technical, Tacoma, Washington,* 1976-1978.
Coursework, *Central Washington University, Ellensburg, Washington.* 1969-1970.
Numerous Training/Educational Activities via Conferences, Professional Seminars, and Factory Training, 1989-2010.

Publications/ Presentations

Mr. Christian has a number of publications and presentations. For a list of these publications and presentations, please contact CAS.

Columbia Analytical Resumes for Key Personnel (cont.)

LEE E. WOLF

1988 TO PRESENT

Columbia Analytical Services, Inc., 1317 South 13th Ave., Kelso, WA 98626 360.577.7222

Current Position

QUALITY ASSURANCE DIRECTOR AND CHIEF QUALITY OFFICER – 2008 to Present

Responsibilities

Directing the overall corporate-wide quality systems and ethics programs for all CAS facilities. Responsible for ensuring that CAS quality systems and data integrity standards are implemented at all facilities. Act as liaison with government entities involving quality, technical and operational issues. Provide QA input and policy as needed for operations, development initiatives, special projects, planning, and information technology implementation. Provide assistance to QA Program Managers.

Experience

Technical Manager IV, Quality Assurance Program Manager, *Columbia Analytical Services, Inc., Kelso, Washington* – 2002 to 2008. As part of the management team, responsibilities included the overall management and implementation of the laboratory QA program. This included maintaining accreditations and certifications, and maintaining all necessary documents (QA Manual, SOPs, and QA records). Acted as primary point of contact during laboratory audits and provided audit responses and corrective actions. Coordinated performance audits (PE/PT testing) and conducted internal audits.

Scientist IV, Quality Assurance Program Manager, *Columbia Analytical Services, Inc., Kelso, Washington,* 1996-2002. Duties primarily as listed above.

Project Chemist/Principal Organic Scientist, *Columbia Analytical Services, Inc., Kelso, Washington,* 1994-1996. Responsibilities included GC and GC/MS method development and special projects coordination. Acts as technical advisor to the GC and GC/MS laboratories and GC/MS interpretation specialist and CLP organics specialist. Also responsible for Project Chemist functions, including management of projects for clients, identifying client needs, and preparation of data reports.

NON-CONTROLLED COPY

Semivolatile Organics Department Manager, *Columbia Analytical Services*, 1988-1994. Responsibilities included overall management of the department. Supervised GC/MS analyses, data review, reporting and related QA/QC functions. Responsible for supervision of staff, training, and scheduling. Beginning in 1992, responsibilities included being a Project Chemist for organics EPA-SAS and other clients. This involved scheduling projects for clients, identifying client requirements, and preparing data reports.

GC/MS Chemist, *U.S. Testing Co., Richland, Washington*, 1985-1988. Responsibilities included GC and GC/MS analysis of water and soil samples for volatiles and semivolatiles by EPA protocol, including Methods 8240, 8270 and CLP. Coordinated extraction and GC-GC/MS areas to manage sample/data flow through the lab. Also performed HPLC analysis and pesticide analysis by GC using EPA Methods.

Laboratory Assistant, *Eastern Washington University, Cheney, Washington,* 1985. Responsibilities included supervision and instruction of organic chemistry labs. Experience with GC and IR operation. Responsible for lab safety.

Education

Pharmaceutical Laboratory Control Systems, *Univ. of Wisconsin Short Course, Las Vegas,* 2004
Test Method Validation in Pharmaceutical Development and Production, *Univ. of Wisconsin Short Course, Las Vegas,* 2004
Documenting Your Quality System, *A2LA Short Course, Las Vegas, Nevada*, 1998.
Internal Laboratory Audits, *A2LA Short Course, Las Vegas, Nevada,* 1998.
Mass Spectra Interpretation, *ACS Short Course, Denver, Colorado*, 1992.
BS, Chemistry, *Eastern Washington University, Cheney, Washington,* 1985.

Publications/ Presentations

Selected Ion Monitoring: Issues for Method Development, Panel Discussion, Association of Official Analytical Chemists, (AOAC) Pacific Northwest Regional Meeting, 1995.

Method Enhancement Techniques for Achieving Low level Detection of Butyl Tin in Marine Sediments and Tissues, Association of Official Analytical Chemists (AOAC) Pacific Northwest Regional Meeting, 1994.

The Determination of Low-Level Concentrations of Polynuclear Aromatic Hydrocarbons (PAHs) in Soil and Water Using Gas Chromatography/Mass Spectroscopy Selected Ion Monitoring (GC/MS SIM), HazMat West, Long Beach, California, 1992.

Affiliations

American Chemical Society.

NON-CONTROLLED
COPY

APPENDIX C

Major Analytical Equipment

Columbia Analytical/Houston Major Analytical Equipment

Equipment	Year Acquired	Manufacturer Maintained or Laboratory Maintained (MM/LM)	Number of Trained Operators
Agilent 6890N GC, CTC A200S Autosampler, Waters Autospec Ultima HRMS	2004	MM	4
Agilent 6890N GC, CTC A200S Autosampler, Waters Autospec Ultima HRMS	2004	MM	4
Agilent 7890A GC, CTC A200S Autosampler, Waters Autospec Premier HRMS	2008	MM	4
Agilent 7890A GC, CTC A200S Autosampler, Waters Autospec Premier HRMS	2008	MM	4
Dionex ASE200 Accelerated Solvent Extractor	2003	MM/LM	5
Eberbach Shaker Model 6000	2007	LM	5
Rotary Evaporators Buchi R-200 (1), R-201 (2)	1999, 2009	LM	5
Analytical Balances Denver XE Series 300, Mettler AJ100, Mettler Toledo PG603-S	1999, 2004	LM	5
Drying Ovens VWR Model 1305U, Blue M C4855Q	1999, 2002	LM	5
Centrifuge, Clay Adams Dynac 101	1999	LM	5
Branson Ultrasonic Cleaners Models 2510R-MT, 5510R-MT	2008, 2010	LM	5
Tissue Homogenizer, Hobart HCM62	2008	LM	5
Tumbler, custom	1999	LM	5
Nitrogen Evaporator, Zanntek Zip Vap #109A custom	2009	LM	5
Muffle Furnace, Blue-M/Lindberg, LGO Element Furnace, BF51842-P-BC	2010	LM	5
Combination Mantles, Glas-col 100D RJ30012 (4)	2008	LM	5

NON-CONTROLLED COPY

NON-CONTROLLED
COPY

APPENDIX D

Data Qualifiers and Acronyms

Columbia Analytical/Houston Data Qualifiers

Qualifier	Description
B	Indicates the associated analyte is found in the method blank, as well as in the sample.
C	Confirmation of the TCDF compound: When 2378-TCDF is detected on the DB-5 column, confirmation analyses are performed on a second column (DB-225). The results from both the DB-5 column and the DB-225 column are included in this data package. The results from the DB-225 analyses should be used to evaluate the 2378-TCDF in the samples. The confirmed result should be used in determining the TEQ value for TCDF.
E	Indicates an estimated value – used when the analyte concentration exceeds the upper end of the linear calibration range.
J	Indicates an estimated value – used when the analyte concentration is below the method reporting limit (MRL) and above the estimated detection limit (EDL).
K	EMPC - When the ion abundance ratios associated with a particular compound are outside the QC limits, samples are flagged with a 'K' flag. A 'K' flag indicates an estimated maximum possible concentration for the associated compound.
U	Indicates the compound was analyzed and not detected.
Y	Samples that had recoveries of labeled standards outside the acceptance limits are flagged with 'Y'. In all cases, the signal-to-noise ratios are greater than 10:1, making these data acceptable.
ND	Indicates concentration is reported as 'Not Detected.'
S	Peak is saturated; data not reportable.
Q	Lock-mass interference by chlorodiphenyl ether compounds.
P	Indicates chlorodiphenyl ether interference present at the retention time of the target compound.
X	See case narrative.

NON-CONTROLLED COPY

NOTE: Where specified by project requirements or laboratory circumstances dictate, data qualifiers may be modified or additional qualifiers may be utilized. All data qualifiers must be completely and unambiguously identified.

Columbia Analytical/Houston Abbreviations, Acronyms, and Definitions

Abbreviation or Acronym	Definition
Cal	Calibration
Conc	Concentration
Dioxin(s)	Polychlorinated dibenzo-p-dioxin(s)
DLCS	Duplicate Laboratory Control Sample
DMS	Duplicate Matrix Spiked sample
EDL	Estimated Detection Limit
EMPC	Estimated Maximum Possible Concentration
Flags	Data qualifiers
Furan(s)	Polychlorinated dibenzofuran(s)
g	Grams
ICAL	Initial Calibration
ID	Identifier
Ions	Masses monitored for the analyte during data acquisition
L	Liter(s)
LCS	Laboratory Control Sample
MB	Method Blank
MCL	Method Calibration Limit
MDL	Method Detection Limit
MRL	Method Reporting Limit
mL	Milliliters
MS	Matrix Spiked sample
NO	Number of peaks meeting all identification criteria
PCDD(s)	Polychlorinated dibenzo-p-dioxin(s)
PCDF(s)	Polychlorinated dibenzofuran(s)
ppb	Parts per billion
ppm	Parts per million
ppq	Parts per quadrillion
ppt	Parts per trillion
QA	Quality Assurance
QC	Quality Control
Ratio	Ratio of areas from monitored ions for an analyte
% Rec.	Percent Recovery
RPD	Relative Percent Difference
RRF	Relative Response Factor
RT	Retention Time
RRT	Relative Retention Time
SDG	Sample Delivery Group
S/N	Signal-to-Noise ratio
TEF	Toxicity Equivalence Factor
TEQ	Toxicity Equivalence Quotient

NON-CONTROLLED COPY

NON-CONTROLLED
COPY

APPENDIX E

Preventive Maintenance Procedures

Columbia Analytical/Houston Preventive Maintenance Procedures

Instrument	Activity	Laboratory Performed or Vendor Performed	Frequency
Refrigerators and coolers	Record temperatures Clean coils Check coolant	Laboratory Vendor Vendor	Daily Annually Annually
Fume Hoods	Face velocity measured Sash operation Change filters Inspect fan belts	Laboratory Laboratory Vendor Vendor	Quarterly As needed Annually Annually
Ovens	Clean Record Temperatures	Laboratory Laboratory	Annually Daily
Analytical Balances	Check alignment Check calibration Clean pans	Laboratory Laboratory Laboratory	Daily Daily After each use
High Resolution GC/MS	Check gas supplies Change septum Change injection port liner Clip first foot of capillary column Change guard column Replace analytical column Clean source Change pump oil	Laboratory Laboratory Laboratory Laboratory Laboratory Laboratory Laboratory Laboratory	Daily; replace when pressure reaches 50psi Daily As needed As needed As needed As needed As needed Annually

NON-CONTROLLED COPY

NON-CONTROLLED
COPY

APPENDIX F

Laboratory SOP List

Columbia Analytical/Houston Administrative SOPs

SOP Title	SOP Code
Sample Receiving	SMO-WET
Waste Disposal	SMO-WASTDISP
HRMS Data Review and Reporting	HMS-DATAREV
Bottle Order Preparation and Shipping	SMO-BOT
Washing Glassware	SMO-WASH
Air Sampling Trap Preparation	MED-AIR_TRAP
Tissue Preparation	WET-TISP
Calibration Check of Measuring Devices	WET-DALCYK
Project Management	HOU-PM
Conducting Internal Quality Assurance Audits	QA-AUDIT
Total Solids	SMO-TS
Subsampling and Compositing Aqueous and Soil Samples	WET-SSMP
Report and Data Archiving	HOU-ARCH
Environmental Health and Safety Manual	CHP
Quality Assurance Manual	QAM

NON-CONTROLLED COPY

Columbia Analytical/Houston Analytical SOPs

SOP Title	SOP Code
Method 1613B: Tetra- through Octa-Chlorinated Dioxins and Furans by Isotope Dilution HRGC/HRMS	HMS-1613B
Method 8290: Analysis of Polychlorinated Dibenzo-*p*-dioxins and Polychlorinated Dibenzofurans by High Resolution Gas Chromatography/High Resolution Mass Spectrometry (HRGC/HRMS)	HMS-8290
Method 23: Determination of Polychlorinated Dibenzo-*p*-dioxins and Polychlorinated Dibenzofurans from Municipal Waste Combustors	HMS-23
Method 8280A: Analysis of Polychlorinated Dibenzo-*p*-dioxins and Polychlorinated Dibenzofurans by Gas Chromatography/High Resolution Mass Spectrometry (GC/HRMS)	HMS-8280A
Method 1668A: Chlorinated Biphenyl Congeners in Water, Soil, Sediment Biosolids and Tissue by HRGC/HRMS	HMS-1668A
Method 1668B: Chlorinated Biphenyl Congeners in Water, Soil, Sediment Biosolids and Tissue by HRGC/HRMS	HMS-1668B
Method TO9A: Determination of Polychlorinated Dibenzo-*p*-Dioxins and Dibenzofurans in Ambient Air	HMS-TO-9A
Method 428: Determination of Polychlorinated dibenzo-*p*-dioxin (PCDD), Polychlorinated Dibenzofuran (PCDF) and Polychlorinated biphenyl Emissions from Stationary Sources	HRMS/CA-428
Method 429: Determination of Polycyclic Aromatic Hydrocarbon (PAH) Emissions From Stationary Sources	HRMS/CA-429
Screening of Dioxins & Furans	D&F Screening

NON-CONTROLLED COPY

NON-CONTROLLED
COPY

APPENDIX G

Certifications, Accreditations, and Primary NELAP Accredited Methods

Columbia Analytical/Houston Laboratory Certifications and Accreditations

As of September 1st, 2010, Columbia Analytical/Houston holds certification/accreditation through the following organizations, with the type indicated parenthetically:

American Association for Laboratory Accreditation (A2LA, DoD QSM, ISO/IEC 17025:2005)
Arizona Department of Health Services (State)
Arkansas Department of Environmental Quality (State)
California Environmental Laboratory Accreditation Program (State)
Florida Department of Health (NELAP)
Hawaii Department of Health (State)
Illinois Environmental Protection Agency (NELAP)
Louisiana Environmental Laboratory Accreditation Program (NELAP)
Louisiana Department of Health and Hospitals (NELAP)
Maine Department of Health and Human Services (State)
Michigan Department of Natural Resources and Environment (State)
Minnesota Department of Health (State)
Nevada Division of Environmental Protection (State)
New Jersey Department of Environmental Protection (NELAP)
New Mexico Drinking Water Bureau (State)
New York Department of Health (NELAP)
Oklahoma Department of Environmental Quality (State)
Oregon Environmental Laboratory Accreditation Program (NELAP)
Pennsylvania Department of Environmental Protection (NELAP)
Tennessee Department of Environment and Conservation (State)
Texas Commission on Environmental Quality (NELAP)
Utah Environmental Laboratory Certification Program (NELAP)
United States Department of Agriculture (Soil Import Permit)
Washington Department of Ecology (NELAP)
West Virginia Department of Environmental Protection (State)

NON-CONTROLLED COPY

**All current certificates and scopes of accreditation are available for review upon request.*

Columbia Analytical/Houston Primary NELAP Accreditated Methods

Columbia Analytical/Houston maintains accreditation through NELAP for the following methods, with the primary accrediting authority indicated parenthetically:

Method 8290 (Texas Commission on Environmental Quality)
Method 1613B (Texas Commission on Environmental Quality)
Method 8280A (Texas Commission on Environmental Quality)
Method 1668A (Florida Department of Health)
Method 23 (Louisiana Environmental Laboratory Accreditation Program)
Method TO-9A (Florida Department of Health)

NON-CONTROLLED
COPY

NON-CONTROLLED COPY

QUALITY ASSURANCE MANUAL

Columbia Analytical Services, Inc.

1 Mustard Street, Suite 250

Rochester, NY 14609

585-288-5380 (phone)

585-288-8475 (fax)

Effective Date: October 25, 2010

Approved by:

Laboratory Director/Technical Director: _____ 10/25/10

Michael K. Perry — Date

MPerry@caslab.com

Quality Assurance Program Manager: _____ 10/25/10

Lisa Reyes — Date

LReyes@caslab.com

© Columbia Analytical Services, Inc. 2010

DOCUMENT CONTROL

NUMBER: _____

Initials: _____ Date: _____

NON-CONTROLLED COPY

1.0 TABLE OF CONTENTS

Section	Heading	Page
-	Title Page with Provision Signatures	1
1.0	Table of Contents	2
2.0	Introduction and Company Quality Assurance Policy	4
3.0	Program Description	5
4.0	Professional Conduct, Data Integrity, and Ethics	14
5.0	Organization and Responsibilities	17
6.0	Information Management	20
7.0	Sample Management	22
8.0	Analytical Procedures	34
9.0	Calibration Procedures	37
10.0	Quality Control	42
11.0	Data Processing, Validation, and Reporting	50
12.0	Performance and System Audits	58
13.0	Preventive Maintenance	60
14.0	Corrective and Preventive Action	62
15.0	Quality Assurance Reports and Management Review	64
16.0	Personnel Training	65
17.0	References for Quality Systems, External Documents, Manuals, Standards, and Analytical Procedures	69

Tables Page

Table 5-1 Summary of Technical Experience and Qualifications 19
Table 7-1 Sample Preservation and Holding Times 26
Table 11-1 Descriptions of Data Deliverables.....57

Figures Page

Figure 3-1 Relationships of Quality Management Systems 6
Figure 3-2 Columbia Analytical/Rochester Laboratory Floor Plan 11
Figure 7-1 Chain of Custody Form.....32
Figure 7-2 Cooler Receipt and Preservation Check Form 33
Figure 14-1 Corrective Action Report.....63
Figure 16-1 Initial Demonstration of Proficiency Requirements.....68

Appendices

Please note that the Appendices provide current information at the time of the revision, but are updated only upon annual review. Please contact the laboratory for up-to-date information.

Appendix A List of QA Program Documents and Standard Operating Procedures
Appendix B Organizational Chart and Resumes of Key Personnel
Appendix C Major Analytical Equipment
Appendix D Data Qualifiers and Acronyms
Appendix E Preventive Maintenance Procedures
Appendix F Laboratory SOP List
Appendix G Certifications, Accreditations, and Primary NELAP Accredited Methods

NON-CONTROLLED COPY

NON-CONTROLLED COPY

2.0 INTRODUCTION AND COMPANY QUALITY ASSURANCE POLICY

Columbia Analytical Services, Inc. (CAS) is an employee-owned professional analytical services laboratory which performs chemical and microbiological analyses on a wide variety of sample matrices, including drinking water, groundwater, surface water, wastewater, soil, sludge, sediment, tissue, industrial and hazardous waste, air, and other material. Columbia Analytical operates a network of laboratory facilites located in Arizona, California, Florida, New York, Texas, and Washington.

We recognize that quality assurance requires a commitment to quality by everyone in the organization - individually, within each operating unit, and throughout the entire laboratory. Laboratory management is committed to ensuring the effectiveness of its quality systems and to ensure that all tests are carried out in accordance to customer requirements. Key elements of this commitment are set forth in the Columbia Analytical Services, Inc. Quality and Ethics Policy Statement, March 2009 (Appendix A) and in this Quality Assurance Manual (QAM). Columbia Analytical Services, Inc. is committed to operate in accordance with these requirements and those of regulatory agencies, accrediting authorities, and certifying organizations.

Quality Management Systems are established, implemented and maintained by management. Policies and procedures are established in order to meet requirements of accreditation bodies and applicable programs, such as the Department of Defense (DOD) Environmental Laboratory Accreditation Program, as well as client's quality objectives. Systems are designed so that there will be sufficient Quality Assurance (QA) activities conducted in the laboratory to ensure that all analytical data generated and processed will be scientifically sound, legally defensible, of known and documented quality, and will accurately reflect the material being tested. Quality Systems are applicable to all fields of testing in which the laboratory in involved.

Quality Control (QC) procedures are used to continually assess performance of the laboratory and quality systems. Columbia Analytical maintains control of analytical results by adhering to written standard operating procedures (SOPs), using analytical control parameters with all analyses, and by observing sample custody requirements. All analytical results are calculated and reported in units consistent with project specifications to allow comparability of data.

This QAM is applicable to the facility listed on the title page. The information in this QAM has been organized according to requirements found in the National Environmental Laboratory Accreditation Program (NELAP) Quality Systems Standards (2003 and 2009), the EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5, USEPA, 2001; and *General Requirements for the Competence of Testing and Calibration Laboratories*, ISO/IEC 17025:2005.

NON-CONTROLLED COPY

3.0 PROGRAM DESCRIPTION

The purpose of the QA program at Columbia Analytical is to ensure that our clients are provided with analytical data that is scientifically sound, legally defensible, and of known and documented quality. The concept of Quality Assurance can be extended, and is expressed in the mission statement of Columbia Analytical:

> "The mission of Columbia Analytical Services, Inc. is to provide high quality, cost-effective, and timely professional testing services to our customers. We recognize that our success as a company is based on our ability to maintain customer satisfaction. To do this requires constant attention to customer needs, maintenance of state-of-the-art testing capabilities and successful management of our most important asset - our people - in a way that encourages professional growth, personal development and company commitment."

3.1 Quality Management Systems

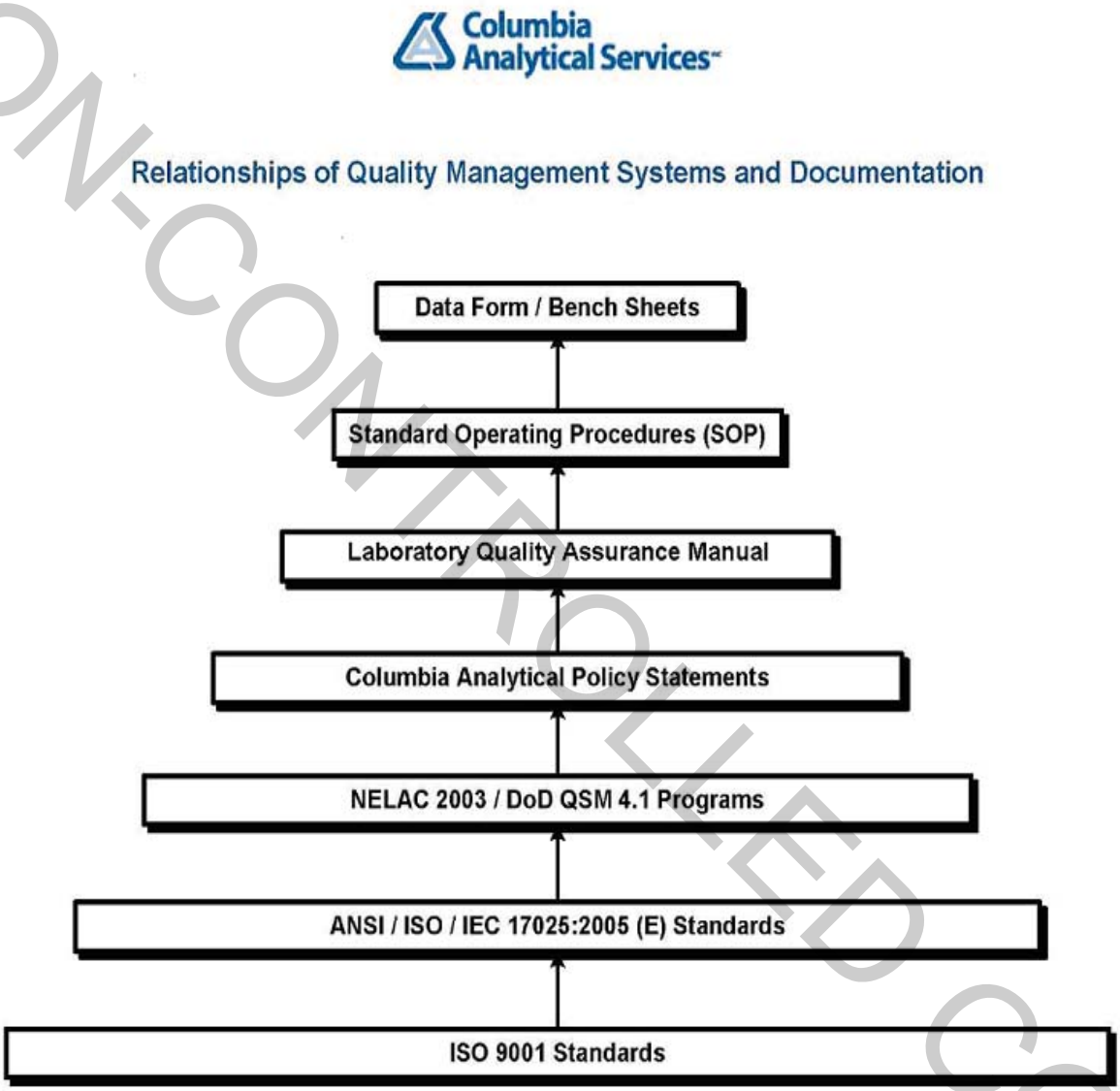
In support of this mission, the laboratory has developed a Quality Management System to ensure all products and services meet our client's needs. The system is implemented and maintained by the Quality Assurance Program Manager (QA PM) with corporate oversight by the Chief Quality Officer (CQO). These systems are based upon ISO 17025:2005 standards, upon which fundamental programs (NELAC 2003, 2009 and DoD QSM) are based. Implementation and documentation against these standards are communicated in corporate policy statements, this QAM, and SOPs. Actual procedures, actions and documentation are defined in both administrative and technical SOPs. Figure 3-1 shows the relationships of the quality systems and associated documentation. Quality systems include:

- Standard Operating Procedures
- Sample Management and Chain of Custody procedures
- Statistical Control Charting
- Standards Traceability
- Ethics Training
- Document Control
- Corrective Action Program
- Management Reviews
- Demonstration of Capability

The effectiveness of the quality system is assessed in several ways, including:

- Internal and External Audits covering all aspects of the organization
- Annual Management Reviews
- Analysis of Customer Feedback
- Internal and External Proficiency Testing

Figure 3-1



NON-CONTROLLED COPY

3.2 Facilities, Equipment, and Security

Columbia Analytical features over 17,000 square feet of laboratory and administrative workspace at its Rochester, NY location. The facility is secured to the rest of the building using a swipe card entry system. The laboratory design provides safeguards against cross-contamination of samples and is arranged according to work function, which enhances the efficiency of analytical operations. The ventilation system has been specially designed to meet the needs of the analyses performed in each work space. Also, Columbia Analytical minimizes laboratory contamination sources by employing janitorial and maintenance staff to ensure that good housekeeping and facilities maintenance are performed. In addition, the segregated laboratory areas are designed for safe and efficient handling of a variety of sample types. These specialized areas (and access restrictions) include:

- Shipping and Receiving/Purchasing
- Sample Management Office
- Separate sample storage areas. See section 7 for further discussion of storage.
- Inorganic/Metals Sample Preparation Laboratories (2)
- ICP-AES and ICP-MS Laboratory
- AA Laboratory
- Water Chemistry & General Chemistry Laboratory
- Semi-volatile Organics Sample Preparation Laboratory
- Semi-volatile Organics Gas Chromatography and Gas Chromatography/Mass Spectrometry
- High Performance Liquid Chromatography Laboratory
- Air Laboratory (Volatiles by GC/MS from canisters)
- Volatile Organics Laboratory (Gas Chromatography and Gas Chromatography/Mass Spectrometry including a separate standard preparation laboratory) Laboratory
- Microbiology Laboratory
- Laboratory Deionized Water System
- Laboratory Management, Client Service, Report Generation and Administration
- Data Archival
- Information Technology (IT) and LIMS
- Hazardous Waste Storage Area

In addition, the designated areas for sample receiving, refrigerated sample storage, dedicated sample container preparation and shipping provide for the efficient and safe handling of a variety of sample types. Figure 3-2 shows the facility floor plan. The laboratory is equipped with state-of-the-art analytical and administrative support equipment. The equipment and instrumentation are appropriate for the procedures in use. Appendix C lists the major equipment, illustrating the laboratory's overall capabilities and depth.

NON-CONTROLLED COPY

NON-CONTROLLED COPY

3.3 Technical Elements of the Quality Assurance Program

The laboratory's technical procedures are based upon procedures published by various agencies or organizations (See Section 17). The Quality Assurance Program provides to the laboratory organization, procedures, and policies by which the laboratory operates. The necessary certifications and approvals administered by external agencies are maintained by the QA department. This includes method approvals and audit administration. In addition, internal audits are performed to assess compliance with policies and procedures. SOPs are maintained for technical and administrative functions. A document control system is used for SOPs, as well as laboratory notebooks, and this QA Manual. A list of QA Program documents is provided in Appendix A and SOPs in Apppendix F.

Acceptable calibration procedures are defined in the SOP for each test procedure. Calibration procedures for other laboratory equipment (balances, thermometers, etc.) are also defined. Quality Control (QC) procedures are used to monitor the testing performed. Each analytical procedure has associated QC requirements to be achieved in order to demonstrate data quality. The use of method detection limit studies, control charting, technical training and preventive maintenance procedures further ensure the quality of data produced. Proficiency Testing (PT) samples are used as an external means of monitoring the quality and proficiency of the laboratory. PT samples are obtained from qualified vendors and are performed on a regular basis. In addition to method proficiency, documentation of analyst training is performed to ensure proficiency and competency of laboratory analysts and technicians. Sample handling and custody procedures are defined in SOPs. Procedures are also in place to monitor the sample storage areas. The technical elements of the QA program are discussed in further detail in later sections of this QA manual.

3.4 Operational Assessments and Service to the Client

The laboratory uses a number of systems to assess its daily operations. In addition to the routine quality control (QC) measurements, the senior laboratory management examines a number of other indicators to assess the overall ability of the laboratory to successfully perform analyses for its clients including; on-time performance, customer complaints, training reports and non-conformity reports. A frequent, routine assessment must also be made of the laboratory's facilities and resources in anticipation of accepting an additional or increased workload.

Columbia Analytical utilizes a number of different methods to ensure that adequate resources are available for service demands. Senior staff meetings, tracking of outstanding proposals and an accurate, current synopsis of incoming work all assist the senior staff in properly allocating sufficient resources. All Requests for Proposal (RFP) documents are reviewed by the Project Chemist and appropriate managerial staff to identify any project specific requirements that differ from the standard practices of the laboratory. Any requirements that cannot be met are noted and communicated to the client, as well as requesting the client to provide any project specific Quality Assurance Project Plans (QAPPs) if available. Status/production meetings are also conducted regularly with the laboratory and project managers to inform the staff of the status of incoming work, future projects, or project requirements.

When a customer requests a modification to an SOP, policy, or standard specification the Project Manager will discuss the proposed deviation with the Client Services Manager, Laboratory Director, and department manager to obtain approval for the deviation. The QA PM may also be involved. All project-specific requirements must be on-file and with the service request upon logging in the samples. The modification or deviation must be documented. A Project-Specific Communication Form, or similar, may be used to document such deviations.

The laboratory shall afford clients cooperation to clarify the client's request and to monitor the laboratory's performance in relation to the work performed, provided that the laboratory ensures confidentiality to other clients. The laboratory maintains and documents timely communication with the client for the purposes of seeking feedback and clarifying customer requests. Feedback is used and analyzed to improve the quality of services. The *SOP for Handling Customer Feedback* (ADM-FDBK) is in place for these events.

3.5 Document Control and Records

Procedures for control and maintenance of documents are described in the *SOP for Document Control (ADM-DOC_CTRL).* The requirements of the SOP apply to all laboratory logbooks (standards, maintenance, run logbooks, etc), certificates of analysis, SOPs, QAMs, quality assurance project plans (QAPPs), Environmental Health & Safety (EHS) manuals, and other controlled Columbia Analytical documents.

Each controlled copy of a controlled document will be released only after a document control number is assigned and the recipient is recorded on a document distribution list. Filing and distribution is performed by the QA PM, or designee, and ensure that only the most current version of the document is distributed and in use. A document control number is assigned to logbooks. Completed logbooks that are no longer in use are archived in a master logbook file. Logbook entries are standardized following the *SOP for Making Entries into Logbooks and onto Benchsheets* (ADM-DATANTRY). The entries made into laboratory logbooks are reviewed and approved at a regular interval (quarterly).

A records system is used which ensures all laboratory records (including raw data, reports, and supporting records) are retained and available. The archiving system is described in the *SOP for Data Archiving (ADM-ARCH).*

3.6 Subcontracting

Analytical services are subcontracted when the laboratory needs to balance workload or when the requested analyses are not performed by the laboratory. Subcontracting is only done with the knowledge and approval of the client and to qualified laboratories. Subcontracting to another Columbia Analytical laboratory is preferred over external-laboratory subcontracting. Further, subcontracting is done using capable and qualified laboratories. Established procedures are used to qualify external subcontract laboratories. These procedures are described in the *SOP for Qualification of Subcontract Laboratories (ADM-SUBLAB).* The Corporate Quality Assurance staff is responsible for maintaining a list of qualified subcontract laboratories.

NON-CONTROLLED COPY

3.7 Procurement

The quality level of reagents and materials (grade, traceability, etc.) required is specified in analytical SOPs. Department supervisors ensure that the proper materials are purchased. Inspection and verification of material ordered is performed at the time of receipt by receiving personnel. The receiving staff labels the material with the date received. Expiration dates are assigned as appropriate for the material. Storage conditions and expiration dates are specified in the analytical SOP. The corporate Policy for Standards and Reagents Expiration Dates provides default expiration requirements. Supplies and services that are critical in maintaining the quality of laboratory testing are procured from pre-approved vendors. The policy and procedure for purchasing and procurement are described in the *SOP for Purchasing and Approval of Vendors* (ADM-PUR). Also, refer to section 9.4 for a discussion of reference materials.

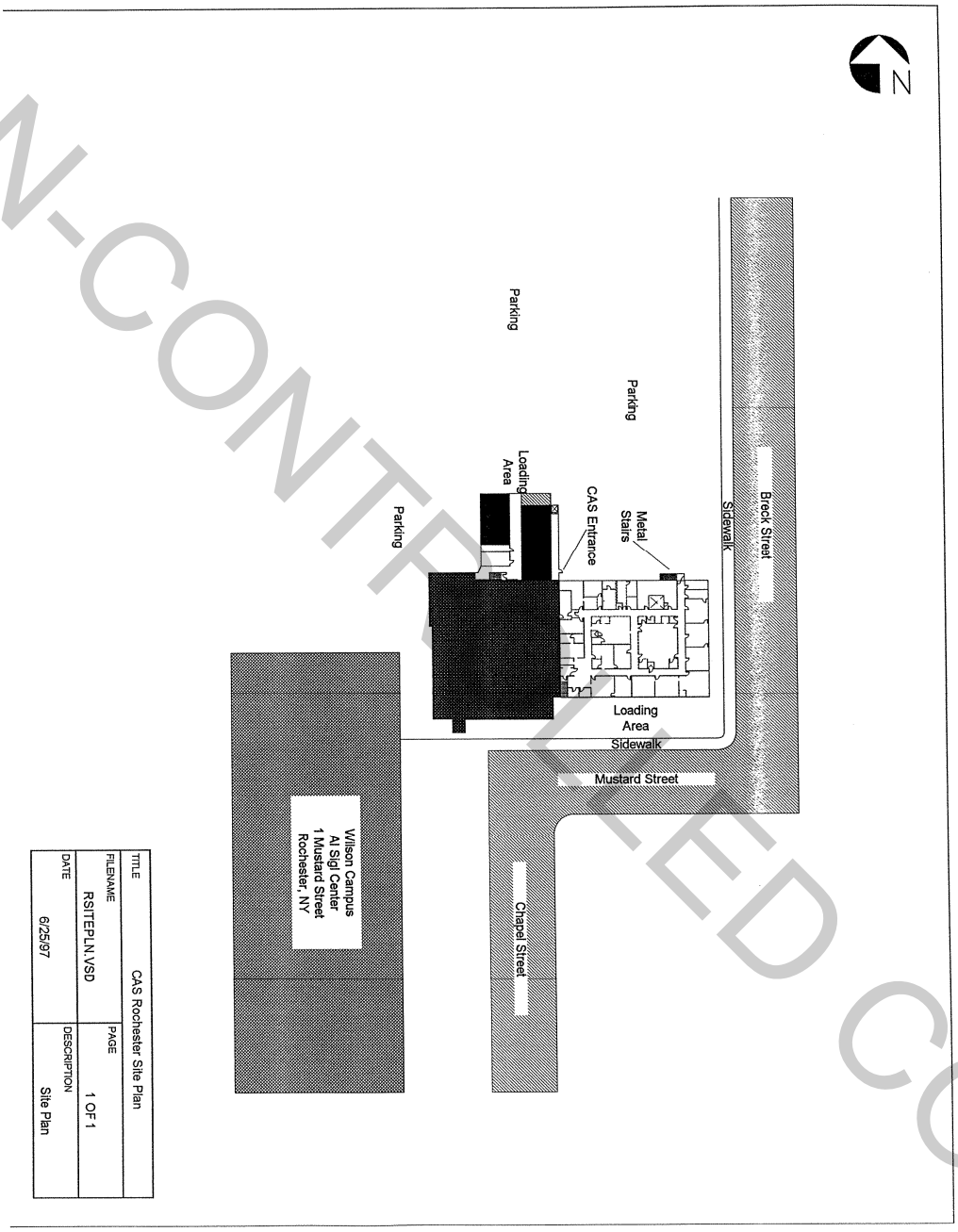
Receipt procedures include technical review of the purchase order/request to verify that what was received is identical to the item ordered. The laboratory checks new lots of reagents for unacceptable levels of contamination prior to use in sample preservation, sample preparation, and sample analysis by following the *SOP for Checking New Lots of Chemicals for Contamination* (ADM-CTMN).

3.8 Review of Requests, Tenders and Contracts (Procedures for Accepting New Work)

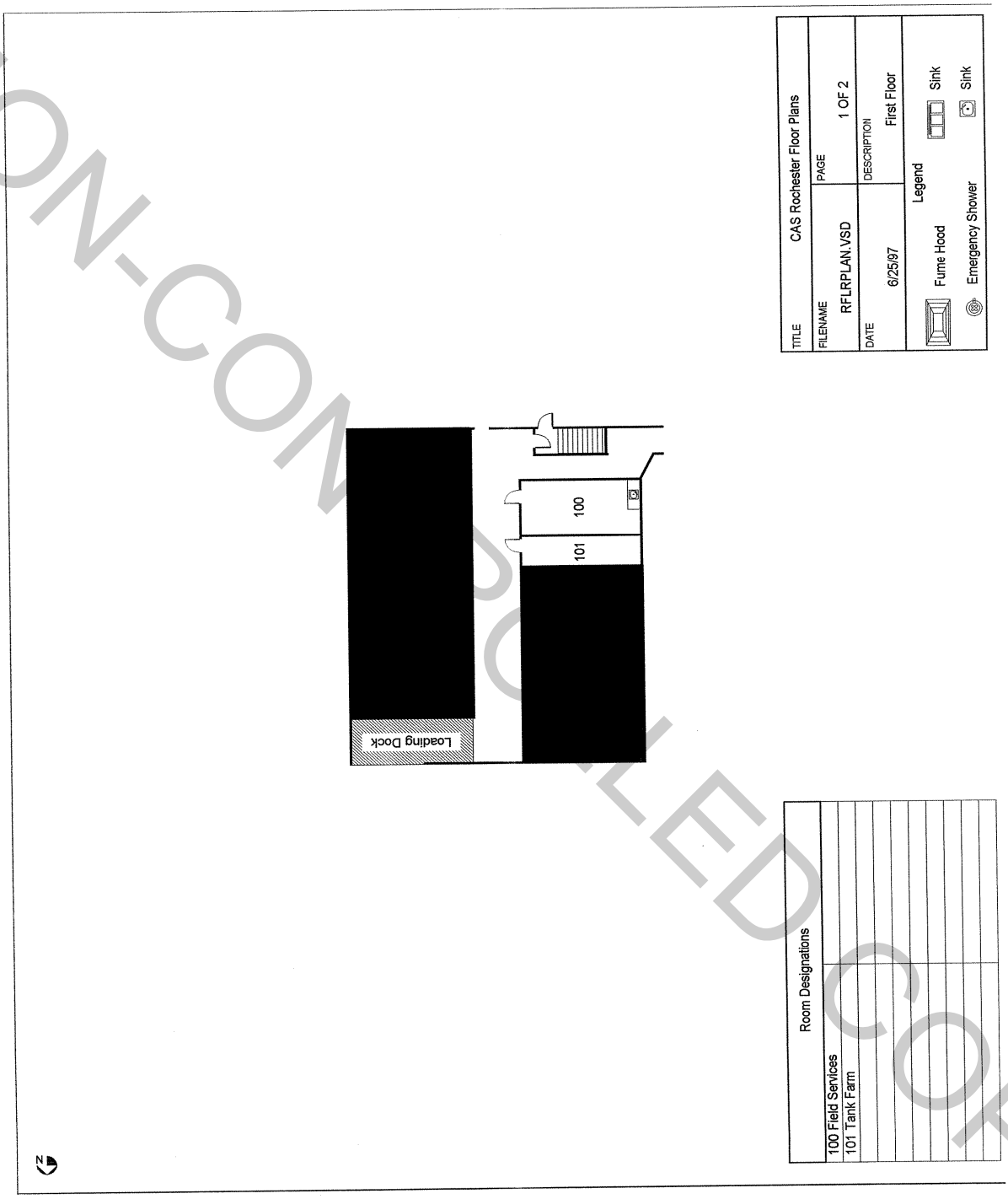
Requests for new work are reviewed prior to signing any contracts or otherwise agreeing to perform the work. The specific methods to be used are agreed upon between the laboratory and the client. A capability review is performed to determine if the laboratory has or needs to obtain certification to perform the work, to determine if the laboratory has the resources (personnel, equipment, materials, capacity, skills, expertise) to perform the work, and if the laboratory is able to meet the client's required reporting and QC limits. The results of this review are communicated to the client and any potential conflict, deficiency, lack of appropriate accreditation status, or concerns of the ability to complete the client's work are resolved. Any differences between the request or tender and the contract shall be resolved before any work commences. The client should be notified at this time if work is expected to be subcontracted. Each contract shall be acceptable both to the laboratory and the client. Records are maintained of pertinent discussions with a client relating to the client's requirements or the results of the work. If a contract needs to be amended after work has commenced, the contract review process is repeated and any amendments are communicated to all affected personnel. Changes in accreditation status affecting ongoing projects must be reported to the client.

NOT CONTROLLED COPY

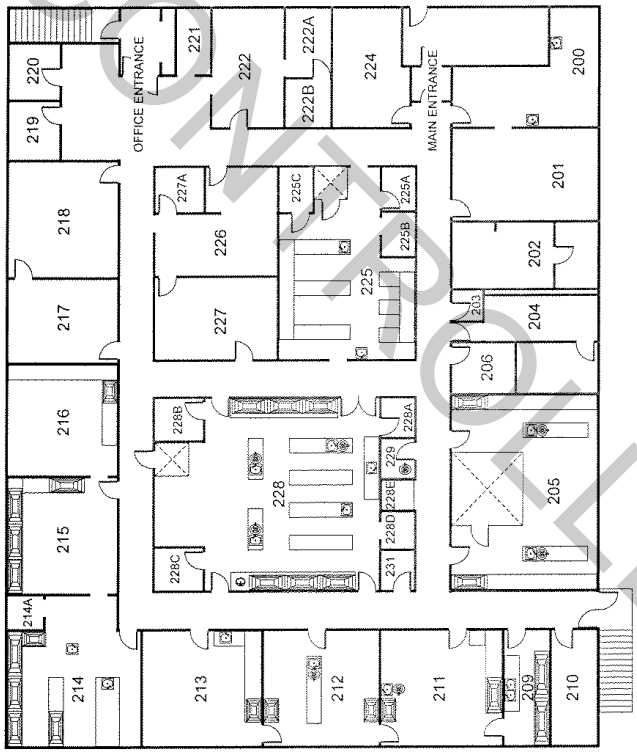
Figure 3-2
Columbia Analytical/Rochester Laboratory Floor Plan



NON-CONTROLLED COPY



NON-CONTROLLED COPY



Room Designations			
200 HPLC and Pet Lab	212 Metal Furnace Lab	222 Copy and Mail Center	227A Project Management Files
201 Sample Storage	213 Metals ICP Lab	222A IT Director Office	228 General Chemistry Laboratory
202 Restroom (W)	214 SVOA Prep Laboratory	222B Computer Room	228A TOX/TOC Laboratory
203 Mop Closet	215 SVOA Prep Laboratory	224 Secure On-site Record Storage	228B Deionized Water System Room
204 Restroom (M)	216 SVOA GC&GCMS Laboratory	225 Volatile Organics Laboratory	228C Metals Office
205 Breakdown	217 Sales Office	225A Office	228D Gen Chem Storage
206 Restroom (ADA)	218 Project Management Office	225B Office	228E BOD Incubator
209 TCLP Lab	219 Lab Director Office	225C Prep Room	229 Microbiology Laboratory
210 Waste Storage	220 QA/Safety Coordinator Office	226 Lunch Room	231 Metals Digestates
211 Metals Prep	221 Office Supply Storage	227 Conference Room	

TITLE	CAS Rochester Floor Plans
FILENAME	RMDESIG.VSD
PAGE	2 OF 2
DATE	7/8/04
DESCRIPTION	Second Floor

Legend

Fume Hood
Sink
Walk-in Cooler
Emergency Shower
Sink
Eyewash

NON-CONTROLLED COPY

NON-CONTROLLED COPY

4.0 PROFESSIONAL CONDUCT, DATA INTEGRITY, AND ETHICS

One of the most important aspects of the success of CAS is the emphasis placed on the integrity of the data provided and the services rendered. This success is reliant on both the professional conduct of all employees within CAS as well as established laboratory practices. All personnel involved with environmental testing and calibration activities must familiarize themselves with the quality documentation and implement the policies and procedures in their work.

4.1 Professional Conduct

To promote quality, CAS requires certain standards of conduct and ethical performance among employees. The following examples of documented CAS policy are representative of these standards, and are not intended to be limiting or all-inclusive:

- Under no circumstances is the willful act of fraudulent manipulation of analytical data condoned. Such acts are to be reported immediately to senior management for appropriate corrective action.
- Unless specifically required in writing by a client, alteration, deviation or omission of written contractual requirements is not permitted. Such changes must be in writing and approved by senior management.
- Falsification of data in any form will not be tolerated. While much analytical data is subject to professional judgment and interpretation, outright falsification, whenever observed or discovered, will be documented, and appropriate remedies and punitive measures will be taken toward those individuals responsible.
- It is the responsibility of all Columbia Analytical employees to safeguard sensitive company information, client data, records, and information; and matters of national security concern should they arise. The nature of our business and the well being of our company and of our clients is dependent upon protecting and maintaining proprietary company/client information. All information, data, and reports (except that in the public domain) collected or assembled on behalf of a client is treated as confidential. Information may not be given to third parties without the consent of the client. Unauthorized release of confidential information about the company or its clients is taken seriously and is subject to formal disciplinary action. All employees sign a confidentiality agreement upon hire to protect the company and client's confidentiality and proprietary rights.

NON-CONTROLLED COPY

4.2 Prevention and Detection of Improper, Unethical or Illegal Actions

It is the intention of CAS to proactively prevent and/or detect any improper, unethical or illegal action conducted within the laboratory. This is performed by the implementation of a program designed for not only the detection but also prevention. Prevention consists of educating all laboratory personnel in their roles and duties as employees, company policies, inappropriate practices, and their corresponding implications as described here.

In addition to education, appropriate and inappropriate practices are included in SOPs such as manual integration, data review and specific method procedures. Electronic and hardcopy data audits are performed regularly, including periodic audits of chromatographic electronic data. Requirements are described in the Policy for Internal Quality Assurance Audits and details are listed in laboratory admininstrative SOPs. All aspects of this program are documented and retained on file according to the company policy on record retention.

The CAS Employee Handbook also contains information on the CAS ethics and data integrity program, including mechanisms for reporting and seeking advice on ethical decisions.

4.3 Laboratory Data Integrity and Ethics Training

Each employee receives in-depth (approximately 6-8 hour) core Data Integrity/Ethics Training. New employees are given a QA and Ethics orientation within the first month of hire, followed by the the core training within 1 year of hire. On an ongoing basis, all employees receive semi-annual ethics refresher training. Topics covered are documented in writing and all training is documented. It is the responsibility of the QA PM to ensure that the training is conducted as described.

Key topics covered are the organizational mission and its relationship to the critical need for honesty and full disclosure in all analytical reporting, how and when to report data integrity issues and record keeping. Training includes discussion regarding all data integrity procedures, data integrity training documentation, in-depth data monitoring and data integrity procedure documentation.

Trainees are required to understand that any infractions of the laboratory data integrity procedures will result in a detailed investigation that could lead to very serious consequences including immediate termination, or civil/criminal prosecution.

The training session includes many concepts and topics, numerous examples of improper actions (defined by DoD as deviations from contract-specified or method-specified analytical practices and may be intentional or unintentional), legal and liability implications (company and personal), causes, prevention, awareness, and reporting mechanisms.

4.4 Management and Employee Commitment

Columbia Analytical makes every attempt to ensure that employees are free from any commercial, financial, or other undue pressures that might affect their quality of work. Related policies are described in the Columbia Analytical Employee Handbook. This includes:

- CAS Open Door Policy (CAS Employee Handbook) – Employees are encouraged to bring any work related problems or concerns to the attention of local management or their Human Resources representative. However, depending on the extent or sensitivity of the concern, employees are encouraged to directly contact any member of upper management.
- CAS Corporate Ethics Point Program – An anonymous and confidential reporting system available to all employees that is used to communicate misconduct and other concerns. The program shall help minimize negative morale, promote a positive work place, and encourage reporting suspected misconduct without retribution. Associated upper management is notified and the investigations are documented.
- Use of flexible work hours. Within reason and as approved by supervisors, employees are allowed flexible work hours in order to help ease schedule pressures which could impact decision-making and work quality.
- Operational and project scheduling assessments are continually made to ensure that project planning is performed and that adequate resources are available during anticipated periods of increased workloads. Procedures for subcontracting work are established, and within the Columbia Analytical laboratory network additional capacity is typically available for subcontracting, if necessary.
- Gifts and Favors (CAS Employee Handbook) – To avoid possible conflict of interest implications, employees do not receive unusual gifts or favors to, nor accept such gifts or favors from, persons outside the Company who are, or may be, in any way concerned with the projects on which the Company is professionally engaged.

All employees are required to sign and adhere to the requirements set forth in the Columbia Analytical *Confidentiality and Conflicts of Interest Employee Agreement* and the Columbia Analytical *Commitment to Excellence in Data Quality* (see Appendix A).

NON-CONTROLLED COPY

NON-CONTROLLED COPY

5.0 ORGANIZATION AND RESPONSIBILITIES

The Columbia Analytical/Rochester staff, consisting of approximately 50 employees, includes chemists, technicians and support personnel. They represent diverse educational backgrounds and experience, and provide the comprehensive skills that the laboratory requires. During seasonal workload increases, additional temporary employees may be hired to perform specific tasks.

CAS is committed to providing an environment that encourages excellence. All employees share the responsibility for maintaining and improving the quality of our analytical services. The responsibilities of key personnel within the laboratory are described below. Table 5-1 lists the Columbia Analytical/Rochester personnel assigned to these key positions. Managerial staff members are provided the authority and resources needed to perform their duties. An organizational chart of the laboratory, as well as the resumes of these key personnel, can be found in Appendix B.

- The role of the **Laboratory Director** is to provide technical, operational, and administrative leadership through planning, allocation and management of personnel and equipment resources. The Laboratory Director provides leadership and support for the QA program and is responsible for overall laboratory efficiency and the financial performance of the Rochester facility. The Laboratory Director has the authority to stop work in response to quality problems. The Laboratory Director also provides resources for implementation of the QA program, reviews and approves this QA Manual, reviews and approves standard operating procedures (SOPs), and provides support for business development by identifying and developing new markets through continuing support of the management of existing client activities.

- The responsibility of the **Quality Assurance Program Manager** (QA PM) is to oversee implementation of the quality program and to coordinate QA activities within the laboratory. The QA PM is responsible for ensuring compliance with NELAC standards (and ISO, DoD QSM, etc. as applicable). The QA PM works with laboratory staff to establish effective quality control and assessment plans and has the authority to stop work in response to quality problems. The QA PM is responsible for maintaining the QA Manual and performing an annual review of it; reviewing and approving SOPs and ensuring the annual review of each SOP; maintaining QA records such as metrological records, archived logbooks, PT study results, etc.; document control; conducting PT sample studies; approving nonconformity and corrective action reports; maintaining the laboratory's certifications and approvals; performing internal QA audits; preparing QA activity reports; etc. The QA PM reports directly to the Laboratory Director and also works closely with the Chief Quality Officer. It is important to note that when evaluating data, the QA PM does so in an objective manner and free of outside, or managerial, influence.

  The Chief Quality Officer (CQO) is responsible for the overall QA program at all the Columbia Analytical laboratories. The CQO is responsible for oversight of QA PMs regulatory compliance efforts (NELAC, ISO, DOD, etc). The CQO performs annual internal audits at each laboratory; maintains a database of laboratory certification/accreditation programs; approves company-wide SOPs; maintains a database of approved subcontract laboratories; provides assistance to the laboratory QA staff and laboratory managers; prepares a quarterly QA activity report; etc.

- In the case of absence of the Laboratory Director or QA PM, deputies are assigned to act in that role. Default deputies for these positions are the Client Services Manager or Organics Department Manager (for the Laboratory Director) and the CQO or Laboratory Director (for the QA PM).

- The **Environmental Health and Safety Officer** (EH&S) is responsible for the administration of the laboratory health and safety policies. This includes the formulation and implementation of safety policies, the supervision of new-employee safety training, the review of accidents, incidents and prevention plans, the monitoring of hazardous waste disposal and the conducting of departmental safety inspections. The EH&S officer is also designated as the Chemical Hygiene Officer. The EH&S Officer has a dotted-line reporting responsibility to Columbia Analytical's EH&S Director.

- The **Client Services Manager** is responsible for the Client Services Department (customer services/project chemists, and Electronic Data Deliverables group) and the sample management office/bottle preparation sections. The Client Services Department provides a complete interface with clients from initial project specification to final deliverables. The sample management office handles all the activities associated with receiving, storage, and disposal of samples. The Client Services Manager has the authority to stop subcontractor work in response to quality problems.

- The **Project Chemist/Project Manager** is a scientist assigned to each client to act as a technical liaison between the client and the laboratory. The project chemist is responsible for ensuring that the analyses performed by the laboratory meet all project, contract, and regulatory-specific requirements. This entails coordinating with the Columbia Analytical laboratory and administrative staff to ensure that client-specific needs are understood and that the services Columbia Analytical provides are properly executed and satisfy the requirements of the client.

- The Analytical Laboratory is divided into operational units based upon specific disciplines. Each department is responsible for establishing, maintaining and documenting a quality control program based upon the unique requirements within the department. Each **Department Manager and Supervisor** has the responsibility to ensure that quality control functions are carried out as planned, and to guarantee the production of high quality data. Department managers and bench-level supervisors have the responsibility to monitor the day-to-day operations to ensure that productivity and data quality objectives are met. Each department manager has the authority to stop work in response to quality problems in their area. Analysts have the responsibility to carry out testing according to prescribed methods, SOPs, and quality control guidelines particular to the laboratory in which he/she is working.

- The **Sample Management Office** plays a key role in the laboratory QA program by maintaining documentation for all samples received by the laboratory, and by assisting in the archival of all laboratory results. The sample management office staff is also responsible for the proper disposal of samples after analysis.

- **Information Technology** (IT) staff are responsible for the administration of the Laboratory Information Management System (LIMS) and other necessary support services. Other functions of the IT staff include laboratory network maintenance, IT systems development and implementation, education of analytical staff in the use of scientific software, Electronic Data Deliverable (EDD) generation, and data back-up, archival and integrity operations.

NON-CONTROLLED COPY

Table 5-1
Summary of Technical Experience and Qualifications

Personnel	Years of Experience	Project Role
Michael Perry, B.S.	35	Laboratory Director/Technical Director
Lisa Reyes, B.S.	24	Quality Assurance Program Manager
Janice Jaeger, B.S.	21	Client Services Manager
Christine Kutzer, B.S.	18	Inorganics Department Supervisor
Thomas Walton, B.S.	21	Volatiles Department Supervisor
Gregg LaForce	8	Sample Management Office Supervisor
Meghan Pedro, B.S.	9	Extractables Preparation Supervisor/ Environmental Health and Safety
Michael Cymbal, B.S.	20	Semivolatile Organics Supervisor/ Information Technology
Jeff Christian, B.S.	31	Chief Operations Officer
Lee Wolf, B.S.	25	Chief Quality Officer/Quality Assurance Director
Jim Carlson, B.S.	24	President/CEO

NON-CONTROLLED COPY

NON-CONTROLLED COPY

6.0 INFORMATION MANAGEMENT

The generation, compilation, reporting, and archiving of electronic data is a critical component of laboratory operations. In order to generate data of known and acceptable quality, the quality assurance systems and quality control practices for electronic data systems must be complete and comprehensive and in keeping with the overall quality assurance objectives of the organization. CAS management provides the tools and resources to implement electronic data systems and establishes information technology standards and policies. Appendix C lists major computing equipment.

6.1 Software Quality Assurance Plan

Columbia Analytical has defined practices for assuring the quality of the computer software used throughout all laboratory operations to generate, compile, report, and store electronic data. These practices are described in the *CAS Software Quality Assurance Plan (SQAP)*. The purpose of the SQAP is to describe the policies and practices for the procurement, configuration management, development, validation and verification, data security, maintenance, and use of computer software. The policies and practices described in the plan apply to purchased computer software as well as to internally developed computer software. Key components of this plan are policies for software validation and control.

6.2 IT Support

The local Columbia Analytical Information Technology (IT) department is established to provide technical support for all computing systems. The IT department staff continually monitors the performance and output of operating systems. The IT department oversees routine system maintenance and data backups to ensure the integrity of all electronic data. A software inventory is maintained. Additional IT responsibilities are described in the SQAP.

In addition to the local IT department, Columbia Analytical corporate IT provides support for network-wide systems. Columbia Analytical also has personnel assigned to information management duties such as development and implementation of reporting systems; data acquisition, and Electronic Data Deliverable (EDD) generation.

6.3 Information Management Systems

Columbia Analytical has various systems in place to address specific data management needs. The Columbia Analytical Laboratory Information Management System (LIMS) is used to manage sample information, sample tracking, sample workload projections, sample result storage, reporting, and invoicing. The LIMS is used to track the status of a sample and is important in maintaining internal chain of custody. Access is controlled by password.

CAS/Rochester currently uses StarLIMS v.9 throughout the laboratory. This data management and retrieval system is deployed via Metaframe Presentation Server from a centralized application server farm located in Portland, OR. This LIMS system utilizes Oracle 10g R1 as its database server, which runs on a Linux Operating System. . The system allows you to acquire data from instrumentation and can generate ASCII, spreadsheet, database, and/or print files.

6.4 Backup and Security

Columbia Analytical laboratory data is either acquired directly to the centralized acquisition server or acquired locally and then transferred to the server. All data is eventually moved to the centralized data acquisition server for reporting and archiving. Differential and full backups are performed and stored according to ADM-BACKUP.

Access to sample information and data is on a need-to-know basis. Access is restricted to the person's areas of responsibility. Passwords are required on all systems. No direct external, non- Columbia Analytical access is allowed to any of our network systems.

The external e-mail system and Internet access is established via a single gateway to discourage unauthorized entry. Columbia Analytical uses a closed system for company e-mail. Files, such as electronic deliverables, are sent through the external e-mail system only via a trusted agent. The external messaging system operates through a single secure gateway. Email attachments sent in and out of the gateway are subject to a virus scan. Because the Internet is not regulated, we use a limited access approach to provide a firewall for added security. Virus screening is performed continuously on all network systems.

NON-CONTROLLED COPY

NON-CONTROLLED COPY

7.0 SAMPLE MANAGEMENT

7.1 Sampling and Sample Preservation

The quality of analytical results is highly dependent upon the quality of the procedures used to collect, preserve and store samples. Columbia Analytical recommends that clients follow sampling guidelines described in 40 CFR 136, 40 CFR 141, USEPA SW-846, and state-specific sampling guidelines, if applicable. Sampling factors that must be taken into account to insure accurate, defensible analytical results include:

- Amount of sample taken
- Type of container used
- Type of sample preservation
- Sample storage time
- Proper custodial documentation

Columbia Analytical uses the sample preservation, container, and holding-time recommendations published in a number of documents. The primary documents of reference are: USEPA SW-846, Third Edition and Updates I, II, IIA, IIB, III, IV for hazardous waste samples; USEPA 600/4-79-020, 600/4-91-010, 600/4-82-057, 600/R-93/100, 600/4-88-039, 600/R-94-111, and Supplements; EPA 40CFR parts 136 and 141; and *Standard Methods for the Examination of Water and Wastewater* for water and wastewater samples (see Section 18 for complete citations). The container, preservation and holding time information for these references is summarized in Table 7-1 for soil, water, and drinking water. The current EPA CLP Statement of Work should be referred to for CLP procedures. Where allowed by project sampling and analysis protocols the holding time for sediment, soil, and tissue samples may be extended for a defined period when stored frozen at -20°C.

Columbia Analytical routinely provides sample containers with appropriate preservatives for our clients. Containers are purchased as precleaned to a level 1 status, and conform to the requirements for samples established by the USEPA. Certificates of analysis for the sample containers are available to clients if requested. Reagent water used for sampling blanks (trip blanks, etc.) and chemical preservation reagents are tested by the laboratory to ensure that they are free of interferences and documented. Our sample kits typically consist of foam-lined, precleaned shipping coolers, (cleaned inside and out with appropriate cleaner, rinsed thoroughly and air-dried), specially prepared and labeled sample containers individually wrapped in protective material, (VOC vials are placed in a specially made, foam holder), chain-of-custody (COC) forms, and custody seals. Container labels and custody seals are provided for each container. See SOP, ADM-CTMN for information about the testing of chemicals added as preservatives. See SOP, SMO-BPS for more specific information regarding the packing and shipping of sample kits. See SOP, SMO-GEN for the Sample Acceptance Policy.

NON-CONTROLLED COPY

Figure 7-1 shows the chain-of-custody form routinely used at Columbia Analytical and included with sample kits. For large sample container shipments, the containers may be shipped in their original boxes. Such shipments will consist of several boxes of labeled sample containers and sufficient materials (bubble wrap, COC forms, custody seals, shipping coolers, etc.) to allow the sampling personnel to process the sample containers and return them to Columbia Analytical. The proper preservative is added to the sample containers prior to shipment, unless otherwise instructed by the client.

Columbia Analytical keeps client-specific shipping requirements on file and utilizes major transportation carriers to guarantee that sample shipping requirements (same-day, overnight, etc.) are met. Columbia Analytical also provides courier service that makes regularly scheduled trips to the Rochester and Buffalo areas.

When Columbia Analytical ships environmental samples to other laboratories for analysis each sample bottle is wrapped in protective material and placed in a plastic bag (preferably Ziploc®) to avoid any possible cross-contamination of samples during shipping. The sample management office (SMO) follows formalized procedures (SMO-GEN) for maintaining the samples' chain of custody, packaging and shipment.

7.2 Sample Receipt and Handling

Standard Operating Procedures (SMO-GEN) are established for the receiving of samples into the laboratory. These procedures ensure that samples are received and properly logged into the laboratory, and that all associated documentation, including chain of custody forms, is complete and consistent with the samples received.

Once samples are delivered to the Columbia Analytical sample management office (SMO), a Cooler Receipt and Preservation Check Form (CRPF - See Figure 7-2 for an example) is used to assess the shipping cooler and its contents as received by the laboratory personnel. Verification of sample integrity includes the following activities:

- Assessment of custody seal presence/absence;
- Temperature of sample containers upon receipt;
- Chain of custody documents properly used (entries in ink, signature present, etc.);
- Sample containers checked for integrity (broken, leaking, etc.);
- Sample is clearly marked and dated (bottle labels complete with required information);
- Appropriate containers (size, type) are received for the requested analyses;
- Sample container labels and/or tags agree with chain of custody entries (identification, required analyses, etc.);
- Assessment of proper sample preservation (if inadequate, corrective action is employed); and
- VOC containers are inspected for the presence/absence of bubbles. (Assessment of proper preservation of VOC containers is performed by lab personnel).

Samples are logged into a Laboratory Information Management System (LIMS). Any anomalies or discrepancies observed during the initial assessment are recorded on the CRPF and COC documents. Potential problems with a sample shipment are addressed by contacting the client and discussing the pertinent issues. When the Project Chemist and client have reached a satisfactory resolution, the login process may continue and analysis may begin.

NON-CONTROLLED COPY

During the login process, each sample container is given a unique laboratory code The laboratory code consists of the local CAS laboratory, the year in which the samples were logged, a folder number unique to the job, and an extension for the sample number within that job. The format of the laboratory code is as follows:

e.g. Lab Code R0903233-001 = R - Rochester
10 - Year 2010
03233- Folder Number (sequential number of jobs logged in that year)
001 – Sample number in that Folder.

The LIMS generates a Service Request Summary that contains client information, sample descriptions, sample matrix information, required analyses, sample collection dates, analysis due dates and other pertinent information. The service request is reviewed by the appropriate Project Chemist for accuracy, completeness, and consistency of requested analyses and for client project objectives.

Samples are stored as per method requirements until they undergo analysis, unless otherwise specified, using various refrigerators or freezers, or designated secure areas. Columbia Analytical/Rochester has four walk-in cold storage units which house the majority of sample containers received at the laboratory. The dedicated storage area for VOC samples are monitored using storage blanks, as described in the *SOP for Volatile Storage Blanks (VOC-BLANK)*. Columbia Analytical also has freezers capable of storing samples at -20° C. The temperature of each sample storage unit is monitored daily and the data recorded in a logbook. Maximum/minimum thermometers have also been placed in the walk-in refrigerators to provide a record of the storage conditions to which samples are exposed.

Columbia Analytical adheres to the method-prescribed or project-specified holding times for all analyses. The sampling date and time are entered into the LIMS system at the time of sample receipt and login. Analysts then monitor holding times by obtaining analysis-specific reports from the LIMS. These reports provide holding time information on all samples for the analysis, calculated from the sampling date and the holding time requirement. To document holding time compliance, the date and time analyzed is printed or written on the analytical raw data. For analyses with a holding time prescribed in hours it is essential that the sample collection time is provided, so holding time compliance can be demonstrated. If not, the sample collection time is assumed as the earliest in the day (i.e. the most conservative).

Unless other arrangements have been made in advance, most aqueous and soil samples are retained at 0-6°C in refrigerators for at least 30 days from receipt (unless other arrangements have been made in advance). Sample are required to be held for at least 60 days for CLP/ASP package work. Samples removed from the refrigerators are moved to an ambient temperature storage room and stored for at least 30 more days. Upon expiration of these time limits, the samples are either returned to the client or disposed of according to approved disposal practices. All samples are characterized according to hazardous/non-hazardous waste criteria and are segregated accordingly. All hazardous waste samples are disposed of according to formal procedures outlined in the Sample Disposal SOP (SMO-SPLDIS). It should be noted that all waste produced at the laboratory, including the laboratory's own various hazardous waste streams, is treated in accordance with all applicable local and Federal laws. The bar coding system used to track samples through the lab, including disposal, produces cradle to grave sample history for each sample aliquot.

7.3 Sample Custody

Sample custody transfer at the time of sample receipt is documented using chain-of-custody (COC) forms accompanying the samples. During sample receipt, it is also noted if custody seals were present. This is described in the *SOP for Sample Receiving (SMO-GEN)*. Figure 7-1 is a copy of the chain-of-custody form routinely used at Columbia Analytical.

Facility security and access is important in maintaining the integrity of samples received at Columbia Analytical/Rochester. Access to the laboratory facility is limited by use of locked exterior doors with a swipe card entry, except for the reception area doors, which are manned during business hours and locked at all other times. The Columbia Analytical facility is equipped with an alarm system.

A barcoding system is used to document internal sample custody. Each person removing or returning samples from/to sample storage while performing analysis is required to document this custody transfer. The system uniquely identifies the sample container and provides an electronic record of the custody of each sample. For sample extracts and digestates the analyst documents custody of the sample extract or digestate by signing on the benchsheet, or custody record, that they have accepted custody. The procedures are described in the *SOP for Sample Tracking and Internal Chain of Custody (SMO-ICOC).*

7.4 Project Setup

The analytical method(s) used for sample analysis are chosen based on the client's requirements. Unless specified otherwise, the most recent versions of reference methods are used. For SW-846 methods, some projects may require the most recent *promulgated* version, and some projects may require the most recent *published* version. The Project Chemist will ensure that the correct method version is used. LIMS codes are chosen to identify the analysis method used for analysis. The Project Chemist ensures that the correct methods are selected for analysis, deliverable requirements are identified, and due dates are specified on the service request. To communicate and specify project-specific requirements, a Project Specific Communication Form is used.

NOT CONTROLLED COPY

NON-CONTROLLED COPY

Table 7-1
Sample Preservation and Holding Times

DETERMINATION	METHOD	MATRIX[b]	CONTAINER[c]	PREFERRED VOLUME (mL)	PRESERVATION	MAXIMUM HOLDING TIME[a]
Bacterial Tests						
Coliform, Fecal and Total	SM9223B	W	Sterile P,G	100	Cool, ≤6°C, 0.008% $Na_2S_2O_3$[d]	6-24 hours[e]
Inorganic Tests						
Alkalinity	SM2320B	W	P,G	250	Cool, ≤6°C no headspace	14 days
Ammonia	350.1	W	P,G	250	Cool, ≤6°C, H_2SO_4 to pH<2	28 days
Ash, Percent	ASTM D482	NonAq Liq	P,G	8 oz.	Cool, ≤6°C	None Listed
Biochemical Oxygen Demand (BOD/ CBOD)	SM5210B	W	P,G	1000	Cool, ≤6°C	48 hours
Bromide	300.0/9056	W	P,G	250	Cool, ≤6°C	28 days
Chemical Oxygen Demand (COD)	410.4	W	P,G	250	Cool, ≤6°C, H_2SO_4 to pH<2	28 days
Chemical Oxygen Demand (COD)	410.4	S	G	4 oz.	Cool, ≤6°C	28 days
Chloride	300.0/ SM4500Cl E	W	P,G	250	Cool, ≤6°C	28 days
Chlorine, Total Residual	SM4500Cl F	W	P,G	500	None Required- field analysis preferred	15 minutes
Chlorine Demand	SM 409A	W	P,G	500	Cool, ≤6°C	None listed
Chlorophyll a	SM 10200H	W	P,G, or filter	1000 or filter	Filter immediately and freeze filter	None listed
Color	SM2120B	W	P,G	100	Cool, ≤6°C	48 hours
Cyanide, Total and Amenable to Chlorination	335.4/ SM 4500CN G /9012A	W	P,G	250	Cool, ≤6°C, NaOH to pH>12	14 days
Cyanide, Weak Acid Dissociable	SM4500CN G	W	P,G	500	Cool, ≤6°C, NaOH to pH >12	14 days
Cyanide, Total	9012	S	P,G	250	Cool, ≤6 °C	14 days
Density	ASTM D4052	NonAq Liq	P,G	250	None	None listed
Ethylene Glycol	NYSDEC 89-9	W	G	2x40 mL	Cool, ≤6°C	None listed
Ferrous Iron	SM 3500 Fe-D	W	P,G	250	No headspace – field analysis preferred	None listed – field preferred
Fluoride	300.0/9056	W	P,G	250	Cool, ≤6°C	28 days
Hardness	SM2340C	W	P,G	250	HNO_3 to pH<2	6 months
Hydrogen Ion (pH)	SM4500 H+B/ 9040	W	P,G	100	None Required – field analysis preferred	15 minutes
Ignitability – closed cup	1010	Liquid	G	3 x 40mL	Cool, ≤6°C	14 days

NON-CONTROLLED COPY

Table 7-1
Sample Preservation and Holding Times

DETERMINATION	METHOD	MATRIX[b]	CONTAINER[c]	PREFERRED VOLUME (mL)	PRESERVATION	MAXIMUM HOLDING TIME[a]
Ignitability – open cup	ASTM D92	S	G	4oz.	Cool, ≤6°C	None listed
Kjeldahl and Organic Nitrogen	351.2	W	P,G	250	Cool, ≤6°C, H_2SO_4 to pH<2	28 days
Nitrate	300.0/9056	W	P,G	250	Cool, ≤6°C	48 hours
Nitrate-Nitrite	353.2	W	P,G	250	Cool, ≤6°C, H_2SO_4 to pH<2	28 days
Nitrite	300.0/9056/ 353.2	W	P,G	250	Cool, ≤6°C	48 hours
Orthophosphate	365.1	W	P,G	250	Filter Immediately, Cool, ≤6°C	48 hours
Perchlorate	6850	W,S	G	2x40 mL	Cool, ≤6°C	28 days
Phenolics, Total	420.4/9066	W	Amber G Only	250	Cool, ≤6°C, H_2SO_4 to pH<2	28 days
Phosphorus, Total	365.1	W	P,G	250	Cool, ≤6°C, H_2SO_4 to pH<2	28 days
Reactive Cyanide and Sulfide	Chpt7/9010	W,S	P,G	10g	Cool, ≤6 °C, no headspace	None listed
Residue, Total	SM2540B	W	P,G	250	Cool, ≤6°C	7 days
Residue, Filterable (TDS)	SM2540C	W	P,G	250	Cool, ≤6°C	7 days
Residue, Nonfilterable (TSS)	SM2540D	W	P,G	1000	Cool, ≤6°C	7 days
Residue, Settleable	SM2540F	W	P,G	1000	Cool, ≤6°C	48 hours
Residue, Volatile	160.4	W	P,G	250	Cool, ≤6°C	7 days
Silica, Dissolved	USGS I-2700-85	W	P Only	250	Cool, ≤6°C	28 days
Specific Conductance	120.1	W	P,G	100	Cool, ≤6°C	28 days
Specific Gravity	ASTM D1475	NonAq Liq	P,G	250	None	None listed
Sulfate	SM15 426C	W	P,G	250	Cool, ≤6°C	28 days
Sulfide, Acid Soluble	SM 4500-S F /9034	W	P,G	500	Cool, ≤6°C, Add Zinc Acetate plus Sodium Hydroxide to pH>9 No headspace	7 days
Sulfide, Acid Volatile (AVS)	EPA Draft 1991	S	G	8 oz.	Cool, ≤6°C No headspace	14 days
Sulfite	SM 4500-SO32-B	W	P,G	250	None Required- field analysis preferred	15 minutes
Surfactants (MBAS)	SM 5540C	W	P,G	500	Cool, ≤6°C	48 hours
Temperature	170.1	W	P,G	50	None Required	Analyze immediately
Turbidity	180.1	W	P,G	50	Cool, ≤6°C	48 hours
Water, Percent	ASTM E203	W	P,G	4 oz.	Cool, ≤6°C	None listed

NON-CONTROLLED COPY

Table 7-1
Sample Preservation and Holding Times

DETERMINATION	METHOD	MATRIX[b]	CONTAINER[c]	PREFERRED VOLUME (mL)	PRESERVATION	MAXIMUM HOLDING TIME[a]
Metals						
Chromium VI	218.6/ SM3500Cr B	W	P,G	250	Cool, ≤6°C Buffering = pH 9.3-9.7 with specific solution	24 hours: 28 days if buffered
Chromium VI	7196A/ 7199	S	P,G	4 oz.	Cool, ≤6°C	30 days until digestion; 7 days until pH adjustment and analysis
Mercury, Low Level	1631	W	Fluoropolymer bottle and cap	500	5 mL 1:1 HCl Cool ≤6°C until BrCl Room Temp after BrCl	28 days to BrCl 90 days from collection to analysis
Mercury	245.1/7470	W	P,G	250	HNO_3 to pH<2	28 days
Mercury	245.5/7471	S	P,G	4 oz.	Cool, ≤6°C	28 days
Metals, except Chromium VI and Mercury	200.7/200.8/6010/06020	W	P,G	250	HNO_3 to pH<2	180 days
Metals, except Chromium VI and Mercury	6010/6020	S	G, Teflon-Lined Cap	4 oz.	Cool, ≤6°C	180 days
Metals, except Chromium VI and Mercury	6010/6020	Tissue	G, Teflon-Lined Cap	4 oz.	Freeze, ≤-10°C	180 days
Organics						
Oil and Grease	1664A	W	G, Teflon-Lined Cap	1000	Cool, ≤6°C, H_2SO_4 to pH<2	28 days
Organic Carbon, Total (TOC)	SM20 5310C /9060	W	G	3x40	Cool, ≤6°C, H_2SO_4 to pH<2	28 days
Organic Carbon, Total (TOC)	EPA Lloyd Kahn	S	G	4 oz	Cool, ≤6°C, no headspace	14 days
Petroleum Hydrocarbons, Total Recoverable (gravimetric)	1664A	W	G, Teflon-Lined Cap	1000	Cool, ≤6°C, HCl or H_2SO_4 to pH<2	28 days
Petroleum Hydrocarbons, Total	310-13	W	G, Teflon-Lined Cap	2000	Cool, ≤6°C, HCl or H_2SO_4 to pH<2	7 days until extraction; 40 days after extraction
Petroleum Hydrocarbons, Total	310-13	S	G, Teflon-Lined Cap	2000	Cool, ≤6°C	14 days until extraction; 40 days after extraction

NON-CONTROLLED COPY

Table 7-1
Sample Preservation and Holding Times

DETERMINATION	METHOD	MATRIX[b]	CONTAINER[c]	PREFERRED VOLUME (mL)	PRESERVATION	MAXIMUM HOLDING TIME[a]
Volatile Organics						
Purgeable Halocarbons and Aromatics (including BTEX, Oxygenates)	524.2/ 601/ 602/ 624/ 8021/ 8260	W	G, Teflon-Lined Septum Cap	3x40	**No Residual Chlorine Present**: HCl to pH<2, Cool, ≤6°C, No Headspace **Residual Chlorine Present**: 10% $Na_2S_2O_3$, HCl to pH<2, Cool, ≤6°C, No Headspace	14 days 7 days if not chemically preserved
Purgeable Halocarbons and Aromatics (including BTEX, Oxygenates)	8021/8260	S	G, Teflon-Lined Cap	8 oz.	Cool, ≤6°C, Minimize Headspace	14 days
Purgeable Halocarbons and Aromatics (including BTEX, Oxygenates)	8021/8260	S - 5035	G, Teflon-Lined, Septum Cap	8 oz.	Freeze at -20°C on site in vial	14 days
					Frozen in coring tool on site	48 hours
					Cool, 4°C, freeze at lab within 48 hours	14 days
					Cool, 4°C, methanol preserved within 48 hours	14 days
					Cool, 4°C in vial	48 hours
					Cool, 4°C in coring tool	48 hours
					Cool, 4°C, sodium bisulfate	14 days
Acrolein	624/8260	W	G, Teflon-Lined Septum Cap	3x40	Adjust pH to 4-5, Cool, ≤6°C, No Headspace or If not pH 4-5	14 days 3 days if not adjusted to pH 4-5
Petroleum Hydrocarbons, Volatile (Gasoline-Range Organics)	8015	W	G, Teflon-Lined Septum Cap	3x40	Cool, ≤6°C, HCl to pH<2 No Headspace	14 days 7 days if not chemically preserved
Petroleum Hydrocarbons, Volatile (Gasoline-Range Organics)	8015	S	G, Teflon-Lined Cap	8 oz.	Cool, ≤6°C Minimize Headspace	14 days
Dissolved Gases	RSK-175	W	G, Teflon-Lined Septum Cap	3x40	Cool, ≤6°C, HCl to pH<2 No Headspace	14 days 7 days if not chemically preserved
Volatiles	TO-15	Air	Canisters	6 L	None Required	30 days recommended

NON-CONTROLLED COPY

Table 7-1
Sample Preservation and Holding Times

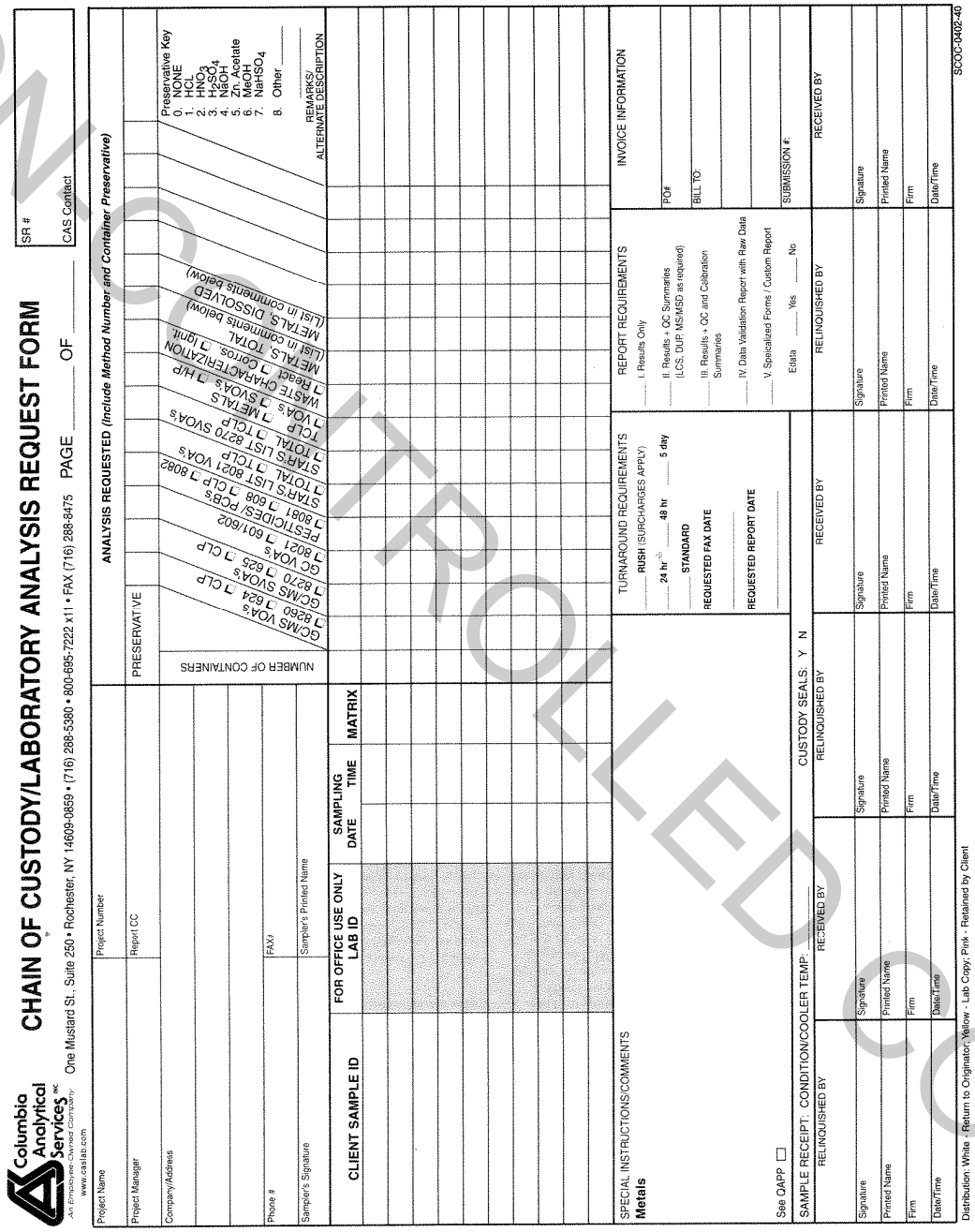
DETERMINATION	METHOD	MATRIX[b]	CONTAINER[c]	PREFERRED VOLUME (mL)	PRESERVATION	MAXIMUM HOLDING TIME[a]
Semivolatile Organics						
Petroleum Hydrocarbons, Extractable (Diesel-Range Organics)	8015	W,S	G, Teflon-Lined Cap	1000, 4 oz.	Cool, ≤6°C	7 days until extraction;[f] 40 days after extraction
EDB and DBCP	504.1	W	G, Teflon-Lined Cap	3x40	Cool, ≤6°C, No Headspace	14 days
EDB and DBCP	8011	W	G, Teflon-Lined Cap	3x40	Cool, ≤6°C, No Headspace	28 days
Non-Halogenated Organics	8015	W,S, NonAq Liq	G, Teflon-Lined Cap	3x40, 4 oz.	Cool, ≤6°C, No Headspace[g]	14 days
Phenols, Phthalate Esters, Nitrosamines, Nitroaromatics and Cyclic Ketones, Haloethers, Chlorinated Hydrocarbons	625/ 8270	W,S	G, Teflon-Lined Cap	1000, 4 oz.	Cool, ≤6°C, store in dark[g]	7 days until extraction;[f] 40 days after extraction
Chlorinated Phenolics	625/ 8270	W	G, Teflon-Lined Cap	1000	Cool, ≤6°C	30 days until extraction, 30 days after extraction
Polynuclear Aromatic Hydrocarbons	625/ 8310/ 8270	W,S	G, Teflon-Lined Cap	1000, 4 oz.	Cool, ≤6°C, Store in Dark	7 days until extraction;[f] 40 days after extraction
Polynuclear Aromatic Hydrocarbons	8270	Tissue	G, Teflon-Lined Cap	4 oz.	Freeze, ≤-10°C, Store in Dark	14 days until extraction;[f] 40 days after extraction
Organochlorine Pesticides	608/ 8081	W,S	G, Teflon-Lined Cap	1000, 4 oz.	Cool, ≤6°C	7 days until extraction;[f] 40 days after extraction
PCBs	608/8082	W,S	G, Teflon-Lined Cap	1000, 4 oz.	Cool, ≤6°C	1 year until extraction[f] and analysis
Chlorinated Herbicides	8151	W,S	G, Teflon-Lined Cap	1000, 4 oz.	Cool, ≤6°C	7 days until extraction;[f] 40 days after extraction
Metabolic/Fatty/Organic Acids	In house	W	G, Teflon-Lined Cap	2x40mL	Cool, ≤6°C, H_3PO_4	28 days recommended
Carbonyl Compounds (Formaldehyde)	8315	W	G, Teflon-Lined Cap	1000	Cool, ≤6°C	3 days until extraction, 3 days after extraction
Carbonyl Compounds (Formaldehyde)	8315	S	G, Teflon-Lined Cap	4 oz.	Cool, ≤6°C	14 days
Toxicity Characteristic Leaching Procedure (TCLP)						
Mercury	7470	HW	P,G	100g/ 1000mL	Sample: Cool, ≤6°C TCLP extract: HNO_3 to pH<2	28 days until extraction; 28 days after extraction
Metals, except Mercury	6010	HW	P,G	100g/ 1000mL	Sample: Cool, ≤6°C TCLP extract: HNO_3 to pH<2	180 days until extraction; 180 days after extraction
Volatile Organics	8260	HW	G, Teflon-Lined Cap	125g	Sample: Cool, ≤6°C Minimize Headspace TCLP extract: Cool, ≤6°C, HCl to pH<2, No Headspace	14 days until extraction; 14 days after extraction
Semivolatile Organics	8270	HW	G, Teflon-Lined Cap	100g/ 1000mL	Sample: Cool, ≤6°C, Store in Darkg TCLP extract: Cool, ≤6°C, Store in Dark	14 days until TCLP ext'n; 7 days until extraction; 40 days after extraction
Organochlorine Pesticides	8081	HW	G, Teflon-Lined Cap	100g/ 1000mL	Sample: Cool, ≤6°C TCLP extract: Cool, ≤6°C	14 days until TCLP ext'n; 7 days until extraction; 40 days after extraction

Table 7-1
Sample Preservation and Holding Times

DETERMINATION	METHOD	MATRIX[b]	CONTAINER[c]	PREFERRED VOLUME (mL)	PRESERVATION	MAXIMUM HOLDING TIME[a]
Chlorinated Herbicides	8151	HW	G, Teflon-Lined Cap	100g/ 1000mL	Sample: Cool, ≤6°C TCLP extract: Cool, ≤6°C	14 days until TCLP ext'n; 7 days until extraction; 40 days after extraction
CLP						
Cyanide, Total	ILM05.3	W	P,G	500	Cool, ≤6°C, NaOH to pH 12, plus 0.6 g Ascorbic Acid	12 days[h]
	ILM05.3	S	P,G	8 oz.	Cool, ≤6°C	12 days[h]
Mercury	ILM05.3	W	P,G	500	HNO_3 to pH<2	26 days[h]
	ILM05.3	S	P,G	8 oz.	Cool, ≤6°C	26 days[h]
Metals, except Mercury	ILM05.3	W	P,G	500	HNO3 to pH<2	180 days[h]
	ILM05.3	S	P,G	8 oz.	Cool, ≤6°C	180 days[h]
Volatile Organics	OLM04.3	W,S	G, Teflon-Lined Cap	3x40	W-Cool, ≤6°C, Minimize Headspace Soil – see SOP	10 days[h]
Semivolatile Organics	OLM04.3	W,S	G, Teflon-Lined Cap	2000	Cool, ≤6°C, Store in Dark[g]	5 days until extraction;[h,i] 40 days after extraction
Organochlorine Pesticides and PCBs	OLM04.3	W,S	G, Teflon-Lined Cap	2000	Cool, ≤6°C	5 days until extraction;[h,i] 40 days after extraction

NON-CONTROLLED COPY

Figure 7-1
Chain of Custody Form



Columbia Analytical Services INC
An Employee-Owned Company
www.caslab.com

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

One Mustard St., Suite 250 • Rochester, NY 14609-0859 • (716) 288-5380 • 800-695-7222 x11 • FAX (716) 288-8475 PAGE _____ OF _____

SR #
CAS Contact

Project Name
Project Number
Project Manager
Report CC
Company/Address
Phone #
FAX#
Sampler's Signature
Sampler's Printed Name

ANALYSIS REQUESTED (Include Method Number and Container Preservative)

PRESERVATIVE
NUMBER OF CONTAINERS

GC/MS VOA's
8260 ☐
GC/MS SVOA's
8270 ☐ 625 ☐ 624 ☐ CLP
GC VOA's
8021 ☐ 601/602
PESTICIDES/ PCB's
8081 ☐ 608 ☐ CLP ☐ 8082
STAR'S LIST 8021 VOA's
TOTAL ☐ TCLP
STAR'S LIST 8270 SVOA's
TOTAL ☐ TCLP
VOA's ☐ METALS
TCLP ☐ SVOA's ☐ H/P
WASTE CHARACTERIZATION
Reactivity ☐ Corros ☐ Ignit.
METALS TOTAL
(List in comments below)
METALS DISSOLVED
(List in comments below)

Preservative Key
0. NONE
1. HCL
2. H_2SO_4
3. HNO_3
4. NaOH
5. Zn. Acetate
6. MeOH
7. $NaHSO_4$
8. Other _____

REMARKS/ ALTERNATE DESCRIPTION

CLIENT SAMPLE ID	FOR OFFICE USE ONLY LAB ID	SAMPLING DATE	SAMPLING TIME	MATRIX

SPECIAL INSTRUCTIONS/COMMENTS
Metals

See QAPP ☐

TURNAROUND REQUIREMENTS
RUSH (SURCHARGES APPLY)
_____ 24 hr[a] _____ 48 hr _____ 5 day
_____ STANDARD
REQUESTED FAX DATE
_____
REQUESTED REPORT DATE
_____

REPORT REQUIREMENTS
_____ I. Results Only
_____ II. Results + QC Summaries (LCS, DUP, MS/MSD as required)
_____ III. Results + QC and Calibration Summaries
_____ IV. Data Validation Report with Raw Data
_____ V. Specialized Forms / Custom Report
Edata _____ Yes _____ No

INVOICE INFORMATION
PO#
BILL TO:
SUBMISSION #:

SAMPLE RECEIPT: CONDITION/COOLER TEMP: _____ CUSTODY SEALS: Y N

RELINQUISHED BY	RECEIVED BY	RELINQUISHED BY	RECEIVED BY	RELINQUISHED BY	RECEIVED BY
Signature	Signature	Signature	Signature	Signature	Signature
Printed Name	Printed Name	Printed Name	Printed Name	Printed Name	Printed Name
Firm	Firm	Firm	Firm	Firm	Firm
Date/Time	Date/Time	Date/Time	Date/Time	Date/Time	Date/Time

Distribution: White - Return to Originator; Yellow - Lab Copy; Pink - Retained by Client

SCOC-0402-40

NON-CONTROLLED COPY

Figure 7-2

NON-CONTROLLED COPY

Cooler Receipt And Preservation Check Form

Project/Client_____Folder Number_____.

Cooler received on_____ by:_____**COURIER:** CAS UPS FEDEX VELOCITY CLIENT

1. Were custody seals on outside of cooler? YES NO
2. Were custody papers properly filled out (ink, signed, etc.)? YES NO
3. Did all bottles arrive in good condition (unbroken)? YES NO
4. Did VOA vials, Alkalinity, or Sulfide have significant* air bubbles? YES NO N/A
5. Were **Ice** or **Ice packs** present? YES NO
6. Where did the bottles originate? CAS/ROC, CLIENT
7. Temperature of cooler(s) upon receipt: _____ _____ _____ _____ _____

Is the temperature within 0° - 6° C?:	Yes	Yes	Yes	Yes	Yes
If No, Explain Below	No	No	No	No	No

Date/Time Temperatures Taken: _____

Thermometer ID: IR GUN#3 / IR GUN#4 Reading From: Temp Blank / Sample Bottle

If out of Temperature, note packing/ice condition, Client Approval to Run Samples:_____
PC Secondary Review: _____

Cooler Breakdown: Date :_____Time:_____by:_____

1. Were all bottle labels complete (*i.e.* analysis, preservation, etc.)? YES NO
2. Did all bottle labels and tags agree with custody papers? YES NO
3. Were correct containers used for the tests indicated? YES NO
4. Air Samples: Cassettes / Tubes Intact Canisters Pressurized Tedlar® Bags Inflated N/A

Explain any discrepancies: _____

pH	Reagent	YES	NO	Lot Received	Exp	Sample ID	Vol. Added	Lot Added	Final pH
≥12	NaOH								
≤2	HNO_3								
≤2	H_2SO_4								
Residual Chlorine (-)	For TCN and Phenol			If present, contact PM to add ascorbic acid					
	$Na_2S_2O_3$	-	-						
	Zn Aceta	-	-						
	HCl	*	*						

*Not to be tested before analysis – pH tested and recorded by VOAs or GenChem on a separate worksheet

Yes = All samples OK

No = Samples were preserved at lab as listed

PM OK to Adjust: _____

Bottle lot numbers:_____
Other Comments:

PC Secondary Review: _____ *significant air bubbles: VOA > 5-6 mm : WC >1 in. diameter

H:\SMODOCS\Cooler Receipt 3.doc

NON-CONTROLLED COPY

8.0 ANALYTICAL PROCEDURES

Columbia Analytical employs methods and analytical procedures from a variety of external sources. The primary method references are: USEPA SW-846, Third Edition and Updates I, II, IIA, IIB, III, IVA, IVB, and online updates for hazardous waste samples, and USEPA 600/4-79-020, 600/4-91-010, 600/4-82-057, 600/R-93/100, 600/4-88-039, 600/R-94-111, EPA 40CFR parts 136 and 141, and Supplements; and *Standard Methods for the Examination of Water and Wastewater* for water and wastewater samples. Complete citations for these references can be found in Section 17.0. Other published procedures, such as state-specific methods, program-specific methods, or in-house methods may be used. Several factors are involved with the selection of analytical methods to be used in the laboratory. These include the method detection limit, the concentration of the analyte being measured, method selectivity, accuracy and precision of the method, the type of sample being analyzed, and the regulatory compliance objectives. The implementation of methods by Columbia Analytical is described in SOPs specific to each method. A list of NELAP-accredited methods is given in Appendix G. Further details are described below.

8.1 Standard Operating Procedures (SOPs) and Laboratory Notebooks.

Columbia Analytical maintains SOPs for use in both technical and administrative functions. SOPs are written following standardized format and content requirements as described in the *SOP for Preparation of Standard Operating Procedures*. Each SOP is reviewed and approved by a minimum of two managers (the Laboratory Director and/or Department Manager and the Quality Assurance Program Manager). All SOPs undergo a documented annual review to make sure current practices are described. The QA PM maintains a comprehensive list of current SOPs. The document control process ensures that only the most currently prepared version of an SOP is being used. The QA Manual, QAPPs, SOPs, standards preparation logbooks, maintenance logbooks, et al., are controlled documents. The procedures for document control are described in the *SOP for Document Control* (ADM-DOC_CTRL). In addition to SOPs, each laboratory department maintains a current file, accessible to all laboratory staff, of the current methodology used to perform analyses. Laboratory notebook entries are standardized following the guidelines in the *SOP for Making Entries into Logbooks and onto Benchsheets* (ADM-DATANTRY). Entries made into laboratory notebooks are reviewed and approved by the appropriate supervisor at a regular interval.

8.2 Deviation from Standard Operating Procedures

When a customer requests a modification to an SOP (such as a change in reporting limit, addition or deletion of target analyte(s), etc.), the project chemist handling that project must discuss the proposed deviation with the department manager in charge of the analysis and obtain their approval to accept the project. The project chemist is responsible for documenting the approved or allowed deviation from the SOP by placing a detailed description of the deviation attached to the quotation or in the project file and also providing an appropriate comment on the service request when the samples are received.

NON-CONTROLLED COPY

For circumstances when a deviation or departure from company policies or procedures involving any non-technical function is found necessary, approval must be obtained from the appropriate supervisor, manager, the laboratory director, or other level of authority. Frequent departure from policy is not encouraged. However, if frequent departure from any policy is noted, the laboratory director will address the possible need for a change in policy.

8.3 Modified Procedures

Columbia Analytical strives to perform published methods as described in the referenced documents. If there is a material deviation from the published method, the method is cited as a "Modified" method in the analytical report. Modifications to the published methods are listed in the standard operating procedure. Standard operating procedures are available to analysts and are also available to our clients for review, especially those for "Modified" methods. Client approval is obtained for the use of "Modified" methods prior to the performance of the analysis.

8.4 Analytical Batch

The basic unit for analytical quality control is the analytical batch. The definition that Columbia Analytical has adopted for the analytical batch is listed below. The overriding principle for describing an analytical batch is that all the samples in a batch, both field samples and quality control samples are to be handled exactly the same way, and all of the data from each analysis is to be manipulated in exactly the same manner. The minimum requirements of an analytical batch are:

1) The number of (field) samples in a batch is not to exceed 20.
2) All (field) samples in a batch are of the same matrix.
3) The QC samples to be processed with the (field) samples include:
   a) Method Blank (a.k.a. Laboratory Reagent Blank)

      Function: Determination of laboratory contamination.

   b) Laboratory Control Sample

      Function: Assessment of method performance

   c) Matrix Spiked (field) Sample (a.k.a. Laboratory Fortified Sample Matrix)*

      Function: Assessment of matrix bias

   d) Duplicate Matrix Spiked (field) Sample or Duplicate (field) Sample (a.k.a. Laboratory Duplicate)*

      Function: Assessment of batch precision

   * A sample identified as a field blank, an equipment blank, or a trip blank is not to be matrix spiked or duplicated.

NON-CONTROLLED COPY

4) A single lot of reagents is used to process the batch of samples.
5) Each operation within the analysis is performed by a single analyst, technician, chemist, or by a team of analysts/technicians/chemists.
6) Samples are analyzed in a continuous manner over a timeframe not to exceed 24-hours between the start of processing of the first and last sample of the batch.
7) Samples are analyzed in a continuous manner over a timeframe not to exceed 24-hours.
8) (Field) samples are assigned to batches commencing at the time that sample processing begins. For example: for analysis of metals, sample processing begins when the samples are digested. For analysis of organic constituents, it begins when the samples are extracted.
9) The QC samples are to be analyzed in conjunction with the associated field samples prepared with them. However, for tests which have a separate sample preparation step that defines a batch (digestion, extraction, etc.), the QC samples in the batch do not require analysis each time a field sample within the preparation batch is analyzed (multiple instrument sequences to analyze all field samples in the batch need not include re-analyses of the QC samples).
10) The batch is to be assigned a unique identification number that can be used to correlate the QC samples with the field samples.
11) Batch QC refers to the QC samples that are analyzed in a batch of (field) samples.
12) Project-specific requirements may be exceptions. If project, program, or method requirements are more stringent than these laboratory minimum requirements, then the project, program, or method requirements will take precedence. However, if the project, program, or method requirements are less stringent than these laboratory minimum requirements, these laboratory minimum requirements will take precedence.

8.5 Specialized Procedures

Columbia Analytical not only strives to provide results that are scientifically sound, legally defensible, and of known and documented quality; but also strives to provide the best solution to analytical challenges. Procedures using specialized instrumentation and methodology have been developed to improve sensitivity (provide lower detection limits), selectivity (minimize interferences while maintaining sensitivity), and overall data quality for low concentration applications. Examples at our various locations are trace-level Mercury and Methylmercury analyses, reductive precipitation metals analysis, specialized GC/MS analyses, LC/MS analyses, and ultra-low level organics analyses (including PAHs, pesticides and PCBs).

8.6 Sample Cleanup

Columbia Analytical commonly employs several cleanup procedures to minimize known common interferences prior to analysis. EPA methods (3620, 3640, 3660, and 3665) for cleanup of sample extracts for organics analysis are routinely used to minimize or eliminate interferences that may adversely affect sample results and data usability.

NON-CONTROLLED COPY

9.0 CALIBRATION PROCEDURES

All equipment and instruments used at Columbia Analytical are operated, maintained and calibrated according to the manufacturer's guidelines and recommendations, as well as to criteria set forth in the applicable analytical methodology. Operation and calibration are performed by personnel who have been properly trained in these procedures. Documentation of calibration information is maintained in appropriate reference files. Brief descriptions of the calibration procedures for our major laboratory equipment and instruments are described below. Calibration verification is performed according to the applicable analytical methodology. Calibration verification procedures and criteria are listed in laboratory Standard Operating Procedures. Documentation of calibration verification is maintained in appropriate reference files. Records are maintained to provide traceability of reference materials.

All analytical measurements generated at Columbia Analytical are performed using materials and/or processes that are traceable to a reference material. Metrology equipment (analytical balances, thermometers, etc.) is calibrated using reference materials traceable to the National Institute of Standards and Technology (NIST). These primary reference materials are themselves recertified on an annual basis. Vendors used for metrology support are required to verify compliance to International Standards by supplying the laboratory with a copy of their scope of accreditation.

Equipment subjected to overloading or mishandling, or has been shown by verification to be defective; is taken out of service until it is repaired. The equipment is placed back in service only after verifying, by calibration, that the equipment performs satisfactorily.

9.1 Temperature Control Devices

Temperatures are monitored and recorded for all of the temperature-regulating support equipment such as refrigerators, freezers, ovens, and incubators. Bound record books are kept which contain daily-recorded temperatures, acceptance criteria and the initials of the technician who performed the checks. The procedure for performing these measurements is provided in the *SOP for Calibration Check Procedures for Support Equipment (SOP ADM-DALYCK).* The SOP also includes the use of acceptance criteria and correction factors. Refrigerators and freezers containing samples are monitored continuously with max/min thermometers

Where the operating temperature is specified as a test condition the temperature is recorded on the raw data. All thermometers are uniquely identified and the calibration is checked annually (or quarterly for digital devices) against a National Institute of Standards and Technology (NIST) certified thermometer. The NIST thermometer is recertified by a vendor accredited to A2LA or ISO/IEC 17025:2005 International Standard every two years. Calibration records are maintained by the QAPM.

NON-CONTROLLED COPY

9.2 Analytical Balances

Analytical balances are serviced on an annual basis by a professional metrology organization. New certificates of calibration for each balance are issued to the laboratory on an annual basis. The calibration of each analytical balance is checked by the user each day of use with Class-1 verified weights bracketing the working range. The reference weights are verified annually by the metrology organization. Bound record books are kept which contain the recorded measurements, identification and location of equipment, acceptance criteria and the initials of the user who performed the checks. See SOP SMO-DALYCK for instructions and further information.

9.3 Water Purification Systems

Columbia Analytical uses a water purification systems designed to produce deionized water meeting method specifications. The system consists of a series of pumps, filters, and resin beds designed to yield deionized water meeting the specifications of ASTM Type II water, and *Standard Methods for the Examination of Water and Wastewater* (SM1080, 20th Ed.) *High Quality* water. The conductivity and pH are checked by the laboratory every business day using meters calibrated according to GEN-9040/SM4500H+B and GEN-120.1. Other checks are performed regularly by the subcontracted water system service. These checks are discussed further in ADM-DALYCK. The laboratory may use the results of laboratory method blanks for impromptu checks of TOC, TDS, and chloroform if a problem is suspected. The water in the volatiles department is further purified by a Millipore polishing system.

9.4 Source and Preparation of Standards and Reference Materials

Consumable reference materials routinely purchased by the laboratories (e.g., analytical standards) are purchased from nationally recognized, reputable vendors. All vendors have fulfilled the requirements for ISO 9001 certification and/or are accredited by A_2LA. Columbia Analytical relies on a primary vendor for the majority of its analytical supplies. Consumable primary stock standards are obtained from certified commercial sources or from sources referenced in a specific method. Supelco, Ultra Scientific, AccuStandard, Chem Services, Inc., Aldrich Chemical Co., Baker, Spex, etc. are examples of the vendors used. Reference material information is recorded in the appropriate logbook(s) and materials are stored under conditions that provide maximum protection against deterioration and contamination. The logbook entry includes such information as an assigned logbook identification code, the source of the material (i.e. vendor identification), solvent (if applicable) and concentration of analyte(s), reference to the certificate of analysis and an assigned expiration date. The date that the standard is received in the laboratory is marked on the container. See ADM-DATANTRY for more detailed information.

Stock solutions and calibration standard solutions are prepared fresh as often as necessary according to their stability. All standard solutions are properly labeled with standard name, analyte concentration, solvent, date, preparer, and expiration date; these entries are also recorded in the appropriate notebook(s) following the *SOP for Making Entries into Logbooks and onto Benchsheets* (SOP No. ADM-DATANTRY). To ensure traceability, all standards are labeled with an in-house code that can be traced back to the original stock standard received by the vendor and thus, the certificate of analysis. Prior to introduction into the analytical system/process, reference materials are verified for accuracy with a second, independent source of the material. In addition, the independent source of reference material is also used to check the calibration standards for signs of deterioration. All standards, reagents and reference materials shall be stored per analytical SOP requirements to ensure their integrity. Safe handling and transportation of these materials are discussed in the respective analytical SOP and/or Laboratory Safety Manual.

9.5 Inductively Coupled Plasma-Atomic Emission Spectrograph (ICP-AES)

Each emission line on the ICP is calibrated daily against a blank and three standards. Analyses of calibration standards, initial and continuing calibration verification standards, and inter-element interference check samples are carried out as specified in the applicable method SOP and analytical method (i.e. EPA 200.7, 6010B, 6010C, CLP SOW, etc.). Calibration policies are described in the *SOP for Initial Calibration (SOP ADM-ICAL).*

9.6 Inductively Coupled Plasma-Mass Spectrometer (ICP-MS)

Each element of interest is calibrated daily against a blank and three standards. Analyses of calibration standards, initial and continuing calibration verification standards, and inter-element interference check samples are carried out as specified in the applicable method SOP and analytical method (i.e. EPA 200.8, 6020A, CLP SOW, etc.). Calibration policies are described in the *SOP for Initial Calibration (SOP ADM-ICAL).*

9.7 Atomic Absorption Spectrophotometers (AAS)

These instruments are calibrated daily using a minimum of four standards and a blank. Calibration is validated using reference standards, and is verified at a minimum frequency of once every ten samples. Calibration policies are described in the *SOP for Initial Calibration (SOP ADM-ICAL).*

NON-CONTROLLED COPY

NON-CONTROLLED COPY

9.8 GC/MS Systems

All GC/MS instruments are calibrated at a minimum of five different concentration levels for the analytes of interest or at a number of levels as prescribed by the method (e.g. The 600 numbered methods require a minimum of three levels), using procedures outlined in Standard Operating Procedures (SOPs) and/or appropriate USEPA method citations. All SRMs used for this function are "EPA-Certified." Compounds selected as system performance check compounds (SPCCs) must show a method-specified response factor in order for the calibration to be considered valid. Calibration check compounds (CCCs) must also meet method specifications for percent difference from the multipoint calibration. Method-specific instrument tuning is regularly checked using bromofluorobenzene (BFB) for volatile organic chemical (VOC) analysis, or decafluorotriphenylphosphine (DFTPP) for semi-volatile analysis. Mass spectral peaks for the tuning compounds must conform both in mass numbers and in relative intensity criteria before analyses can proceed. Calibration policies are described in the *SOP for Initial Calibration (SOP ADM-ICAL).*

9.9 Gas Chromatographs and High Performance Liquid Chromatographs

Calibration and standardization follow SOP guidelines and/or appropriate USEPA method citations. All GC and HPLC instruments are calibrated at a minimum of five different concentration levels for the analytes of interest (unless specified otherwise). The lowest standard is equivalent to the method reporting limit; additional standards define the working range of the GC or LC detector. Results are used to establish response factors (or calibration curves) and retention-time windows for each analyte. Calibration is verified at a minimum frequency of once every ten samples, unless otherwise specified by the reference method. Calibration policies are described in the *SOP for Initial Calibration (SOP ADM-ICAL)..*

9.10 LC/MS Systems

Calibration and tuning procedures are included in analytical SOPs written specifically for these tests. In general, multiple concentration levels for the analytes of interest are used to generate calibration curves. All reference materials used for this function are vendor-certified standards. Calibration and tuning verification is performed at SOP-defined intervals. Any other system performance checks are described in the applicable SOP. Calibration policies are described in the *SOP for Initial Calibration (SOP ADM-ICAL).*

9.11 UV-Visible Spectrophotometer (manual colorimetric analyses)

Routine calibrations for colorimetric analyses involve generating a 5-point calibration curve including a blank. Correlation coefficients must meet method or SOP specifications before analysis can proceed. Independent calibration verification standards (ICVs) are analyzed with each batch of samples. Continuing calibration is verified at a minimum frequency of once every ten samples.

NON-CONTROLLED COPY

9.12 Flow Injection Analyzer (automated colorimetric analysis)

A minimum of five standards and a blank (unless otherwise specified in the applicable SOP) are used to calibrate the instrument daily. Standard CAS acceptance limits are used to evaluate the calibration curve prior to sample analysis. All linear regressions must have a correlation coefficient of 0.995 or better before analysis may proceed.

9.13 Ion Chromatographs

Calibration of the ion chromatograph (IC) involves generating a minimum of a 5-point calibration curve. A correlation coefficient of 0.995 or better for the curve is required before analysis can proceed. Quality Control (QC) samples that are routinely analyzed include blanks and laboratory control samples. The target analytes typically determined by the IC include nitrate, chloride, fluoride, and sulfate.

9.14 Turbidimeter

Calibration of the turbidimeter requires analysis of formazin and polymer standards measured as NTU. Quality Control samples that are routinely analyzed include blanks, and duplicates.

9.15 Ion-selective electrode

The method-prescribed numbers of standards are used to calibrate the electrodes before analysis. The slope of the curve must be within acceptance limits before analysis can proceed. Quality Control samples that are routinely analyzed include blanks, LCSs and duplicates.

9.16 Pipets

The calibration of pipets and autopipettors used to make critical-volume measurements is verified following the *SOP Use and Calibration of Mechanical Volumetric Dispensing Devices (ADM-PCAL)*. Both accuracy and precision verifications are performed, at intervals applicable to the pipet and use. The results of all calibration verifications are recorded in bound logbooks.

9.17 Other Instruments

Calibration for the total organic carbon (TOC), and other instruments is performed following manufacturer's recommendations and applicable SOPs.

NON-CONTROLLED COPY

10.0 QUALITY CONTROL

A primary focus of Columbia Analytical's QA Program is to ensure the accuracy, precision and comparability of all analytical results. Prior to using a procedure for the analysis on field samples, acceptable method performance is established by performing demonstration of capability analyses. Performance characteristics are established by performing method detection limit studies and assessing accuracy and precision according to the reference method. Columbia Analytical has established Quality Control (QC) objectives for precision and accuracy that are used to determine the acceptability of the data that is generated. These QC limits are either specified in the test methodology or are statistically derived based on the laboratory's historical data. Quality Control objectives are defined below.

10.1 Quality Control Objectives

10.1.1 Demonstration of Capability - A demonstration of capability (DOC) is made prior to using any new test method or when a technician is new to the method. This demonstration is made following regulatory, accreditation, or method specified procedures. In general, this demonstration does not test the performance of the method in real world samples, but in the applicable clean matrix free of target analytes and interferences.

A quality control sample material may be obtained from an outside source or may be prepared in the laboratory. The analyte(s) is (are) diluted in a volume of clean matrix (for analytes which do not lend themselves to spiking, e.g., TSS, the demonstration of capability may be performed using quality control samples). Where specified, the method-required concentration levels are used. Four aliquots are prepared and analyzed according to the test procedure. The mean recovery and standard deviations are calculated and compared to the corresponding acceptance criteria for precision and accuracy in the test method or laboratory-generated acceptance criteria (if there are not established mandatory criteria). All parameters must meet the acceptance criteria. Where spike levels are not specified, actual Laboratory Control Sample results may be used to meet this requirement, provided acceptance criteria is met.

10.1.2 Accuracy - Accuracy is a measure of the closeness of an individual measurement (or an average of multiple measurements) to the true or expected value. Accuracy is determined by calculating the mean value of results from ongoing analyses of laboratory-fortified blanks, standard reference materials, and standard solutions. In addition, laboratory-fortified (i.e. matrix-spiked) samples are also measured; this indicates the accuracy or bias in the actual sample matrix. Accuracy is expressed as percent recovery (% REC.) of the measured value, relative to the true or expected value. If a measurement process produces results whose mean is not the true or expected value, the process is said to be biased. Bias is the systematic error either inherent in a method of analysis (e.g., extraction efficiencies) or caused by an artifact of the measurement system (e.g., contamination).

NON CONTROLLED COPY

Columbia Analytical utilizes several quality control measures to eliminate analytical bias, including systematic analysis of method blanks, laboratory control samples and independent calibration verification standards. Because bias can be positive or negative, and because several types of bias can occur simultaneously, only the net, or total, bias can be evaluated in a measurement.

10.1.3 Precision - Precision is the ability of an analytical method or instrument to reproduce its own measurement. It is a measure of the variability, or random error, in sampling, sample handling and in laboratory analysis. The American Society of Testing and Materials (ASTM) recognizes two levels of precision: repeatability - the random error associated with measurements made by a single test operator on identical aliquots of test material in a given laboratory, with the same apparatus, under constant operating conditions, and reproducibility - the random error associated with measurements made by different test operators, in different laboratories, using the same method but different equipment to analyze identical samples of test material.

"Within-batch" precision is measured using replicate sample or QC analyses and is expressed as the relative percent difference (RPD) between the measurements. The "batch-to-batch" precision is determined from the variance observed in the analysis of standard solutions or laboratory control samples from multiple analytical batches.

10.1.4 Control Limits - The control limits for accuracy and precision originate from two different sources. For analyses having enough QC data, control limits are calculated at the 99% confidence limits. For analyses not having enough QC data, or where the method is prescriptive, control limits are taken from the method on which the procedure is based. If the method does not have stated control limits, then control limits are assigned method-default or reasonable values. Control limits are updated periodically when new statistical limits are generated for the appropriate surrogate, laboratory control sample, and matrix spike compounds (typically once a year) or when method prescribed limits change. The updated limits are reviewed by the QA PM. The new control limits replace the previous limits and data is assessed using the new values. Current acceptance limits for accuracy and precision are available from the laboratory. For inorganics, the precision limit values listed are for laboratory duplicates. For organics, the precision limit values listed are for duplicate laboratory control samples or duplicate matrix spike analyses. Procedures forestablishing control limits are found in the *SOP for Control Limits* (ADM-CTRL_LIM).

10.1.5 Representativeness - Representativeness is the degree to which the field sample, being properly preserved, free of contamination, and analyzed within holding time, represents the overall sample site or material. This can be extended to the sample itself, in that representativeness is the degree to which the subsample that is analyzed represents the entire field sample submitted for analysis. Columbia Analytical has sample handling procedures to ensure that the sample used for analysis is representative of the entire sample. See the *SOP for Sample Preparation, Compositing and Subsampling.* Further, analytical SOPs specify appropriate sample handling and sample sizes to further ensure the sample aliquot that is analyzed is representative in entire sample.

10.1.6 Comparability – Comparability expresses the confidence with which one data set can be compared to another and is directly affected by data quality (accuracy and precision) and sample handling (sampling, preservation, etc). Only data of known quality can be compared. The objective is to generate data of known quality with the highest level of comparability, completeness, and usability. This is achieved by employing the quality controls listed below and standard operating procedures for the handling and analysis of all samples. Data is reported in units specified by the client and using Columbia Analytical or project-specified data qualifiers.

10.1.7 Completeness - Completeness is a measure of the amount of valid data that is obtained, compared to the amount that is expected. It is expected that all analyses conducted in accordance with the approved analytical methods and standard laboratory operating procedures will meet QC acceptance criteria for 95% of the samples tested, however, the CAS objective for completeness is 100%.

$$\text{Completeness (\%)} = \frac{\text{valid data obtained}}{\text{total data planned}} \times 100$$

10.2 Method Detection Limits, Method Reporting Limits, and Limits of Detection/Quantitation

Method Detection Limits (MDL) for methods performed at Columbia Analytical/Rochester are determined during initial method set up and if any significant changes are made. If an MDL study is not performed annually, the established MDL is verified by performing a limit of detection (LOD) verification on every instrument used in the analysis. The MDLs are determined by following the *SOP for Performing Method Detection Limits Studies and Establishing Limits of Detection and Quantitation (ADM-MDL),* which is based on the procedure in 40 CFR Part 136, Appendix B. As required by NELAP and DoD protocols, the validity of MDLs is verified using LOD verification samples.

The Method Reporting Limit (MRL) is the lowest amount of an analyte in a sample that can be quantitatively determined with stated, acceptable precision and accuracy under stated analytical conditions (i.e. limit of quantitation- LOQ). LOQ are analyzed on an annual basis and cannot be lower than the lowest calibration standard. Current MDLs and MRLs are available from the laboratory.

NON-CONTROLLED COPY

10.3 Quality Control Procedures

The specific types, frequencies, and processes for quality control sample analysis are described in detail in method-specific standard operating procedures and listed below. These sample types and frequencies have been adopted for each method and a definition of each type of QC sample is provided below.

10.3.1 Method Blank (a.k.a. Laboratory Reagent Blank)

The method blank is an analyte-free matrix (water, soil, etc.) subjected to the entire preparation and analytical process. When analyte-free soil is not available, anhydrous sodium sulfate, organic-free sand, glass beads, Teflon chips or an acceptable substitute is used. The method blank is analyzed to demonstrate that the analytical system itself does not introduce contamination. The method blank results should be below the Method Reporting Limit (MRL) or, if required for DoD projects, < ½ MRL for the analyte(s) being tested. Otherwise, corrective action must be taken. A method blank is included with the analysis of every sample preparation batch, every 20 samples, or as stated in the method, whichever is more frequent.

10.3.2 Calibration Blanks

For some methods, calibration blanks are prepared along with calibration standards in order to create a calibration curve. Calibration blanks are free of the analyte of interest and, where applicable, provide the zero point of the calibration curve. Additional project-specific requirements may also apply to calibration blanks.

10.3.3 Continuing Calibration Blanks

Continuing calibration blanks (CCBs) are solutions of either analyte-free water, reagent, or solvent that are analyzed in order to verify the system is contamination-free. The frequency of CCB analysis is either once every ten samples or as indicated in the method, whichever is greater. Additional project-specific requirements may also apply to continuing calibration blanks.

10.3.4 Calibration Standards

Calibration standards are solutions of known concentration prepared from primary standard or stock standard materials. Calibration standards are used to calibrate the instrument response with respect to analyte concentration. Standards are analyzed in accordance with the requirements stated in the particular method being used.

NON-CONTROLLED COPY

NON-CONTROLLED COPY

10.3.5 Initial (or Independent) Calibration Verification Standards

Initial (or independent) calibration verification standards (ICVs) are standards that are analyzed *after* calibration but *prior to* sample analysis, in order to verify the validity and accuracy of the standards used for calibration. Once it is determined that there is no defect or error in the calibration standard(s), standards are considered valid and may be used for subsequent calibrations and quantitative determinations (as expiration dates and methods allow). The ICV standards are prepared from materials obtained from a source independent of that used for preparing the calibration standards ("second-source"). ICVs are also analyzed in accordance with method-specific requirements.

10.3.6 Continuing Calibration Verification Standards

Continuing calibration verification standards (CCVs) are midrange standards that are analyzed in order to verify that the calibration of the analytical system is still acceptable. The frequency of CCV analysis is either once every ten samples, or as indicated in the method.

10.3.7 Internal Standards

Internal standards are known amounts of specific compounds that are added to each sample prior to instrument analysis. Internal standards are generally used for GC/MS and ICP-MS procedures to correct sample results that have been affected by changes in instrument conditions or changes caused by matrix effects. The requirements for evaluation of internal standards are specified in each method and SOP.

10.3.8 Surrogates

Surrogates are organic compounds which are similar in chemical composition and chromatographic behavior to the analytes of interest, but which are not normally found in environmental samples. Depending on the analytical method, one or more of these compounds is added to method blanks, calibration and check standards, and samples (including duplicates, matrix spike samples, duplicate matrix spike samples and laboratory control samples) prior to extraction and analysis in order to monitor the method performance on each sample. The percent recovery is calculated for each surrogate, and the recovery is a measurement of the overall method performance.

$$Recovery\ (\%) = (M/T) \times 100$$

Where: M = The measured concentration of analyte,
T = The theoretical concentration of analyte added.

NON CONTROLLED COPY

10.3.9 Laboratory Control Samples

The laboratory control sample (LCS) is an aliquot of analyte-free water or analyte-free solid (or anhydrous sodium sulfate or equivalent) to which known amounts of the method analyte(s) is (are) added. A reference material of known matrix type, containing certified amounts of target analytes, may also be used as an LCS. An LCS is prepared and analyzed at a minimum frequency of one LCS per 20 samples, with every analytical batch or as stated in the method, whichever is more frequent. The LCS sample is prepared and analyzed in exactly the same manner as the field samples.

The percent recovery of the target analytes in the LCS is compared to established control limits and assists in determining whether the methodology is in control and whether the laboratory is capable of making accurate and precise measurements at the required reporting limit. Comparison of batch-to-batch LCS analyses enables the laboratory to evaluate batch-to-batch precision and accuracy.

$$Recovery\ (\%) = (M/T) \times 100$$

Where: M = The measured concentration of analyte,
T = The theoretical concentration of analyte added.

10.3.10 Laboratory Fortified Blanks - LFB

A laboratory blank fortified at the MRL used to verify the minimum reporting limit. The LFB is carried through the entire extraction and analytical procedure. A LFB is required with every batch of drinking water samples.

10.3.11 Matrix Spikes (a.k.a. Laboratory Fortified Sample Matrix)

Matrix spiked samples are aliquots of samples to which a known amount of the target analyte (or analytes) is (are) added. The samples are then prepared and analyzed in the same analytical batch, and in exactly the same manner as are routine samples. For the appropriate methods, matrix spiked samples are prepared and analyzed and at a minimum frequency of one spiked sample (and one duplicate spiked sample, if appropriate) per twenty samples. The spike recovery measures the effects of interferences caused by the sample matrix and reflects the accuracy of the method for the particular matrix in question. Spike recoveries are calculated as follows:

$$Recovery\ (\%) = (S - A) \times 100 \div T$$

Where: S = The observed concentration of analyte in the spiked sample,
A = The analyte concentration in the original sample, and
T = The theoretical concentration of analyte added to the spiked sample.

NON-CONTROLLED COPY

10.3.12 Laboratory Duplicates and Duplicate Matrix Spikes

Duplicates are additional replicates of samples that are subjected to the same preparation and analytical scheme as the original sample. Depending on the method of analysis, either a duplicate analysis (and/or a matrix spiked sample) or a matrix spiked sample and duplicate matrix spiked sample (MS/DMS) are analyzed. The relative percent difference between duplicate analyses or between an MS and DMS is a measure of the precision for a given method and analytical batch. The relative percent difference (RPD) for these analyses is calculated as follows:

$$\textit{Relative Percent Difference (RPD)} = (S1 - S2) \times 100 \div S_{ave}$$

Where S1 and S2 = The observed concentrations of analyte in the sample and its duplicate, or in the matrix spike and its duplicate matrix spike, and

S_{ave} = The average of observed analyte concentrations in the sample and its duplicate, or in the matrix spike and its duplicate matrix spike.

Depending on the method of analysis, either duplicates (and/or matrix spikes) or MS/DMS analyses are performed at a minimum frequency of one set per 20 samples. If an insufficient quantity of sample is available to perform a laboratory duplicate or duplicate matrix spikes, duplicate LCSs will be prepared and analyzed.

10.3.13 Interference Check Samples

An interference check sample (ICS) is a solution containing both interfering and analyte elements of known concentration that can be analyzed to verify background and interelement correction factors in metals analyses. The ICS is prepared to contain known concentrations (method or program specific) of elements that will provide an adequate test of the correction factors. The ICS is analyzed at the beginning and end of an analytical run or at a method-specified frequency. Results must meet method criteria and any project-specific criteria.

10.3.14 Post Digestion Spikes

Post digestion spikes are samples prepared for metals analyses that have an analyte spike added to determine if matrix effects may be a factor in the results. The spike addition should produce a method-specified minimum concentration above the method reporting limit. A post digestion spike is analyzed with each batch of samples and recovery criteria are specified for each method.

10.3.15 Control Charting

The generation of control charts is routinely performed at Columbia Analytical. Surrogate, Matrix Spike and LCS recoveries are all monitored and charted using Quality Analyst software. Control charts are available to monitor the data and to identify various trends in the analytical results. If trends in the data are perceived, various means of corrective action may then be employed in order to prevent future problems with the analytical system(s). Data quality reports using control charts are generated for specific clients and projects pursuant to contract requirements (every 6 months for state specific and method specific requirements - all other methods are monitored every 12 months). The Quality Assurance Program Manager compares the newly generated statistical limits to the old and determines whether the new acceptance criteria is to replace the previous criteria. Investigative action may be taken if charts reveal a potential problem with data quality. See SOP for *Determination of Statistical Control Limits* (ADM-CRTL-LIM). Old charts are archived for a period of 5 years.

10.3.16 Glassware Washing

Glassware washing and maintenance play a crucial role in the daily operation of a laboratory. The glassware used at Columbia Analytical undergoes a rigorous cleansing procedure prior to every usage. A number of SOPs have been generated that outline the various procedures used at Columbia Analytical; each is specific to the end-use of the equipment as well as to the overall analytical requirements of the project. In addition, other equipment that may be routinely used at the laboratory is also cleaned following instructions in the appropriate SOP.

NON-CONTROLLED COPY

NON-CONTROLLED COPY

11.0 DATA PROCESSING, VALIDATION, AND REPORTING

Columbia Analytical reports the analytical data produced in its laboratories to the client via the certified analytical report. This report includes a transmittal letter, a case narrative, client project information, specific test results, quality control data, chain of custody information, and any other project-specific support documentation. The following procedures describe our data reduction, validation and reporting procedures.

11.1 Data Reduction and Review

Results are generated by the analyst who performs the analysis and works up the data. All data is initially reviewed and processed by analysts using appropriate methods (e.g., chromatographic software, instrument printouts, hand calculation, etc.). Equations used for calculation of results are found in the applicable analytical SOPs. The resulting data set is either manually entered into LIMS (e.g., field data), manually entered into an electronic spreadsheet and electronically transferred into LIMS (e.g., titrimetric or microbiological data) or is electronically transferred into LIMS from the software used to process the original data set (e.g., chromatographic software). Once the complete data set has been transferred into LIMS, it is reviewed by the analyst for accuracy. Once the primary analyst has checked the data for accuracy and acceptability, the data is forwarded to the supervisor or second qualified analyst, who performs a full secondary review of the data. Where calculations are not performed using a validated software system, the reviewer rechecks a minimum of 10% of the calculations. When the entire data set has been found to be acceptable, the laboratory supervisor, departmental manager or designated laboratory staff approves the data in LIMS. Once approved, the reporting department generates the appropriate hardcopy and/or electronic copy of the final report. An electronic copy is saved for archival. The final report is reviewed and by the Project Manager for client specifications and completeness. Data review procedures are described in the *SOP for Laboratory Data Review Process.*

Policies and procedures for manual editing of data are established. The analyst making the change must initial and date the edited data entry, without obliteration of the original entry. The policies and procedures are described in the *SOP for Making Entries into Logbooks and onto Benchsheets* (ADM-DATANTRY).

Policies and procedures for electronic manual integration of chromatographic data are established. The analyst performing the integration must document the integration change by printing both the “before” and “after” integrations and including them in the raw data records. The policies and procedures are described in the *SOP for Manual Integration of Chromatographic Peaks* (ADM-INT).

11.2 Confirmation Analysis

11.2.1 Gas Chromatographic and Liquid Chromatographic Analyses

For gas chromatographic (GC) and liquid chromatographic (LC) analyses, all positive results are confirmed by a second column, a second detector, a second wavelength (HPLC/UV), or by GC/MS analysis, unless exempted by one of the following situations:

- The analyte of interest produces a chromatogram containing multiple peaks exhibiting a characteristic pattern, which matches appropriate standards. This is limited to petroleum hydrocarbon analyses (e.g., gasoline and diesel) and does not include polychlorinated biphenyls.
- The sample meets all of the following requirements:
    1. All samples (liquid or solid) come from the same source (e.g., groundwater samples from the same well) for continuous monitoring. Samples of the same matrix from the same site, but from different sources (e.g., different sampling locations) are not exempt.
    2. All analytes have been previously analyzed in sample(s) from the same source, identified and confirmed by a second column or by GC/MS. The chromatogram is largely unchanged from the one for which confirmation was carried out. The documents indicating previous confirmation must be available for review.

11.2.2 Confirmation Data

Confirmation data will be provided as specified in the method. Identification criteria for GC, LC or GC/MS methods are summarized below:

- GC and LC Methods
    1. The analyte must fall within plus or minus three times the standard deviation (established for the analyte/column) of the retention time of the daily midpoint standard in order to be qualitatively identified. The retention-time windows will be established and documented, as specified in the appropriate Standard Operating Procedure (SOP).
    2. When sample results are confirmed by two dissimilar columns or detectors, the agreement between quantitative results must be evaluated. The relative percent difference between the two results is calculated and evaluated against SOP and/or method criteria.
- GC/MS Methods - Two criteria are used to verify identification:
    1. Elution of the analyte in the sample will occur at the same relative retention time (RRT) as that of the analyte in the standard.
    2. The mass spectrum of the analyte in the sample must, in the opinion of a qualified analyst or the department manager, correspond to the spectrum of the analyte in the standard or the current GC/MS reference library.

NON-CONTROLLED COPY

11.3 Data Review and Validation of Results

The integrity of the data generated is assessed through the evaluation of the sample results, calibrations, and QC samples (method blanks, laboratory control samples, sample duplicates, matrix spikes, trip blanks, etc.). A brief description of the evaluation of these analyses is described below, with details listed in applicable SOPs. The criteria for evaluation of QC samples are listed within each method-specific SOP. Other data evaluation measures may include (as necessary) a check of the accuracy check of the QC standards and a check of the system sensitivity. Data transcriptions and calculations are also reviewed.

Note: Within the scope of this document, all possible data assessment requirements for various project protocols cannot be included in the listing below. This listing gives a general description of data evaluation practices used in the laboratory in compliance with NELAP Quality Systems requirements. Additional requirements exist for certain programs, such as projects under the DoD QSM protocols, and project-specific QAPPs.

- Method Calibration – Following the analysis of calibration blanks and standards according to the applicable SOP, the calibration correlation coefficient, average response factor, etc. is calculated and compared to specified criteria. If the calibration meets criteria, analysis may continue. If the calibration fails, any problems are isolated and corrected and the calibration standards reanalyzed. Following calibration and analysis of the independent calibration verification standard(s) the percent difference for the ICV is calculated. If the percent difference is within the specified limits the calibration is complete. If not, the problem associated with the calibration and/or ICV are isolated and corrected and verification and/or calibration is repeated.
- Continuing Calibration Verification (CCV) – Following the analysis of the CCV standard the percent difference is calculated and compared to specified criteria. If the CCV meets the criteria analysis may continue. If the CCV fails, routine corrective action is performed and documented and a 2nd CCV is analyzed. If this CCV meets criteria, analysis may continue, including any reanalysis of samples that were associated with a failing CCV. If the routine corrective action failed to produce an immediate CCV within criteria, then either acceptable performance is demonstrated (after additional corrective action) with two consecutive calibration verifications or a new initial calibration is performed.
- Method Blank – Results for the method blank are calculated as performed for samples. If results are less than the MRL (<½ MRL for DoD projects), the blank may be reported. If not, associated sample results are evaluated to determine the impact of the blank result. If possible, the source of the contamination is determined. If the contamination has affected sample results, the blank and samples are reanalyzed. If positive blank results are reported, the blank (and sample) results are flagged with an appropriate flag, qualifier, or footnote.

NON-CONTROLLED COPY

NON-CONTROLLED COPY

- Sample Results (Inorganic) – Following sample analysis and calculations (including any dilutions made due to the sample matrix) the result is verified to fall within the calibration range. If not, the sample is diluted and analyzed to bring the result into calibration range. When sample and sample duplicates are analyzed for precision, the calculated RPD is compared to the specified limits. The sample and duplicate are reanalyzed if the criteria are exceeded. The samples may require re-preparation and reanalysis. For metals, additional measures as described in the applicable SOP may be taken to further evaluate results (dilution tests and/or post-digestion spikes). Results are reported when within the calibration range, or as estimates when outside the calibration range. When dilutions are performed, the MRL is elevated accordingly and qualified. Efforts are made to meet the project MRL's including alternative analysis.
- Sample Results (Organic) – For GC/MS analyses, it is verified that the analysis was within the prescribed tune window. If not, the sample is reanalyzed. Following sample analysis and calculations (including any dilutions made due to the sample matrix) peak integrations, retention times, and spectra are evaluated to confirm qualitative identification. Internal standard responses and surrogate recoveries are evaluated against specified criteria. If internal standard response does not meet criteria, the sample is diluted and reanalyzed. Results outside of the calibration range are diluted to within the calibration range. For GC and HPLC tests, results from confirmation analysis are evaluated to confirm positive results and to determine the reported value. The procedure to determine which result to report is described in the SOP for *Confirmation of Organic Analyte Identification and Quantitation (ADM-CONFIRM).* If obvious matrix interferences are present, additional cleanup of the sample using appropriate procedures may be necessary and the sample is reanalyzed. When dilutions are performed, the MRL is elevated accordingly and qualified. Efforts are made to meet the project MRL's including additional cleanup.
- Surrogate Results (Organic) – The percent recovery of each surrogate is compared to specified control limits. If recoveries are acceptable, the results are reported. If recoveries do not fall within control limits, the sample matrix is evaluated. When matrix interferences are present or documented, the results are reported with a qualifier that matrix interferences are present. If no matrix interferences are present and there is no cause for the outlier, the sample is reprepared and reanalyzed. However, if the recovery is above the upper control limit with non-detected target analytes, the sample may be reported. All surrogate recovery outliers are appropriately qualified on the report.
- Duplicate Sample and/or Duplicate Matrix Spike Results – The RPD is calculated and compared to the specified control limits. If the RPD is within the control limits the result is reported. If not, an evaluation of the sample is made to verify that a homogenous sample was used. Despite the use of homogenizing procedures prior to sample preparation or analysis, the sample may not be homogenous or duplicate sample containers may not have been sampled consistently. If non-homogenous, the result is reported with a qualifier about the homogeneity of the sample. Also, the results are compared to the MRL. If the results are less than five times the MRL, the results are reported with a qualifier that the high RPD is due to the results being near the MRL.

- Laboratory Control Sample Results – The LCS percent recovery is calculated and compared to specified control limits. If the recovery is within control limits, the analysis is in control and results may be reported. If not, this indicates that the analysis is not in control. Samples associated with the 'out of control' LCS, shall be considered suspect and the samples re-extracted or re-analyzed or the data reported with the appropriate qualifiers.
- Matrix Spike Results – The MS percent recovery is calculated and compared to specified control limits. If the recovery is within control limits the results are reported. If not, and the LCS is within control limits, this indicates that the matrix potentially biases analyte recovery. It is verified that the spike level is at least five times the background level. If not, the results are reported with a qualifier that the background level is too high for accurate recovery determination. If matrix interferences are present or results indicate a potential problem with sample preparation, steps may be taken to improve results; such as performing any additional cleanups, dilution and reanalysis, or re-preparation and reanalysis. Results that do not meet acceptance limits are reported with an appropriate qualifier.

11.4 Data Reporting

When an analyst determines that a data package has met the data quality objectives (and/or any client-specific data quality objectives) of the method and has qualified any anomalies in a clear, acceptable fashion, the data package is reviewed by a trained chemist. Prior to release of the report to the client, the project chemist reviews and approves the entire report for completeness and to ensure that any and all client-specified objectives were successfully achieved. The original raw data, along with a copy of the final report, is filed in project files by service request number for archiving. Columbia Analytical maintains control of analytical results by adhering to standard operating procedures and by observing sample custody requirements. All data are calculated and reported in units consistent with project specifications, to enable easy comparison of data from report to report.

To the extent possible, samples shall be reported only if all QC measures are acceptable. If a QC measure is found to be out of control, and the data is to be reported, all samples associated with the failed quality control measure shall be reported with the appropriate data qualifier(s). The *SOP for Data Reporting and Report Generation* addresses the flagging and qualification of data. The Columbia Analytical-defined data qualifiers, state-specific data qualifiers, or project-defined data qualifiers are used depending on project requirements. A case narrative may be written by the project chemist to explain problems with a specific analysis or sample, etc.

For subcontracted analyses, the Project Chemist verifies that the report received from the subcontractor is complete. This includes checking that the correct analyses were performed, the analyses were performed for each sample as requested, a report is provided for each analysis, and the report is signed. The Project Chemist accepts the report if all verification items are complete. Acceptance is demonstrated by forwarding the report to the client.

NON-CONTROLLED COPY

11.5 Documentation

Columbia Analytical maintains a records system which ensures that all laboratory records of analysis data retained and available. Analysis data is retained for 5 years from the report date unless contractual terms or regulations specify a longer retention time. The archiving system is described in the *SOP for Data Archiving*. In the event that the laboratory transfers ownership or goes out of business, laboratory records shall be retained for the contracted period and clients shall be notified prior to early destruction or disposal of samples or data.

11.5.1 Documentation and Archiving of Sample Analysis Data

The archiving system includes the following items for each set of analyses performed:

- Benchsheets describing sample preparation (if appropriate) and analysis;
- Instrument parameters (or reference to the data acquisition method);
- Sample analysis sequence;
- Instrument printouts, including chromatograms and peak integration reports for all samples, standards, blanks, spikes and reruns;
- Logbook ID number for the appropriate standards;
- Copies of report sheets submitted to the work request file; and
- Copies of Nonconformity and Corrective Action Reports, if necessary.

Individual sets of analyses are identified by analysis date and service request number. Since many analyses are performed with computer-based data systems, the final sample concentrations can be automatically calculated. If additional calculations are needed, they are written on the integration report or securely stapled to the chromatogram, if done on a separate sheet.

For organics analysis, data applicable to all analyses within the batch, such as GCMS tunes, CCVs, batch QC, and analysis sequences; are kept using a separate documentation system. This system is used to archive data on a batch-specific basis and is segregated according to the date of analysis. This system also includes results for the most recent calibration curves, as well as method validation results.

NON-CONTROLLED COPY

11.6 Deliverables

In order to meet individual project needs, Columbia Analytical provides several levels of analytical reports. Standard specifications for each level of deliverable are described in Table 11-1. Variations may be provided based on client or project specifications. This includes (but is not limited to) the following specialized deliverables:

- ADEC – Alaska Department of Conservation specified data package
- ACOE/HTRW – Army Corps of Engineers specified data package and reporting requirements (HTRW, CERP, FUDS, etc.)
- AFCEE – Air Force Center for Environmental Excellence project-specific reporting

When requested, Columbia Analytical provides Electronic Data Deliverables (EDDs) in the format specified by client need or project specification. Columbia Analytical is capable of generating EDDs with many different formats and specifications. The EDD is prepared by report production staff using the electronic version of the laboratory report to minimize transcription errors. User guides and EDD specification outlines are used in preparing the EDD. The EDD is reviewed and compared to the hard-copy report for accuracy.

NON-CONTROLLED COPY

NON-CONTROLLED COPY

Table 11-1
Descriptions of Columbia Analytical Standard Data Deliverables

Tier I. Routine Certified Analytical Report (CAR) includes the following:

1. Transmittal letter
2. Chain of custody documents and sample/cooler receipt documentation
3. Sample analytical results
4. Method blank results
5. Surrogate recovery results and acceptance criteria for applicable organic methods
6. Dates of sample preparation and analysis for all tests
7. Case narrative - **optional**

Tier II. In addition to the Tier I Deliverables, this CAR includes the following:

1. Matrix spike result(s) with calculated recovery and including associated acceptance criteria
2. Duplicate or duplicate matrix spike result(s) (as appropriate to method), with calculated relative percent difference
3. Laboratory Control Sample result(s) with calculated recovery and including associated acceptance criteria
4. Case narrative - **optional**

Tier III. Data Validation Package. In addition to the Tier II Deliverables, this CAR includes the following:

1. Case narrative - **required**
2. Summary forms for all associated QC and Calibration parameters, with associated control criteria/acceptance limits

Note: Other summary forms specified in QAPPs or project/program protocols, or those related to specialized analyses such as HRGC/MS will be included.

Tier IV. Full Data Validation Package.

1. All raw data associated with the sample analysis, including but not limited to:
   a. Preparation and analysis bench sheets and instrument printouts,
   b. For organics analyses, all applicable chromatograms, spectral, confirmation, and manual integration raw data. For GC/MS this includes tuning results, mass spectra of all positive hits, and the results and spectra of TIC compounds when requested.
   c. QC data,
   d. Calibration data (initial, verification, continuing, etc),
   e. Calibration blanks or instrument blanks (as appropriate to method).
2. If a project QAPP or program protocol applies, the report will be presented as required by the QAPP.

NON CONTROLLED COPY

12.0 PERFORMANCE AND SYSTEM AUDITS*

Quality audits are an essential part of Columbia Analytical/Rochester's quality assurance program. There are two types of audits used at the facility: System Audits are conducted to qualitatively evaluate the operational details of the QA program, while Performance Audits are conducted by analyzing proficiency testing samples in order to quantitatively evaluate the outputs of the various measurement systems.

12.1 System Audits

The system audit examines the presence and appropriateness of laboratory systems. External system audits of Columbia Analytical/Rochester are conducted regularly by various regulatory agencies and clients. Appendix G lists the certification and accreditation programs in which Columbia Analytical/Rochester participates. Programs and certifications are added as required. Additionally, internal system audits of Columbia Analytical/Rochester are conducted regularly under the direction of the Quality Assurance Program Manager. The internal audit procedures are described in the *SOP for Internal Audits*. The internal audits are performed as follows:

- Comprehensive lab-wide system audit – performed annually. This audit is conducted such that systems, technical operations, hardcopy data, and electronic data are assessed.
- Technical/method audits – minimum of 3 per quarter
- Hardcopy report audits – minimum of 2 per quarter.
- Chromatographic electronic data audits – each applicable instrument per quarter.

All audit findings, and corrective actions are documented. The results of each audit are reported to the Laboratory Director and Department Managers for review. Any deficiencies identified are summarized in the audit report. Managers must respond with corrective actions correcting the deficiency within a defined timeframe. Should problems impacting data quality be found during an internal audit, any client whose data is adversely impacted will be given written notification within the corrective action period (if not already provided).

Electronic data audits may be performed in conjunction with hardcopy data audits. The electronic audits focus on organic chromatographic data and include an examination of audit trails, peak integrations, calibration practices, GCMS tuning data, peak response data, use of appropriate files, and other components of the analysis. The audit also verifies that the electronic data supports the hardcopy reported data.

Additional internal audits or data evaluations may be performed as needed to address any potential data integrity issues that may arise.

*Please note that many SOPs reference Section 12 of the Quality Assurance Manual for Figures for Corrective Action. This information is now found in the text of Section 11 of this Manual.

12.2 Performance Audits

Columbia Analytical/Rochester also participates in the analysis of interlaboratory proficiency testing (PT) samples. Participation in PT studies is performed on a regular basis and is designed to evaluate all analytical areas of the laboratory. General procedures for these analyses are described in the SOP for Proficiency Sample Testing Analysis (ADM-PTS). Columbia Analytical routinely participates in the following studies:

- Water Pollution (WP) and additional water parameters, 2 per year.
- Water Supply (WS) PT studies, 2 per year.
- Hazardous Waste/Soil PT studies, 2 per year.
- Underground Storage Tank PT studies, 2 per year.
- Microbiology (WS and WP) PT studies, 2 per year.
- Other studies as required for specific certifications, accreditations, or validations.

PT samples are processed by entering them into the LIMS system as samples (assigned Service Request, due date, testing requirements, etc.) and are processed the same as field samples. The laboratory sections handle samples the same as field samples, performing the analyses following method requirements and performing data review. The laboratory sections submit results to the QA Program Manager for subsequent reporting to the appropriate agencies or study provider. Results of the performance evaluation samples and audits are reviewed by the QA PM, Laboratory Director, the laboratory staff, and the Chief Quality Officer. For any results outside acceptance criteria, the analysis data is reviewed to identify a root cause for the deficiency, and corrective action is taken and documented through nonconformance (NCAR) procedures.

NON-CONTROLLED COPY

NON-CONTROLLED COPY

13.0 PREVENTIVE MAINTENANCE

Preventive maintenance is a crucial element of the Quality Assurance program. Instruments at Columbia Analytical (e.g., ICP/MS and ICP systems, GC/MS systems, atomic absorption spectrometers, analytical balances, gas and liquid chromatographs, etc.) are maintained under commercial service contracts or by qualified, in-house personnel. All instruments are operated and maintained according to the instrument operating manuals. All routine and special maintenance activities pertaining to the instruments are recorded in instrument maintenance logbooks. The maintenance logbooks used at Columbia Analytical contain extensive information about the instruments used at the laboratory.

An initial demonstration of analytical control is required on every instrument used at Columbia Analytical before it maybe used for sample analysis. If an instrument is modified or repaired, a return to analytical control is required before subsequent sample analyses can occur. When an instrument is acquired at the laboratory, the following information is noted in a bound maintenance notebook specifically associated with the new equipment:

- Instrument Name, manufacturer, make, model and type
- The equipment's serial number;
- Date the equipment was received;
- Date the equipment was placed into service;
- Condition of equipment when received (new, used, reconditioned, etc.); and
- Prior history of damage, malfunction, modification or repair (if known).

Preventive maintenance procedures, frequencies, etc. are available for each instrument used at Columbia Analytical. They may be found in the various SOPs for routine methods performed on an instrument and may also be found in the operating or maintenance manuals provided with the equipment at the time of purchase.

Responsibility for ensuring that routine maintenance is performed lies with the section supervisor. The supervisor may perform the maintenance or assign the maintenance task to a qualified bench level analyst who routinely operates the equipment. In the case of non-routine repair of capital equipment, the section supervisor is responsible for providing the repair, either by performing the repair themselves with manufacturer guidance or by acquiring on-site manufacturer repair. Each laboratory section maintains a critical parts inventory. The parts inventories include the items needed to perform the preventive maintenance procedures listed in Appendix D.

This inventory or "parts list" also includes the items needed to perform any other routine maintenance and certain in-house non-routine repairs such as gas chromatography/mass spectrometry jet separators and electron multipliers and ICP/MS nebulizer. When performing maintenance on an instrument (whether preventive or corrective), additional information about the problem, attempted repairs, etc. is also recorded in the notebook. Typical logbook entries include the following information:

- Details and symptoms of the problem;
- Repairs and/or maintenance performed;
- Description and/or part number of replaced parts;
- Source(s) of the replaced parts;
- Analyst's signature and date; and
- Demonstration of return to analytical control.

See the table in Appendix E for a list of preventive maintenance activities and frequency for each instrument.

NON-CONTROLLED COPY

NON-CONTROLLED COPY

14.0 CORRECTIVE AND PREVENTIVE ACTION

The laboratory takes all appropriate steps necessary to ensure all sample results are reported with acceptable quality control results. When sample results do not conform to established quality control procedures, responsible management will evaluate the significance of the nonconforming work and take corrective action to address the nonconformance.

Nonconforming events such as errors, deficiencies, deviations from SOP, proficiency (PT) failure or results that fall outside of established QC limits are documented using a *Nonconformity and Corrective Action Report* form (See Figure 14-1). The procedure and responsibilities for addressing nonconforming work is defined in the SOP ADM-CA *Corrective Action.* Nonconformances are reported to the client using various means (voice, email, narrative, etc). When a nonconformance occurs that casts doubt on the validity of the test results or additional client instructions are needed, the Prjoject Chemist notifies the client the within 10 business days of the discovery. This gives the laboratory time to ascertain the extent and significance of the problem. The QA PM reviews each problem, ensuring that appropriate corrective action has been taken by the appropriate personnel. The Nonconformity and Corrective Action Report (NCAR) is filed in the associated service request file and a copy is kept by the QA PM. The QA PM periodically reviews all NCARs looking for chronic, systematic problems that need more in-depth investigation and alternative corrective action consideration. In addition, the appropriate project chemist is promptly notified of any problems in order to inform the client and proceed with any action the client may want to initiate.

If a quality control measure is found to be out of control, and the data is to be reported, all samples associated with the failed quality control measure shall be reported with the appropriate data qualifier(s). Failure to meet established analytical controls, such as the quality control objectives, prompts corrective action. Corrective action may take several forms and may involve a review of the calculations, a check of the instrument maintenance and operation, a review of analytical technique and methodology, and reanalysis of quality control and field samples. If a potential problem develops that cannot be solved directly by the responsible analyst, the supervisor, team leader, the department manager, and/or the QA PM may examine and pursue alternative solutions. In addition, the appropriate project chemist is notified in order to ascertain if the client needs to be notified.

Part of the corrective action process involves determining the root cause. Identifying the root cause of a nonconformance can be difficult, but important for implementing effective corrective action. Root cause principles are used to determine assignable causes, which leads to corrective action taken to prevent recurrence. Various preventive action processes are used for eliminating a potential problem or averting a problem before it occurs. This is explained in the *SOP for Preventive Action* (ADM-PA).

In addition to internal communication of data issues, the laboratory also maintains a system for dealing with customer complaints. The person who initially receives the feedback (typically the project chemist) is responsible for documenting the complaint. If the project chemist is unable to satisfy the customer, the complaint is brought to the attention of the Client Services Manager, Laboratory Director, or QA PM for final resolution. The complaint and resolution are documented. The procedure is described in the *SOP for Handling Customer Feedback* (ADM-FDBK).

NON-CONTROLLED COPY

Figure 14-1

Nonconformity and Corrective Action Report

NCAR No: *Assigned by QA*

PROCEDURE (SOP or METHOD): EVENT DATE: _____

EVENT:
- ☐ Missed Holding Time
- ☐ Method Blank Contamination
- ☐ Equipment Failure
- ☐ SOP Deviation
- ☐ QC Failure
- ☐ Login Error
- ☐ Unacceptable PT Sample Result
- ☐ Other (describe):
- ☐ Lab Error (spilled sample, spiking error, etc.)
- ☐ Project Management Error

INCLUDE NUMBER OF SAMPLES / PROJECTS / CUSTOMERS / SYSTEMS AFFECTED

DETAILED DESCRIPTION

ORIGINATOR: _____ DATE: _____

PROJECT MANAGER(S): _____ NOTIFIED BY: _____ DATE: _____

ROOT CAUSE OF NON-CONFORMITY (POTENTIAL CAUSES COULD BE TRAINING, COMMUNICATION, SPECIFICATIONS, EQUIPMENT, KNOWLEDGE)

What is the cause of the error or finding:

CORRECTIVE ACTION AND OUTCOME

Re-establishment of conformity must be demonstrated and documented. Describe the steps that were taken, or are planned to be taken, to correct the particular Nonconformity and prevent its reoccurrence. Include Project Manager Instructions here.

Is the data to be flagged in the Analytical Report with an appropriate qualifier? ☐ **No** ☐ **Yes**

APPROVAL AND NOTIFICATION

Supervisor Verification and Approval of Corrective Action _____ Date: _____
Comments:

QA PM Verification and Approval of Corrective Action _____ Date: _____
Comments:

Project Manager Verification and Approval of Corrective Action _____ Date: _____
Comments:

Customer Notified by ☐ Telephone ☐ Fax ☐ E-mail ☐ Narrative ☐ Not notified

(Attach record or cite reference where record is located.)

NON-CONTROLLED COPY

15.0 QUALITY ASSURANCE REPORTS AND MANAGEMENT REVIEW*

Quality assurance requires an active, ongoing commitment by Columbia Analytical personnel at all levels of the organization. Communication and feedback mechanisms are designed so that analysts, supervisors and managers are aware of QA issues in the laboratory. Analysts performing routine testing are responsible for generating a data quality narrative or data review document with every analytical batch processed. This report also allows the analyst to provide appropriate notes and/or a narrative if problems were encountered with the analyses. A Non-Conformity and Corrective Action Report (NCAR) (see Section 14.0) may also be attached to the data prior to review. Supervisors or qualified analysts review all of the completed analytical batches to ensure that all QC criteria have been examined and any deficiencies noted and addressed.

It is the responsibility of each laboratory unit to provide the project chemist with a final report of the data, accompanied by signature approval. Footnotes and/or narrative notes must accompany any data package if problems were encountered that require further explanation to the client. Each data package is submitted to the appropriate project chemist, who in turn reviews the entire collection of analytical data for completeness and to ensure that any and all client-specified objectives were successfully achieved. A case narrative is written by the project chemist to explain any unusual problems with a specific analysis or sample, etc.

The QA PM provides overview support to the project chemists as required (e.g., contractually specified, etc.). The QAPM is also responsible for the oversight of all internal and external audits, for all proficiency testing sample and analysis programs, and for all laboratory certification/accreditation responsibilities. The QAPM provides the Laboratory Director with quarterly reports that summarize the various QA/QC activities that occurred during the previous quarter. The report addresses such topics as the following:

- Status, schedule, and results of internal and external audits;
- Status, schedule, and results of internal and external proficiency testing studies;
- Status of certifications, accreditations, and approvals;
- Status of QA Manual and SOP review and revision;
- Status of MDLs studies;
- Discussion of QC problems in the laboratory;
- Discussion of corrective action program issues;
- Status of staff training and qualification; and
- Other topics as appropriate.

An annual management review of the quality and testing systems is perfomed as described in the *SOP for Managerial Reviews of the Laboratory's Quality Systems and Testing Activities* (ADM-MGMTRVW). This is done to identify any necessary changes or improvements to the quality system or quality assurance policies. This review is documented in a Managerial Review of the Laboratory's Quality Systems and Testing Activities and sent to senior management.

*Please note that many SOPs reference Section 15 of the Quality Assurance Manual for handling out of control data. This information is now found in the text of Section 14 of this Manual.

NON-CONTROLLED COPY

16.0 PERSONNEL TRAINING

Technical position descriptions are available for all employees, regardless of position or level of seniority. These documents are maintained by the Human Resources personnel and are available for review. In order to assess the technical capabilities and qualifications of a potential employee, all candidates for employment at Columbia Analytical are evaluated, in part, against the appropriate technical description.

Training begins the first day of employment at Columbia Analytical when the company policies are presented and discussed. Safety and QA/QC requirements are integral parts of all technical SOPs and, consequently, are integral parts of all training processes at Columbia Analytical. Safety training begins with the reading of the *Environmental Health and Safety Manual.* Employees are also required to attend periodic safety meetings where additional safety training may be performed by the Environmental, Health and Safety Officer.

Employees are responsible for complying with the requirements of the QA Manual and QA/QC requirements associated with their function(s). Quality Systems training begins with Quality Assurance orientation for new employees and reading the Quality Assurance Manual. During the employees first year, the employee attends Core Ethics training and learns about Columbia Analytical Services quality systems. Each employee participates in annual Ethics Refresher training, which is part of the Columbia Analytical Improper Practices Prevention Program.

Columbia Analytical also encourages its personnel to continue to learn and develop new skills that will enhance their performance and value to the Company. Ongoing training occurs for all employees through a variety of mechanisms. The corporate, company-wide training and development program, external and internal technical seminars and training courses, and laboratory-specific training exercises are all used to provide employees with professional growth opportunities.

All technical training is documented and records are maintained in the QA department. Training requirements and its documentation are described in the *SOP for Documentation of Training.* (ADM-TRANDOC). A training plan is developed whenever an employee starts a new procedure to new position. The training plan includes a description of the step-by-step process for training an employee and for initial demonstration of capability. Where the analyst performs the entire procedure, a generic training plan may be used.

NON-CONTROLLED COPY

16.1 Initial Demonstration of Capability (IDOC)

Training in analytical procedures typically begins with the reading of the Standard Operating Procedure (SOP) for the method. Hands-on training begins with the observation of an experienced analyst performing the method, followed by the trainee performing the method under close supervision, and culminating with independent performance of the method on quality control samples. Successful completion of the applicable Demonstration of Capability analysis qualifies the analyst to perform the method independently. Demonstration of Capability is performed by one of the following:

- Successful completion of an Initial Precision and Recovery (IPR) study (required where mandated by the method).
- Analysis of 4 consecutive Laboratory Control Samples, with acceptable accuracy and precision.
- Where spiking is not possible but QC standards are used ("non-spiked" Laboratory Control Samples), analysis of 4 consecutive Laboratory Control Samples with acceptable accuracy and precision.
    - Where one of the three above is not possible, see the special requirements in ADM-TRANDOC.

A flowchart identifying the Demonstration of Proficiency requirements is given in Figure 16-1. The flowchart identifies allowed approaches to assessing Demonstration of Capability when a 4-replicate study is not mandated by the method, when spiking is not an option, or when QC samples are not readily available.

16.2 Continuing Demonstration of Proficiency

A periodic demonstration of proficiency is required to maintain continuing qualification. Continuing Demonstration of Proficiency is required each year, and may be performed one of the following ways:

- Successful performance on external (independent) single-blind sample analyses using the test method, or a similar test method using the same technology. I.e. PT sample or QC sample blind to the analyst.
- Performing Initial Demonstration of Capability as described above, with acceptable levels of precision and accuracy.
- Analysis of at least 4 consecutive LCSs with acceptable levels of accuracy and precision from in-control analytical batches.
- If the above cannot be performed,see the special requirements in ADM-TRANDOC.

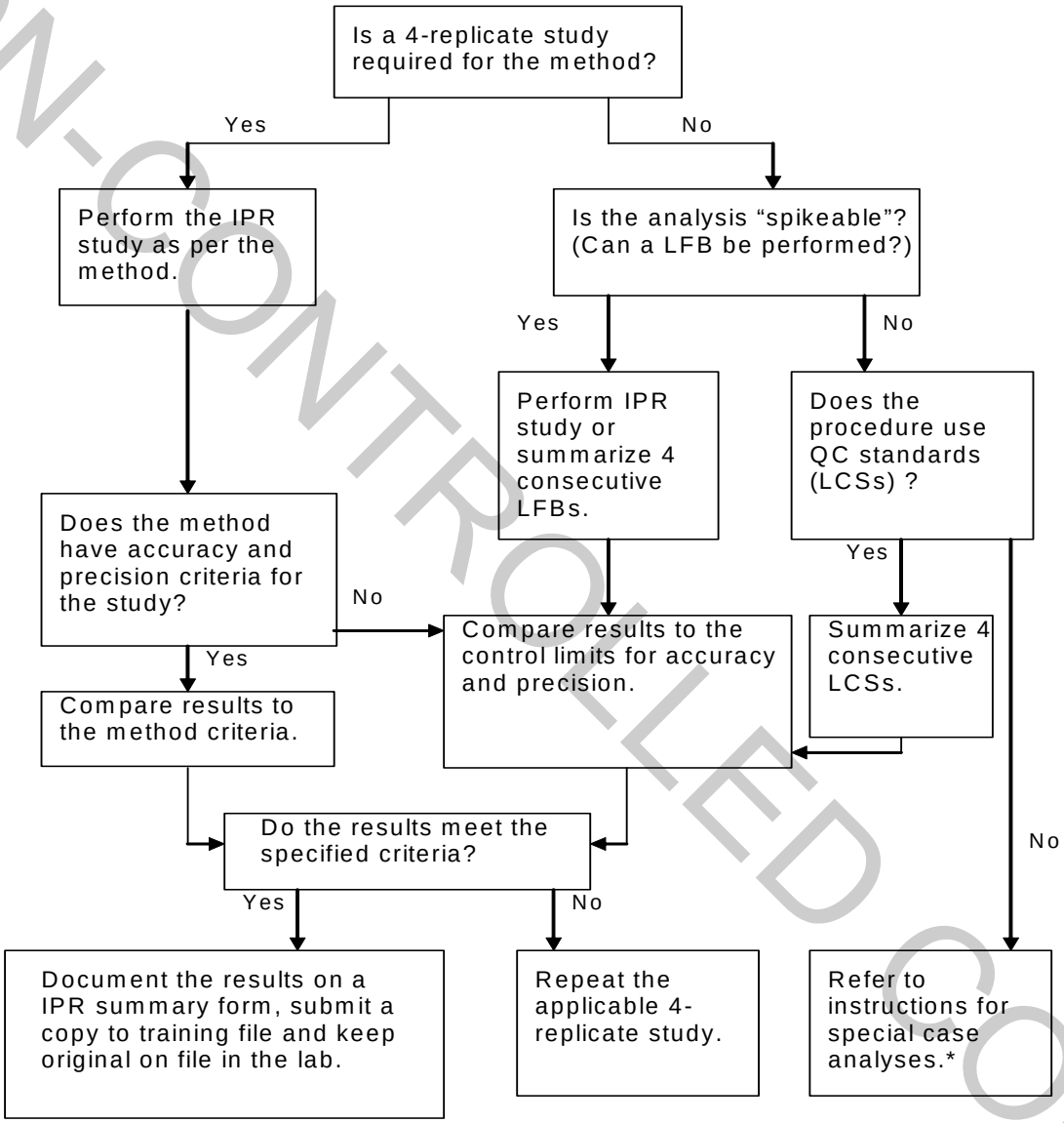
16.3 Documentation of Training

Records are maintained to indicate the employee has the necessary training, education, and experience to perform their functions. Information of previously acquired skills and abilities for a new employee is maintained in Human Resources personnel files and Columbia Analytical resumes. QA maintains a database to record the various technical skills and training acquired while employed by Columbia Analytical. Information includes the employee's name, a description of the skill including the appropriate method and SOP reference, the mechanism used to document proficiency, and the date the training was completed. General procedures for documenting technical training are described in the *SOP for Documentation of Training* (ADM-TRANDOC).

NON-CONTROLLED COPY

NON-CONTROLLED COPY

Figure 16-1
Initial Demonstration of Capability Requirements[a]



[a] For IDOC IPR or LFB studies, "second-source" reference materials are used, as per NELAP requirements
* Refer to the SOP for Documentation of Training for details.

NON-CONTROLLED COPY

17.0 REFERENCES FOR QUALITY SYSTEMS, EXTERNAL DOCUMENTS, MANUALS, STANDARDS, AND ANALYTICAL PROCEDURES

The analytical methods used at Columbia Analytical generally depend upon the end-use of the data. Since most of our work involves the analysis of environmental samples for regulatory purposes, specified federal and/or state testing methodologies are used and followed closely. Typical methods used at Columbia Analytical are taken from the following references:

- National Environmental Laboratory Accreditation Program (NELAP), 2003 Quality Standards.
- American National Standard *General requirements for the competence of testing and calibration laboratories,* ANSI/ISO/IEC 17025:2005(E)
- *DoD Quality Systems Manual for Environmental Laboratories,* Version 4.1, 4/22/2009
- *Good Automated Laboratory Practices, Principles and Guidance to Regulations For Ensuring Data Integrity In Automated Laboratory Operations*, EPA 2185 (August 1995).
- *Manual for the Certification of Laboratories Analyzing Drinking Water*, 4th Edition, EPA 815-B-97-001 (March 1997).
- *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, SW-846, Third Edition, (September 1986) and Updates I (July 1992), II (September 1994), IIA (August 1993), IIB (January 1995), III (December 1996), Final Update IV (February 2007), and updates posted online at http://www.epa.gov/epaoswer/hazwaste/test/sw846.htm. See Chapters 1, 2, 3, and 4.
- *Methods for Chemical Analysis of Water and Wastes*, EPA-600/4-79-020, (Revised March 1983).
- *Methods for the Determination of Inorganic Substances in Environmental Samples*, EPA/600/R-93/100 (August 1993).
- *Methods for the Determination of Metals in Environmental Samples*, EPA/600/4-91/010 (June 1991) and Supplements.
- *Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater*, EPA 600/4-82-057 (July 1982) and 40 CFR Part 136, Appendix A.
- *Methods for the Determination of Organic Compounds in Drinking Water*, EPA/600/4-88/039 (December 1988) and Supplements.
- *Standard Methods for the Examination of Water and Wastewater*, 18th Edition (1992); 19th Edition (1995), 20th Edition (1998). See Introduction in Part 1000.
- 40 CFR Part 136, Guidelines for Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act.
- 40 CFR Part 141, National Primary Drinking Water Regulations.

- State-specific total petroleum hydrocarbon methods for the analysis of samples for gasoline, diesel, and other petroleum hydrocarbon products.
- Annual Book of ASTM Standards, Part 31, Water.
- EPA Contract Laboratory Program, Statement of Work for Organic Analysis, SOW Nos. OLM03.1, OLM03.2, OLM04.2, and OLM04.3.
- EPA Contract Laboratory Program, Statement of Work for Inorganic Analysis, SOW No. ILM05.3.
- *U. S. EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, EPA-540/R-94/012 (February 1993).
- *U. S. EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, EPA-540/R-94/013 (February 1994).

NON-CONTROLLED COPY

NON-CONTROLLED COPY

APPENDIX A

LIST OF QA PROGRAM DOCUMENTS AND STANDARD OPERATING PROCEDURES

Please note that the Appendices provide current information at the time of the revision, but are updated only upon annual review. Please contact the laboratory for up-to-date information.

Please also note that many SOPs reference this Appendix (A) for the Equipment List. The Equipment List is now found in Appendix C of this Quality Assurance Manual.

CAS QUALITY AND ETHICS POLICY STATEMENT

NON-CONTROLLED COPY

Columbia Analytical Services

CAS Quality and Ethics Policy Statement
September 2010

Columbia Analytical Services (CAS) is committed to excellence and superior performance in everything we do. This includes ethics and professional practice where CAS is committed to the highest standards of ethical behavior and quality of its analytical testing. We will not sacrifice our ethical principles in order to achieve business success, because unethical behavior carries a heavy price - one that we do not want to bear. This includes diminished self respect, loss of reputation, loss of business, civil and criminal penalties, and government and customer sanctions.

This means we will always strive to conduct business honestly and with integrity. We will always follow and obey the laws and statutes applicable to the operation of our business. We will always follow, to the best of our ability, standard operating procedures, rules and regulations that apply to our industry and specifically to our laboratory operations. Our customers, employees, suppliers and communities that we serve expect and deserve nothing less than the highest standards of conduct and compliance.

The following are the critical elements of the Quality and Ethics program at CAS.

- The Executive Management and Board of Directors of CAS sponsor and support the Quality and Ethics program through their personal commitment and by providing the necessary resources to promote this program throughout the organization.
- Chief Quality and Ethics Officer. The position is responsible for the quality and ethics program, ensures that appropriate resources are provided, reviews and recommends changes in the program, and resolves ethical and quality issues brought to management attention. This Officer periodically provides a quality and ethics report directly to the Board of Directors.
- Core Values. The CAS Statement of Core Values was developed internally with input from the entire company. We are committed to ensuring the integrity and quality of data, and meeting the needs of our clients, while conducting business with high ethical standards. We hold strong to the core values of Honor, Truth, and Fairness. We are committed to these values and rely on them when confronted by difficult choices.
- Code of Conduct. CAS supports the ethical codes established for the laboratory industry by the American Council of Independent Laboratories (ACIL) and is committed to meeting the data integrity and ethics requirements of accreditation bodies; including NELAP and the Department of Defense (DOD). The "CAS Commitment to Excellence in Data Quality" statement must be acknowledged and signed by all employees; and all employees are expected to comply with standards outlined in Section 6, Employee Conduct, of our Employee Handbook. All personnel concerned with analytical testing activities within the laboratory are required to be familiar with the quality documentation and to implement these policies and procedures in their work.

CAS QUALITY AND ETHICS POLICY STATEMENT CONT.

NON-CONTROLLED COPY

Columbia Analytical Services

- Open Door Policy. CAS will maintain a work environment where employees have the right and obligation for open communications to ask questions, seek guidance, and report incorrect practices and wrong doing without fear of retribution. This is described in the CAS Open Door Policy in the Employee Handbook. CAS believes that using the chain-of-command channels for this dialogue is generally most appropriate. However, if there is apprehension or a concern that using this approach is not appropriate, employees are free to take their concerns to the President/CEO, the Director of Human Resources, or the Chief Quality Officer. Employees may do so without fear of retribution.
- Ombudsman Program. In addition to the Open Door Policy, CAS has implemented an external ombudsman/hotline program through EthicsPoint, a phone and internet-based reporting system. This is another mechanism available to enhance communication and empower employees to promote quality, data integrity, and ethical behavior. Employees can file a report anonymously to address ethics, data integrity, or improper conduct issues in the workplace.
- Internal Audits. Policies are established to ensure that internal systems and data audits are conducted periodically in addition to external agency and client audits. The data audits include assessments of both hardcopy data and electronic data to ensure on-going data integrity and compliance with the CAS Quality program.
- Certification/Accreditation Compliance. CAS management is committed to ensuring compliance with the accreditation or certification standards applicable to each CAS laboratory, including NELAP accreditations at laboratories conducting environmental testing and DOD ELAP accreditation at laboratories performing testing for the DOD. Required quality systems are documented in QA Manuals, administrative Standard Operating Procedures (SOPS) and policies; and technical SOPs.
- Ethics Training. CAS provides training to its employees with respect to quality, ethics, data integrity, and business conduct. This includes introductory training on employment policies, quality, and ethics at the time of hire; in-depth "core" ethics training within one year of hire, and on-going ethics refresher training on a semi-annual basis.

The CAS Quality and Ethics Program has been in place for several years. However, this is a "living" program that will change and improve as the company grows and changes.

Jim Carlson, President/CEO — Date: 9-28-10

Lee Wolf, Chief Quality and Ethics Officer — Date: 9-21-10

COLUMBIA ANALYTICAL/ROCHESTER APPROVED SIGNATORIES

The following Columbia Analytical/Rochester employees are authorized to issue certified analytical reports and sign other critical documents (such as QAPPs, other program protocols, etc.). In the event that these individuals are not available, an assigned designee or the Chief Operating Officer may approve these documents.

Employee:	Position:
Michael Perry	Laboratory Director/Technical Director
Lisa Reyes	Quality Assurance Program Manager
Janice Jaeger	Client Services Manager
Karen Bunker	Project Manager
Carl Beechler	Project Manager
Deb Patton	Project Manager
Vicky Collom	Quality Assurance Assistant (QA documents)

NON-CONTROLLED COPY

Columbia Analytical/Rochester QA Program Documents

Software Quality Assurance Plan	7/11/05 QA Office
Master Logbook of Laboratory Logbooks	QA-1 and QA-12 QA Office
Thermometer Calibration Logbook	QA-2 QA Office
Signature Log	QA Office
Balance Service Records	QA Office
Spectrophotometer Verification Records	QA Office
Internal, External, and Performance Audits	QA Office
Management Reports	QA Office
Training Records	QA Office
QC Charts	QA Office
Non-Conformities	QA Office
SOP Master Copies	QA Office
Data Quality Objective Table	P:\QAQC\QA_DOCUM\QCLIMITS\QAMTBLS\CAS DQO Table 2010.xls
Data Quality Checklists	P:\INTRANET\QAQC\DQChecklists
Training Database	P:\QAQC\QA_DOCUM\TRAINING\DATABASE\TrainApp.mdb
Training Plans	P:\INTRANET\QAQC\TRAINING\FORMS
DOC Templates	P:\QAQC\TRAINING\Template_IDC
MDL Summaries	P:\QAQC\MDLs\Client Copies Scanned MDL Summaries-LOCKED 2010
Method Development Form	P:\INTRANET\QAQC\SOPS\Method Development.doc
Certificates and Accreditations	P:\INTRANET\QAQC\CAS Rochester Certs
Certification Summary Table	P:\QAQC\QA_DOCUM\Qam\QAM 20\Certs09232010.DOC
Certification Master Table	P:\QAQC\QA_DOCUM\CERT\Certification Master.xls
SOP Tracking List	P:\QAQC\QA_DOCUM\SOP\CASFINAL\2010toc.xls
PT Tracking List	P:\QAQC\QA_DOCUM\PE\Tracking\PT tracking master.xls
PE Study Schedule	P:\QAQC\QA_DOCUM\PE\PESCHED.XLS
MDL Schedule	P:\QAQC\MDLs\MDL Schedule 2010.xls
NCAR Tracking	H:\NCAR TRACKING\NCAR Assignment and Tracking.xls
Organization Charts	Available through Corporate Intranet
Resumes	Available through Corporate Human Resources
Equipment List	P:\QAQC\QA_DOCUM\Qam\QAM 20\EquipList09222010.pdf
Data Qualifiers	H:\FORMS\QUALIF_routine.DOC
Preventive Maintenance Table	P:\QAQC\QA_DOCUM\Qam\QAM 20\PM_TBL.XLS
PT Reports	P:\QAQC\QA_DOCUM\PE\Results
Lab Acronyms	Available through Corporate Intranet
Other Corporate Forms (see later in this Appendix)	Available through Corporate Intranet

NON-CONTROLLED COPY

Columbia Analytical Job Descriptions

Analyst I

Entry level analyst position within the laboratory. Employee performs routine tasks in the lab under close supervision or by following detailed instructions. Progressively learning methods and procedures commonly used. Entry level skills performed at this level include titrations, gravimetric, and volumetric measurements, and routine small instrument use. Duties performed are routine in nature with a limited number of alternatives available. Work is closely supervised and reviewed.

Analyst II

Analyst at this position is progressively developing a proficiency performing a variety of analyses including instrumental and wet chemistry techniques. He/she has a mastery of the basic laboratory skills and has the ability to work with moderate supervision following project assignment. Able to identify problems and take corrective action on own work within the range of alternatives available.

Analyst III

Analyst at this position is progressively developing a proficiency performing a variety of analysPosition requires a complete level of knowledge and understanding in a specific application of laboratory principles and practices. An analyst at this level should be proficient in applicable scientific procedures and techniques to independently conduct tests or experiments for scientific projects as assigned and provide initial analyses of results for the supervisor.
Performs non-routine assignments of substantial variety and complexity under general supervisory direction. Receives objectives and technical advice from supervisor of project scientist. Compiles data and computes results on a variety of scientific procedures and techniques according to standard operation procedures. May assist in the training of junior analysts and technical assistants.es including instrumental and wet chemistry techniques. He/she has a mastery of the basic laboratory skills and has the ability to work with moderate supervision following project assignment. Able to identify problems and take corrective action on own work within the range of alternatives available.

Senior Analyst

Position requires an advanced level of knowledge and understanding of vocational field containing recognized formal principles and practices, complete knowledge in multiple fields, or full competence in a specialized skill or field encompassing the major business function of the Company. Examples of such skill areas would include gas chromatography, mass spectrometry, emissions spectrometry, AA, TOC, and TOX.
Position may direct work of other analyst, as lead analyst on an on-going basis, or as a project analyst on a project basis.
Performs non-routine and complex technical assignments involving responsibility for planning and conducting a complete project of limited scope or a portion of a larger and more diverse project.
Requires well-developed interpersonal skills in training junior analysts and assisting scientists with assigned tasks.

NON-CONTROLLED COPY

Scientist I

As an entry-level scientist, the focus is on developing basic laboratory skills, learning routine tests, and using some instrumentation. Progressively learning and utilizing entry level applications of specialized methods, techniques, and instrumentation, including AA, IPC, and GC. Performs competently with entry-level scientific instrumentation and methods and is responsible for data interpretation, quality control, and reporting of own work. May prepare, or assist in preparing, standard operating procedures, and specifications for process and test. Handles routine maintenance and troubleshooting of instrumentation. Develops quality assurance skills, supervisory responsibilities, technical report writing, and project managements skills. May assist in training of analysts and technical assistants, and instruct lower level staff on routine project set-ups. Will assist the supervisor and/or senior scientists in setting up more complex procedures.
Requires moderately close supervision by experienced staff.

Scientist II

Performs work requiring the application of a specialized field of chemical analysis and ingenuity in the independent evaluation, selection, and adaptation of standard methods and techniques. Progressively learning and utilizing intermediate applications of specialized methods techniques. Performs competently with entry-level scientific instrumentation and methods and is responsible for data interpretation, quality control, and reporting of own work. Prepares standard operating procedures and specifications for process and test. Handles routine maintenance and troubleshooting of instrumentation.
Progressively developing quality assurance and project management skills, becoming involved with more complex analytical systems, technical report writing, and possible client interface. May assist in training of analyst and technical assistants, and instruct lower level staff on more complex project set-ups. Will assist the supervisor and/or senior scientists in setting up more complex procedures.
Works independently with only moderate supervision by experienced staff.

Scientist III

Performs work requiring the application of a specialized field of chemical analysis and ingenuity in the independent evaluation, selection, and adaptation of standard methods and techniques. Progressively learning and utilizing intermediate applications of specialized methods techniques. Performs competentlyPerforms work requiring the application of a specialized field of chemical analysis and ingenuity in the independent evaluation, selection, and adaptation of standard methods and techniques. May have expertise in several areas of analytical chemistry or have specific skills in a highly specialized, technical operation, such as GC/MS or metals analysis. Performs competently with intermediate to advanced interments and methods and is responsible for data interpretation, quality control and reporting of own work. Prepares standard operating procedures and specifications for process and test. Handles routine maintenance and troubleshooting of instrumentation.
Progressively developing quality assurance skills, supervisory responsibilities, and project management skills, becoming involved with more complex analytical systems, technical report writing, and client interface. May assist in training of analysts and technical assistants, and instruct lower level staff on more complex project set-ups. Will assist the supervisor and/or senior scientists in setting up more complex procedures.
May serve as a team leader, or back up supervisor, overseeing three to eight employees. As such, will be responsible for ensuring conformance to company policies and applicable laws and

NON-CONTROLLED COPY

regulations. Responsibilities may include interviewing, selecting and training employees; planning, assigning and directing work; evaluating performance; rewarding and disciplining employees; and addressing complaints and resolving problems. May be asked to perform other duties of a similar nature or level of responsibility.
Works independently, with only moderate supervision by experienced staff. with entry-level scientific instrumentation and methods and is responsible for data interpretation, quality control, and reporting of own work. Prepares standard operating procedures and specifications for process and test. Handles routine maintenance and troubleshooting of instrumentation.
Progressively developing quality assurance and project management skills, becoming involved with more complex analytical systems, technical report writing, and possible client interface. May assist in training of analyst and technical assistants, and instruct lower level staff on more complex project set-ups. Will assist the supervisor and/or senior scientists in setting up more complex procedures.
Works independently with only moderate supervision by experienced staff.

Scientist IV

Typically viewed as the department or laboratory technical specialist for particular area of expertise. At this level, the laboratory scientist's career path begins to fork in two directions. Those exhibiting both the desire and ability for management will enter the management track, while those whose strength and interests lie more in the scientific realm will follow this one. There may, however, be lateral movement between the two tracks.
A senior level scientist performs work requiring the application of a specialized field of chemical analysis and ingenuity in the independent evaluation, selection, and adaptation of standard methods and techniques. Performs competently with complex instruments and methods and is responsible for data interpretation, quality control and reporting of own work. Plans, conducts, and supervises (as a lead) complex analyses requiring advanced instrumentation such as IPC/MS, GC/MS, and GC. Handles routine and advanced maintenance and troubleshooting of instrumentation.
Works comfortably with complex analytical systems, technical report writing, and client interface. Assists in training of staff scientist, analysts and technical assistants, and instructing entry level staff on more complex project set ups. Will assist the supervisor and/or other senior scientists in setting up more complex procedures. Serves as technical advisor for teams and projects. May be asked to perform other duties of a similar nature or level of responsibility. May present formal technical training seminars to both clients and staff.
Works independently, under little supervision.

NOT CONTROLLED COPY

Project Manager

A project manager is an individual who works with customers to determine their analytical needs, coordinates with CAS laboratory and administrative staff to ensure that these needs are understood, and ensures that the service CAS provides adequately meets these defined needs.

1. Client Responsibilities
   - Establish a working relationship with client.
   - Identify clients analytical needs and how the lab can address these needs.
   - Plan analytical program to meet these needs.
   - Keep client informed of progress of work.
   - Report findings and results back to client.
   - Communicate client concerns/issues to lab management.
   - Keep client informed of new developments and lab services.
   - Provides quotations and job specifications for specific work.
2. Project Responsibilities
   - Work with client and lab to define project specifications.
   - Communicate project schedule to lab.
   - Work with Sample Management to ensure proper type and number containers are provided.
   - Review incoming work to ensure work requests are properly specified according to project requirements.
   - Track as required projects through the lab keeping client and lab personnel appraised of progress.
   - Prepare, review, and approve invoices for specific work orders.
3. Reporting and QA/QC Responsibilities
   - Ensure consistent reporting formats for clients.
   - Review reported data against historical results for consistency.
   - Responsible for meeting QA objectives for specified projects.
   - Approves certified analytical reports.
   - Brings problems or issues relative to work to the QA Coordinator, Lab Operations, or Lab Management for study and resolution.
   - At times may be involved with QAP development.
   - May participate in specific marketing activities (i.e., trade show booths), if appropriate.
   - Identifies and communicates to management on new marketing opportunities and other issues.
   - Works closely with SMO, Lab Operations, QA/QC, and administrative staff to keep everyone informed as appropriate on client issues and projects.

NON-CONTROLLED COPY

Business Development Manager

Responsible for supporting the marketing efforts of a region's upper management, sales force, and technical staff. Accountable for the quality and timeliness of all work produced and for coordinating client development efforts with other branch offices. Establishes and maintains contact with smaller clients to market the company's services. Creates client awareness of company services and their applications. Develops and maintains a staff client orientation through training and team-building exercises. Conducts local market research, coordinates and recommends marketing strategies, identifies target markets, and is responsible for consolidating marketing plans into the branch business development plan. Budgets and controls annual business development expenditures while reviewing and approving branch activities and budgets to minimize redundancy and waste.
Prepares and updates an accurate Business Portfolio Analysis and Client Market Profile by branch. Coordinates and assists in developing strategic and tactical marketing plans for the region as well as for other local operations. Prepares standardized market information collection, distribution and utilization formats, and procedures for regional marketing staff use. Also conducts market analysis.

Quality Assurance Program Manager

Accountable for the conduct of the Quality Assurance (QA) program for a branch laboratory. Is generally responsible for all branch laboratory QA activities and maintaining QA related documents. Accountable for obtaining and maintaining certifications and accreditations and maintaining laboratory proficiency testing programs.
Responsible for the overall coordination of the laboratory QA program and for ensuring that quality objectives established by management, certification programs, and project plans are met. Responsible for Quality Assurance functions including the Quality Assurance Manual, documentation of certifications, documenting standard operating procedures, and maintaining proficiency testing records. Oversees balance calibration and sample storage temperature control. Maintains certifications/accreditations for regulatory agencies and client certification or approval programs. Acts as primary point of contact during laboratory audits and coordinates the audit schedule with laboratory and audit staff. Provides audit responses and initiates any changes in procedures resulting from an audit. Coordinates the analysts of proficiency testing samples required for certification/accreditation programs. Reports and reviews result s for these analyses. Conducts informal audits and makes recommendations for corrective action. Provides technical assistance to laboratory staff on QA/QC issues, project feasibility, and methods interpretation/development. Receives operational supervision from the Laboratory Direction; may receive general administrative supervision and guidance from the Corporate Chief Quality Officer.

NON-CONTROLLED COPY

Technical Director

Accountable for timely performance and quality of work assigned, and may be responsible for the work of a small department, including profit and loss responsibility for the unit. Under minimal direction, plans and manages all activities relating to specific laboratory operations or may operate within a key functional area such as client services. Assist in identifying project opportunities, developing proposals, and developing and maintaining client relationships. Manages administration and project schedules, provides technical consultation services to project teams, government agencies, and clients. Responsible for quality control of laboratory work including final review of all reports for specific area of responsibility or as required. Assures that work is being performed using appropriate technology. Attends trade shows and gives marketing and client presentations as required. Encourages and directs development and application of state-of-the-art methodologies and techniques.

Personnel responsibilities include coordination of unit workloads, conducting employee performance reviews, recommending personnel changes, additions, and participation in recruiting process. Marketing responsibilities may include attending trade shows and professional conferences, authoring technical papers, and contacting existing clients and new clients to market company's capabilities.

Has high level role in data evaluation and report responsibility. Supervises, trains and develops scientists, supervisors, analysts, and technician assistants. Monitors work load and project flow through self or assigned team leaders. Monitors adherence to corporate safety plans and policies. High level client and regulatory agency contact. Participation in internal and external meetings involving project strategy and major technical issues. Monitors and reviews budget and schedule status of projects with supervisors. High financial responsibility for profit and loss considerations. Works with regional senior management in short- and long-range planning, e.g., staff requirements, primary areas of technical development, marketing program. May be asked to perform other duties of a similar nature or level of responsibility.

NON-CONTROLLED COPY

Laboratory Director

Accountable for the growth and profitability of a medium-sized branch office. Is generally responsible for all branch office staff, client relations, and marketing. Accountable for the quality and timeliness of all work produced and for coordinating work efforts with other branch offices.
Responsible for all operations within assigned region, including personnel, scheduling, coordination of daily project field and office activities. Supervised operations normally include SMO, facilities, administration, laboratory operations, and related activities. Maintains close working relationships with clients and staff and plays a key role in conflict resolution.
Directs and monitors the activities of the branch office through the appropriate supervisors, technical and administrative managers. Formulates and recommends to the Regional Regional Managers and/or President policies, procedures, plans and programs for the branch office that are commensurate with the overall objective of the region. Formulates and recommends to the Regional Regional Managers and/or President an annual operating budget for the branch office and conducts operations within approved budget limits.
Reviews and approves organizational and key staffing assignments within the branch office. Directs periodic status reviews of major projects to ensure that technical and quality standards are being met and that the performance is within budget and schedule. Participates, as required, in project and management reviews of proposals, reports, and client contract negotiations, including final pricing of proposals. Provides counsel and information about the project's feasibility.
Responsible for branch office programs and procedures, including staff planning and development, personnel administration, and compliance with corporate policies and procedures. Stays abreast of technological developments and trends which could lead to new applications or markets, Responsible for maintaining proper and timely controls over all branch office work, ensuring that billability targets and overall profitability goals are met. Maintains good client relations and actively pursues expansion of new clients and business lines in conjunction with regional and corporate marketing goals.
Receives operational supervision from the Regional Managers and/or President; may receive general administrative supervision and guidance from the regional CAO.

NON-CONTROLLED COPY

Columbia Analytical Services, Inc.

Corporate QA Standard Operating Procedures, Policies, and Forms

Page 1 – SOPs

SOP TITLE	SOP Code	Rev	SOP Date	Date of Last
SOP for Checking New Lots of Chemicals for Contamination	ADM-CTMN	4	1/26/09	1/13/10
SOP for Control Limits	ADM-CTRL_LIM	7	12/14/09	12/16/09
SOP for Corrective Action	ADM-CA	6	9/15/09	9/22/10
SOP for Data Recall	ADM-DATARECALL	0	9/21/07	11/16/09
SOP for Document Control	ADM-DOC_CTRL	8	9/15/09	9/22/10
SOP for Documentation of Training	ADM-TRANDOC	11	12/17/09	12/17/09
SOP for Estimation of Uncertainty of Measurements	ADM-UNCERT	6	9/23/10	9/29/10
SOP for Handling Customer Feedback	ADM-FDBK	5	12/14/09	12/17/09
SOP for Making Entries into Logbooks and onto Analytical Records	ADM-DATANTRY	9	9/27/10	9/29/10
SOP for Managerial Review of the Laboratory's Quality Systems and Testing Activities	ADM-MGMTRVW	3	12/10/09	12/16/09
SOP for Manual Integration of Chromatographic Peaks	ADM-INT	4	10/5/10	10/9/10
SOP for Performing Method Detection Limit Studies and Establishing Limits of Detection and Quantitation	ADM-MDL	9	9/8/09	9/21/10
SOP for Preparation of Electronic-data for Organic Analyses for Electronic-data Audits	ADM-E_DATA	3	8/29/07	11/16/09
SOP for Preparation of SOPs	ADM-SOP	9	12/14/09	12/16/09
SOP for Preventive Action	ADM-PA	1	12/14/09	12/16/09
SOP for Proficiency Testing Sample Analysis	ADM-PTS	3	9/22/10	9/29/10
SOP for Purchasing and Approval of Vendors	ADM-PUR	4	10/15/09	10/5/10
SOP for Qualification of Subcontract Laboratories	ADM_SUBLAB	5	9/15/09	9/22/10
SOP for Significant Figures	ADM-SIGFIG	8	1/28/09	1/13/10

NON-CONTROLLED COPY

Columbia Analytical Services, Inc.

Corporate QA Standard Operating Procedures, Policies, and Forms

Page 2 – Policies

POLICY TITLE	POLICY DATE	DATE APPROVED	DATE EFFECTIVE
CAS Quality and Ethics Policy Statement	September 2010	9/28/10	9/28/10
Policy for Data Review and Validation	September 2010	9/9/10	9/10/10
Policy for Internal Quality Assurance Audits	May 2009	5/5/09	7/1/09
Policy for Standards and Reagents Expiration Dates	September 2009	9/15/09	9/28/09
Policy for Use of Accreditation Organization's Name, Symbols, and Logos	September 2009	9/21/09	10/1/09
Policy for Conducting Research, Method Development, and Method Investigations	December 2009	12/15/09	12/17/09

NON-CONTROLLED COPY

Columbia Analytical Services, Inc.

Corporate QA Standard Operating Procedures, Policies, and Forms

Page 3 – Forms

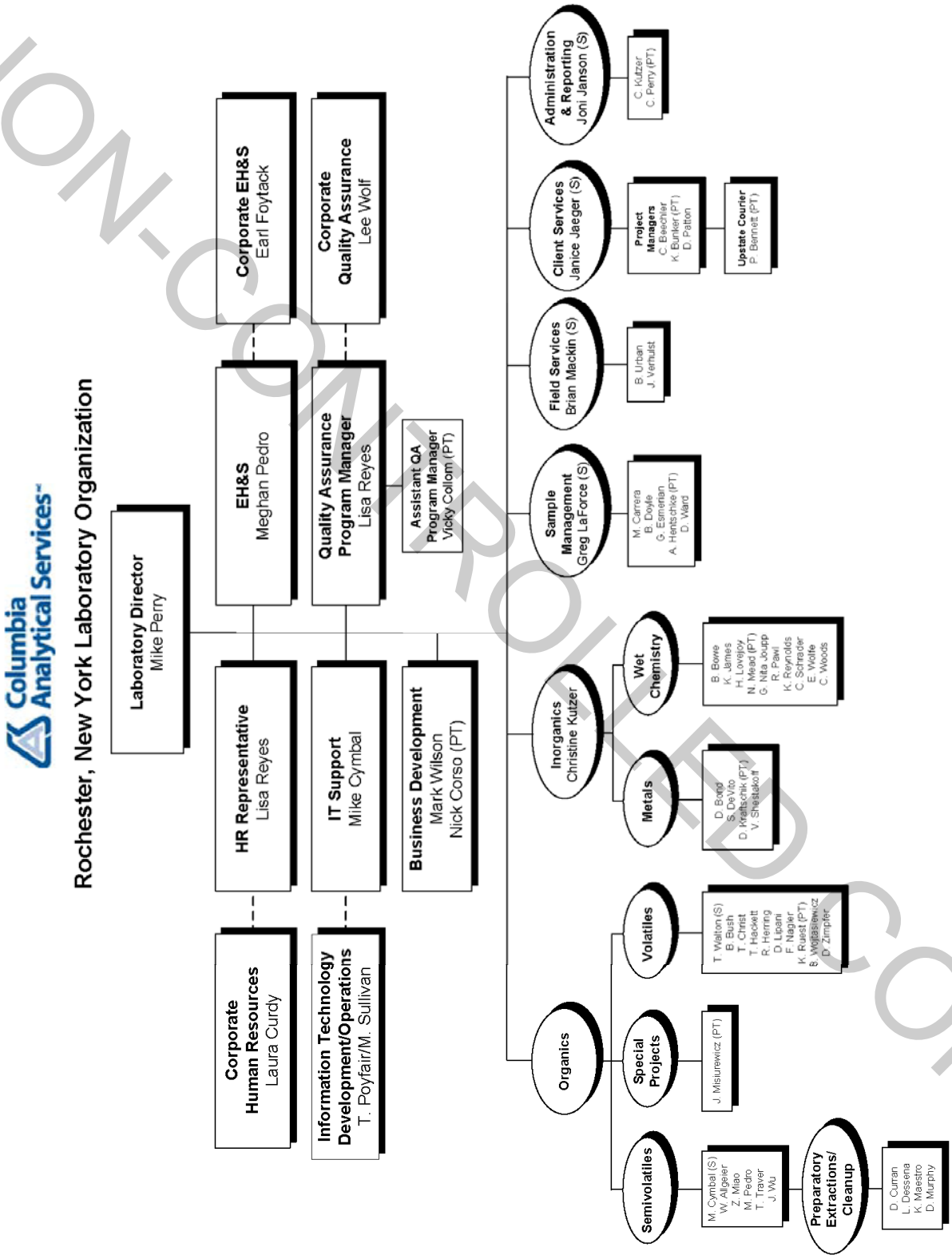
FORM	FILE NAME	DATE
Audit Finding Response Form	Audit Finding Response Form_r042110	4/21/10
Chemical Contamination Check Log	Chemical Contamination Check Log_r091503	9/15/03
Chemical Lot Testing Memo	Chemical Lot Testing Memo_r092109	9/21/09
Complaint Report	Complaint Report_r121509	12/15/09
Critical Job Function Authorization Statement	Critical Job Function Authorization Statement_r071206	7/12/06
Data Re-submittal Request Form	Data Resubmittal Request Form_r112107	11/21/07
Demonstration of Capability Certification Statement (no table version)	DOC Certification Statement_r071206-	7/12/06
Demonstration of Capability Certification Statement	IDC Certification Statement_r032503	3/25/03
Laboratory Training Certification	LAB-TRNG_r092109	9/21/09
Method Detection Limit Study Calculation Spreadsheet	MDL_FORMR3_r092109	9/21/09
New Vendor Evaluation	Vendor Evaluation Form_r101509	10/15/09
Nonconformity and Corrective Action Report	NCAR09_r092109	9/21/09
Quarterly QA Report to Management Template	Quarter QAReport Template 092309r1	11/6/09
Preventive Action Report	PA Report_r072108	7/21/08
Standard Operating Procedure Change Form	SOP Change Form_r092109	9/21/09

NON-CONTROLLED COPY

NON-CONTROLLED COPY

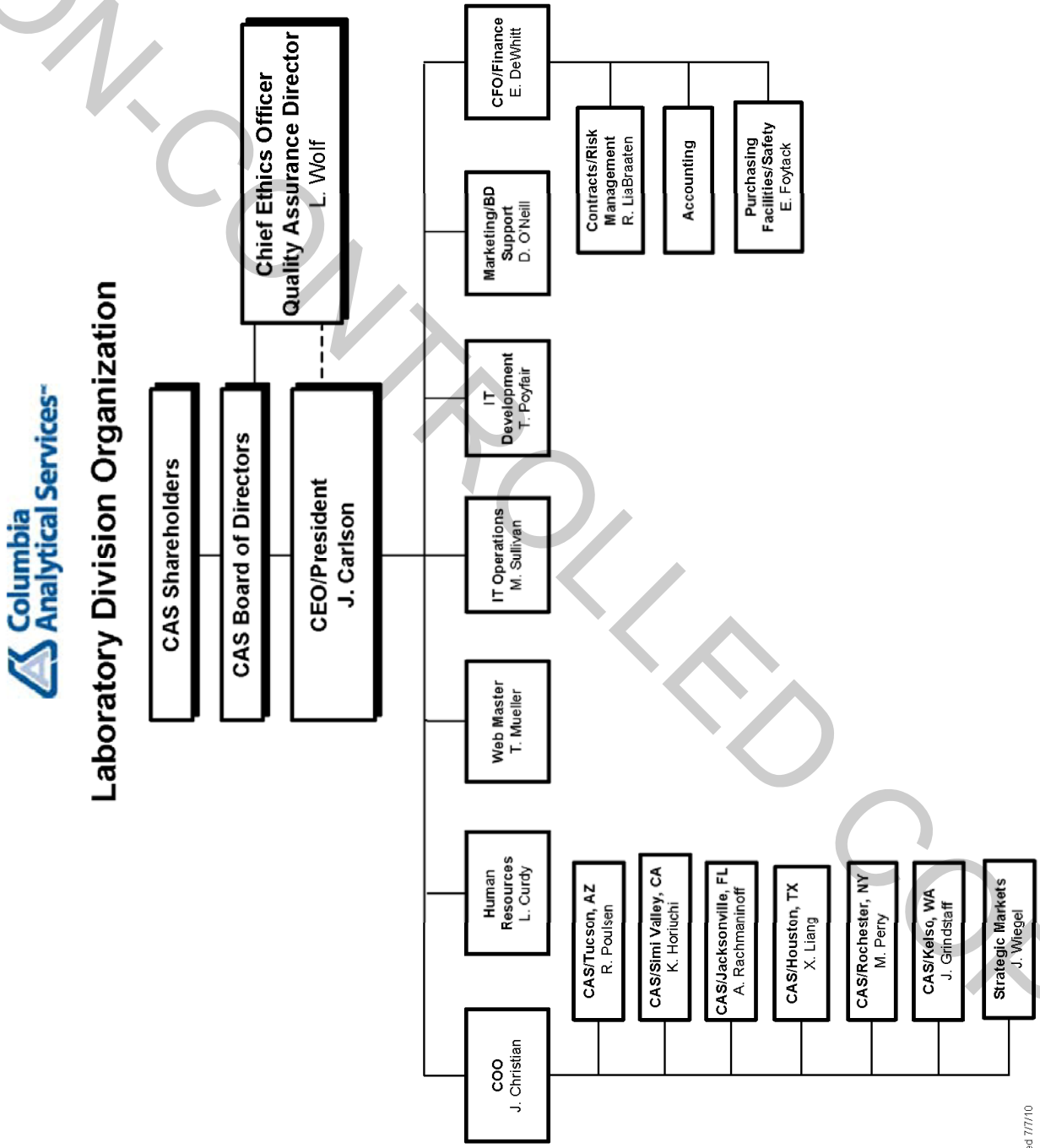
APPENDIX B
ORGANIZATIONAL CHART AND RESUMES OF KEY PERSONNEL

Please note that the Appendices provide current information at the time of the revision, but are updated only upon annual review. Please contact the laboratory for up-to-date information.



NON-CONTROLLED COPY

NON-CONTROLLED COPY



Revised 7/7/10

NON-CONTROLLED COPY

MICHAEL K. PERRY

1996 TO PRESENT

Columbia Analytical Services, Inc., 1 Mustard St., Suite 250, Rochester, NY 14609 (585) 228-5380

Current Position

LABORATORY DIRECTOR/TECHNICAL DIRECTOR – 1996 to Present

Responsibilities

Primary responsibilities include management of all laboratory departments, scheduling, productivity, reporting and evaluation of analytical methodologies, project planning and Quality Assurance/Quality Control protocols. In addition, other responsibilities include direct responsibility for contracts and consultants relating to the EPA SITE program, ACOE remediation program and the technical interface for the New York State ASP CLP program and other large national based clients.

Documentation of Demonstration of Capabilities is available for review.

Experience

Project Chemist, *General Testing Corporation, Rochester, New York*, 1995-1996. In addition to the duties of Laboratory Director listed below, responsibilities expanded to include the supervision of four teams of Project Chemists. Production management was shifted to the Laboratory Supervisors in order to increase client contact. Directly responsible for contracts and consultants relating to the EPA SITE program, ACOE remediation program and the New York State ASP CLP program.

Laboratory Director, *General Testing Corporation, Rochester, New York*, 1985-1995. Primary responsibilities included management of all laboratory departments, scheduling, productivity, reporting and evaluation of analytical methodologies and Quality Assurance/Quality Control protocols.

Instrument Manager, *General Testing Corporation, Rochester, New York*, 1979-1985. Responsibilities included operation and maintenance of all laboratory instruments and supervision of personnel associated with the instrumentation laboratory. Analyses included metals, volatile organics, pesticides/PCBs, and semi-volatile organics.

Senior Quality Assurance Technician, *Coca-Cola Corporation, Atlanta, Georgia*, 1976-1979. Responsible for analysis of raw materials and finished product using both wet chemistry and instrumentation techniques.

Laboratory Technician, *Penwalt Pharmaceutical Company, Rochester, New York*, 1975. Worked in the Quality Control Department.

Education

Coursework toward MS, Chemistry, *Rochester Institute of Technology, Rochester, New York*, 1983-1986
GC/MS, *ACS Short Course*, 1986
Effective Management of Chemical Analysis Laboratories, *ACS Short Course*, 1985
BS, Chemistry, *Georgia State University, Atlanta, Georgia*, 1979
AAS, Chemistry, *State University of New York at Alfred, Alfred, New York*, 1975

Affiliations

American Chemical Society

NON-CONTROLLED COPY

LISA M. REYES

1997 TO PRESENT

Columbia Analytical Services, Inc., 1 Mustard St., Suite 250, Rochester, NY 14609 (585) 2285380

Current Position

QUALITY ASSURANCE/QUALITY CONTROL PROGRAM MANAGER – 1997 to Present

Responsibilities

Responsible for the overall coordination of the laboratory QA program and for ensuring implementation and compliance with established quality objectives and quality systems at all times. Responsible for Quality Assurance functions including the Quality Assurance Manual, certifications, documenting standard operating procedures, and maintaining performance evaluation records. Oversees balance calibration and sample storage temperature control. Maintains certifications/accreditations for regulatory agencies and client certifications or approval programs. Acts as primary point of contact during laboratory audits. Provides audit responses and initiates any changes in procedures resulting from an audit. Ensures continuous process improvement through the use of control charts, performance evaluation samples and preventive action. Conducts internal audits and makes recommendations for corrective action and improving effective quality assurance and quality control. Ensures that all personnel understand their contributions to the quality system and that communication takes place at all levels within the laboratory regarding the effectiveness of the quality system, and evaluating the effectiveness of training.

Provides technical assistance to laboratory staff on QA/QC issues, project feasibility, and methods interpretation/development.

Documentation of Demonstration of Capabilities is available for review.

Experience

Environmental Chemist, *TreaTek-CRA Company/Conestoga-Rovers & Associates, Niagara Falls, New York,* 1992-1997. Data quality, assessments and validations of ASP, CLP, and SW-846 organic and inorganic analytical data. Liaison with analytical contract laboratories, CRA field personnel, and state and federal agencies. Prepared QAPPs, laboratory bidding documents, and contracts. Also responsible for performance of laboratory audits

Manager of Quality Management Office, *Huntingdon Analytical Services, Middleport, New York,* 1989-1992. Manager of QA for Environmental, Agrochemical, Asbestos, and Engineering Soil laboratories. Responsible for in-house QA/QC programs, inspections, and instrument maintenance. Also responsible for employee safety and hazardous waste training, as well as manifesting hazardous waste. Routinely performed inorganic analyses, and reviewed analytical data, reports, and CLP packages.

Research Assistant, *Research Foundation, State University of New York College at Brockport, Brockport, New York,* 1986-1989. Performed routine sampling of surface water and lakes. Also did inorganic analyses on water and soil matrices. Assisted in graduate projects dealing with fish, plankton, water chemistry, and crayfish.

Education

CLP Inorganic Data Validation, *US EPA Region II, Westchester Community, Westchester, New York,* 1993.
CLP Organic Data Validation, *US EPA Region II, Westchester Community, Westchester, New York,* 1992.
BS, Biology, *State University of New York at Brockport, Brockport, New York,* 1988

Affiliations

American Chemical Society

NON-CONTROLLED COPY

JANICE M. JAEGER

1996 TO PRESENT

Columbia Analytical Services

Columbia Analytical Services, Inc., 1 Mustard St., Ste. 250, Rochester, NY 14609 585.288.5380

Current Position	**CLIENT SERVICES MANAGER I**, 2004-Present
Responsibilities	Responsible for the supervision of Project Managers, Sample Management Office (SMO) and Reporting Departments. Assist clients to determine what analyses are required. Oversee projects from quote initiation to final report submission. Act as liaison between client requirements and laboratory capabilities for projects. Update clients on progress if their project and answer any questions they may have. Respond promptly to client requests and develop new client contacts within and outside of our current client base. **Documentation of Demonstration of Capabilities is available for review.**
Experience	**Project Manager III**, *Columbia Analytical Services, Rochester, NY*. 1996-2004. Assist clients to determine what analyses are required. Responsibilities primarily as above without the supervisory role. **Customer Service Representative/Sample Receiving**, *General Testing Corporation, Rochester, New York*, 1989-1996. Primary responsibilities included client services as listed above. Also responsible for sample receipt, log in and distribution as well as bottle preparation. **Surgical Assistant**, *Penfield Veterinary Hospital Rochester, New York*, 1984-1989. Primary responsibilities included preparation of instruments, surgical area, and animal for surgery. Also responsible for monitoring the animal before and after surgery.
Education	**BA, Pre-Veterinary Medicine and Pre-Professional Zoology (double Major)**, *Ohio Wesleyan University, Delaware, Ohio*, 1983.

Revised: 2/26/2008

NON-CONTROLLED COPY

CHRISTINE M. KUTZER

1996 TO PRESENT

Columbia Analytical Services

Columbia Analytical Services, Inc., 1 Mustard St., Ste. 250, Rochester, NY 14609 585.288.5380

Current Position	TECHNICAL MANAGER II, INORGANICS LABORATORY – 2004 to Present
Responsibilities	Plans and manages all activities in the Inorganics Department, including Metals and General Chemistry. Responsible for coordinating the workload and scheduling employees' daily activities. Assist in the operation, troubleshooting, and maintenance of instrumentation. Responsible for scheduling samples. Accountable for analytical data entry, analytical data approval and High Level metals package generation through MARRS. **Documentation of Demonstration of Capabilities is available for review.**
Experience	**Technical Manager II, Metals and Organics Prep Laboratories,** *Columbia Analytical Services, Inc., Rochester, New York,* 2002-2004. Duties as above for Metals Department. Responsible for coordinating the workload and scheduling employees' daily activities and troubleshooting in the organics preparation laboratory. **Technical Manager I, Metals Laboratory,** *Columbia Analytical Services, Inc., Rochester, New York,* 1996-2002. Duties as above for Metals Department. **Analyst III,** *Columbia Analytical Services, Rochester, New York,* 1996. Responsible for instrument troubleshooting and maintenance, digestion of samples, and TCLP extractions. Also responsible for data entry, approval, and package review. **Chemist,** *General Testing Corporation, Rochester, New York,* 1992-1996. Duties were as listed above.
Education	**BS, Chemistry,** *St. Bonaventure University, Olean, New York,* 1992

Revised: 2/26/2008

NON-CONTROLLED COPY

MICHAEL W. CYMBAL

1996 TO PRESENT

Columbia Analytical Services

Columbia Analytical Services, Inc., 1 Mustard St., Ste. 250, Rochester, NY 14609 585.288.5380

Current Position	**TECHNICAL MANAGER I** - Information Technology 1998 to Present - Extractables Department Supervisor 2004 to Present
Responsibilities	Responsible for computer systems (Novel Lan, Starlims) and instrument analysis of software. Also responsible for client spreadsheets and disk deliverables, computer maintenance and upgrades. Responsible for the oversight of the extractables department including extactions and instrumental analysis (HPLC, GC, and GC/MS). **Documentation of Demonstration of Capabilities is available for review.**
Experience	**Systems Analyst III**, *Columbia Analytical Services, Inc., Rochester, New York,* 1997-1998. Duties primarily as above. **Systems Analyst I**, *Columbia Analytical Services, Inc., Rochester, New York,* 1996-1997. Duties primarily as above. **Computer Administration**, *General Testing Corporation, Rochester, New York,* 1995-1996. Oversaw computer systems (Novel Lan, StarLIMS, Seven Reporting Systems) and created client spreadsheets and disk deliverables. **Analyst**, *General Testing Corporation, Rochester, New York,* 1990-1995. Responsible for Organic Analyses (Volatile and Semi-Volatile Pesticides) for GC and GC/MS. Also responsible for Instrument Maintenance and Sample Preparation.
Education	**BS, Chemistry**, *Robert's Wesleyan College, Rochester, New York,* 1990.

Revised: 2/26/2008

NON-CONTROLLED COPY

THOMAS WALTON

2006 TO PRESENT

Columbia Analytical Services™

Columbia Analytical Services, Inc., 1 Mustard St., Ste. 250, Rochester, NY 14609 585.288.5380

Current Position	TECHNICAL MANAGER I, GC/VOA LABORATORY – 2009 to Present
Responsibilities	Responsible for the daily operations of the GC/MS laboratory, including the scheduling of department analyses, instrument calibration, and troubleshooting/maintenance activities. Accountable for personnel training, data approval, quality program support. **Documentation of Demonstration of Capabilities is available for review.**
Experience	**Scientist IV**, *Columbia Analytical Services, Rochester, New York*. 2006-2009. Responsible for GC/MS analysis of air for presence of volatile organic compounds, data reduction and preparation of data for reporting. Also responsible for instrument maintenance as needed. **Chemist**, *Eastman Kodak Company, Rochester, New York*, 1989-2005. Analytical Chemist supporting environmental and industrial hygiene testing, equipment and process monitoring; method development, and quality control; and experience with EPA methods TO-15, 8015, 8260, and 8270.
Education	**BS, Chemistry**, *Suny at Cortland, Cortland, New York*, 1985.

Revised: 2/26/2008

NON-CONTROLLED COPY

MEGHAN D. PEDRO

2001 TO PRESENT

Columbia Analytical Services

Columbia Analytical Services, Inc., 1 Mustard St., Ste. 250, Rochester, NY 14609 585.288.5380

Current Position	**SCIENTIST III** – 2004 to Present
	Environmental Health and Safety Program Manager – 2009 to Present
Responsibilities	Supervision of the organics prep lab. Analysis of, and generation of reports, pesticides/PCBs, herbicides, and other miscellaneous analyses/extractions using GC/ECD. Prepares standards, surrogates and spikes.
	Administration of the laboratory health and safety policies, including formulation and implementation, supervision of new employee safety training, review of accidents, incidents and prevention plans, and the conducting of departmental safety inspections.
	Documentation of Demonstration of Capabilities is available for review.
Experience	**Scientist II**, *Columbia Analytical Services, Inc., Rochester, NY*, 2003-2004. Responsibilities were primarily as above without the supervisory role. Analysis of, and generation of reports, pesticides/PCBs, herbicides, and other miscellaneous analyses/extractions using GC/ECD. Prepares standards, surrogates and spikes.
	Scientist I, *Columbia Analytical Services, Inc., Rochester, NY*, 2002-2003. Analysis of, and generation of reports for, pesticides/PCBs, herbicides, and other miscellaneous analyses/extractions using GC/ECD. Prepares standards, surrogates and spikes.
	Senior Analyst, *Columbia Analytical Services, Inc., Rochester, New York*, 2001-2002. Extraction, concentration, and clean-up of water, soil and oil samples for Semi-VOA compounds using EPA methodologies.
	Prior work history is not relevant to laboratory position.
Education	**BS, Chemistry**, *Nazareth College, Rochester, New York*, 2000.

Revised: 8/14/2009

NON-CONTROLLED COPY

MARK WILSON

1996 TO PRESENT

Columbia Analytical Services

Columbia Analytical Services, Inc., 1 Mustard St., Ste. 250, Rochester, NY 14609 585.288.5380

Current Position	**SENIOR ACCOUNT MANAGER/DIRECTOR OF BUSINESS DEVELOPMENT II**– 2004 to Present
Responsibilities	Responsible for Large Account Management. Responsible for sales maintenance for the Rochester laboratory territory including coordination of marketing and sales with national sales team.
	Documentation of Demonstration of Capabilities is available for review.
Experience	**Client Services Manager**, *Columbia Analytical Services, Rochester, NY*, 1996-2004. Responsible for supervision of Project Chemists, sales staff, Sample Management Office (SMO) and reporting departments. Responsible for project management and client interface regarding analytical services.
	Laboratory Manager, *Columbia Analytical Services, Rochester, New York*, 1996. Responsible for supervision of laboratory staff, scheduling of projects, evaluations of analytical QC procedures, and review of all analytical data.
	Laboratory Manager, *General Testing Corporation, Rochester, New York*, 1992-1996. Responsibilities were primarily same as above.
	Assistant Laboratory Director, *General Testing Corporation, Rochester, New York*, 1988-1992. Was responsible for assisting lab director with supervision of lab staff, scheduling of projects, evaluations of analytical and QC procedures, and review of all analytical data.
	Organics Department Manager, *General Testing Corporation, Rochester, New York*, 1986-1996. Responsible for supervising all organics analyses including GC/MS, GC volatile organics, and GC extractables, and coordinating production and method development.
	Organic Extractables Manager, *General Testing Corporation, Rochester, New York*, 1985-1992. Was responsible for GC operation and analysis, GC maintenance, trouble shooting, development, and GC/MS operation and start up.
	Staff Technician II, *Medical Center University of Kentucky, Lexington, Kentucky*, 1979-1985. Was responsible for GC and AA analysis on biological fluids, drug screening and monitoring, heavy metals analysis, thin-layer chromatography, HPLC, and water testing.
Education	**BS, Medical Technology with 32 hours of Chemistry**, *State University of New York at Buffalo, Buffalo, New York*, 1978.

Revised: 2/26/2008

NON-CONTROLLED COPY

JAMES M. CARLSON

1999 TO PRESENT

Columbia Analytical Services

Columbia Analytical Services, Inc., 1317 South 13th Ave., Kelso, WA 98632 360.577.7222

Current Position

PRESIDENT AND CHIEF EXECUTIVE OFFICER – 2010 to Present

Responsibilities

Responsible for overall management direction and coordination of all business activities, develops and implements business plans. Works closely with Branch Managers, and support staff, including Financial and Administration. Approves all policies, procedures, plans, and programs for the company and ensures their conformity with corporate guidelines and policies. Approves annual operating budgets for the branch offices and ensures operations perform within approved budget limits. Stays abreast of technological developments and trends, which could lead to new applications or markets. Maintains good client relations and actively pursues expansion of new clients and business lines in conjunction with regional and corporate marketing goals.

Experience

CHIEF OPERATING OFFICER (COO), *Columbian Analytical Services, Kelso, Washington,* 1999-2010. Responsible for oversight of operating units of Columbia Analytical Services, inc. with all Laboratory Directors reporting to the COO. Primary responsibilities include establishment of consistent quality, technical, and client service enhancements across the company, as well as the financial performance of the individual operating units. In addition, a significant role is to represent operations as a member of the Senior Management Team (SMT) consisting of the Chief Executive Officer, Chief Financial Officer, Chief Quality Officer, and the Director of Information Technology

Financial Services Manager, *BHP Coated Steel Corporation, Kalama, Washington,* 1997-1999. Developed and managed the financial accounting and services department for a two-plant facility with revenues exceeding $200 million. Supervised a staff of 11 and provided shared services for five organizations. Responsible for all internal and external financial reporting and audit requirements. Additional duties included supporting the general management team as relief CFO and acting as a meeting and process facilitator.

Finance and Administration Manager, *BHP Diamonds, Inc., Yellowknife, Northwest Territory, Canada,* 1993-1997. Developed and managed effective accounting, financial reporting, purchasing, and logistics systems for the start up of the BHP/Blackwater NWT Diamond Project in the high Arctic. Negotiated and administered contracts related to the supply of goods, services, and facilities for the construction and administration of the 100 person camp, including the development of HR, safety, and security systems. Participated in the general management team, including extensive public relations regarding the project's environmental and socioeconomic impacts. Participated in negotiations involving aboriginal, provincial, and the Canadian federal government.

Accounting and Administration Manager, *BHP Exploration, Herndon, Virginia,* 1992-1993. Controller and administration manager for BHP's world coal and industrial minerals programs. Oversight of 12 international office locations, including the 40-person office in Herndon, Virginia, and 30 international exploration and geophysical projects. Responsible for all aspects of office and accounting administration, including international and domestic staffing. Retained local external accounting and legal services in foreign locations and negotiated foreign labor agreements.

Senior Accountant, *BHP Western US Mining, Farmington, New Mexico,* 1989-1992. Responsible for general ledger, equipment, and fixed asset accounting for three coal mines with a combined annual revenue exceeding $300 million. Also responsible for administration of royalties, taxes, and land lease obligations with external entities, including governments, tribes, and individual landowners; preparation of monthly business reports; annual budgets; and ten-year forecasts. Trained developing accountants in major mining accounting and administration.

Management Trainee, *Financial Management Development Program, BHP Utah International, San Francisco, California,* 1986-1989. Performed three one-year training assignments within the BHP Minerals San Francisco office. One year of consolidation accounting, one year of exploration accounting, and one year of financial planning and analysis.

Education

Leading Organizational Change Program, *BHP, Kalama, Washington,* 1998.
Global Leadership Program 2, *BHP, Kota Kinabalu, Malaysia,* 1995.
Resident Management Course I, *BHP, Melbourne, Australia,* 1993.
BS, Business Administration/Accounting, *California State University, San Jose, California,* 1986.

NON-CONTROLLED COPY

JEFFREY D. CHRISTIAN

1989 TO PRESENT

Columbia Analytical Services

Columbia Analytical Services, Inc., 1317 South 13th Ave., Kelso, WA 98626 360.577.7222

Current Position

CHIEF OPERATING OFFICER (COO) – 2010 to Present

Responsibilities

Responsible for oversight of operating units of Columbia Analytical Services, inc. with all Laboratory Directors reporting to the COO. Primary responsibilities include establishment of consistent quality, technical, and client service enhancements across the company, as well as the financial performance of the individual operating units. In addition, a significant role is to represent operations as a member of the Senior Management Team (SMT) consisting of the Chief Executive Officer, Chief Financial Officer, Chief Quality Officer, and the Director of Information Technology.

Experience

Vice President/Laboratory Director, Kelso Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington,* 1993-2010. Responsible for all phases of laboratory operations, including project planning, budgeting, and quality assurance.

Operations Manager, Kelso Laboratory, *Columbia Analytical Services, Inc., Kelso, Washington,* 1992-1993. Responsibilities included directing the daily operation of the Kelso laboratory. Other responsibilities and duties included functioning as a technical consultant to clients, providing assistance in developing and planning analytical schemes to match client objectives, and writing and developing analytical procedures/methods. Also, served as Project Manager for State of Alaska Department of Environmental Conservation contract and Coordinator for EPA Special Analytical Services (SAS) contracts.

Project Chemist and Manager, Metals Analysis Laboratory, *Columbia Analytical Services, Kelso, Washington,* 1989-1992. Responsible for directing the daily operation of the Metals Laboratory, including the sample preparation, AAS, ICP-OES, and ICP-MS Laboratories.

Scientist, *Weyerhaeuser Technology Center, Federal Way, Washington,* 1986-1989. Responsibilities included supervising atomic spectroscopy laboratory which included flame and furnace AAS, ICP-OES, and sample preparation capabilities to handle a wide variety of sample types. Interfaced with internal and external clients to provide technical support. Wrote and developed analytical procedures/methods.

Lead Technician, Metals Lab, *Weyerhaeuser Technology Center, Federal Way, Washington,* 1981-1986. Responsibilities included primary ICP and AAS analyst for EPA-CLP contract work. Extensive experience in wide variety of environmental and product-related testing.

Research Assistant, *ITT Rayonier, Olympic Research Division, Shelton, Washington,* 1978-1981. Responsibilities included performing water quality tests, product-related analytical tests, corrosion tests (i.e., potentiometric polarization techniques), and operated pilot equipment specific to the pulp and paper industry.

Education

B.S., Chemistry, *Evergreen State College, Olympia, Washington,* 1993.
Coursework, *Pacific Lutheran University, Tacoma, Washington.* 1988-1989.
Coursework, *Tacoma Community College, Tacoma, Washington.* 1970-1971, 1988-1989.
CERTIFICATION, Chemistry, *L.H. Bates Technical, Tacoma, Washington,* 1976-1978.
Coursework, *Central Washington University, Ellensburg, Washington.* 1969-1970.
Numerous Training/Educational Activities via Conferences, Professional Seminars, and Factory Training, 1989-2010.

Publications/ Presentations

Mr. Christian has a number of publications and presentations. For a list of these publications and presentations, please contact CAS.

NON-CONTROLLED COPY

LEE E. WOLF

1988 TO PRESENT

Columbia Analytical Services

Columbia Analytical Services, Inc., 1317 South 13th Ave., Kelso, WA 98626 360.577.7222

Current Position

QUALITY ASSURANCE DIRECTOR AND CHIEF QUALITY OFFICER – 2008 to Present

Responsibilities

Directing the overall corporate-wide quality systems and ethics programs for all CAS facilities. Responsible for ensuring that CAS quality systems and data integrity standards are implemented at all facilities. Act as liaison with government entities involving quality, technical and operational issues. Provide QA input and policy as needed for operations, development initiatives, special projects, planning, and information technology implementation. Provide assistance to QA Program Managers.

Experience

Technical Manager IV, Quality Assurance Program Manager, *Columbia Analytical Services, Inc., Kelso, Washington* – 2002 to 2008. As part of the management team, responsibilities included the overall management and implementation of the laboratory QA program. This included maintaining accreditations and certifications, and maintaining all necessary documents (QA Manual, SOPs, and QA records). Acted as primary point of contact during laboratory audits and provided audit responses and corrective actions. Coordinated performance audits (PE/PT testing) and conducted internal audits.

Scientist IV, Quality Assurance Program Manager, *Columbia Analytical Services, Inc., Kelso, Washington,* 1996-2002. Duties primarily as listed above.

Project Chemist/Principal Organic Scientist, *Columbia Analytical Services, Inc., Kelso, Washington,* 1994-1996. Responsibilities included GC and GC/MS method development and special projects coordination. Acts as technical advisor to the GC and GC/MS laboratories and GC/MS interpretation specialist and CLP organics specialist. Also responsible for Project Chemist functions, including management of projects for clients, identifying client needs, and preparation of data reports.

Semivolatile Organics Department Manager, *Columbia Analytical Services*, 1988-1994. Responsibilities included overall management of the department. Supervised GC/MS analyses, data review, reporting and related QA/QC functions. Responsible for supervision of staff, training, and scheduling. Beginning in 1992, responsibilities included being a Project Chemist for organics EPA-SAS and other clients. This involved scheduling projects for clients, identifying client requirements, and preparing data reports.

GC/MS Chemist, *U.S. Testing Co., Richland, Washington,* 1985-1988. Responsibilities included GC and GC/MS analysis of water and soil samples for volatiles and semivolatiles by EPA protocol, including Methods 8240, 8270 and CLP. Coordinated extraction and GC-GC/MS areas to manage sample/data flow through the lab. Also performed HPLC analysis and pesticide analysis by GC using EPA Methods.

Laboratory Assistant, *Eastern Washington University, Cheney, Washington,* 1985. Responsibilities included supervision and instruction of organic chemistry labs. Experience with GC and IR operation. Responsible for lab safety.

Education

Pharmaceutical Laboratory Control Systems, *Univ. of Wisconsin Short Course, Las Vegas,* 2004
Test Method Validation in Pharmaceutical Development and Production, *Univ. of Wisconsin Short Course, Las Vegas,* 2004
Documenting Your Quality System, *A2LA Short Course, Las Vegas, Nevada*, 1998.
Internal Laboratory Audits, *A2LA Short Course, Las Vegas, Nevada*, 1998.
Mass Spectra Interpretation, *ACS Short Course, Denver, Colorado*, 1992.
BS, Chemistry, *Eastern Washington University, Cheney, Washington,* 1985.

Publications/ Presentations

Selected Ion Monitoring: Issues for Method Development, Panel Discussion, Association of Official Analytical Chemists, (AOAC) Pacific Northwest Regional Meeting, 1995.

Method Enhancement Techniques for Achieving Low level Detection of Butyl Tin in Marine Sediments and Tissues, Association of Official Analytical Chemists (AOAC) Pacific Northwest Regional Meeting, 1994.

The Determination of Low-Level Concentrations of Polynuclear Aromatic Hydrocarbons (PAHs) in Soil and Water Using Gas Chromatography/Mass Spectroscopy Selected Ion Monitoring (GC/MS SIM), HazMat West, Long Beach, California, 1992.

Affiliations

American Chemical Society.

Revised: 2/26/2008

NON-CONTROLLED COPY

APPENDIX C
MAJOR ANALYTICAL EQUIPMENT

Please note that the Appendices provide current information at the time of the revision, but are updated only upon annual review. Please contact the laboratory for up-to-date information.

Please also note that many SOPs reference this Appendix (C) for control limits. These limits are now found in the Data Quality Objectives Table, as referenced in the Columbia Analytical/Rochester QA Program Documents Table in Appendix A.

Columbia Analytical Services
Rochester, NY

EQUIPMENT LIST

Instrument ID	Instrument Configuration	Manufacturer Part	Serial Number	Analyses Performed	Year Acquired
MASS SPECTROMETERS - VOAs					
GC/MS #5	Gas Chromatograph	HP 5890II	3121A35679	VOAs	1991
	Mass Spec Detector	HP 5971	3118A02532		
	AutoSampler	Archon	12727		
	Concentrator	Tekmar 3000	98125008		
	Computer Workstation	Gateway P5-133	5360357		
	Analytical Software	Enviroquant Chemstation G1032C v.c.01.00			
GC/MS #6	Gas Chromatograph	HP 6890	US00023178	VOAs	1998
	Mass Spec Detector	HP 5973	US82311143		
	AutoSampler	Archon			
	Concentrator	EST Encon	261043003		
	Computer Workstation	HP Kayak XA	US3T653217		
	Analytical Software	Enviroquant Chemstation G1701BA v.B.00.00			
GC/MS #7	Gas Chromatograph	HP 5890II	3235A43994	VOAs	2001
	Mass Spec Detector	HP 5971	323A03964		
	AutoSampler	Archon	13589		
	Concentrator	Tekmar 2000	91267022		
	Computer Workstation	Compaq DeskPro	6124FR4ZD257		
	Analytical Software	Enviroquant Chemstation G1701BA v.B.01.00			

NON-CONTROLLED COPY

NON-CONTROLLED COPY

Columbia Analytical Services
Rochester, NY

EQUIPMENT LIST

Instrument ID	Instrument Configuration	Manufacturer Part	Serial Number	Analyses Performed	Year Acquired
GC/MS #8	Gas Chromatograph	HP 5890II	3126A36850	VOAs	2004
	Mass Spec Detector	HP 5972	3435A01975		
	AutoSampler	EST Centurion	CENT145061104		
	Concentrator	EST Encon	374062504		
	Computer Workstation	Compaq DeskPro	6946CJM7M878		
	Analytical Software	Enviroquant Chemstation G1701BA v.B.01.00			
GC/MS #9	Gas Chromatograph	HP 6890	US00029263	VOAs in air TO-15	2004
	Mass Spec Detector	HP 5973	US91922619		
	AutoSampler	Enteck 7016CA	00156		
	Concentrator	Enteck 7100	0088		
	Computer Workstation	HP Kayak XA	92181198		
	Analytical Software	Enviroquant Chemstation G1701BA v.B.01.00 Enteck Smart Lab 2000 v3.32			
GC/MS #10	Gas Chromatograph	Agilent 6890N	CN10633045	VOAs	2006
	Mass Spec Detector	Agilent 5975B	US62723782		
	Purge and Trap	EST-Varian Archon	14702		
	Concentrator	EST Encon	ELEC-523103006E PATH-523103006P		
	Computer Workstation	Dell E520	8PT52C1		
	Analytical Software	Chemstation	D.03.00.552		
GC/MS #11	Instrument	EST Markelov+R[46]C HS9000	HS137042108	VOAs	2008
	Gas Chromatograph	Agilent 6890N	US00033857		
	Mass Spec Detector	Agilent 5973	US94212218		
	Concentrator				
	Computer Workstation	HP Kayak xA	FR94720557		
	Analytical Software	HP Enviroquant 61701BA	B.0100		

NON-CONTROLLED COPY

Columbia Analytical Services
Rochester, NY

EQUIPMENT LIST

Instrument ID	Instrument Configuration	Manufacturer Part	Serial Number	Analyses Performed	Year Acquired
GC/MS #12	Gas Chromatograph	Agilent 6890	US00026365	VOAs	2008
	Mass Spec Detector	Agilent 5973	US71191002		
	Purge & Trap	Archon	13070		
	Concentrator	Encon Tekmar 2000	91227014		
	Computer Workstation	IBM Lenovo (8212-KUE)	LKHZC49		
	Analytical Software	Chemstation	W6G86-222ZT-YK65P N82JA		
GC/MS #13	Gas Chromatograph	Agilent 7890A	CN10945114	VOAs in Air	2010
	Mass Spec Detector	Agilent 5975C	US94333887		
	Autosampler	Entech 7016CA	1262		
	PreConcentrator	Entech 7100A	1533		
	Computer Workstation	IBM 8212KUE	LKTAK9B		
	Analytical Software	Enviroquant Chemstation Core Software Software Upgrade Entech Smartlab v4.17b	USK0104163 91701EA		
Digital Display 1-Channel	Mass Flow Controller Digital Display	MKS Instruments 247C	92290101A	VOAs	2006
Digital Display 4-Channel		MKS Instruments 246B	94200203A	VOAs	2006
Flow Controller #1	Mass Flow Controllers	Model 1359C-10000SK	0258C10583442	VOAs	2006
Flow Controller #2		Model 1359C-00200SK	0258C10598442	VOAs	2006
Flow Controller #3		Model 1359C-000205SK	0258C15231304	VOAs	2006
Flow Controller #4		Model 1359C-00010SK	0258C10581442	VOAs	2006

NON-CONTROLLED COPY

Columbia Analytical Services
Rochester, NY

EQUIPMENT LIST

Instrument ID	Instrument Configuration	Manufacturer Part	Serial Number	Analyses Performed	Year Acquired
MASS SPECTROMETERS -SVOAs					
GC/MS 5973A	Gas Chromatograph	HP 6890	US00024148	SemiVOAs/CLP	1998
	Mass Spec Detector	HP 5973	US82311266		
	AutoSampler	HP 7683	CN23021382		
	Injector	Agilent 7683	US10301831		
	Computer Workstation	Gateway GP7-600	17904248		
	Analytical Software	HP Chemstation B.02.05 EnviroQuant G1701BA v.B.01.00			
GC/MS 5973B	Gas Chromatograph	HP 6890	US00029105	SemiVOAs/CLP	1999
	Mass Spec Detector	HP 5973	US91911849		
	AutoSampler	HP7683	US81501041		
	Injector	HP7683	US93408790		
	Computer Workstation	HP Kayak XA6/400	US92280466		
	Analytical Software	HP Chemstation B.02.05 EnviroQuant G1701BA v.B.01.00			
GC/MS 5973C	Gas Chromatograph	Agilent 6890N (G1530N)	US10232036	SemiVOAs	2002
	Mass Spec Detector	Agilent 5973 (G2578A)	US21853642		
	AutoSampler	Agilent 7683 (G2614A)	US00307019		
	Injector	Agilent 7683 (G2613A) Agilent LVI being installed	CN23126455		
	Computer Workstation	Gateway P7-450	13645026		
	Analytical Software	HP Chemstation Enviroquant G1701 v.D.00.00.38			
GC/MS 5973D	Gas Chromatograph	HP6890	US00025479	SemiVOAs	2008
	Mass Spec Detector	HP5973	DE82320565		
	AutoSampler	HP7683			
	Injector	HP7683			
	Computer Workstation	IBM Think Center	LKH2F83		
	Analytical Software	Chemstation G1701DA			

NON-CONTROLLED COPY

Columbia Analytical Services
Rochester, NY

EQUIPMENT LIST

Instrument ID	Instrument Configuration	Manufacturer Part	Serial Number	Analyses Performed	Year Acquired
GAS CHROMATOGRAPHS - EXTRACTABLES					
HP5890(II)-B	Gas Chromatograph	HP 5890	2728A14298	Petroleum Hydrocarbons	1988
	Detector	FID	(integrated)		
	Autosampler	HP7673	3417A35264		
	Injector	HP7673	3120A26909		
	Controller	HP7673	3416A35332		
	Computer Workstation	Gateway P5-133	5360538		
	Analytical Software	HPChemstation G1034C v.03.00			
HP6890- D	Gas Chromatograph	HP 6890	22174	Pest/PCB/8011	1998
	Detector	Dual ECD			
	Injector	HP7683	US93408790		
	Autosampler	G2614A	US81800809		
	Computer Workstation	DELL	7BQRS71		
	Analytical Software	Enviroquant MSD Chemstation D.01.02.16 15 June 2001			
HP5890(II)- F	Gas Chromatograph	HP 5890II	2950A26574	8011	1989
	Detector	Dual ECD			
	Autosampler	18596B	3032A22303		
	Injector	HP7673	3205A29661		
	Computer Workstation	HP Vectra XA 5/233	US81450241		
	Analytical Software	HP Chemstation v.B.02.05 EnviroQuant G1701BA v.B.01.00			
6890N- G	Gas Chromatograph	Agilent 6890N	US10520018	Herb/PCB	2005
	Detector	Micro ECD			
	Injector	Agilent G2913A	CN51624717		
	Autosampler	Agilent G2614A	CN51032422		
	Computer Workstation	DELL	7BQRS71		
	Analytical Software	Enviroquant MSD Chemstation D.01.02.16 15 June 2001			

NON-CONTROLLED COPY

Columbia Analytical Services
Rochester, NY

EQUIPMENT LIST

Instrument ID	Instrument Configuration	Manufacturer Part	Serial Number	Analyses Performed	Year Acquired
HP5890(II)-H	Gas Chromatograph	HP 5890II	3336A56596	Alcohols/ WAPA	2005
	Detector	FID	(integrated)		
	Autosampler	18596C	US22508151		
	Injector	Agilent 6890	CN34222775		
	Controller	G1512A	CN00005087		
	Computer Workstation	HP KAYAK XA	US8345093		
	Analytical Software	HP Chemstation B.02.05 EnviroQuant G1701BA v.B.01.00			
6890N- I	Gas Chromatograph	Agilent 6890N	US10552066	Petroleum Hydrocarbons	2008
	Detector	FID			
	Injector	Agilent G2913A_7683B	CN60931630		
	Autosampler	Agilent G2614A	CN60738562		
	Computer Workstation	DELL	818W761		
	Analytical Software	Chemstation D.02.00.275			
HP5890- J	Gas Chromatograph	Agilent 6890	US00039730	Method 18	2008
	Detector	FID			
	Injector	7683 Tower	de82400931		
	Controller	none			
	Computer Workstation	Windows XP			
	Analytical Software	Agilent Chemstation 1701 H V2.00			
HP5890-K	Gas Chromatograph	Agilent 6890	US00008526	8015B	2008
	Detector	FID			
	Injector	7673 Tower	US72102123		
	Controller	G1512A	US72002014		
	Computer Workstation	Windows XP			
	Analytical Software	Agilent Chemstation 1701 A U2.00			

NON-CONTROLLED COPY

Columbia Analytical Services
Rochester, NY

EQUIPMENT LIST

Instrument ID	Instrument Configuration	Manufacturer Part	Serial Number	Analyses Performed	Year Acquired
HP5890(II)-L	Gas Chromatograph	HP 5890II	2950A27718	Herb/PCB	1989
	Detector	Dual ECD			
	Autosampler	18596C	US4008144		
	Injector	Agilent 6890	CN22321966		
	Computer Workstation	HP Vectra XA 5/233	US81450241		
	Analytical Software	HP Chemstation v.B.02.05 EnviroQuant G1701BA v.B.01.00			

EXTRACTABLES SUPPORT EQUIPMENT

GPC	GPC	OI Analytical AP2000	A122330318	Cleanups	2002
RapidVap #1	Nitrogen Evaporation System	LabConco RapidVap	11296345E	Concentrations	2001
RapidVap #2	Nitrogen Evaporation System	LabConco RapidVap	20998065F	Concentrations	2002
RapidVap #3	Nitrogen Evaporation System	LabConco RapidVap	70975713	Concentrations	2007
N-EVAP	Organomation N-EVAP	Model 112	7531	Concentrations	
Hot Orbital Shaker		Armalab OR200	3560	Extractions	2004
Automated Soxhlet #1	Automated Soxhlet	Gerhardt SOX416	1/8465080006	Extractions	2008
Automated Soxhlet #2	Automated Soxhlet	Gerhardt SOX416	1/8465080007	Extractions	2008
Autoshaker#1	Lab-Line Extraction Mixer	Model 6000	0904-3735	Extractions	2004
Autoshaker#2	Lab-Line Extraction Mixer	Model 6000	0904-3736	Extractions	2004
Autoshaker#3	Lab-Line Extraction Mixer	Model 6000	0904-3737	Extractions	2004
SPE-DEX 4790#1	Solid Phase Extractor	Horizon	05-0593	Extractions	2005
SPE-DEX 4790#2	Solid Phase Extractor	Horizon	05-0595	Extractions	2005
SPE-DEX 4790#3	Solid Phase Extractor	Horizon	05-0594	Extractions	2005
Tekmar 500		TM-500	7460E	Sonication	
Tekmar 600		TM-600	13232	Sonication	
VibraCell #1		VC375	15144E	Sonication	
VibraCell#2		VC505	37629G	Sonication	

Columbia Analytical Services
Rochester, NY

EQUIPMENT LIST

Instrument ID	Instrument Configuration	Manufacturer Part	Serial Number	Analyses Performed	Year Acquired
GAS CHROMATOGRAPHS - VOLATILES					
V2	Gas Chromatograph	Varian 3300	4130	Alcohols/Gases	1999
	Detector	FID	(integrated)		
	Computer Workstation	PowerFlex	120518		
	Analytical Software	Varian System Control v.4.51	D57543610		
V3	Gas Chromatograph	Varian 3400	10989	VOAs	1999
	PID Controller	OIA 5200	B509500481		
	PID Detector	OI 4430			
	ELCD Detector	OIA 5300	B05223456		
	AutoSampler	Varian Archon	13316		
	Concentrator	Tekmar 3000	98124003		
	Computer Workstation	Gateway 2000	10221502		
	Analytical Software	Varian System Control v.4.51	D57543610		
V4	Gas Chromatograph	Varian 3400	15248	VOAs	2001
	PID Detector	OI 4436	OI1000		
	ELCD Detector	OI 5300	C449553665		
	PID Controller		A218047		
	AutoSampler	Archon	13596		
	Concentrator	Encon	130122900 E/P		
	Computer Workstation	GP6-233	9767125		
	Analytical Software	Varian System Control v.4.5.2	D57543610		
HP1	Gas Chromatograph	HP5890II	3121A35575	VOAs	2001
	PID Detector	OIA 4430	31030		
	FID Detector	(integrated)	-		
	AutoSampler	Tekmar 2016	89220008		
	Concentrator	Tekmar 2000	89013002		
	Sample Heater	Tekmar	91065008		
	Computer Workstation	Gateway GP5-233	9352344		
	Analytical Software	Varian System Control v.4.5.2	00159-1908-cd1-22bd		

NON-CONTROLLED COPY

Columbia Analytical Services
Rochester, NY

EQUIPMENT LIST

Instrument ID	Instrument Configuration	Manufacturer Part	Serial Number	Analyses Performed	Year Acquired
T6	Gas Chromatograph	Varian 3400	4143	VOAs/VPH/GRO	1998
	PID Detector	OI 4430	OI1006		
	FID Detector	Integrated	-		
	AutoSampler	Tekmar 2016	91298028		
	Concentrator	Tekmar 2000	91331001		
	Sample Heater	Tekmar	88264001		
	Computer Workstation	Gateway GP5-233	9352344		
	Analytical Software	Varian System Control v.4.5.2	00159-1a08-cd1-22bd		

NON-CONTROLLED COPY

NON-CONTROLLED COPY

Columbia Analytical Services
Rochester, NY

EQUIPMENT LIST

Instrument ID	Instrument Configuration	Manufacturer Part	Serial Number	Analyses Performed	Year Acquired
HPLC					
HPLC02 (LC/MS)	Binary Pump	Agilent 1100	DE11108496	Perchlorate	2005
	Column Thermostat	Agilent 1100	DE11120893		
	Wellplate Autosampler	Agilent 1100	DE11300879		
	Sample Thermostat	Agilent 1100	DE82207519		
	MSD	Agilent G1946D	US12411208		
	Computer Workstation	HP Vectra	US12475439		
	Analytical Software	Chemstation for HPLC Rev.A.10.02			
HPLC03	Binary Pumps	Shimadzu LCD10ADVP	1(A) C20963851348US 2(B) C20963851344US	Metabolic Acids Hydroquinone Tolytriazole PAHs	2005
	UV/VIS Detector	Shimadzu SPD10AVVP	C21004050470US		
	Fluorescence Detector	Waters 470	470-00067		
	Electrochemical Detector	BAS LC4C/CC5	LC-4C 7014		
	AutoSampler	Shimadzu SIL10ADVP	C21053850511US		
	System Controller	Shimadzu SCL10AVP	C21013851302US		
	Degasser	Shimadzu DGU 14A	101076		
	Temperature Control Module	Waters	TCM-001304		
	Computer Workstation				
	Analytical Software				
HPLC04	Solvent Delivery System	HP1050	3019A00475	Formaldehyde UV-MISC	2007
	Variable Wavelength UV Detector	HP1050	3225J01126		
	Scanning Fluorescence Detector	HP1046A			
	AutoSampler	HP1050	LR47359C		
	Quaternary Pump	HP1050			
	Column Thermostat	HP1050			
	Analytical Software	Chemstation for HPLC Rev A.09.0E1206	Data Acquisition and Instrument Control		

Columbia Analytical Services
Rochester, NY

EQUIPMENT LIST

Instrument ID	Instrument Configuration	Manufacturer Part	Serial Number	Analyses Performed	Year Acquired
HPLC05	Degasser	Degasser G1322A	JP 7305035	To Be Determined	2007
	Binary Pump	Agilent 1100/G1312A	US70600653		
	Diode Array Detector	Agilent 1100/G1315B	DE11112376		
	AutoSampler	Agilent 1100/G1313A ALS	DE72003859		
	Analytical Software	Chemstation for HPLC Rev A 09.0S1206	Data Acquisition and Instrument Control		

NON-CONTROLLED COPY

NON-CONTROLLED COPY

Columbia Analytical Services
Rochester, NY

EQUIPMENT LIST

Instrument ID	Instrument Configuration	Manufacturer Part	Serial Number	Analyses Performed	Year Acquired
METALS					
FIMS	CVAA-FIMS	Perkin Elmer	1258	Mercury	1997
	Computer Workstation	Soyata			
	Analytical Software	PE AA WinLab for Windows v.2.50			
4100ZL #1	AA	Perkin Elmer AA 4100ZL	6066	Furnace Metals	1991
	Computer Workstation	Gateway GP5-233			
	Analytical Software	PE AA WinLab for Windows v.2.50			
4100ZL #2	AA	Perkin Elmer AA 4100ZL	6245	Furnace Metals	1998
	Computer Workstation	Gateway GP6-400			
	Analytical Software	PE AA WinLab for Windows v.2.50			
Leeman Hydra AFG+	CVAF	Leeman Hydra AFG+	112-00067-1	Low Level Mercury (Method 1631)	2004
	Computer Workstation	Dell Dimension 2400	35180912881		
	Analytical Software	WinHg Runner 1.5 CT Rev0.286	-		
ICP #1	Instrument	Perkin Elmer Optima 3000XL	069N4060401	Metals - Low Level	1994
	Computer Workstation	Gateway GP5-233	10221500		
	Analytical Software	PE ICP WinLab v.1.42			
ICP #2	Instrument	Perkin Elmer Optima 3000XL	069N6062602	Metals - Low Level	1999
	Computer Workstation	Gateway GP5-233	9352702		
	Analytical Software	PE ICP WinLab v.1.42			
ICP #3	Instrument	Perkin Elmer 5300DV	077N5112802	Metals	2006
	Computer Workstation	Dell Optiplex GX620			
	Analytical Software	PE ICP WinLab v.3.1			
ICPMS	SCIEX ICP/MS	Perkin Elmer Elan 9000	PO370203	Metals	2002
	Autosampler	PE AS93Plus			
	Computer Workstation	Dell Optiplex GX150			
	Analytical Software	ELAN v.2.4			

Columbia Analytical Services
Rochester, NY

EQUIPMENT LIST

Instrument ID	Instrument Configuration	Manufacturer Part	Serial Number	Analyses Performed	Year Acquired
HOTBLOCKS - METALS					
Hotblock #1		Environmental Express		Metals Digestions	2001
Hotblock #2		Environmental Express		Metals Digestions	2001
Hotblock #3		Environmental Express		Metals Digestions	2005
Hotblock #4		Environmental Express		Metals Digestions	2005
ModBlock A		CPI		Metals Digestions	2003
ModBlock B		CPI		Metals Digestions	2003

NON CONTROLLED COPY

Columbia Analytical Services
Rochester, NY

EQUIPMENT LIST

Instrument ID	Instrument Configuration	Manufacturer Part	Serial Number	Analyses Performed	Year Acquired
GENERAL CHEMISTRY					
TOC#1	TOC Analyzer	OI Model 1010	J245710349	TOC - waters	2003
	Autosampler	OI Model 1051	B247751184		
	Computer Workstation	Gateway GP6-300	10709094		
	Analytical Software	OI WinTOC for 1010 v.01 Rev 225	-		
TOC#2	TOC Analyzer	Dohrman DC190	9507646	TOC - soils	2001
	Boat Sampler	Dohrman 183 s/s1	9507610		
Lachat 8000	Flow Injection System	Lachat 8000		Chloride, TKN, NO2/NO3, NH3, Alkalinity, Hardness, Phosphorus, Silica, Cr6+	1999
	Colorimeter	Lachat	A83000-1286		
	Pump	Lachat	A82000-525		
	Autosampler	Lachat	A81010-168		
	Computer Workstation	Gateway GP6-233	9767124		
	Analytical Software	Omnion FIA v.2	-		
Technicon #2	Flow Injection System	Technicon		Phenol	Pre-1982
	Colorimeter	Technicon	199-006701D		
	Pump	Technicon	PR0276		
	Chart Recorder	Technicon	82A3321		
	Autosampler	Technicon	681-Rest worn off		
	Module	Technicon	83035		
AquaKem	Instrument	AquaKem 200	A0419913	Nitrite, Ammonia, Phosphate, Chloride, Hexavalent Chromium, Cyanide	2005
	Computer Workstation	Sell SX280	3KSDF1J		
	Analytical Software	6.5.AQ1 rc4			

NON-CONTROLLED COPY

NON-CONTROLLED COPY

Columbia Analytical Services
Rochester, NY

EQUIPMENT LIST

Instrument ID	Instrument Configuration	Manufacturer Part	Serial Number	Analyses Performed	Year Acquired
IC#1	Ion Chromatograph	Dionex Series 4000i		Anions	Pre-1982
	Basic Chromatography Module	Dionex	871602		
	Gradient Pump	Dionex	871608		
	Conductivity Detector	Dionex	871242		
	Controller Pump	Dionex	31528		
	Autosampler	Dionex	931526		
	Integrator	4270	037/24782		
	Computer Workstation	Gateway GP6-400	11809650		
	Analytical Software	Dionex PeakNet v.5.1	116-987-2806		
IC#3	Ion Chromatograph	Metrohm 861 Advanced Compact IC		Anions	2005
	Basic Chromatography Module	Metrohm	861-02114		
	Pump	Metrohm	62824100s20		
	Conductivity Detector	Metrohm	integrated		
	Autosampler	Metrohm	838-04105		
	Computer Workstation	Dell OptiPlex GX520	6VRC581		
	Analytical Software	IC NET 2.3 SR2	A.701.0016		
IC # 4	Ion Chromatograph	Dionex 500DX		ANIONS	2007
	Basic Chromatography Module	LC20-1	97110393		
	Gradient Pump	GP40-1	97110534		
	Conductivity Detector	ED40-1	97110074		
	Autosampler	AS40-1	97110671		
	Computer Workstation	Gateway 2000 GP6-266	10239250		
	Analytical Software	Peaknet 5.21	192-994-1564		

Columbia Analytical Services
Rochester, NY

EQUIPMENT LIST

Instrument ID	Instrument Configuration	Manufacturer Part	Serial Number	Analyses Performed	Year Acquired
IC # 5	Ion Chromatograph	Dionex ICS-1000	7090145	Cr6+ ANIONS	2007
	Gradient Pump	GP40			
	Conductivity Detector	DS6	7081071		
	Autosampler	AS40	7090325		
	Computer Workstation	Dell Optiplex 745	1441DAA99		
	Analytical Software	Chromeleon 6.80	56276		
IC # 6	Ion Chromatograph	DX-120	10169	ANIONS	2008
	Conductivity Detector	DS4-1	10133		
	Autosampler	AS40	4070066		
	Computer Workstation	Dell Optiplex GX110	5ZBVK01		
	Analytical Software	Peaknet 5.11	147-994-3278		
IC # 7	Ion Chromatograph	DX500		ANIONS	2008
	Basic Chromatography Module	LC20	99050321		
	Gradient Pump	GP50	99050419		
	Conductivity Detector	CD20	99050289		
	Autosampler	AS40	99011702		
	Computer Workstation	Dell Optiplex GX110	5ZBVK01		
	Analytical Software	Peaknet 5.11	147-994-3278		
Adiabatic Calorimeter	Adiabatic Calorimeter	Parr 1241	3744	BTU, Combustion Prep	1997
Isoperibol Calorimeter	Isoperibol Calorimeter	Parr 6300	27187	BTU, Combustion Prep	2004
Autoclave	Autoclave	Amsco	none	Micro/TPO4	Pre-1970

NON-CONTROLLED COPY

NON-CONTROLLED COPY

Columbia Analytical Services
Rochester, NY

EQUIPMENT LIST

Instrument ID	Instrument Configuration	Manufacturer Part	Serial Number	Analyses Performed	Year Acquired
Midi A	Midi Cyanide Distillation System	BSL Co	none	Cyanide/Phenol/ Sulfide Distillation	1997
Midi B	Midi Cyanide Distillation System	BSL Co	none	Cyanide/Phenol/ Sulfide Distillation	1997
Midi C	Midi Cyanide Distillation System			Cyanide/Phenol/ Sulfide Distillation	2004
Bullwinkle	pH Meter	Orion SA520	2305	pH	1990
Rocky	pH Meter	Orion 720A	5012		1992
	pH Electrode	Orion 915600			
	Fluoride Electrode	Orion 9409			
	Reference Electrode	Orion 90-01-00			
SympHony	pH/Conductivity Meter	SympHony SB80PC	D00582	ph/Conductivity	2008
Turbidimeter	Turbidimeter	HF Scientific Micro 100	609246	Turbidity	2000
MR 21	Spectro-photometer	Milton Roy Spectronic 21	1225601	COD, MBAS, Cr6+, Ferrous Iron	1989
Buck IR	IR Spec / TPH Analyzer	Buck Scientific HC404	492	TPH	1994
DO Meter #1	Dissolved Oxygen Meter	YSI Model 54A	D8024621	DO, BOD	Pre-1990
DO Meter #2	Dissolved Oxygen Meter	YSI Model 57	A9016921	DO, BOD	Pre-1990
Open Cup	Open Cup Flashpoint Tester	Koehler Instru.Co. Model 420	none	Ignitability - solids	1989
Closed Cup	Closed Cup Flashpoint Tester	Boekel Model 152800	none	Ignitability - liquids	1993
Aquameter	Aquameter	Beckman KF4	none	% Water	1988
Density Meter	Density Meter	DE40	MPJ17625	Density	2007

NON-CONTROLLED COPY

Columbia Analytical Services
Rochester, NY

EQUIPMENT LIST

Instrument ID	Instrument Configuration	Manufacturer Part	Serial Number	Analyses Performed	Year Acquired
Autotitrator	Robotic Titrosampler	Metrohm 855		Photoprocessing Samples	2007
	Pump Unit	Metrohm 772			
	Dosing Interface	Metrohm 846			
	Dosino	(7) Metrohm 800			
	Computer Workstation	Dell Optiplex 745			
	Analytical Software				
TKN Digestion Blocks	Technicon	Technicon block	206	TKN digest	<1997
		Omega CN 2110 Temperature Controller	-		
	AIM600	AI Scientific Pty Ltd AIM600	4726A12136	TKN digest	2007
Vacuum Pumps		Gast DOL-101-AA	787	1664	
		Gast DOA-P704-AA		1664	
		Gast 0522-U31-G18DX	687	General Filtration	
		Gast 0522-U31-G18DX	987	General Filtration	
R-Balance-01	Top Loading Balances	American Scientific DTL2500-1	20466	Wetchem	<1997
R-Balance-03		Mettler Toledo PB602-S	1118331281	Metals	<2002
R-Balance-04		Cole Parmer Symmetry	ED1200	SMO	2009
R-Balance-05		Mettler Toledo PB602-S	1125322050	Extractables	2004
R-Balance-06		Fisher XL 500	7384	Metals	<1997
R-Balance-07		Ohaus Adventure Pro AV412	8026261026	Volatiles	2005
R-Balance-08	Analytical Balances	Fisher XA200	8887	Volatiles	1990
R-Balance-09		Mettler AE160	D25222	Wetchem	2008 used
R-Balance-10		Mettler AE200	J29745	Wetchem	2008 used
R-Balance-11		Mettler AG204	120330501	Wetchem	2001
R-Balance-12		Mettler PM 4800	K76041	Wetchem	2008 used
R-Balance-13		Mettler AE160	D40689	Extractables	2008 used
R-Balance-02		Mettler AE240	F96727	Wetchem	1996 used
Thermolyne 48000	Muffle Furnace	Thermolyne 48000		Volatile/Fixed Solids	

Columbia Analytical Services
Rochester, NY

EQUIPMENT LIST

Instrument ID	Instrument Configuration	Manufacturer Part	Serial Number	Analyses Performed	Year Acquired
C-1	Sample Cooler	Bally Engineered Structures, Inc.		Sample Storage	
C-2	Sample Cooler	Bally Engineered Structures, Inc.		Sample Storage	
C-3	Sample Cooler	Bally Engineered Structures, Inc.		Sample Storage	
C-4	Sample Cooler			Sample Storage	
R-2B	Fridge	VWR	013G-327106-0G	Extractables solvents	
R-3	Standards Fridge	Labline		Extractables Standards	
R-4	Reagent Fridge	Revco Scientific	TY90605E	WC Reagents	
R-5	Standards Fridge	General Motors	CAS03991	WC Standards	
R-6	Micro Fridge	General Motors	CAS03992	Micro Reagents	
R-7	Fridge	GE		Not in use	
F-1	Sample Freezer	GE		Metals Tissue	
F-2	Extract Freezer	Baxter Cryo-Fridge	CAS06056	Extractables	
Freezer 5	Sample Freezer	Maytag	12377439GV	VOA Sample Storage	
F-6	Extract Freezer	GE	SH175743	Extractables	
F-7	Extract Freezer	GE	FL171960	Extractables	
F-08	Standard Freezer	Signature	23429-1	VOA Standards	
Freezer 9	Sample Freezer	GE	MS145661	VOA Sample Storage	

Note that the computers listed with the instruments are dedicated to that instrument for data aquisition, but the data files are saved to a lab-wide network and data may be accessed by any computer with the correct software - provided the user is authorized to do so.

NON-CONTROLLED COPY

NON-CONTROLLED COPY

APPENDIX D
DATA QUALIFIERS AND ACRONYMS

Please note that the Appendices provide current information at the time of the revision, but are updated only upon annual review. Please contact the laboratory for up-to-date information.

NON-CONTROLLED COPY

Columbia Analytical Services™

REPORT QUALIFIERS

U	Analyte was analyzed for but not detected. The sample quantitation limit has been corrected for dilution and for percent moisture, unless otherwise noted in the case narrative.
J	Estimated value due to either being a Tentatively Identified Compound (TIC) or that the concentration is between the MRL and the MDL. Concentrations are not verified within the linear range of the calibration. For DoD: concentration >40% difference between two GC columns (pesticides/Arclors).
B	Analyte was also detected in the associated method blank at a concentration that may have contributed to the sample result.
E	Inorganics- Concentration is estimated due to the serial dilution was outside control limits.
E	Organics- Concentration has exceeded the calibration range for that specific analysis.
D	Concentration is a result of a dilution, typically a secondary analysis of the sample due to exceeding the calibration range or that a surrogate has been diluted out of the sample and cannot be assessed.
*	Indicates that a quality control parameter has exceeded laboratory limits.
#	Spike was diluted out.
+	Correlation coefficient for MSA is <0.995.
N	Inorganics- Matrix spike recovery was outside laboratory limits.
N	Organics- Presumptive evidence of a compound (reported as a TIC) based on the MS library search.
S	Concentration has been determined using Method of Standard Additions (MSA).
W	Post-Digestion Spike recovery is outside control limits and the sample absorbance is <50% of the spike absorbance.
P	Concentration >40% (25% for CLP) difference between the two GC columns.
C	Confirmed by GC/MS
Q	DoD reports: indicates a pesticide/Aroclor is not confirmed (≥100% Difference between two GC columns).
X	See Case Narrative for discussion.

ACCREDITED IN ACCORDANCE WITH nelac

CAS/Rochester Lab ID # for State Certifications[1]

NELAP Accredited
Delaware Accredited
Connecticut ID # PH0556
Florida ID # E87674
Illinois ID #200047
Maine ID #NY0032
Nebraska Accredited
Navy Facilities Engineering Service Center Approved
Nevada ID # NY-00032
New Jersey ID # NY004
New York ID # 10145
New Hampshire ID # 294100 A/B
Pennsylvania ID# 68-786
Rhode Island ID # 158
West Virginia ID # 292

[1] Analyses were performed according to our laboratory's NELAP-approved quality assurance program and any applicable state requirements. The test results meet requirements of the current NELAP standards or state requirements, where applicable, except as noted in the laboratory case narrative provided. For a specific list of accredited analytes, refer to the certifications section at www.caslab.com.

H:\FORMS\QUALIF_ routine.DOC

NON-CONTROLLED COPY

Columbia Analytical Services™

REPORT QUALIFIERS

U	Analyte was analyzed for but not detected. The sample quantitation limit has been corrected for dilution and for percent moisture, unless otherwise noted in the case narrative.
J	Estimated value due to either being a Tentatively Identified Compound (TIC) or that the concentration is between the MRL and the MDL. Concentrations are not verified within the linear range of the calibration. For DoD: concentration >40% difference between two GC columns (pesticides/Arclors).
B	Analyte was also detected in the associated method blank at a concentration that may have contributed to the sample result.
E	Inorganics- Concentration is estimated due to the serial dilution was outside control limits.
E	Organics- Concentration has exceeded the calibration range for that specific analysis.
D	Concentration is a result of a dilution, typically a secondary analysis of the sample due to exceeding the calibration range or that a surrogate has been diluted out of the sample and cannot be assessed.
*	Indicates that a quality control parameter has exceeded laboratory limits.
#	Spike was diluted out.
+	Correlation coefficient for MSA is <0.995.
N	Inorganics- Matrix spike recovery was outside laboratory limits.
N	Organics- Presumptive evidence of a compound (reported as a TIC) based on the MS library search.
S	Concentration has been determined using Method of Standard Additions (MSA).
W	Post-Digestion Spike recovery is outside control limits and the sample absorbance is <50% of the spike absorbance.
P	Concentration >40% (25% for CLP) difference between the two GC columns.
C	Confirmed by GC/MS
Q	DoD reports: indicates a pesticide/Aroclor is not confirmed (≥100% Difference between two GC columns).
X	See Case Narrative for discussion.

ACCREDITED IN ACCORDANCE WITH nelac

CAS/Rochester Lab ID # for Massachusetts Certification
M-NY032

Analyses were conducted in accordance with Massachusetts Department of Environmental Protection certification standards, except as noted in the laboratory case narrative provided. A copy of the current Department issued parameter list is included in this report.

H:\FORMS\QUALIF_routine for MA.DOC

Laboratory Acronyms

The following is a list of laboratory acronyms commonly used in environmental testing:

ACRONYM	DEFINITION
AA	Atomic Absorption Spectrometry (aka AAS) instrument used to measure concentration of metals in samples
ACS	American Chemical Society
APG	Analytical Products Groups (manufacturer of PE Samples)
ASTM	American Society for Testing and Materials
A2LA	American Association for Laboratory Accreditation
BFB	4-Bromofluorobenzene
BNA	Base Neutral Acid organic compounds (aka SOC or SVOCs)
BOD	Biochemical Oxygen Demand
BTEX/BETX	Benzene, Toluene, Ethylbenzene, Xylenes
CARB	California Air Resources Board
CAS Number	Chemical Abstract Service Registry Number
CCB	Continuing Calibration Blank sample
CCC	Continuing Calibration Check sample
CCV	Continuing Calibration Verification sample
CFC	Chlorofluorocarbon
CFU	Colony-Forming Unit
CLP	Contract Laboratory Program (through USEPA)
COC	Chain-of-Custody
COD	Chemical Oxygen Demand
DCM	Dichloromethane (aka Methylene Chloride)
DEC	Department of Environmental Conservation
DEQ	Department of Environmental Quality

NON-CONTROLLED COPY

DHS	Department of Health Services
DOE	Department of Ecology (state or federal)
DOH	Department of Health
EPA	U. S. Environmental Protection Agency (aka USEPA)
EPCRA	Emergency Planning & Community Right-to-Know Act
ERA	Environmental Resource Associates
ELAP	Environmental Laboratory Accreditation Program
FAA	Flame Atomic Absorption Spectrophotometry
FDA	Food & Drug Administration
FIA	Flow Injection Analysis
FID	Flame Ionization Detector
FIFRA	Federal Insecticide, Fungicide & Rodenticide Act
FR	Federal Register
GAO	General Accounting Office
GC	Gas Chromatography
GC/MS	Gas Chromatography/Mass Spectrometry
GFAA	Graphite Furnace Atomic Absorption Spectrometry
HECD/ELCE	Hall Electrolytic Conductivity Detector
HP	Hewlett-Packard (mfg. GC instruments)
HPLC	High Pressure Liquid Chromatography
IC	Ion Chromatography
ICB	Initial Calibration Blank sample
ICP-AES	Inductively Coupled Plasma Atomic Emission Spectrometry (aka ICPAES)
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
ICV	Initial Calibration Verification sample
IFB	Invitation for Bid
IR	Infrared Spectrophotometer
LCS	Laboratory Control Sample
LIMS	Laboratory Information Management System

NON-CONTROLLED COPY

LUFT	Leaking Underground Fuel Tank
MB	Method Blank
M	Modified
MCL	Maximum Contaminant Level is the highest permissible concentration of a substance allowed in drinking water as established by the USEPA.
MDL	Method Detection Limit
MPN	Most Probable Number
MRL	Method Reporting Limit
MS	Matrix Spike
NA	Not Applicable
NAN	Not Analyzed
NAS	National Academy of Sciences
NC	Not Calculated
NCASI	National Council for Air and Stream Improvement (for the Paper Industry)
NCI	National Cancer Institute
ND	Not Detected (at or above MRL)
NIH	National Institute of Health
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
NPD	Nitrogen Phosphorus Detector
NPDES	National Pollutant Discharge Elimination System
NSF	National Science Foundation
NTIS	National Technical Information System
NTP	National Toxicology Program
ORB	Original Record Book (aka raw data books)
OSHA	Occupational Safety and Health Administration
PCBs	Polychlorinated Biphenyls
PE	Performance Evaluation sample
PID	Photoionization Dectector

NON-CONTROLLED COPY

PQL	Practical Quantitation Limit
QA	Quality Assurance
QC	Quality Control
RAS	Routine Analytical Services (contracts through USEPA)
RCRA	Resource Conservation and Recovery Act
RFP	Request for Proposal
RPD	Relative Percent Difference
SAS	Special Analytical Services (contracts through USEPA)
SIE	Selective Ion Electrode
SIM	Selected Ion Monitoring
SMO	Sample Management Office (aka Sample Receiving)
SOC	Semi-Volatile Organic Compounds
SOQ	Statement of Qualifications
SOW	Statement of Work
SVOAs	Semi-Volatile Organic Analytes
SVOCs	Semi-Volatile Organic Compounds
SW-846	Test Methods for Evaluating Solid Waste, Physical/Chemical Methods
TOC	Total Organic Carbon (test to determine organic content)
TOX	Total Organic Halides (test to determine organic halide content)
TPH	Total Petroleum Hydrocarbons
tr	Trace level in the concentration of an analyte that is less than the PQL but greater than or equal to the MDL
TSCA	Toxic Substances Control Act
UST	Underground Storage Tank
UV	Ultraviolet Spectrophotometer
VOA	Volatile Organic Analyte
VOC	Volatile Organic Compounds
WP	Water Pollution
WS	Water Supply

NON-CONTROLLED COPY

UNITS	
mg/kg	Milligrams per Kilogram (same as ppm)
mg/L	Milligrams per Liter (same as ppm)
ug/L	Micrograms per liter (same as ppb)
ppb	Parts Per Billion
ppm	Parts Per Million

NON-CONTROLLED COPY

NON-CONTROLLED COPY

APPENDIX E
PREVENTIVE MAINTENANCE PROCEDURES

Please note that the Appendices provide current information at the time of the revision, but are updated only upon annual review. Please contact the laboratory for up-to-date information.

NON-CONTROLLED COPY

Preventive Maintenance Procedures

Instrument	Activity	Laboratory or Vendor Performed	Frequency
Refrigerators and Coolers	Record temperatures	Laboratory	Daily
	Clean coils	Vendor	As needed
	Check coolant	Vendor	As needed or if temperature outside limit
Fume Hoods	Face velocity measured	Laboratory	Quarterly
	Sash operation	Laboratory	As needed
Ovens	Clean	Laboratory	As needed or if temperature outside limit
Incubators	Record temperatures	Laboratory	Daily, morning and evening
Water Baths	Wash with disinfectant solution	Laboratory	When water is murky, dirty, or growth appears
Autoclave	Check temperature	Laboratory	Every month
	Clean	Laboratory	When mold or growth appears
Top Loading Balances	Check calibration	Laboratory	Before every use
	Check alignment	Laboratory	Before every use
	Cleaning, calibration, adjustment, and spec compliance	Vendor	Annually
	Repair	Vendor	As needed
Analytical Balances	Check alignment	Laboratory	Before every use
	Check calibration	Laboratory	Before every use
	Clean pans and compartment	Laboratory	After every use
	Cleaning, calibration, adjustment, and spec compliance	Vendor	Annually
	Repair	Vendor	As needed
Dissolved Oxygen Meter	Change membrane	Laboratory	When fluctuations occur
pH probes	Condition probe	Laboratory	When fluctuations occur
UV-visible Spectrophotometer	Wavelength check	Vendor	Every 6 Months

NON-CONTROLLED COPY

Preventive Maintenance Procedures

Instrument	Activity	Laboratory or Vendor Performed	Frequency
Discrete Analyzer	Review Water Check	Laboratory	Daily
	Empty Waste Bin	Laboratory	Daily
	Fill Diluent with fresh DI	Laboratory	Daily
	Check Waste Container	Laboratory	Daily
	Print or save results to file	Laboratory	Daily
	Clear Daily Files	Laboratory	Daily
	Empty Liquid Waste	Laboratory	Weekly
	Clean wash wells and tubing	Laboratory	Weekly
	Clean off any chemical residue	Laboratory	Weekly
	Check syringe tip	Laboratory	Weekly
	Run Dichromate test at 480nm	Laboratory	Weekly
	Restore adjustments from disk	Laboratory	Monthly
	Save database to CD	Laboratory	Monthly
	Print then delete messages	Laboratory	Monthly
	Print water check	Laboratory	Monthly
	Clean and lube incubator rod	Laboratory	Monthly
	Clean and lube fetched rod	Laboratory	Monthly
Total Organic Carbon Analyzers	Check IR zero	Laboratory	Weekly
	Check digestion/condensation vessels	Laboratory	Each use
	Clean digestion chamber	Laboratory	Every 2000 hours, or as needed
	Clean permeation tube	Laboratory	Every 2000 hours, or as needed
	Clean six-port valves	Laboratory	Every 200 - 2000 hours, or as needed
	Clean sample pump	Laboratory	Every 200 - 2000 hours, or as needed
	Clean carbon scrubber	Laboratory	Every 200 - 2000 hours, or as needed
	Clean IR cell	Laboratory	Every 2000 - 4000 hours, or as needed
Flow Injection Analyzer	Check valve flares	Laboratory	Quarterly
	Check valve ports	Vendor	As needed
	Check pump tubing	Laboratory	Daily
	Check flow cell flares	Laboratory	Quarterly
	Change bulb	Laboratory	As needed
	Check manifold tubing	Laboratory	Every six months
	Check T's and connectors	Laboratory	Every six months
Ion Chromatograph	Change column bed supports	Laboratory	Monthly or as needed
	Clean column	Laboratory	Monthly or as needed
	Change column	Laboratory	Every six months or as needed
	Change tubing	Laboratory	Annually or as needed
	Eluent pump	Laboratory	Annually

NON-CONTROLLED COPY

Preventive Maintenance Procedures

Instrument	Activity	Laboratory or Vendor Performed	Frequency
Atomic Absorption Spectro-photometers - CVAA	Check gases	Laboratory	Daily
	Check aspiration tubing	Laboratory	Daily
	Empty waste container	Laboratory	Weekly
Atomic Absorption Spectro-photometers - GFAA	Check gases	Laboratory	Daily
	Check argon dewar	Laboratory	Daily, or as needed
	Change graphite tube	Laboratory	Daily, or as needed
	Clean furnace windows	Laboratory	Monthly or as needed
ICP-AES	Check argon dewar	Laboratory	Daily
	Replace peristaltic pump tubing	Laboratory	Daily, or as needed
	Empty waste container	Laboratory	Daily, or as needed
	torch	Laboratory	Every two weeks, or as needed
	Replace water filter	Laboratory	Quarterly, or as needed
	Replace or vacuum air filters	Laboratory	Monthly, or as needed
ICP-MS	Check argon dewar	Laboratory	Daily
	Replace peristaltic pump tubing	Laboratory	Daily, or as needed
	Empty waste container	Laboratory	Daily, or as needed
	Clean nebulizer, spray chamber, and torch	Laboratory	Every two weeks, or as needed
	Clean Cone	Laboratory	As needed
	Check air filters	Laboratory	Annually or as needed
	Check rotary pump oil	Laboratory	Quarterly, or as needed
	Clean ion lens stack	Laboratory	Annually or as needed

NON-CONTROLLED COPY

Preventive Maintenance Procedures

Instrument	Activity	Laboratory or Vendor Performed	Frequency
Chromatographs	Clean and repack column	Laboratory	As needed
	Backflush valves	Laboratory	As needed
Gas Chromatographs, Semivolatiles	Check gas supplies	Laboratory	Daily, replace when pressure reaches 250 psi
	Change in-line filters	Laboratory	Quarterly or after 30 tanks of gas
	Change injection port liner	Laboratory	Daily or as needed
	Clip first foot of capillary column	Laboratory	As needed
	Change guard column	Laboratory	As needed
	Replace analytical column	Laboratory	As needed when peak resolution fails
	Check system for gas leaks	Laboratory	After changing columns
	Clean FID	Laboratory	As needed
	Leak test ECD	Laboratory	Annually
Gas Chromatograph/Mass Spectrometers, Semivolatiles	Check gas supplies	Laboratory	Daily, replace when pressure reaches 50 psi
	Change in-line filters	Laboratory	Quarterly or after 30 tanks of gas
	Change septum	Laboratory	Daily
	Change injection port liner	Laboratory	Weekly or as needed
	Clip first foot of capillary column	Laboratory	As needed
	Change guard column	Laboratory	As needed
	Replace analytical column	Laboratory	As needed when peak resolution fails
	Clean jet separator	Laboratory	As needed
	Clean source	Laboratory	As needed when tuning problems
	Change pump oil	Laboratory	Every six months
	Oil wick	Laboratory	Every six months

NON-CONTROLLED COPY

Preventive Maintenance Procedures

Instrument	Activity	Laboratory or Vendor Performed	Frequency
Purge and Trap Concentrators	Change trap	Laboratory	As needed
	Change transfer lines	Laboratory	As needed
	Clean purge vessel	Laboratory	As needed
Gas Chromatographs, Volatiles	Check gas supplies	Laboratory	Daily, replace when pressure reaches 200 psi
	Change in-line filters	Laboratory	When indicator changes color
	Change septum	Laboratory	As needed
	Clip first foot of capillary column	Laboratory	As needed
	Change guard column	Laboratory	As needed
	Replace analytical column	Laboratory	As needed when peak resolution fails
	Check system for gas leaks	Laboratory	After changing columns or as needed
	Replenish ELCD solvents	Laboratory	Weekly
	Clean PID lamp	Laboratory	As needed
	Clean FID	Laboratory	As needed
	Change ion exchange resin	Laboratory	As needed
	Replace nickel tubing	Laboratory	As needed
Gas Chromatograph/Mass Spectrometers, Volatiles	Check gas supplies	Laboratory	Weekly, replace when pressure reaches 200 psi
	Change in-line filters	Laboratory	When indicator changes color
	Change septum	Laboratory	Daily, depending on use and component recovery
	Clip first foot of capillary column	Laboratory	As needed
	Change guard column	Laboratory	As needed
	Replace analytical column	Laboratory	As needed when peak resolution fails
	Clean jet separator	Laboratory	As needed
	Clean source	Laboratory	As needed when tuning problems
	Change pump oil	Laboratory	Annually
HPLC	Check gas supplies	Laboratory	Daily, replace when pressure reaches 200 psi
	Change guard column	Laboratory	As needed
	Change analytical column	Laboratory	As needed
	Change inlet filters	Laboratory	As needed
TCLP/SPLP Extractors	Monitor Room Temperature	Laboratory	Daily
	Monitor RPM of Rotators	Laboratory	Bi-weekly
	Grease fittings	Laboratory	As needed
	O-ring replacement	Laboratory	As needed

NON-CONTROLLED COPY

APPENDIX F
LABORATORY SOP LIST

Please note that the Appendices provide current information at the time of the revision, but are updated only upon annual review. Please contact the laboratory for up-to-date information.

NON-CONTROLLED COPY

STANDARD OPERATING PROCEDURES AND CONTROLLED DOCUMENTS

SOP NAME	FILE NAME
CORPORATE:	
CHECKING NEW LOTS OF CHEM. FOR CONTAMINATION	ADM-CTMN
DETM. OF STATISICAL CONTROL LIMITS	ADM-CTRL_LIM
DOC. OF TECHNICAL PERSONNEL TRAINING	ADM-TRANDOC
DOCUMENT CONTROL	ADM-DOCCTRL
MAKING ENTRIES INTO LOGS AND ONTO ANALYTICAL RECORDS	ADM-DATANTRY
DATA RECALL	ADM-DATARECALL
PREP OF ELECTRONIC-DATA FOR ORGANIC ANALYSES FOR E-DATA AUDITS	ADM-E_DATA
HANDLING CUSTOMER FEEDBACK	ADM-FDBK
CORRECTIVE ACTION	ADM-CA
MANUAL INTEGRATION OF CHROMATOGRAPHY PEAKS	ADM-INT
PREPARATION OF SOPs	ADM-SOP
QUALIFYING SUBCONTRACT LABS	ADM-SUBLAB
SIGNIFICANT FIGURES	ADM-SIG.FIG
DETERMINATION OF METHOD DETECTION LIMIT	ADM-MDL
MANAGEMENT REVIEW	ADM-MGMTRVW
PREVENTIVE ACTION	ADM-PA
PROFICIENCY TESTING SAMPLE ANALYSIS	ADM-PTS
PURCHASING THROUGH CAS PURCHASING DEPT IN KELSO	ADM-PUR
ESTIMATION OF UNCERTAINTY OF MEASUREMENTS	ADM-UNCERT
LOCAL:	
QUALITY ASSURANCE MANUAL	QAM
ANALYTICAL BATCHES AND SEQUENCES	ADM-BATCH
CONFIRMATION OF ORGANIC ANALYTE IDENTIFICATION AND QUANTITATION	ADM-CONFIRM
AUTOPIPET CALIBRATION	ADM-PCAL
INITIAL CALIBRATION	ADM-ICAL
PREPARING SAMPLE DILUTIONS	ADM-DIL
GENERATION OF ELECTRONIC DATA DELIVERABLES USING EDDGE	ADM-EDD
LABORATORY DATA REVIEW PROCESS	ADM-DREV
PROJECT CHEMIST DUTIES AND REPORT REVIEW	ADM-PCR
REPORT GENERATION	ADM-RG
DATA ARCHIVING	ADM-ARCH
ELECTRONIC DATA ARCHIVING	ADM-BACKUP
INTERNAL QUALITY ASSURANCE AUDITS	ADM-IAUD
DAILY BALANCE CALIB. AND TEMP. CHECKS	ADM-DALYCK
PH MEASUREMENTS FOR SUPPORT OF OTHER METHODS - CALIBRATION, USE, AND DOCUMENTATION	ADM-PhSUPPORT
SAMPLE PREPARATION, COMPOSITING, AND SUBSAMPLING	ADM-SPLPREP
CARBON DIOXIDE BY CALCULATION	ADM-4500 CO2 D
TOTAL HARDNESS BY CALCULATION	GEN-2340B
LANGELIER INDEX CALCULATION	ADM-2230B

NOT CONTROLLED COPY

STANDARD OPERATING PROCEDURES AND CONTROLLED DOCUMENTS

SOP NAME	FILE NAME
FIELD SAMPLING	FLD-SAMPLE
FIELD CHLORINE RESIDUAL	FLD-4500Cl-G
TEMPERATURE - FIELD	FLD-2550B
OXYGEN - FIELD	FLD-4500-OG
BOTTLE PREPARATION, PACKING, AND SHIPPING	SMO-BPS
SAMPLE RECEIVING	SMO-GEN
INTERNAL CHAINS OF CUSTODY	SMO-ICOC
SAMPLE DISPOSAL	SMO-SPLDIS
pH IN WATER AND AQUEOUS WASTE	GEN-9040B/SM4500H+B
TURBIDITY	SMO-180.1
SETTEABLE SOLIDS	GEN-160.5
CONDUCTIVITY IN WATER	GEN-120.1
CORROSIVITY	GEN-9045C
COLOR	GEN-110.2
DENSITY OR SPECIFIC GRAVITY BY WEIGHT PER GALLON CUF	GEN-D1475Cup
REACTIVITY BY OBSERVATION	GEN-ReactObs
REDOX	GEN-REDOX
PAINT FILTER TEST	SMO-9095
PASSIVE DIFFUSION BAGS	SMO-BAG
WKI PREPARATION	GEN-WKI

NON CONTROLLED COPY

STANDARD OPERATING PROCEDURES AND CONTROLLED DOCUMENTS

SOP NAME	FILE NAME
ALKALINITY, TOTAL	GEN-2320B
ALKALINITY FOR PHOTOPROCESSING SAMPLES	GEN-ALK-CARE
AMMONIA	GEN-350.1
AMMONIA IN SEDIMENTS BY SALICYLIC COLORIMETRY	GEN-I-6522-90
ASH, DETERMINATION OF	GEN-ASH
BIOCHEMICAL OXYGEN DEMAND	GEN-5210B
BOMB CALORIMETRY PREP AND HEAT OF COMBUSTION	GEN-BOMB
BROMIDE BY AUTOMATED TITRATOR	GEN-BROMIDE-CARE
CATION EXCHANGE CAPACITY OF SOILS USING SODIUM ACETATE	GEN-9081
CHEMICAL OXYGEN DEMAND-Soils	GEN-CODS
CHEMICAL OXYGEN DEMAND-Waters	GEN-410.4
CHLORIDE	GEN-4500ClE
CHLORINE DEMAND	GEN-409A
CHLORINE RESIDUAL	GEN-4500ClF
CHLOROPHYLL A	GEN-10200H
COLILERT AND VERIFICATION OF E.COLI IN MUG CULTURES	GEN-9223B
CYANIDE, AMENABLE TO CHLORINE	GEN-4500 CN G
CYANIDE, MIDI DISTILLATION	GEN-9012
CYANIDE, ILM05.3	GEN-ILM5.3CN
DENSITY BY OSCILLATING CELL METER	GEN-D4052
DISSOLVED OXYGEN	GEN-4500OG
ETHYLENE GLYCOL	GEN-89-9
FERROUS IRON	GEN-3500Fe
FIXER TITRATION OF PHOTOPROCESSING SAMPLES FOR HYPO INDEX AND THIOSULFATE	GEN-FIXER-TITR-CARE
HARDNESS, TOTAL	GEN-2340C
ALKALINE DIGESTION FOR HEXAVALENT CHROMIUM IN SOIL	GEN-3060A
COLORIMETRIC DETERMINATION OF HEXAVALENT CHROMIUM IN SOIL	GEN-7196A
HEXAVALENT CHROMIUM BY IC	GEN-7199
HEXAVALENT CHROMIUM - WATERS	GEN-CR+6
HYDROGEN PEROXIDE IN WATER BY IODOMETRIC TITRATION	GEN-Hperoxide
HYDROGEN PEROXIDE BY MANUAL COLORIMETRY WITH TITANIUM(IV)SULFATE	GEN-HP
HYPO (FIXER) CONTAMINATION IN PHOTOPROCESSING SAMPLES	GEN-HYPO-CARE
IGNITABILITY - CLOSED CUP	GEN-CCIGN
IGNITABILITY - OPEN CUP	GEN-OCIGN
IN-LAB FILTRATION	GEN-FILTER
IODIDE BY ION CHROMATOGRAPHY	GEN-IODIDE
ION CHROMATOGRAPHY, DETERMINATION OF ANIONS BY	GEN-300.0
LIPIDS, PERCENT	GEN-LIPID
NITRATE AND NITRITE	GEN-353.2
NITROGEN, TOTAL KJELDAHL	GEN-351.2
ODOR	GEN-2150B
OIL AND GREASE HEXANE EXTRACTION	GEN-1664A

NOT CONTROLLED COPY

STANDARD OPERATING PROCEDURES AND CONTROLLED DOCUMENTS

SOP NAME	FILE NAME
PERCENT WATER BY KARL FISCHER	GEN-%W
PHENOLICS, TOTAL	GEN-420.4/9066
PHOSPHORUS, ORTHC	GEN- OPO4
PHOSPHORUS, TOTAL	GEN-365.1
REACTIVITY, SULFIDE AND CYANIDE	GEN-RS/RCN
SILICA	GEN-I-2700-85
SILICON, GRAVIMETRIC	GEN-SILICON
SOLIDS, PERCENT	GEN-DWPS
SOLIDS, TOTAL	GEN-2540B
SOLIDS, TOTAL DISSOLVED	GEN-2540C
SOLIDS, TOTAL SUSPENDED	GEN-2540D
SOLIDS, VOLATILE AND FIXED (TOTAL, DISSOLVED, and SUSPENDED)	GEN-160.4
SOLIDS, PERCENT VOLATILE	GEN-2540G
SULFIDE, ACID SOLUBLE	GEN-9030B/9034
SULFIDE, ACID VOLATILE	GEN-AVS/SEM
SULFIDE, TOTAL AND DISSOLVED IN WATERS	GEN-4500S2F
SULFITE	GEN-4500SO3B
SULFURIC ACID BY METHOD 8	GEN-8
SURFACTANTS (MBAS)	GEN-425.1
THIOCYANATE	GEN-4500 CN M
THIOSULFATE BY TITRETS	GEN-S2O3
TMA and TMAH IN SORBENT TUBES AND WATER USNG IC	GEN-TMA(H)
TOTAL ORGANIC CARBON OR TIC B Y LLOYD KAHN/9060	GEN-TOCLK/9060
TOTAL ORGANIC CARBON-WATERS	GEN-5310C/9060
TOTAL INORGANIC CARBON - WATERS	GEN-TICW
WET CHEMISTRY GLASSWARE CLEANING	GEN-GC

NON-CONTROLLED COPY

STANDARD OPERATING PROCEDURES AND CONTROLLED DOCUMENTS

SOP NAME	FILE NAME
DETERMINATION OF METALS AND TRACE ELEMENTS BY ICP	MET-200.7/6010B
DETERMINATION OF METALS AND TRACE ELEMENTS BY ICP-MS	MET-6020A
DETERMINATION OF METALS ANG TRACE ELEMENTS BY ICP-MS BY ILM05.3	MET-ILM05.3MS
DETERMINATION OF METALS AND TRACE ELEMENTS BY ICP BY ILM05.3	MET-ILM5.3AES
DETERMINATION OF TRACE METALS BY GFAA	MET-GFAA
MERCURY IN WATER BY COLD VAPOR ATOMIC ABSORPTION SPEC.	MET-7470A/245.1
MERCURY IN SOLID OR SEMISOLID BY COLD VAPOR ATOMIC ABSORPTION SPEC.	MET-7471B/245.5
MERCURY IN WATER BY OXIDATION, P&T, AND CVAFS	MET-1631
MERCURY IN WATER BY COLD VAPOR ATOMIC ABSORPTION SPEC.CLP	MET-HgILM-W
MERCURY IN SOLID OR SEMISOLID BY COLD VAPOR ATOMIC ABSORPTION SPEC.	MET-HgILM-S
METALS DIGESTION, WATERS FOR ICP	MET-3010A
METALS DIGESTION, WATERS FOR GFAA ANALYSIS	MET-3020A
METALS DIGESTION, SOIL, SEDIMENT, SLUDGE FOR ICP AND GFAA ANALYSIS	MET-3050B

SPLP EXTRACTION FOR METALS AND SEMIVOLATILES	MET-SPLP
SPLP ZHE EXTRACTION	MET-SPLPZHE
SULFUR FOR ION CHROMATOGRAPHY	MET-ICS
METALS AND SEMIVOLATILES TCLP EXTRACTION (METHOD 1311)	MET-TCLP
ZERO HEADSPACE EXTRACTION (EPA METHOD 1311)	MET-TZHE
DEIONIZED WATER EXTRACTION OF SOIL FOR CLIENT USING ROTATING EXTRACTORS	MET-ClientDI Extraction
SAMPLE PREPARATION OF BIOLOGICAL TISSUE FOR METALS ANALYSIS	MET-TDIG
CLP DIGESTION TECHNIQUES FOR WATERS AND SOILS	MET-CLPDIG
METALS GLASSWARE CLEANING	MET-GC

NON-CONTROLLED COPY

STANDARD OPERATING PROCEDURES AND CONTROLLED DOCUMENTS

SOP NAME	FILE NAME
VOLATILE SCREENING	VOC-SCREEN
VOA STORAGE BLANKS	VOC-BLAN
PURGEABLE VOLATILES BY GC	VOC-601/602
MINERIAL SPIRITS	VOC-8015MS
ANALYSIS OF WATER, SOLIDS, AND SOLUBLE WASTES FOR TOTAL PETROLEUM HYDROCARBONS AS GASOLINE RANGE ORGANICS	VOC-8015GRO
AROMATIC AND HALOGENATED VOCS BY GC	VOC-8021B
MIXED GASES BY RSK-175M	VOC-8015/RSK175

CLOSED SYSTEM PURGE AND TRAP	VOC-5035
DRINKING WATER VOLATILES BY GC/MS	VOC-524.2
PURGEABLE VOLATILES BY GC/MS	VOC-624
VOLATILE ORGANIC COMPOUNDS BY GC/MS	VOC-8260B
CLP VOLATILE ORGANICS COMPOUNDS BY GC/MS SOW OLM04.3/95.1	VOC-CLP4.3
LOW CONC WATER FOR VOCS BY OLC02.1 AND OLC03.2 SOW	VOC-OLC
VOCs IN AIR COLLECTED IN CANs AND GAS COLLECTION BAGS BY GC/MS	VOC-TO-15
CLEANING AND CERTIFICATION OF SUMMA CANISTERS	VOC-CanCert
1,4-DIOXANE IN PERSONAL CARE PRODUCTS BY HEADSPACE GC/MS	VOC-p-Dioxane

NON-CONTROLLED COPY

STANDARD OPERATING PROCEDURES AND CONTROLLED DOCUMENTS

SOP NAME	FILE NAME
DETERMINATION OF POLYAROMATIC HYDROCARBONS BY HPLC	HPLC-8310
DETERMINATION OF CARBONYL COMPOUNDS BY HPLC	HPLC-8315A
ANALYSIS OF WATER SAMPLES FOR METABOLIC ACIDS	HPLC-METACIDS
PERCHLORATE IN WATER, SOIL, SOLID WASTE USING HPLC/ESI/MS	HPLC-6850
DETERMINATION OF HYDROQUINONE BY HPLC/ECD FOR "Client'	HPLC-"Client"Hyd
MISCELLANEOUS ANALYTES BY ULTRAVIOLET DETECTOR	HPLC-UV-MISC
SEPARATORY FUNNEL LIQUID-LIQUID EXTRACTION	EXT-3510C
CONTINUOUS LIQUID LIQUID EXTRATION	EXT-3520C
AUTOMATED SOXHLET EXTRACTION	EXT-3541
ULTRASONIC EXTRACTION	EXT-3550B
WASTE DILUTION	EXT-3580A
ADDITION OF SPIKES AND SURROGATES	EXT-SAS
PREPARATION OF ANHYDROUS SODIUM SULFATE	EXT-SUL
CONCENTRATION OF EXTRACTS	EXT-CONC
FLORISIL CLEANUP	EXT-3620B
SILICA GEL CLEANUP	EXT-3630
GEL PERMEATION CLEANUP	EXT-3640A
SULFUR CLEANUP	EXT-3660B
SULFURIC ACID CLEANUP OF PCB EXTRACTS	EXT-3665A
ORGANIC EXTRACTIONS GLASSWARE CLEANING	EXT-GC
DIAZOMETHANE PREPARATION	EXT-DIAZ
GASEOUS ORGANIC COMPOUNDS ON MEDIA BY GC/FID	SOC-18
PETROLEUM PRODUCTS IN WATER (HYDROCARBON SCAN)-NYSDOH Mtd	SOC-310-13
ORGANOCHLORINE PESTICIDES AND PCBs IN WATERS AND SOILS	SOC-608
BASE NEUTRALS AND ACIDS	SOC-625
PCBs BY GC/MS	SOC-680
1,2 DIBROMO-3-CHLOROPROPANE & 1,2-DIBROMOETHANE IN WATER	SOC-504/8011
NONHALOGENATED ORGANICS BY GC/FID	SOC-8015B
ORGANOCHLORINE PESTICIDES AND PCBs IN WATERS AND SOILS	SOC-8081A
PCBs IN WATERS and SOILS	SOC-8082
PETROLEUM HYDROCARBONS AS DIESEL IN WATERS, SOILS, AND WASTE INCLUDING MODS FOR MAINE AND CONNECTICUT	SOC-8015B DRO
CHLORINATED HERBICIDES	SOC-8151A
SEMIVOLATILE ORGANIC COMPOUNDS BY GC/MS	SOC-8270C

NON-CONTROLLED COPY

APPENDIX G

CERTIFICATIONS, ACCREDITATIONS, AND PRIMARY NELAP ACCREDITED METHODS

Please note that the Appendices provide current information at the time of the revision, but are updated only upon annual review. Please contact the laboratory for up-to-date information.

NON-CONTROLLED COPY

CAS/Rochester Certifications/Accreditations/Contracts

Federal, National, and International Programs

- NELAP Accreditation, since January 2001.
  Primary Accreditation with New York (see below).
  Secondary Accreditation with Florida, New Jersey, New Hampshire, Pennsylvania and Illinois (see below).

- United States Department of Defense Environmental Laboratory Accreditation Program (DOD-ELAP) since January 2010. Expires 1/21/2012.

- ISO/IEC 17025:2005 since January 2010. Expires 1/21/2012.

State and Local Programs

- State of Connecticut, Department of Health Services, Approved Public Health Laboratory.
  Certified Laboratory for Potable Water, Waste Water, Solid Waste and Soil.
  Examination for Inorganic Chemicals and Organic Chemicals. Registration No. PH-0556.
  Exp. 06/30/2012.

- State of Delaware, Department of Natural Resources and Environmental Control. Approved for Delaware Hazardous Substance Cleanup Act.

- State of Florida, Department of Health.
  Drinking water, Wastewater, Solid Hazardous Waste. Certification No. E87674. Expires 06/30/2011.

- State of Illinois, Environmental Protection Agency.
  Inorganic and Organic Hazardous and Solid Waste. Certification No. 200047. Expires 11/17/2010.

- State of Maine, Department of Health and Human Services.
  Drinking Water, Wastewater, and Solid Waste. Certification No.NY0032. Expires 11/12/2010.

- The Commonwealth of Massachusetts, Department of Environmental Protection.
  Non-Potable Water. Certification No. M-NY032. Exp. 06/30/2011.

- State of Nevada, Department of Conservation and Natural Resources, Division of Environmental Protection.
  Perchlorate, PCB Congeners. Lab ID number NY-00032. Expires 7/31/11.

- State of New Jersey, Department of Environmental Protection
  State Certified Environmental Laboratory for Drinking Water, Waste Water, and Solid Waste.
  Certification No. NY004. Exp. 06/30/2011.

- State of New York, Department of Health, Environmental Laboratory Approval Program.
  Potable Water, Air, Non-Potable Water, and Solid and Hazardous Waste.
  Certification No. 10145. Exp. 04/01/2011.

- State of New Hampshire, Department of Environmental Services
  Non-Potable Water, Drinking Water, Solid Waste. Certification No. 294102. Exp. 10/14/2011.

- Pennsylvania Department of Environmental Protection.
  Non-Potable Water. Lab ID No. 68-00786. Expires 6/30/2011.

- State of Rhode Island, Department of Health
  Approved for Surface Water, WasteWater, and Sewage. License No. 158. Exp. 12/30/2010.

NON-CONTROLLED COPY

CAS/Rochester Certifications/Accreditations/Contracts

Unregulated State Programs

- State of Minnesota
  Reciprocal Certification for all parameters certified under New York State.
- State of Georgia Environmental Protection Division
  Reciprocal Approval for Non-Potable/Environmental Waters and Wastes.
- State of Indiana Hazardous Waste Division
  Reciprocal Approval for Non-Potable/Environmental Waters and Wastes.
- State of Michigan - Reciprocal Approval for Non-Potable/Environmental Waters and Wastes.
- Commonwealth of Virginia, Department of General Services
  Reciprocal Approval for Non-Potable/Environmental Waters and Wastes.
- State of Mississippi - Reciprocal Approval for Non-Potable/Environmental Waters and Wastes.
- State of Maryland - Reciprocal Approval for Non-Potable/Environmental Waters and Wastes.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES POTABLE WATER All approved analytes are listed below:

Disinfection By-products	
Free Residual Chlorine	SM 18-21 4500-Cl F (00)
Total Residual Chlorine	SM 18-21 4500-Cl F (00)
Drinking Water Bacteriology	
Coliform, Total / E. coli (Qualitative)	SM 18-21 9223B (97) (Colilert)
Drinking Water Metals I	
Arsenic, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
	SM 18-19, 21 3113B (99)
Barium, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
Cadmium, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
Chromium, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
Copper, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
Iron, Total	EPA 200.7 Rev. 4.4
Lead, Total	EPA 200.8 Rev. 5.4
	SM 18-19, 21 3113B (99)
Manganese, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
Mercury, Total	EPA 245.1 Rev. 3.0
Selenium, Total	EPA 200.8 Rev. 5.4
	SM 18-19, 21 3113B (99)
Silver, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
Zinc, Total	EPA 200.7 Rev. 4.4
Drinking Water Metals I	
Zinc, Total	EPA 200.8 Rev. 5.4
Drinking Water Metals II	
Antimony, Total	EPA 200.8 Rev. 5.4
Beryllium, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
Nickel, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
Thallium, Total	EPA 200.8 Rev. 5.4
Drinking Water Metals III	
Sodium, Total	EPA 200.7 Rev. 4.4
Drinking Water Miscellaneous	
Organic Carbon, Total	SM 18-21 5310C (00)
Turbidity	EPA 180.1 Rev. 2.0
Drinking Water Non-Metals	
Alkalinity	SM 18-21 2320B (97)
Calcium Hardness	EPA 200.7 Rev. 4.4
Chloride	EPA 300.0 Rev. 2.1
	SM 18-21 4500-Cl- E (97)
Color	SM 18-21 2120B (01)
Cyanide	EPA 335.4 Rev. 1.0
Fluoride, Total	EPA 300.0 Rev. 2.1
Hydrogen Ion (pH)	SM 18-21 4500-H B (00)
Nitrate (as N)	EPA 300.0 Rev. 2.1
	EPA 353.2 Rev. 2.0
Nitrite (as N)	EPA 300.0 Rev. 2.1
	EPA 353.2 Rev. 2.0

Serial No.: 43052

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES POTABLE WATER All approved analytes are listed below:

Drinking Water Non-Metals

Orthophosphate (as P)	EPA 365.1 Rev. 2.0
Silica, Dissolved	SM 18-19 4500-Si F
	USGS I-2700-85
Solids, Total Dissolved	SM 18-21 2540C (97)
Specific Conductance	EPA 120.1 Rev. 1982
Sulfate (as SO4)	EPA 300.0 Rev. 2.1

Drinking Water Trihalomethanes

Bromodichloromethane	EPA 524.2
Bromoform	EPA 524.2
Chloroform	EPA 524.2
Dibromochloromethane	EPA 524.2

Fuel Additives

Methyl tert-butyl ether	EPA 524.2

Microextractibles

1,2-Dibromo-3-chloropropane	EPA 504.1
1,2-Dibromoethane	EPA 504.1

Volatile Aromatics

1,2,3-Trichlorobenzene	EPA 524.2
1,2,4-Trichlorobenzene	EPA 524.2
1,2,4-Trimethylbenzene	EPA 524.2
1,2-Dichlorobenzene	EPA 524.2
1,3,5-Trimethylbenzene	EPA 524.2
1,3-Dichlorobenzene	EPA 524.2
1,4-Dichlorobenzene	EPA 524.2
2-Chlorotoluene	EPA 524.2
4-Chlorotoluene	EPA 524.2

Volatile Aromatics

Benzene	EPA 524.2
Bromobenzene	EPA 524.2
Chlorobenzene	EPA 524.2
Ethyl benzene	EPA 524.2
Hexachlorobutadiene	EPA 524.2
Isopropylbenzene	EPA 524.2
n-Butylbenzene	EPA 524.2
n-Propylbenzene	EPA 524.2
p-Isopropyltoluene (P-Cymene)	EPA 524.2
sec-Butylbenzene	EPA 524.2
Styrene	EPA 524.2
tert-Butylbenzene	EPA 524.2
Toluene	EPA 524.2
Total Xylenes	EPA 524.2

Volatile Halocarbons

1,1,1,2-Tetrachloroethane	EPA 524.2
1,1,1-Trichloroethane	EPA 524.2
1,1,2,2-Tetrachloroethane	EPA 524.2
1,1,2-Trichloroethane	EPA 524.2
1,1-Dichloroethane	EPA 524.2
1,1-Dichloroethene	EPA 524.2
1,1-Dichloropropene	EPA 524.2
1,2,3-Trichloropropane	EPA 524.2
1,2-Dichloroethane	EPA 524.2
1,2-Dichloropropane	EPA 524.2
1,3-Dichloropropane	EPA 524.2
2,2-Dichloropropane	EPA 524.2
Bromochloromethane	EPA 524.2

Serial No.: 43052

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE
Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES POTABLE WATER
All approved analytes are listed below:

Volatile Halocarbons

Bromomethane	EPA 524.2
Carbon tetrachloride	EPA 524.2
Chloroethane	EPA 524.2
Chloromethane	EPA 524.2
cis-1,2-Dichloroethene	EPA 524.2
cis-1,3-Dichloropropene	EPA 524.2
Dibromomethane	EPA 524.2
Dichlorodifluoromethane	EPA 524.2
Methylene chloride	EPA 524.2
Tetrachloroethene	EPA 524.2
trans-1,2-Dichloroethene	EPA 524.2
trans-1,3-Dichloropropene	EPA 524.2
Trichloroethene	EPA 524.2
Trichlorofluoromethane	EPA 524.2
Vinyl chloride	EPA 524.2

Serial No.: 43052

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER All approved analytes are listed below:

Acrylates

Acrolein (Propenal)	EPA 624
	EPA 8260B
	EPA 8260C
Acrylonitrile	EPA 624
	EPA 8260B
	EPA 8260C
Ethyl methacrylate	EPA 8260B
	EPA 8260C
Methyl acrylonitrile	EPA 8260B
	EPA 8260C
Methyl methacrylate	EPA 8260B
	EPA 8260C

Amines

1,4-Phenylenediamine	EPA 8270C
	EPA 8270D
1-Naphthylamine	EPA 8270C
	EPA 8270D
2-Naphthylamine	EPA 8270C
	EPA 8270D
2-Nitroaniline	EPA 8270C
	EPA 8270D
3-Nitroaniline	EPA 8270C
	EPA 8270D
4-Chloroaniline	EPA 8270C
	EPA 8270D
4-Nitroaniline	EPA 8270C
	EPA 8270D
5-Nitro-o-toluidine	EPA 8270C

Amines

5-Nitro-o-toluidine	EPA 8270D
Aniline	EPA 8270C
	EPA 8270D
Carbazole	EPA 8270C
	EPA 8270D
Diphenylamine	EPA 8270C
	EPA 8270D
Methapyrilene	EPA 8270C
	EPA 8270D
Pronamide	EPA 8270C
	EPA 8270D
Propionitrile	EPA 8260B
	EPA 8260C
Pyridine	EPA 625
	EPA 8270C
	EPA 8270D

Benzidines

3,3'-Dichlorobenzidine	EPA 625
	EPA 8270C
	EPA 8270D
3,3'-Dimethylbenzidine	EPA 8270C
	EPA 8270D
Benzidine	EPA 625
	EPA 8270C
	EPA 8270D

Chlorinated Hydrocarbon Pesticides

4,4'-DDD	EPA 608

Serial No.: 43053

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER All approved analytes are listed below:

Chlorinated Hydrocarbon Pesticides	
4,4'-DDD	EPA 8081A
	EPA 8081B
4,4'-DDE	EPA 608
	EPA 8081A
	EPA 8081B
4,4'-DDT	EPA 608
	EPA 8081A
	EPA 8081B
Aldrin	EPA 608
	EPA 8081A
	EPA 8081B
alpha-BHC	EPA 608
	EPA 8081A
	EPA 8081B
alpha-Chlordane	EPA 8081A
	EPA 8081B
beta-BHC	EPA 608
	EPA 8081A
	EPA 8081B
Chlordane Total	EPA 608
	EPA 8081A
	EPA 8081B
Chlorobenzilate	EPA 8270C
	EPA 8270D
delta-BHC	EPA 608
	EPA 8081A
	EPA 8081B
Diallate	EPA 8270C

Chlorinated Hydrocarbon Pesticides	
Diallate	EPA 8270D
Dieldrin	EPA 608
	EPA 8081A
	EPA 8081B
Endosulfan I	EPA 608
	EPA 8081A
	EPA 8081B
Endosulfan II	EPA 608
	EPA 8081A
	EPA 8081B
Endosulfan sulfate	EPA 608
	EPA 8081A
	EPA 8081B
Endrin	EPA 608
	EPA 8081A
	EPA 8081B
Endrin aldehyde	EPA 608
	EPA 8081A
	EPA 8081B
Endrin Ketone	EPA 8081A
	EPA 8081B
gamma-Chlordane	EPA 8081A
	EPA 8081B
Heptachlor	EPA 608
	EPA 8081A
	EPA 8081B
Heptachlor epoxide	EPA 608
	EPA 8081A

Serial No.: 43053

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER All approved analytes are listed below:

Chlorinated Hydrocarbon Pesticides

Heptachlor epoxide	EPA 8081B
Isodrin	EPA 8270C
	EPA 8270D
Kepone	EPA 8081A
	EPA 8081B
Lindane	EPA 608
	EPA 8081A
	EPA 8081B
Methoxychlor	EPA 608
	EPA 8081A
	EPA 8081B
PCNB	EPA 8270C
	EPA 8270D
Toxaphene	EPA 608
	EPA 8081A
	EPA 8081B

Chlorinated Hydrocarbons

1,2,3-Trichlorobenzene	EPA 8260B
	EPA 8260C
1,2,4,5-Tetrachlorobenzene	EPA 8270C
	EPA 8270D
1,2,4-Trichlorobenzene	EPA 625
	EPA 8270C
	EPA 8270D
2-Chloronaphthalene	EPA 625
	EPA 8270C
	EPA 8270D
Hexachlorobenzene	EPA 625

Chlorinated Hydrocarbons

Hexachlorobenzene	EPA 8081A
	EPA 8081B
	EPA 8270C
	EPA 8270D
Hexachlorobutadiene	EPA 625
	EPA 8270C
	EPA 8270D
Hexachlorocyclopentadiene	EPA 625
	EPA 8270C
	EPA 8270D
Hexachloroethane	EPA 625
	EPA 8270C
	EPA 8270D
Hexachloropropene	EPA 8270C
	EPA 8270D
Pentachlorobenzene	EPA 8270C
	EPA 8270D

Chlorophenoxy Acid Pesticides

2,4,5-T	EPA 1978 p.115
	EPA 8151A
2,4,5-TP (Silvex)	EPA 1978 p.115
	EPA 8151A
2,4-D	EPA 1978 p.115
	EPA 8151A
Dicamba	EPA 1978 p.115
	EPA 8151A
Dinoseb	EPA 8151A
	EPA 8270C

Serial No.: 43053

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER All approved analytes are listed below:

Chlorophenoxy Acid Pesticides	
Dinoseb	EPA 8270D
Demand	
Biochemical Oxygen Demand	SM 18-21 5210B (01)
Carbonaceous BOD	SM 18-21 5210B (01)
Chemical Oxygen Demand	EPA 410.4 Rev. 2.0
Dissolved Gases	
Acetylene	RSK-175
Ethane	RSK-175
Ethene (Ethylene)	RSK-175
Methane	RSK-175
Propane	RSK-175
Fuel Oxygenates	
Di-isopropyl ether	EPA 8015 B
	EPA 8015C
	EPA 8260B
	EPA 8260C
Ethanol	EPA 8015 B
	EPA 8015C
Methyl tert-butyl ether	EPA 8021B
	EPA 8260B
	EPA 8260C
tert-amyl methyl ether (TAME)	EPA 8260B
	EPA 8260C
tert-butyl alcohol	EPA 8260B
	EPA 8260C
tert-butyl ethyl ether(ETBE)	EPA 8260B
	EPA 8260C
Haloethers	
4-Bromophenylphenyl ether	EPA 625
	EPA 8270C
	EPA 8270D
4-Chlorophenylphenyl ether	EPA 625
	EPA 8270C
	EPA 8270D
Bis (2-chloroisopropyl) ether	EPA 625
	EPA 8270C
	EPA 8270D
Bis(2-chloroethoxy)methane	EPA 625
	EPA 8270C
	EPA 8270D
Bis(2-chloroethyl)ether	EPA 625
	EPA 8270C
	EPA 8270D
Low Level Polynuclear Aromatics	
Acenaphthene	EPA 610
	EPA 8270C
	EPA 8270D
	EPA 8310
Acenaphthylene	EPA 610
	EPA 8270C
	EPA 8270D
	EPA 8310
Anthracene	EPA 610
	EPA 8270C
	EPA 8270D
	EPA 8310

Serial No.: 43053

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE
Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER All approved analytes are listed below:

Low Level Polynuclear Aromatics

Benzo(a)anthracene	EPA 610
	EPA 8270C
	EPA 8270D
	EPA 8310
Benzo(a)pyrene	EPA 610
	EPA 8270C
	EPA 8270D
	EPA 8310
Benzo(b)fluoranthene	EPA 610
	EPA 8270C
	EPA 8270D
	EPA 8310
Benzo(g,h,i)perylene	EPA 610
	EPA 8270C
	EPA 8270D
	EPA 8310
Benzo(k)fluoroanthene	EPA 610
	EPA 8270C
	EPA 8270D
	EPA 8310
Chrysene	EPA 610
	EPA 8270C
	EPA 8270D
	EPA 8310
Dibenzo(a,h)anthracene	EPA 610
	EPA 8270C
	EPA 8270D
	EPA 8310

Low Level Polynuclear Aromatics

Fluoranthene	EPA 610
	EPA 8270C
	EPA 8270D
	EPA 8310
Fluorene	EPA 610
	EPA 8270C
	EPA 8270D
	EPA 8310
Indeno(1,2,3-cd)pyrene	EPA 610
	EPA 8270C
	EPA 8270D
	EPA 8310
Naphthalene	EPA 610
	EPA 8270C
	EPA 8270D
	EPA 8310
Phenanthrene	EPA 610
	EPA 8270C
	EPA 8270D
	EPA 8310
Pyrene	EPA 610
	EPA 8270C
	EPA 8270D
	EPA 8310

Microextractables

1,2-Dibromo-3-chloropropane	EPA 8011
	EPA 8260B
	EPA 8260C

Serial No.: 43053

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NELAP RECOGNIZED TNI ACCREDITATION BODY

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER All approved analytes are listed below:

Microextractables	
1,2-Dibromoethane	EPA 8011
	EPA 8260B
	EPA 8260C
Mineral	
Alkalinity	SM 18-21 2320B (97)
Calcium Hardness	EPA 200.7 Rev. 4.4
	SM 18-21 2340B (97)
Chloride	EPA 300.0 Rev. 2.1
	EPA 9056A
	SM 18-21 4500-Cl- E (97)
Fluoride, Total	EPA 300.0 Rev. 2.1
	EPA 9056A
Hardness, Total	EPA 200.7 Rev. 4.4
	SM 18-21 2340B (97)
	SM 18-21 2340C (97)
Sulfate (as SO4)	EPA 300.0 Rev. 2.1
	EPA 9056A
Nitroaromatics and Isophorone	
1,3,5-Trinitrobenzene	EPA 8270C
	EPA 8270D
1,3-Dinitrobenzene	EPA 8270C
	EPA 8270D
1,4-Naphthoquinone	EPA 8270C
	EPA 8270D
2,4-Dinitrotoluene	EPA 625
	EPA 8270C
	EPA 8270D
Nitroaromatics and Isophorone	
2,6-Dinitrotoluene	EPA 625
	EPA 8270C
	EPA 8270D
Isophorone	EPA 625
	EPA 8270C
	EPA 8270D
Nitrobenzene	EPA 625
	EPA 8270C
	EPA 8270D
Nitrosoamines	
N-Nitrosodiethylamine	EPA 8270C
	EPA 8270D
N-Nitrosodimethylamine	EPA 625
	EPA 8270C
	EPA 8270D
N-Nitrosodi-n-butylamine	EPA 8270C
	EPA 8270D
N-Nitrosodi-n-propylamine	EPA 625
	EPA 8270C
	EPA 8270D
N-Nitrosodiphenylamine	EPA 625
	EPA 8270C
	EPA 8270D
N-nitrosopiperidine	EPA 8270C
	EPA 8270D
N-Nitrosopyrrolidine	EPA 8270C
	EPA 8270D

Serial No.: 43053

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NELAP RECOGNIZED TNI ACCREDITATION BODY

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER All approved analytes are listed below:

Nutrient	
Ammonia (as N)	EPA 350.1 Rev. 2.0
Kjeldahl Nitrogen, Total	EPA 351.2 Rev. 2.0
Nitrate (as N)	EPA 300.0 Rev. 2.1
	EPA 353.2 Rev. 2.0
	EPA 9056A
Nitrite (as N)	EPA 300.0 Rev. 2.1
	EPA 353.2 Rev. 2.0
	EPA 9056A
Orthophosphate (as P)	EPA 365.1 Rev. 2.0
Phosphorus, Total	EPA 365.1 Rev. 2.0
Organophosphate Pesticides	
Atrazine	EPA 8270C
	EPA 8270D
Dimethoate	EPA 8270C
	EPA 8270D
Disulfoton	EPA 8270C
	EPA 8270D
Parathion ethyl	EPA 8270C
	EPA 8270D
Parathion methyl	EPA 8270C
	EPA 8270D
Phorate	EPA 8270C
	EPA 8270D
Phthalate Esters	
Benzyl butyl phthalate	EPA 625
	EPA 8270C
	EPA 8270D

Phthalate Esters	
Bis(2-ethylhexyl) phthalate	EPA 625
	EPA 8270C
	EPA 8270D
Diethyl phthalate	EPA 625
	EPA 8270C
	EPA 8270D
Dimethyl phthalate	EPA 625
	EPA 8270C
	EPA 8270D
Di-n-butyl phthalate	EPA 625
	EPA 8270C
	EPA 8270D
Di-n-octyl phthalate	EPA 625
	EPA 8270C
	EPA 8270D
Polychlorinated Biphenyls	
PCB-1016	EPA 608
	EPA 8082
	EPA 8082A
PCB-1221	EPA 608
	EPA 8082
	EPA 8082A
PCB-1232	EPA 608
	EPA 8082
	EPA 8082A
PCB-1242	EPA 608
	EPA 8082
	EPA 8082A

Serial No.: 43053

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NELAP RECOGNIZED TNI ACCREDITATION BODY

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER All approved analytes are listed below:

Polychlorinated Biphenyls

PCB-1248	EPA 608
	EPA 8082
	EPA 8082A
PCB-1254	EPA 608
	EPA 8082
	EPA 8082A
PCB-1260	EPA 608
	EPA 8082
	EPA 8082A
PCB-1262	EPA 8082
	EPA 8082A
PCB-1268	EPA 8082
	EPA 8082A

Polynuclear Aromatics

3-Methylcholanthrene	EPA 8270C
	EPA 8270D
7,12-Dimethylbenzyl (a) anthracene	EPA 8270C
	EPA 8270D
Acenaphthene	EPA 625
	EPA 8270C
	EPA 8270D
Acenaphthylene	EPA 625
	EPA 8270C
	EPA 8270D
Anthracene	EPA 625
	EPA 8270C
	EPA 8270D
Benzo(a)anthracene	EPA 625

Polynuclear Aromatics

Benzo(a)anthracene	EPA 8270C
	EPA 8270D
Benzo(a)pyrene	EPA 625
	EPA 8270C
	EPA 8270D
Benzo(b)fluoranthene	EPA 625
	EPA 8270C
	EPA 8270D
Benzo(ghi)perylene	EPA 625
	EPA 8270C
	EPA 8270D
Benzo(k)fluoranthene	EPA 625
	EPA 8270C
	EPA 8270D
Chrysene	EPA 625
	EPA 8270C
	EPA 8270D
Dibenzo(a,h)anthracene	EPA 625
	EPA 8270C
	EPA 8270D
Fluoranthene	EPA 625
	EPA 8270C
	EPA 8270D
Fluorene	EPA 625
	EPA 8270C
	EPA 8270D
Indeno(1,2,3-cd)pyrene	EPA 625
	EPA 8270C

Serial No.: 43053

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER All approved analytes are listed below:

Polynuclear Aromatics

Indeno(1,2,3-cd)pyrene	EPA 8270D
Naphthalene	EPA 625
	EPA 8270C
	EPA 8270D
Phenanthrene	EPA 625
	EPA 8270C
	EPA 8270D
Pyrene	EPA 625
	EPA 8270C
	EPA 8270D

Priority Pollutant Phenols

2,3,4,6 Tetrachlorophenol	EPA 8270C
	EPA 8270D
2,4,5-Trichlorophenol	EPA 625
	EPA 8270C
	EPA 8270D
2,4,6-Trichlorophenol	EPA 625
	EPA 8270C
	EPA 8270D
2,4-Dichlorophenol	EPA 625
	EPA 8270C
	EPA 8270D
2,4-Dimethylphenol	EPA 625
	EPA 8270C
	EPA 8270D
2,4-Dinitrophenol	EPA 625
	EPA 8270C
	EPA 8270D

Priority Pollutant Phenols

2,6-Dichlorophenol	EPA 8270C
	EPA 8270D
2-Chlorophenol	EPA 625
	EPA 8270C
	EPA 8270D
2-Methyl-4,6-dinitrophenol	EPA 625
	EPA 8270C
	EPA 8270D
2-Methylphenol	EPA 8270C
	EPA 8270D
2-Nitrophenol	EPA 625
	EPA 8270C
	EPA 8270D
3-Methylphenol	EPA 8270C
	EPA 8270D
4-Chloro-3-methylphenol	EPA 625
	EPA 8270C
	EPA 8270D
4-Methylphenol	EPA 8270C
	EPA 8270D
4-Nitrophenol	EPA 625
	EPA 8270C
	EPA 8270D
Cresols, Total	EPA 8270C
	EPA 8270D
Pentachlorophenol	EPA 625
	EPA 8151A
	EPA 8270C

Serial No.: 43053

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER
All approved analytes are listed below:

Priority Pollutant Phenols

Pentachlorophenol	EPA 8270D
Phenol	EPA 625
	EPA 8270C
	EPA 8270D

Purgeable Aromatics

1,2,4-Trichlorobenzene, Volatile	EPA 8260B
	EPA 8260C
1,2,4-Trimethylbenzene	EPA 8021B
	EPA 8260B
	EPA 8260C
1,2-Dichlorobenzene	EPA 601
	EPA 602
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
1,3,5-Trimethylbenzene	EPA 8021B
	EPA 8260B
	EPA 8260C
1,3-Dichlorobenzene	EPA 601
	EPA 602
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
1,4-Dichlorobenzene	EPA 601
	EPA 602
	EPA 624

Purgeable Aromatics

1,4-Dichlorobenzene	EPA 8021B
	EPA 8260B
	EPA 8260C
2-Chlorotoluene	EPA 8260C
4-Chlorotoluene	EPA 8260C
Benzene	EPA 602
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
Chlorobenzene	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
Ethyl benzene	EPA 602
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
Isopropylbenzene	EPA 8021B
	EPA 8260B
	EPA 8260C
Naphthalene, Volatile	EPA 8260B
	EPA 8260C
n-Butylbenzene	EPA 8021B
	EPA 8260B
	EPA 8260C

Serial No.: 43053

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER All approved analytes are listed below:

Purgeable Aromatics

n-Propylbenzene	EPA 8021B
	EPA 8260B
	EPA 8260C
p-Isopropyltoluene (P-Cymene)	EPA 8021B
	EPA 8260B
	EPA 8260C
sec-Butylbenzene	EPA 8021B
	EPA 8260B
	EPA 8260C
Styrene	EPA 624
	EPA 8260B
	EPA 8260C
tert-Butylbenzene	EPA 8260C
Toluene	EPA 602
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
Total Xylenes	EPA 602
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C

Purgeable Halocarbons

1,1,1,2-Tetrachloroethane	EPA 8260B
	EPA 8260C
1,1,1-Trichloroethane	EPA 601
	EPA 624

Purgeable Halocarbons

1,1,1-Trichloroethane	EPA 8021B
	EPA 8260B
	EPA 8260C
1,1,2,2-Tetrachloroethane	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
1,1,2-Trichloro-1,2,2-Trifluoroethane	EPA 8260B
	EPA 8260C
1,1,2-Trichloroethane	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
1,1-Dichloroethane	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
1,1-Dichloroethene	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
1,1-Dichloropropene	EPA 8260B
	EPA 8260C
1,2,3-Trichloropropane	EPA 8260B

Serial No.: 43053

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER All approved analytes are listed below:

Purgeable Halocarbons	
1,2,3-Trichloropropane	EPA 8260C
1,2-Dichloro-1,1,2-Trifluoroethane	EPA 8260C
1,2-Dichloroethane	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
1,2-Dichloropropane	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
1,3-Dichloropropane	EPA 8260B
	EPA 8260C
2,2-Dichloropropane	EPA 8260B
	EPA 8260C
2-Chloro-1,3-butadiene (Chloroprene)	EPA 8260B
	EPA 8260C
2-Chloroethylvinyl ether	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
3-Chloropropene (Allyl chloride)	EPA 8260B
	EPA 8260C
Bromochloromethane	EPA 8260B
	EPA 8260C
Bromodichloromethane	EPA 601

Purgeable Halocarbons	
Bromodichloromethane	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
Bromoform	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
Bromomethane	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
Carbon tetrachloride	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
Chloroethane	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
Chloroform	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B

Serial No.: 43053

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER All approved analytes are listed below:

Purgeable Halocarbons	
Chloroform	EPA 8260C
Chloromethane	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
cis-1,2-Dichloroethene	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
cis-1,3-Dichloropropene	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
Dibromochloromethane	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
Dibromomethane	EPA 8260B
	EPA 8260C
Dichlorodifluoromethane	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
Hexachlorobutadiene, Volatile	EPA 8260B

Purgeable Halocarbons	
Hexachlorobutadiene, Volatile	EPA 8260C
Methyl iodide	EPA 8260B
	EPA 8260C
Methylene chloride	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
Tetrachloroethene	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
trans-1,2-Dichloroethene	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
trans-1,3-Dichloropropene	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
trans-1,4-Dichloro-2-butene	EPA 8260B
	EPA 8260C
Trichloroethene	EPA 601
	EPA 624
	EPA 8021B

Serial No.: 43053

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER All approved analytes are listed below:

Purgeable Halocarbons	
Trichloroethene	EPA 8260B
	EPA 8260C
Trichlorofluoromethane	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
Vinyl chloride	EPA 601
	EPA 624
	EPA 8021B
	EPA 8260B
	EPA 8260C
Purgeable Organics	
1,4-Dioxane	EPA 8260B
	EPA 8260C
2-Butanone (Methylethyl ketone)	EPA 8260B
	EPA 8260C
2-Hexanone	EPA 8260B
	EPA 8260C
4-Methyl-2-Pentanone	EPA 8260B
	EPA 8260C
Acetone	EPA 8260B
	EPA 8260C
Acetonitrile	EPA 8260B
	EPA 8260C
Carbon Disulfide	EPA 8260B
	EPA 8260C
Cyclohexane	EPA 8260B

Purgeable Organics	
Cyclohexane	EPA 8260C
Ethyl Acetate	EPA 8015 B
	EPA 8015C
	EPA 8260B
	EPA 8260C
Isobutyl alcohol	EPA 8015 B
	EPA 8015C
	EPA 8260B
	EPA 8260C
Methyl acetate	EPA 8260B
	EPA 8260C
Methyl cyclohexane	EPA 8260B
	EPA 8260C
	EPA 8270D
o-Toluidine	EPA 8260B
	EPA 8260C
	EPA 8270C
	EPA 8270D
Vinyl acetate	EPA 8260B
	EPA 8260C
Residue	
Settleable Solids	SM 18-21 2540 F (97)
Solids, Total	SM 18-21 2540B (97)
Solids, Total Dissolved	SM 18-21 2540C (97)
Solids, Total Suspended	SM 18-21 2540D (97)
Semi-Volatile Organics	
1,1'-Biphenyl	EPA 8270C

Serial No.: 43053

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NELAP RECOGNIZED TNI ACCREDITATION BODY

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER All approved analytes are listed below:

Semi-Volatile Organics	
1,1'-Biphenyl	EPA 8270D
1,2-Dichlorobenzene, Semi-volatile	EPA 8270C
	EPA 8270D
1,3-Dichlorobenzene, Semi-volatile	EPA 8270C
	EPA 8270D
1,4-Dichlorobenzene, Semi-volatile	EPA 8270C
	EPA 8270D
2-Methylnaphthalene	EPA 8270C
	EPA 8270D
4-Amino biphenyl	EPA 8270C
	EPA 8270D
Acetophenone	EPA 8270C
	EPA 8270D
Benzaldehyde	EPA 8270C
	EPA 8270D
Benzoic Acid	EPA 8270C
	EPA 8270D
Benzyl alcohol	EPA 8270C
	EPA 8270D
Caprolactam	EPA 8270C
	EPA 8270D
Dibenzofuran	EPA 8270C
	EPA 8270D
Ethyl methanesulfonate	EPA 8270C
	EPA 8270D
Isosafrole	EPA 8270C
	EPA 8270D
Methyl methanesulfonate	EPA 8270C

Semi-Volatile Organics	
Methyl methanesulfonate	EPA 8270D
O,O,O-Triethyl phosphorothioate	EPA 8270C
	EPA 8270D
p-Dimethylaminoazobenzene	EPA 8270C
	EPA 8270D
Phenacetin	EPA 8270C
	EPA 8270D
Safrole	EPA 8270C
	EPA 8270D
Volatile Chlorinated Organics	
Benzyl chloride	EPA 8260B
	EPA 8260C
Wastewater Metals I	
Barium, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
Cadmium, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
Calcium, Total	EPA 200.7 Rev. 4.4
	EPA 6010B

Serial No.: 43053

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE
Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER All approved analytes are listed below:

Wastewater Metals I

Calcium, Total	EPA 6010C
Chromium, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
Copper, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
Iron, Total	EPA 200.7 Rev. 4.4
	EPA 6010B
	EPA 6010C
Lead, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
	EPA 7010
	EPA 7421
	SM 18-19, 21 3113B (99)
Magnesium, Total	EPA 200.7 Rev. 4.4
	EPA 6010B
	EPA 6010C

Wastewater Metals I

Manganese, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
Nickel, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
Potassium, Total	EPA 200.7 Rev. 4.4
	EPA 6010B
	EPA 6010C
Silver, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
Sodium, Total	EPA 200.7 Rev. 4.4
	EPA 6010B
	EPA 6010C
Strontium, Total	EPA 200.7 Rev. 4.4
	EPA 6010B
	EPA 6010C

Serial No.: 43053

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER All approved analytes are listed below:

Wastewater Metals II

Aluminum, Total	EPA 200.7 Rev. 4.4
	EPA 6010B
	EPA 6010C
Antimony, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
Arsenic, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
	EPA 7010
	EPA 7060A
	SM 18-19, 21 3113B (99)
Beryllium, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
Chromium VI	EPA 218.6 Rev. 3.3
	EPA 7196A
	EPA 7199
	SM 18-19 3500-Cr D

Wastewater Metals II

Chromium VI	SM 20-21 3500-Cr B (01)
Mercury, Low Level	EPA 1631E
Mercury, Total	EPA 245.1 Rev. 3.0
	EPA 245.2 Rev. 1974
	EPA 7470A
Selenium, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
	EPA 7010
	EPA 7740
	SM 18-19, 21 3113B (99)
Vanadium, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
Zinc, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A

Wastewater Metals III

Cobalt, Total	EPA 200.7 Rev. 4.4

Serial No.: 43053

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER All approved analytes are listed below:

Wastewater Metals III

Cobalt, Total	EPA 200.8 Rev. 5.4
	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
Gold, Total	EPA 200.7 Rev. 4.4
Molybdenum, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
Palladium, Total	EPA 200.7 Rev. 4.4
Thallium, Total	EPA 200.7 Rev. 4.4
	EPA 200.8 Rev. 5.4
	EPA 279.2 Rev. 1978
	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
	EPA 7010
	EPA 7841
	SM 18-19, 21 3113B (99)
Tin, Total	EPA 200.7 Rev. 4.4
	EPA 6010B
	EPA 6010C
Titanium, Total	EPA 200.7 Rev. 4.4
	EPA 6010B

Wastewater Metals III

Titanium, Total	EPA 6010C
Uranium (Mass)	EPA 6020
	EPA 6020A

Wastewater Miscellaneous

Boron, Total	EPA 200.7 Rev. 4.4
	EPA 6010B
	EPA 6010C
Bromide	EPA 300.0 Rev. 2.1
	EPA 9056A
Color	SM 18-21 2120B (01)
Corrosivity	SM 18-19 2330
Cyanide, Total	EPA 335.4 Rev. 1.0
	EPA 9012A
	SM 18-21 4500-CN E (99)
Formaldehyde	EPA 8315
Hydrogen Ion (pH)	EPA 9040B
	SM 18-21 4500-H B (00)
Oil & Grease Total Recoverable (HEM)	EPA 1664A
Organic Carbon, Total	EPA 9060
	SM 18-21 5310C (00)
Perchlorate	EPA 6850
Phenols	EPA 420.4 Rev. 1.0
	EPA 9066
Silica, Dissolved	USGS I-2700-85
Specific Conductance	EPA 120.1 Rev. 1982
	EPA 9050
Sulfide (as S)	EPA 9034
	SM 18 4500-S E

Serial No.: 43053

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE
Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER All approved analytes are listed below:

Wastewater Miscellaneous

Sulfide (as S)	SM 19-21 4500-S F (00)
Surfactant (MBAS)	SM 18-21 5540C (00)
Temperature	SM 18-21 2550B (00)
Total Chlorine Residual, Low Level	SM 18-21 4500-Cl G (00)
Total Petroleum Hydrocarbons	EPA 1664A
Total Residual Chlorine	SM 18-21 4500-Cl F (00)
	SM 18-21 4500-Cl G (00)
Turbidity	EPA 180.1 Rev. 2.0

Sample Preparation Methods

EPA 3005A
EPA 3010A
EPA 3015
EPA 3020A
EPA 3510C
EPA 3520C
EPA 5030B
EPA 9030B

Serial No.: 43053

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES SOLID AND HAZARDOUS WASTE All approved analytes are listed below:

Acrylates	
Acrolein (Propenal)	EPA 8260B
	EPA 8260C
Acrylonitrile	EPA 8260B
	EPA 8260C
Ethyl methacrylate	EPA 8260B
	EPA 8260C
Methyl acrylonitrile	EPA 8260B
	EPA 8260C
Methyl methacrylate	EPA 8260B
	EPA 8260C
Amines	
1,2-Diphenylhydrazine	EPA 8270C
	EPA 8270D
1,4-Phenylenediamine	EPA 8270C
	EPA 8270D
1-Naphthylamine	EPA 8270C
	EPA 8270D
2-Naphthylamine	EPA 8270C
	EPA 8270D
2-Nitroaniline	EPA 8270C
	EPA 8270D
3-Nitroaniline	EPA 8270C
	EPA 8270D
4-Chloroaniline	EPA 8270C
	EPA 8270D
4-Nitroaniline	EPA 8270C
	EPA 8270D
5-Chloro-2-methylaniline	EPA 8270C
Amines	
5-Chloro-2-methylaniline	EPA 8270D
5-Nitro-o-toluidine	EPA 8270C
	EPA 8270D
Aniline	EPA 8270C
	EPA 8270D
Carbazole	EPA 8270C
	EPA 8270D
Diphenylamine	EPA 8270C
	EPA 8270D
Methapyrilene	EPA 8270C
	EPA 8270D
Pronamide	EPA 8270C
	EPA 8270D
Benzidines	
3,3'-Dichlorobenzidine	EPA 8270C
	EPA 8270D
3,3'-Dimethylbenzidine	EPA 8270C
	EPA 8270D
Benzidine	EPA 8270C
	EPA 8270D
Characteristic Testing	
Corrosivity	EPA 9045C
Ignitability	EPA 1010
Reactivity	SW-846 Ch7 Sec. 7.3
Chlorinated Hydrocarbon Pesticides	
4,4'-DDD	EPA 8081A
	EPA 8081B

Serial No.: 43054

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES SOLID AND HAZARDOUS WASTE All approved analytes are listed below:

Chlorinated Hydrocarbon Pesticides

4,4'-DDE	EPA 8081A
	EPA 8081B
4,4'-DDT	EPA 8081A
	EPA 8081B
Aldrin	EPA 8081A
	EPA 8081B
alpha-BHC	EPA 8081A
	EPA 8081B
alpha-Chlordane	EPA 8081A
	EPA 8081B
Atrazine	EPA 8270C
	EPA 8270D
beta-BHC	EPA 8081A
	EPA 8081B
Chlordane Total	EPA 8081A
	EPA 8081B
Chlorobenzilate	EPA 8270C
	EPA 8270D
delta-BHC	EPA 8081A
	EPA 8081B
Diallate	EPA 8270C
	EPA 8270D
Dieldrin	EPA 8081A
	EPA 8081B
Endosulfan I	EPA 8081A
	EPA 8081B
Endosulfan II	EPA 8081A
	EPA 8081B

Chlorinated Hydrocarbon Pesticides

Endosulfan sulfate	EPA 8081A
	EPA 8081B
Endrin	EPA 8081A
	EPA 8081B
Endrin aldehyde	EPA 8081A
	EPA 8081B
Endrin Ketone	EPA 8081A
	EPA 8081B
gamma-Chlordane	EPA 8081A
	EPA 8081B
Heptachlor	EPA 8081A
	EPA 8081B
Heptachlor epoxide	EPA 8081A
	EPA 8081B
Kepone	EPA 8081A
	EPA 8081B
Lindane	EPA 8081A
	EPA 8081B
Methoxychlor	EPA 8081A
	EPA 8081B
Pentachloronitrobenzene	EPA 8270C
	EPA 8270D
Toxaphene	EPA 8081A
	EPA 8081B

Chlorinated Hydrocarbons

1,2,4,5-Tetrachlorobenzene	EPA 8270C
	EPA 8270D
1,2,4-Trichlorobenzene	EPA 8270C

Serial No.: 43054

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NELAP RECOGNIZED TNI ACCREDITATION BODY

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES SOLID AND HAZARDOUS WASTE All approved analytes are listed below:

Chlorinated Hydrocarbons

1,2,4-Trichlorobenzene	EPA 8270D
1-Chloronaphthalene	EPA 8270C
	EPA 8270D
2-Chloronaphthalene	EPA 8270C
	EPA 8270D
Hexachlorobenzene	EPA 8270C
	EPA 8270D
Hexachlorobutadiene	EPA 8270C
	EPA 8270D
Hexachlorocyclopentadiene	EPA 8270C
	EPA 8270D
Hexachloroethane	EPA 8270C
	EPA 8270D
Hexachlorophene	EPA 8270C
	EPA 8270D
Hexachloropropene	EPA 8270C
	EPA 8270D
Pentachlorobenzene	EPA 8270C
	EPA 8270D

Chlorophenoxy Acid Pesticides

2,4,5-T	EPA 8151A
2,4,5-TP (Silvex)	EPA 8151A
2,4-D	EPA 8151A
Dicamba	EPA 8151A
Dinoseb	EPA 8270C
	EPA 8270D

Haloethers

4-Bromophenylphenyl ether	EPA 8270C
	EPA 8270D
4-Chlorophenylphenyl ether	EPA 8270C
	EPA 8270D
Bis (2-chloroisopropyl) ether	EPA 8270C
	EPA 8270D
Bis(2-chloroethoxy)methane	EPA 8270C
	EPA 8270D
Bis(2-chloroethyl)ether	EPA 8270C
	EPA 8270D

Low Level Polynuclear Aromatic Hydrocarbons

Acenaphthene	EPA 8270C
	EPA 8270D
Acenaphthylene	EPA 8270C
	EPA 8270D
Anthracene	EPA 8270C
	EPA 8270D
Benzo(a)anthracene	EPA 8270C
	EPA 8270D
Benzo(a)pyrene	EPA 8270C
	EPA 8270D
Benzo(b)fluoranthene	EPA 8270C
	EPA 8270D
Benzo(g,h,i)perylene	EPA 8270C
	EPA 8270D
Benzo(k)fluoroanthene	EPA 8270C
	EPA 8270D
Chrysene	EPA 8270C

Serial No.: 43054

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NELAP RECOGNIZED TNI ACCREDITATION BODY

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE
Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES SOLID AND HAZARDOUS WASTE
All approved analytes are listed below:

Low Level Polynuclear Aromatic Hydrocarbons

Chrysene	EPA 8270D
Dibenzo(a,h)anthracene	EPA 8270C
	EPA 8270D
Fluoranthene	EPA 8270C
	EPA 8270D
Fluorene	EPA 8270C
	EPA 8270D
Indeno(1,2,3-cd)pyrene	EPA 8270C
	EPA 8270D
Naphthalene	EPA 8270C
	EPA 8270D
Phenanthrene	EPA 8270C
	EPA 8270D
Pyrene	EPA 8270C
	EPA 8270D

Metals I

Barium, Total	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
Cadmium, Total	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
Calcium, Total	EPA 6010B
	EPA 6010C
Chromium, Total	EPA 6010B
	EPA 6010C

Metals I

Chromium, Total	EPA 6020
	EPA 6020A
Copper, Total	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
Iron, Total	EPA 6010B
	EPA 6010C
Lead, Total	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
	EPA 7010
	EPA 7421
Magnesium, Total	EPA 6010B
	EPA 6010C
Manganese, Total	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
Nickel, Total	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
Potassium, Total	EPA 6010B
	EPA 6010C
Silver, Total	EPA 6010B
	EPA 6010C

Serial No.: 43054

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE
Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES SOLID AND HAZARDOUS WASTE All approved analytes are listed below:

Metals I

Silver, Total	EPA 6020
	EPA 6020A
Sodium, Total	EPA 6010B
	EPA 6010C
Strontium, Total	EPA 6010B
	EPA 6010C

Metals II

Aluminum, Total	EPA 6010B
	EPA 6010C
Antimony, Total	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
Arsenic, Total	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
	EPA 7010
	EPA 7060A
Beryllium, Total	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
Chromium VI	EPA 7196A
	EPA 7199
Lithium, Total	EPA 6010B
	EPA 6010C
Mercury, Total	EPA 7471A

Metals II

Mercury, Total	EPA 7471B
Selenium, Total	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
	EPA 7010
	EPA 7740
Vanadium, Total	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
Zinc, Total	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A

Metals III

Cobalt, Total	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
Molybdenum, Total	EPA 6010B
	EPA 6010C
	EPA 6020
	EPA 6020A
Silica, Dissolved	EPA 6010B
	EPA 6010C
Thallium, Total	EPA 6010B
	EPA 6010C

Serial No.: 43054

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NELAP RECOGNIZED ACCREDITATION BODY

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES SOLID AND HAZARDOUS WASTE All approved analytes are listed below:

Metals III	
Thallium, Total	EPA 6020
	EPA 6020A
	EPA 7010
	EPA 7841
Tin, Total	EPA 6010B
	EPA 6010C
Titanium, Total	EPA 6010C
Minerals	
Bromide	EPA 9056A
Chloride	EPA 9056A
Fluoride, Total	EPA 9056A
Sulfate (as SO4)	EPA 9056A
Miscellaneous	
Boron, Total	EPA 6010B
	EPA 6010C
Cyanide, Total	EPA 9012A
Formaldehyde	EPA 8315
Hydrogen Ion (pH)	EPA 9040B
	EPA 9045C
Perchlorate	EPA 6850
Phenols	EPA 9066
Sulfide (as S)	EPA 9034
Nitroaromatics and Isophorone	
1,3,5-Trinitrobenzene	EPA 8270C
	EPA 8270D
	EPA 8330
1,3-Dinitrobenzene	EPA 8270C

Nitroaromatics and Isophorone	
1,3-Dinitrobenzene	EPA 8270D
	EPA 8330
1,4-Naphthoquinone	EPA 8270C
	EPA 8270D
2,4,6-Trinitrotoluene	EPA 8330
2,4-Dinitrotoluene	EPA 8270C
	EPA 8270D
	EPA 8330
2,6-Dinitrotoluene	EPA 8270C
	EPA 8270D
	EPA 8330
2-Amino-4,6-dinitrotoluene	EPA 8330
2-Nitrotoluene	EPA 8330
3-Nitrotoluene	EPA 8330
4-Amino-2,6-dinitrotoluene	EPA 8330
4-Dimethylaminoazobenzene	EPA 8270C
	EPA 8270D
4-Nitrotoluene	EPA 8330
Hexahydro-1,3,5-trinitro-1,3,5-triazine	EPA 8330
Isophorone	EPA 8270C
	EPA 8270D
Methyl-2,4,6-trinitrophenylnitramine	EPA 8330
Nitrobenzene	EPA 8270C
	EPA 8270D
	EPA 8330
Nitroquinoline-1-oxide	EPA 8270C
	EPA 8270D
Octahydro-tetranitro-tetrazocine	EPA 8330

Serial No.: 43054

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES SOLID AND HAZARDOUS WASTE All approved analytes are listed below:

Nitroaromatics and Isophorone	
Pyridine	EPA 8270C
	EPA 8270D
Nitrosoamines	
N-Nitrosodiethylamine	EPA 8270C
	EPA 8270D
N-Nitrosodimethylamine	EPA 8270C
	EPA 8270D
N-Nitrosodi-n-butylamine	EPA 8270C
	EPA 8270D
N-Nitrosodi-n-propylamine	EPA 8270C
	EPA 8270D
N-Nitrosodiphenylamine	EPA 8270C
	EPA 8270D
N-nitrosomethylethylamine	EPA 8270C
	EPA 8270D
N-nitrosomorpholine	EPA 8270C
	EPA 8270D
N-nitrosopiperidine	EPA 8270C
	EPA 8270D
N-Nitrosopyrrolidine	EPA 8270C
	EPA 8270D
Nutrients	
Nitrate (as N)	EPA 9056A
Nitrite (as N)	EPA 9056A
Organophosphate Pesticides	
Dimethoate	EPA 8270C
	EPA 8270D
Organophosphate Pesticides	
Disulfoton	EPA 8270C
	EPA 8270D
Parathion ethyl	EPA 8270C
	EPA 8270D
Parathion methyl	EPA 8270C
	EPA 8270D
Phorate	EPA 8270C
	EPA 8270D
Sulfotepp	EPA 8270C
	EPA 8270D
Thionazin	EPA 8270C
	EPA 8270D
Petroleum Hydrocarbons	
Diesel Range Organics	EPA 8015 B
	EPA 8015C
Gasoline Range Organics	EPA 8015 B
	EPA 8015C
Phthalate Esters	
Benzyl butyl phthalate	EPA 8270C
	EPA 8270D
Bis(2-ethylhexyl) phthalate	EPA 8270C
	EPA 8270D
Diethyl phthalate	EPA 8270C
	EPA 8270D
Dimethyl phthalate	EPA 8270C
	EPA 8270D
Di-n-butyl phthalate	EPA 8270C

Serial No.: 43054

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES SOLID AND HAZARDOUS WASTE All approved analytes are listed below:

Phthalate Esters	
Di-n-butyl phthalate	EPA 8270D
Di-n-octyl phthalate	EPA 8270C
	EPA 8270D
Polychlorinated Biphenyls	
PCB-1016	EPA 8082
	EPA 8082A
PCB-1221	EPA 8082
	EPA 8082A
PCB-1232	EPA 8082
	EPA 8082A
PCB-1242	EPA 8082
	EPA 8082A
PCB-1248	EPA 8082
	EPA 8082A
PCB-1254	EPA 8082
	EPA 8082A
PCB-1260	EPA 8082
	EPA 8082A
PCB-1262	EPA 8082
	EPA 8082A
PCB-1268	EPA 8082
	EPA 8082A
Polynuclear Aromatic Hydrocarbons	
3-Methylcholanthrene	EPA 8270C
	EPA 8270D
7,12-Dimethylbenzyl (a) anthracene	EPA 8270C
	EPA 8270D

Polynuclear Aromatic Hydrocarbons	
Acenaphthene	EPA 8270C
	EPA 8270D
Acenaphthylene	EPA 8270C
	EPA 8270D
Anthracene	EPA 8270C
	EPA 8270D
Benzo(a)anthracene	EPA 8270C
	EPA 8270D
Benzo(a)pyrene	EPA 8270C
	EPA 8270D
Benzo(b)fluoranthene	EPA 8270C
	EPA 8270D
Benzo(ghi)perylene	EPA 8270C
	EPA 8270D
Benzo(k)fluoranthene	EPA 8270C
	EPA 8270D
Chrysene	EPA 8270C
	EPA 8270D
Dibenzo(a,h)anthracene	EPA 8270C
	EPA 8270D
Fluoranthene	EPA 8270C
	EPA 8270D
Fluorene	EPA 8270C
	EPA 8270D
Indeno(1,2,3-cd)pyrene	EPA 8270C
	EPA 8270D
Naphthalene	EPA 8270C
	EPA 8270D

Serial No.: 43054

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE
Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES SOLID AND HAZARDOUS WASTE All approved analytes are listed below:

Polynuclear Aromatic Hydrocarbons

Phenanthrene	EPA 8270C
	EPA 8270D
Pyrene	EPA 8270C
	EPA 8270D

Priority Pollutant Phenols

2,3,4,6 Tetrachlorophenol	EPA 8270C
	EPA 8270D
2,4,5-Trichlorophenol	EPA 8270C
	EPA 8270D
2,4,6-Trichlorophenol	EPA 8270C
	EPA 8270D
2,4-Dichlorophenol	EPA 8270C
	EPA 8270D
2,4-Dimethylphenol	EPA 8270C
	EPA 8270D
2,4-Dinitrophenol	EPA 8270C
	EPA 8270D
2,6-Dichlorophenol	EPA 8270C
	EPA 8270D
2-Chlorophenol	EPA 8270C
	EPA 8270D
2-Methyl-4,6-dinitrophenol	EPA 8270C
	EPA 8270D
2-Methylphenol	EPA 8270C
	EPA 8270D
2-Nitrophenol	EPA 8270C
	EPA 8270D
3-Methylphenol	EPA 8270C

Priority Pollutant Phenols

3-Methylphenol	EPA 8270D
4-Chloro-3-methylphenol	EPA 8270C
	EPA 8270D
4-Methylphenol	EPA 8270C
	EPA 8270D
4-Nitrophenol	EPA 8270C
	EPA 8270D
Pentachlorophenol	EPA 8151A
	EPA 8270C
	EPA 8270D
Phenol	EPA 8270C
	EPA 8270D

Purgeable Aromatics

1,2,4-Trichlorobenzene, Volatile	EPA 8260B
	EPA 8260C
1,2,4-Trimethylbenzene	EPA 8021B
	EPA 8260B
	EPA 8260C
1,2-Dichlorobenzene	EPA 8260B
	EPA 8260C
1,3,5-Trimethylbenzene	EPA 8021B
	EPA 8260B
	EPA 8260C
1,3-Dichlorobenzene	EPA 8260B
	EPA 8260C
1,4-Dichlorobenzene	EPA 8260B
	EPA 8260C
2-Chlorotoluene	EPA 8260B

Serial No.: 43054

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES SOLID AND HAZARDOUS WASTE All approved analytes are listed below:

Purgeable Aromatics	
2-Chlorotoluene	EPA 8260C
4-Chlorotoluene	EPA 8260B
	EPA 8260C
Benzene	EPA 8021B
	EPA 8260B
	EPA 8260C
Bromobenzene	EPA 8260B
	EPA 8260C
Chlorobenzene	EPA 8021B
	EPA 8260B
	EPA 8260C
Ethyl benzene	EPA 8021B
	EPA 8260B
	EPA 8260C
Isopropylbenzene	EPA 8021B
	EPA 8260B
	EPA 8260C
Naphthalene, Volatile	EPA 8260B
	EPA 8260C
n-Butylbenzene	EPA 8021B
	EPA 8260B
	EPA 8260C
n-Propylbenzene	EPA 8021B
	EPA 8260B
	EPA 8260C
p-Isopropyltoluene (P-Cymene)	EPA 8021B
	EPA 8260B
	EPA 8260C

Purgeable Aromatics	
sec-Butylbenzene	EPA 8021B
	EPA 8260B
	EPA 8260C
Styrene	EPA 8260B
	EPA 8260C
tert-Butylbenzene	EPA 8021B
	EPA 8260B
	EPA 8260C
Toluene	EPA 8021B
	EPA 8260B
	EPA 8260C
Total Xylenes	EPA 8021B
	EPA 8260B
	EPA 8260C

Purgeable Halocarbons	
1,1,1,2-Tetrachloroethane	EPA 8260B
	EPA 8260C
1,1,1-Trichloroethane	EPA 8260B
	EPA 8260C
1,1,2,2-Tetrachloroethane	EPA 8260B
	EPA 8260C
1,1,2-Trichloro-1,2,2-Trifluoroethane	EPA 8260B
	EPA 8260C
1,1,2-Trichloroethane	EPA 8260B
	EPA 8260C
1,1-Dichloroethane	EPA 8260B
	EPA 8260C
1,1-Dichloroethene	EPA 8260B

Serial No.: 43054

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES SOLID AND HAZARDOUS WASTE All approved analytes are listed below:

Purgeable Halocarbons	
1,1-Dichloroethene	EPA 8260C
1,1-Dichloropropene	EPA 8260B
	EPA 8260C
1,2,3-Trichloropropane	EPA 8260B
	EPA 8260C
1,2-Dibromo-3-chloropropane	EPA 8260B
	EPA 8260C
1,2-Dibromoethane	EPA 8260B
	EPA 8260C
1,2-Dichloroethane	EPA 8260B
	EPA 8260C
1,2-Dichloropropane	EPA 8260B
	EPA 8260C
1,3-Dichloropropane	EPA 8260B
	EPA 8260C
2,2-Dichloropropane	EPA 8260B
	EPA 8260C
2-Chloro-1,3-butadiene (Chloroprene)	EPA 8260B
	EPA 8260C
2-Chloroethylvinyl ether	EPA 8260B
	EPA 8260C
3-Chloropropene (Allyl chloride)	EPA 8260B
	EPA 8260C
Bromochloromethane	EPA 8260B
	EPA 8260C
Bromodichloromethane	EPA 8260B
	EPA 8260C
Bromoform	EPA 8260B

Purgeable Halocarbons	
Bromoform	EPA 8260C
Bromomethane	EPA 8260B
	EPA 8260C
Carbon tetrachloride	EPA 8260B
	EPA 8260C
Chloroethane	EPA 8260B
	EPA 8260C
Chloroform	EPA 8260B
	EPA 8260C
Chloromethane	EPA 8260B
	EPA 8260C
cis-1,2-Dichloroethene	EPA 8260B
	EPA 8260C
cis-1,3-Dichloropropene	EPA 8260B
	EPA 8260C
Dibromochloromethane	EPA 8260B
	EPA 8260C
Dibromomethane	EPA 8260B
	EPA 8260C
Dichlorodifluoromethane	EPA 8260B
	EPA 8260C
Hexachlorobutadiene, Volatile	EPA 8260B
	EPA 8260C
Methylene chloride	EPA 8260B
	EPA 8260C
Tetrachloroethene	EPA 8260B
	EPA 8260C
trans-1,2-Dichloroethene	EPA 8260B

Serial No.: 43054

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE
Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES SOLID AND HAZARDOUS WASTE
All approved analytes are listed below:

Purgeable Halocarbons

trans-1,2-Dichloroethene	EPA 8260C
trans-1,3-Dichloropropene	EPA 8260B
	EPA 8260C
trans-1,4-Dichloro-2-butene	EPA 8260B
	EPA 8260C
Trichloroethene	EPA 8260B
	EPA 8260C
Trichlorofluoromethane	EPA 8260B
	EPA 8260C
Vinyl chloride	EPA 8260B
	EPA 8260C

Purgeable Organics

1,4-Dioxane	EPA 8260B
	EPA 8260C
2-Butanone (Methylethyl ketone)	EPA 8260B
	EPA 8260C
2-Hexanone	EPA 8260B
	EPA 8260C
4-Methyl-2-Pentanone	EPA 8260B
	EPA 8260C
Acetone	EPA 8260B
	EPA 8260C
Acetonitrile	EPA 8260B
	EPA 8260C
Carbon Disulfide	EPA 8260B
	EPA 8260C
Cyclohexane	EPA 8260B
	EPA 8260C

Purgeable Organics

Ethyl Acetate	EPA 8260B
	EPA 8260C
Ethylene Glycol	EPA 8015 B
	EPA 8015C
Isobutyl alcohol	EPA 8260B
	EPA 8260C
Methyl acetate	EPA 8260B
	EPA 8260C
Methyl cyclohexane	EPA 8260B
	EPA 8260C
Methyl tert-butyl ether	EPA 8021B
	EPA 8260B
	EPA 8260C
o-Toluidine	EPA 8260B
	EPA 8260C
	EPA 8270C
	EPA 8270D
Propionitrile	EPA 8260B
	EPA 8260C
tert-butyl alcohol	EPA 8260B
	EPA 8260C
Vinyl acetate	EPA 8260B
	EPA 8260C

Semi-Volatile Organics

1,1'-Biphenyl	EPA 8270C
	EPA 8270D
1,2-Dichlorobenzene, Semi-volatile	EPA 8270C
	EPA 8270D

Serial No.: 43054

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NELAP RECOGNIZED TNI ACCREDITATION BODY

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE
Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES SOLID AND HAZARDOUS WASTE All approved analytes are listed below:

Semi-Volatile Organics

1,3-Dichlorobenzene, Semi-volatile	EPA 8270C
	EPA 8270D
1,4-Dichlorobenzene, Semi-volatile	EPA 8270C
	EPA 8270D
2-Methylnaphthalene	EPA 8270C
	EPA 8270D
4-Amino biphenyl	EPA 8270C
	EPA 8270D
Acetophenone	EPA 8270C
	EPA 8270D
Aramite	EPA 8270C
	EPA 8270D
Benzaldehyde	EPA 8270C
	EPA 8270D
Benzoic Acid	EPA 8270C
	EPA 8270D
Benzyl alcohol	EPA 8270C
	EPA 8270D
Caprolactam	EPA 8270C
	EPA 8270D
Dibenzofuran	EPA 8270C
	EPA 8270D
Ethyl methanesulfonate	EPA 8270C
	EPA 8270D
Isosafrole	EPA 8270C
	EPA 8270D
Methyl methanesulfonate	EPA 8270C
	EPA 8270D

Semi-Volatile Organics

O,O,O-Triethyl phosphorothioate	EPA 8270C
	EPA 8270D
Phenacetin	EPA 8270C
	EPA 8270D
Safrole	EPA 8270C
	EPA 8270D

Sample Preparation Methods

EPA 1311
EPA 1312
EPA 3050B
EPA 3060A
EPA 3540C
EPA 3541
EPA 3550B
EPA 3550C
EPA 5030B
EPA 5035
EPA 9030B

Serial No.: 43054

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

NELAP RECOGNIZED ACCREDITATION BODY

Page 13 of 13

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010
Revised October 05, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE
Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory for the category
ENVIRONMENTAL ANALYSES SOLID AND HAZARDOUS WASTE
All approved subcategories and/or analytes are listed below:

Miscellaneous

Lead in Dust Wipes	EPA 6010B

Sample Preparation Methods

EPA 3050B

Serial No.: 43055

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

Page 1 of 1

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES AIR AND EMISSIONS
All approved analytes are listed below:

Acrylates	
Acrylonitrile	EPA TO-15
Ethyl acrylate	EPA TO-15
Methyl methacrylate	EPA TO-15
Chlorinated Hydrocarbons	
1,2,4-Trichlorobenzene	EPA TO-15
Hexachlorobutadiene	EPA TO-15
Metals I	
Lead, Total	EPA 200.7 Rev. 4.4
Miscellaneous Air	
Sulfuric Acid	40 CFR 60 METH 8
Purgeable Aromatics	
1,2,4-Trimethylbenzene	EPA TO-15
1,2-Dichlorobenzene	EPA TO-15
1,3,5-Trimethylbenzene	EPA TO-15
1,3-Dichlorobenzene	EPA TO-15
1,4-Dichlorobenzene	EPA TO-15
Benzene	EPA TO-15
Chlorobenzene	EPA TO-15
Ethyl benzene	EPA TO-15
m/p-Xylenes	EPA TO-15
o-Xylene	EPA TO-15
Styrene	EPA TO-15
Toluene	EPA TO-15
Total Xylenes	EPA TO-15
Purgeable Halocarbons	
1,1,1-Trichloroethane	EPA TO-15
1,1,2,2-Tetrachloroethane	EPA TO-15
1,1,2-Trichloroethane	EPA TO-15
1,1,2-Trifluoro-1,2,2-Trichloroethane	EPA TO-15
1,1-Dichloroethane	EPA TO-15
1,1-Dichloroethene	EPA TO-15
1,2-Dibromoethane	EPA TO-15
1,2-Dichloro-1,1,2,2-tetrafluoroethane	EPA TO-15
1,2-Dichloroethane	EPA TO-15
1,2-Dichloropropane	EPA TO-15
Bromodichloromethane	EPA TO-15
Bromoform	EPA TO-15
Bromomethane	EPA TO-15
Carbon tetrachloride	EPA TO-15
Chloroethane	EPA TO-15
Chloroform	EPA TO-15
Chloromethane	EPA TO-15
cis-1,2-Dichloroethene	EPA TO-15
cis-1,3-Dichloropropene	EPA TO-15
Dibromochloromethane	EPA TO-15
Dichlorodifluoromethane	EPA TO-15
Methylene chloride	EPA TO-15
Tetrachloroethene	EPA TO-15
trans-1,2-Dichloroethene	EPA TO-15
trans-1,3-Dichloropropene	EPA TO-15
Trichloroethene	EPA TO-15
Trichlorofluoromethane	EPA TO-15
Vinyl chloride	EPA TO-15

Serial No.: 41185

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

Page 1 of 2

NELAP Recognized

NON-CONTROLLED COPY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER
RICHARD F. DAINES, M.D.

Expires 12:01 AM April 01, 2011
Issued April 01, 2010

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE
Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL PERRY
COLUMBIA ANALYTICAL SERVICES
1 MUSTARD ST - STE 250
ROCHESTER, NY 14609

NY Lab Id No: 10145
EPA Lab Code: NY00032

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards for the category ENVIRONMENTAL ANALYSES AIR AND EMISSIONS
All approved analytes are listed below:

Volatile Chlorinated Organics	
Benzyl chloride	EPA TO-15
Volatile Organics	
1,3-Butadiene	EPA TO-15
2,2,4-Trimethylpentane	EPA TO-15
2-Butanone (Methylethyl ketone)	EPA TO-15
4-Methyl-2-Pentanone	EPA TO-15
Acetone	EPA TO-15
Carbon Disulfide	EPA TO-15
Cyclohexane	EPA TO-15
Hexane	EPA TO-15
Methyl iodide	EPA TO-15
Methyl tert-butyl ether	EPA TO-15
n-Heptane	EPA TO-15
Vinyl acetate	EPA TO-15

Serial No.: 41185

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

Page 2 of 2

NELAP Recognized

Analytical Resources Inc. Quality Assurance Plan

Analytical Resources, Incorporated
Analytical Chemists and Consultants

Quality Assurance Plan

Analytical Resources, Inc.
4611 S. 134th Place, Suite 100
Tukwila, WA 98168-3240

Revision 013-000
8/17/09

Uncontrolled Copy

A web page is configured to inform you if this is the most recent version of ARI's LQAP. Click on the link or type the URL into your web browser. No web access? Phone 206-695-6200

http://arilabs.com/cgi-bin/rcheck.cgi?f=LQAP&r=R13000

This Quality Assurance Plan is approved and authorized for release by:

Mark Weidner
Laboratory Technical Director

Brian N. Bebee
Organic Analysis Section Technical Director

Jay Kuhn
Inorganic Analysis Section Technical Director

David Mitchell
Quality Assurance Manager

Analytical Resources, Incorporated
Analytical Chemists and Consultants

Quality Assurance Plan

Analytical Resources Inc.

Table of Contents:

Section 01:	Introduction	Page 04
Section 02:	QA Management and Responsibility	Page 09
Section 03:	Personnel Training	Page 22
Section 04:	Facilities, Equipment and Instrumentation	Page 24
Section 05:	Laboratory Documentation and Records	Page 31
Section 06:	Sample Control	Page 38
Section 07:	Project Management and Tracking	Page 48
Section 08:	Analytical Methods	Page 51
Section 09	Instrument Control	Page 55
Section 10:	Data Validation and Review	Page 66
Section 11:	Quality Control	Page 71
Section 12:	Corrective Actions	Page 78
Section 13:	Laboratory Evaluation and Audits	Page 89
Section 14:	Appendices	Page 94

A – Personnel and Organization *Page 95*
B – Training *Page 101*
C – Laboratory Facilities *Page 104*
D –Laboratory Instrumentation *Page 107*
E – Standard Operating Procedures *Page 113*
F – Sample Containers and Preservatives *Page 114*
G – Laboratory Workflow *Page 115*
H – Analytical methods *Page 117*
I – Method Detection Limits and Reporting Limits *Page 122*
J – Quality Control Recovery Limits *Page 123*
K – Internal Audit Schedule *Page 124*
L – Certifications and Accreditations *Page 126*
M – Data Reporting Qualifiers *Page 128*
N – Personal Conduct Statement *Page 131*
O – Quality Assurance Policies *Page 134*
P – Modification to ARI's LQAP *Page 148*

SECTION 1: INTRODUCTION

Quality Assurance Policy and Objectives

Analytical Resources, Inc. (ARI) is dedicated to providing accurate and reliable data in a timely and cost effective manner. The management of ARI is committed to analytical excellence and will provide the facilities and a professional environment to achieve this goal. The quality assurance program detailed in this document sets forth the policies and procedures that are followed by ARI to ensure that all reported results are both legally defensible and of the highest quality.

To ensure that data quality goals are achieved, the following characteristics must be considered:

Precision, Bias and Accuracy

For all analyses, there is a degree of uncertainty or error in the measurement process. This measurement error is generally one of two types: random error (precision) or systematic error (bias). Precision is a measure of agreement between replicate measurements. Bias is considered to be the difference between the expected value and the true value for a measurement or series of measurements. Accuracy is a determination of how closely a measurement is to the expected value. Both precision and bias are considered when determining the accuracy of measurements. Precision, bias and accuracy are evaluated through the use of method guidelines, and project and laboratory control limits.

Representativeness

Representativeness is an indicator of how closely one sample aliquot resembles another aliquot from the same bulk source or sample site. Sample representativeness is more easily obtained for particulate-free water samples than for solid samples or viscous liquids. Representativeness is an important consideration in achieving other data quality objectives.

Completeness

Completeness is an indicator of the number of valid (useable) data points compared with the overall number of data points obtained. Valid data are normally obtained when sample collection and analysis is performed in accordance with specified methods and procedures. Completeness is often expressed as a percentage: the higher the number of valid data points, the higher the overall completeness percentage. Conversely, fewer valid data points will result in an overall lower percentage of completeness. Project specifications will dictate the required level of completeness.

Comparability

Comparability is an indicator of how confidently one data set can be compared with another, as well as the consistency between data sets. Stable analytical conditions and adherence to standard procedures, combined with high levels of accuracy; help ensure that results obtained over a period of time will be comparable.

Timeliness

To ensure that the most accurate results possible are obtained, samples must be processed within specified time periods. Analytical holding times have been established to allow sufficient time for sample processing without compromising sample integrity. It is important that, while meeting timeliness requirements, other data quality objectives are still considered and met.

Documentation

Complete and accurate documentation is essential for verifying the integrity of analytical results. Achievement of other quality objectives cannot be used to substantiate data quality without full documentation of the analytical process. Documentation must be concise and readily available for subsequent review.

The quality assurance program at ARI has been developed to ensure that the specified data quality objectives are met for all reported results and the highest degree of completeness possible is achieved.

1.2 Ethics Policy on Data Quality and Confidentiality

To ensure that data quality or confidentiality is not compromised, ARI has established the following policy on corporate ethics. These steps must be taken when the quality or confidentiality of data is suspected or known to be compromised. This policy applies to all ARI employees at every organizational level.

General

ARI's corporate commitment to integrity and honesty in the workplace is clearly stated in the ARI Employee's Handbook, under "Standards of Conduct". The Standards of Conduct statement is attached as Appendix O. The ARI commitment to excellence in data quality extends to and includes all aspects of data production, review and reporting.

Any attempt by management or any employee to compromise this commitment presents a case for serious disciplinary action. Any indications or allegations of waste, fraud or abuse will be rigorously investigated by ARI management, with the penalties for verified cases to be employment termination, and if appropriate, prosecution. In addition to these steps, any such

charges related to data generated for the federal government will also be reported to the Inspector General of the appropriate department.

Circumstances

All ARI employees will immediately report to management any information concerning the misrepresentation or possible misrepresentation of analytical data (or any associated components).

Misrepresentation of data includes (but is not limited to) the following:

Altering an instrument, computer or clock to falsify time or output
Altering the content of a logbook or data sheet in order to misrepresent data
Falsifying analyst identity
Changing documents with correction fluid with the intent of falsifying information
Preparing or submitting counterfeit data packages or reports
Unauthorized release (either written or verbal) of confidential data
Illegal calibration techniques (peak shaving, fraudulent integrator parameters)
Any attempt to misrepresent data or events as they actually occur in the course of data production or reporting

Responsibilities

It is the responsibility of all ARI employees to report any situation which may be adverse to data quality or confidentiality, or which may impact the final data quality. All ARI employees have the obligation to discuss known or suspected violations of this policy with laboratory management, who in turn are obliged to inform the ARI Laboratory Manager. If a satisfactory resolution is not obtained or is not possible at laboratory level, all ARI employees have the right and responsibility to discuss the matter directly with the ARI Laboratory Manager.

It is the responsibility of the ARI Laboratory Manager to promptly investigate any reports of known or suspected violations. The ARI Laboratory Manager has the authority and responsibility to resolve all known or potential violations of the policy.

It is the responsibility of ARI management to provide all of its employees with the facilities, equipment, and training to achieve the quality goals stated in the policy. It is the responsibility of ARI to provide our clients with data of known and documented quality.

Documentation

To reaffirm an awareness of and commitment to the highest standards of data quality, excellence, and integrity, all employees are required to sign the following "Commitment to Excellence in Data Quality" statement:

"As an ARI employee, I have the right and responsibility to report any situation which may be adverse to quality or which may impact the final quality or integrity of data produced for our clients."

"I will report immediately to management any information concerning the misrepresentation or possible misrepresentation of analytical data (or any of its associated components). Examples of this include (but are not limited to): alteration of an instrument computer or clock, alteration of the contents of logbooks and/or data sheets in order to misrepresent data, misrepresentation of analyst identity, intentional falsification of documents with correction fluid ("white-out"), preparation and submittal of counterfeit data packages, use of illegal calibration techniques (peak shaving, use of fraudulent integrator parameters, etc.), or any attempt to misrepresent data or events as they actually occur in the course of an analysis."

"I will likewise alert management of any situation or activity which may be adverse to the confidentiality of clients' data."

"I will not knowingly participate in any such activity, nor fail to report such activities of which I may become aware. I understand that any voluntary participation on my part in such activities may result in the termination of my employment, and possible legal prosecution."

"Where circumstances permit, I will report any actual or suspected violations of this policy to my lab or section supervisor. If a satisfactory resolution is not obtained or is not possible at that level, I have the right and obligation to discuss the matter directly with the ARI Laboratory Manager."

Confidentiality

All information related to client projects, such as client work plans, documentation and analytical data will be considered confidential. This information will be released only to the

client or an authorized representative. Should an outside agency request information related to a client project, the client will be contacted for approval prior to releasing any information.

Some programs or contractual agreements (such as the USEPA Contract Laboratory Program) may have specific requirements for protecting a client's confidentiality Project Managers will be responsible for strict control of access to any such confidential information or documentation. All data generated from the analysis of confidential samples will also be considered confidential.

SECTION 2.0: QA MANAGEMENT AND RESPONSIBILITIES

The principal tenet of the Quality Assurance Program at Analytical Resources Inc. (ARI) is that every employee knows she/he is a vital component of the program, and holds a responsibility to produce high-quality, defensible data in a timely manner. While production of quality data is a global philosophy, held by the entire laboratory, each section is responsible for ensuring that the data produced within that section meets the required quality objectives.

2.1 Overall Structure

The Board of Directors shall direct ARI's QA Policy and shall determine the Philosophy of the QA Program. It shall be the responsibility of the Laboratory Director to translate this policy into practical procedures with respect to the business plan developed for ARI, and direct the Laboratory Manager and Section Managers regarding the incorporation of these procedures into daily laboratory activities.

The Laboratory Manager is responsible for coordination of laboratory activities to result in an integrated approach to quality data production. The Laboratory Manager will coordinate Client Services, Laboratory Section Management, Computer Services, and Data Services to ensure that project requirements and data quality objectives are met.

The Laboratory Section Managers and Supervisors shall hold the final authority in decisions concerning implementation of QA policy, with the contributions of the Laboratory Director, Laboratory Manager, QA Manager and Project Managers. Section Managers and Section Supervisors shall instruct employees in the proper employment of QA policies.

Each Section Supervisor will ensure that analyses are completed within required holding times, that data is submitted within required submission times, and all analyses are performed according to the current Standard Operating Procedures (SOPs). They will ensure that any client modifications or QA issues are well documented for each sample set and that all required documents are complete when submitted with each data set.

The analytical staff shall execute all methods following QA policies, and will write SOPs reflecting the methods exactly as performed. These SOPs will be reviewed for compliance by Section Managers and the Laboratory Director, and once approved will be submitted to the Quality Assurance Program Manager (QAPM).

The QAPM will be responsible for controlling Company SOPs and other internal documents, overseeing the scheduling and completion of detection limit studies. The QAPM will coordinate the production of control charts and distribution of control limit data to all laboratory sections. The QAPM will administer the blind QA proficiency tests and performance samples as described in the QA Program. The QAPM will verify that QA policies and procedures are followed through out ARI.

Data reviewers will be responsible for ensuring that all samples have been analyzed by the approved and requested methods, that data calculations are performed correctly, and that analyses meet the Data Quality Objectives of the client. They shall also be responsible for ensuring that the documentation from each laboratory section is intact and complete.

Computer Services is responsible for ensuring that the Laboratory Information Management System (LIMS) correctly reflects the preparations and analyses performed and that the LIMS is updated with the current SOP, MDL, RL and QL data as submitted from the QAPM. Computer Services personnel are also responsible for ensuring that all electronic deliverables for clients are formatted correctly as requested by the Project Managers and that this data matches the hardcopy deliverables submitted.

Client Services (Project Management, Sample Receiving), shall be responsible for ensuring that the laboratories understand and can meet project specific analytical requirements and DQO.

2.2 Hierarchical Responsibilities

Technical Director

> *It shall be the responsibility of the Laboratory Director to translate QA policy into practical procedures with respect to ARI's business plan, and to direct the Laboratory Manager and Section Managers in the implementation of these procedures in daily laboratory activities.*

The Director shall interpret overall QA Policy, and determine the broad practicality of policies based on methodologies, technological advances, and the current environmental market. It shall be the interpretation of these policies that will, in turn, direct the growth ARI, the addition or withdrawal of methods to ARI's repertoire, and ARI's marketing focus.

At a minimum of once a year the Technical Director shall include on the agenda of the Board of Directors meeting a discussion of ARI′s QA Policy. This discussion will include the reputation of ARI for producing quality analyses, the affect of QA policies on turn-around time, competitive edge and cost-of-analysis, needs for stricter or more flexible policies, and the response of employees to the QA policies in place at that time.

At a minimum of once every six months the Director shall attend management meetings, which include on the agenda the subject 'QA Program'. This format will allow for the dissemination of information on any QA issues addressed in the laboratory or by the Board of Directors. Management shall also use these meetings to discuss requirements of clients that are not met by ARI′s present QA Program, and the appropriate response to these requirements.

The Technical Director may be required to act as a technical advisor at any impromptu meetings called by management to address QA issues that cannot be immediately resolved within a laboratory section.

It shall also be the Director's authority and responsibility to hold final review approval for all SOPs of ARI. Once an SOP has been updated and reviewed by the laboratory section, it shall go through the Section and Laboratory Managers for approval, and then to the Laboratory Director for final approval before the SOP is released.

Laboratory Manager

> *The Laboratory Manager is responsible for coordination of laboratory activities to result in an integrated approach to quality data production. It shall be the Laboratory Manager's responsibility to coordinate Client Services, Laboratory Management, Computer Services, and Data Services to ensure that QA Program requirements and data quality objectives are met.*

The Laboratory Manager is required to attend all management meetings, at which the QA Program will be an agenda item. Management shall use these meetings to discuss requirements of clients that are not met by ARI′s present QA Program, the appropriate response to these requirements, and dissemination of information on any QA issues addressed in the laboratory or by the Board of Directors.

It is the responsibility of the Laboratory Manager, along with the QA Manager, Laboratory Director, Section Managers and Client Services, to determine in which QA Proficiency

Programs the Laboratory will participate, and those accreditations that ARI will pursue. It is the responsibility of the Laboratory Manager, with the Section Managers, to ensure that all laboratory sections perform the tasks required by the QA Manager to pursue each accreditation or to complete a scheduled audit.

The Laboratory Manager has the authority to direct Client Services to discontinue the bidding/contracting process for a new project, refuse samples, or to re-schedule projects based on Data Quality Objectives or current workload. The Laboratory Manager also shall evaluate staffing and equipment needs based on information from the Section Managers and Client Services and may elect to meet new project requirements by increasing staffing levels or purchasing additional equipment.

The Laboratory Manager serves as a senior-level technical reference for all laboratory activities, and as such will be brought in to advise on out-of-control events and trends, corrective actions, and/or other QA issues that require his/her expertise.

Laboratory Section Managers

> *The Section Managers shall hold the final authority in decisions concerning implementation of QA policy, with the contributions of the Laboratory Director, Laboratory Manager, QAPM and Project Managers. Section Managers are responsible for correcting out of control events within their respective laboratories. Section Managers and supervisors shall instruct employees in the proper employment of QA Policies.*

Laboratory Sections Managers shall have the final authority in decisions concerning QA policy. It is their expertise that will determine the final acceptable format of each method SOP, as they are the best resource to integrate methods into ARI′s philosophy.

Laboratory Section Managers are responsible for completing or delegating updates of laboratory procedures and quality assurance manual sections as scheduled by the QA Manager.

The Section Managers are best able to determine capacity of the Laboratory Sections. To ensure that analyses are completed within required hold times, the Section Managers will give Supervisors the authority to balance employee workloads and modify employee work schedules. It is the Section Manager's responsibility to take reports from supervisors and work

with the Laboratory Manager to increase staffing levels or reject samples as needed. It is the Section Manager's responsibility to work with the Laboratory Manager and the section supervisor and analysts to ensure that sample capacity does not affect the quality of data generated from that laboratory section.

It is the responsibility of the Laboratory Section Managers, along with the QA Manager, Laboratory Director, Laboratory Manager and Client Services, to determine in which QA Proficiency Programs the Laboratory will participate, and which accreditation processes ARI will pursue. It is the responsibility of the Section Managers, with the Section Supervisors, to ensure that all laboratory sections perform the tasks required by the QA Manager to pursue each accreditation or to complete a scheduled audit.

The Section Manager will be responsible for reviewing training records of analysts produced by the Section Supervisor. Training shall be the responsibility of the Section Supervisor, but it is the responsibility of the Section Manager to oversee this training.

It is the Section Managers' responsibility to work with the Section Supervisor and Project Manager to assure that Project Requirements are achievable and valid for the given methods. At times, ARI′s clients have requests or requirements for methods that are 1) not the method of choice in the laboratory, 2) not presently performed by the laboratory, or 3) unachievable by the instrumentation used in the laboratory. It is the responsibility of the Section Supervisor, Section Manager and Project Manager to work with the client to resolve these issues before samples are accepted.

Clients may also request modifications to the methods that must be approved by the Section Supervisor, the Section Manager and the QAPM. These modifications must be thoroughly documented and all pertinent information on modifications must be conveyed to the analysts, sample preparation sections, sample receiving, and computer services, as needed for implementation.

The Section Manager is responsible for resolution of out-of-control events that have not or cannot be resolved by the analysts or Section Supervisor.

The Section Manager has the authority to re-classify analysts or require additional training of analysts based on their performance.

The Section Manager has the responsibility of balancing client requests and requirements with the QA policies of ARI. It is the Section Manager's task to evaluate a client's Data Quality Objectives (submitted through Client Services), and with the Project Managers, Laboratory Supervisors and Quality Assurance Manager to determine the feasibility of laboratory performance. Feasibility will be based on the quality objectives requested, current QA Manual, present workload (in-house and scheduled/pending), the technology in place, and staffing levels available. Current workload in-house will be evaluated using reports from Computer Services, and scheduled/pending workload will be evaluated using written and verbal input from Client Services.

Section Supervisors

> *It is the responsibility of each section Supervisor to ensure that analyses are completed following the most current version of ARI's SOP, within required holding and turn around times, and assure that analyses meet the Data Quality Objectives of each project. They will ensure that any client modifications or QA issues are well documented for each sample set, and that all documentation is complete when submitted with each data set.*

To ensure that analyses are completed within required hold times, the Supervisors have the authority to balance employee workloads and modify employee work schedules. The Section Supervisors, with the input of the Section Manager, have the authority to request overtime from employees should the workload warrant the additional effort, or to modify employee schedules to extend the operating hours of the laboratory section.

The Section Supervisors shall oversee the day-to-day section operations, using LIMS printouts and verbal or written workload estimates and requests from Project Managers to adjust section efforts as needed. It is also the Section Supervisors' responsibility to inform management (Section Manager, Data Review, and Project Managers), when capacities are limited, so that the appropriate adjustments can be made to reduce workloads or increase laboratory capacities. At no time should sample capacity be allowed to affect the quality of data generated from any laboratory section.

It is the Section Supervisor's responsibility to assure that employees have the proper training for their positions. This training will include training in the methods, use of the LIMS system if applicable, training in correct documentation procedures, and all information necessary for

adherence to the ARI QA Program. The Supervisor shall either perform the training personally, or designate the trainer for given methods or procedures. It is the Supervisor's responsibility to test each employee for each method or procedure, and to thoroughly document each employee's advances and current capabilities. The Supervisor shall have the authority to require further training or supervision for any employee, and shall be the authority to approve each employee for working without supervision. There will be a training record for each employee. These will be kept in the laboratory section; copies will be submitted to the QA Manager for record keeping.

It is the Supervisor's responsibility to work with the Section Manager and Project Manager to ensure that Project Requirements are achievable and valid for the given methods. At times clients have requests and/or requirements for methods that are 1) not the method of choice in the laboratory, 2) not presently part of the method as performed by the laboratory, or 3) unachievable by the instruments used in the laboratory. It is the responsibility of the Supervisor, Section Manager and Project Manager to work with the client to resolve these issues before samples are accepted.

It is the responsibility of the Section Supervisor to ensure that each analyst reads and understands all requirements submitted with each sample set, including those for any special analyte, calibration, or data deliverable. It is the Section Supervisor’s responsibility to clarify any issues, with the input of the Section Manager and the Project Manager for the client.

Clients also at times will request modifications to methods, which must be approved by the Supervisor and Section Manager. These modifications must be thoroughly documented and all pertinent information on modifications must be conveyed to the analysts, sample preparation sections, sample receiving, and computer services as needed for implementation.

It is the Supervisor's responsibility to ensure that each employee understands the requirements of all projects they work with. This may necessitate section meetings or project-specific cross-section teams to work with Project Managers for large, specialty projects to ensure that everyone has the same understanding of project requirements.

The Supervisor is responsible for resolution of out-of-control events that have not or cannot be resolved by the analysts, and for ensuring that the analysts complete all documentation. If the

Supervisor and laboratory section analysts cannot resolve the issues in a timely manner, the Supervisor's will request the assistance of laboratory management to bring the section into compliance. The Supervisor will also inform Project Management and his/her Section Manager of possible delays, and inform Data Review of possible time constraints they may face in preparation of data submissions from the lab section.

The Section Supervisors shall have the authority, usually in consultation with Laboratory or Project Management to use professional judgment in requiring samples be re-prepared, and shall determine which analysts have the authority to require re-preparation of samples.

It is the responsibility of the Section Supervisor to inform the QAPM, Section Manager and the Computer Services section of any changes in methodologies that will require revision of SOPs, MDLs, Control Limits or the LIMS programming. This includes changes in spiking compounds, spiking levels, preparation methods and analytical methods.

Analysts

> *The analytical staff shall execute all methods following QA Policies, and will write SOPs reflecting the methods exactly as performed. These SOPs will be reviewed for compliance by Section Managers, the Laboratory Manager, and the Laboratory Director, and once approved will be submitted to the QA Manager.*

The analysts are responsible for following the current SOPs (with project-specific modifications if required) in preparing and analyzing client samples and quality control samples to meet the project specific Data Quality Objectives. It is the analyst's responsibility to ensure that he/she understands all requirements of a project before proceeding with sample preparation or analysis.

Analysts are responsible for working with the Supervisor to ensure that all sample preparations and analyses are performed within required holding times and required turn-around times, and that all documentation is completed in a timely fashion. It is each analyst's responsibility to bring any recurrent or anticipated problems to the attention of laboratory management.

It is each analyst's responsibility to correct his/her own errors, to document corrective actions thoroughly, to perform peer review, and to ensure that fellow employees within the section follow documentation procedures.

The Section Supervisor may give lead analysts responsibility for training and evaluation of new staff members. This training will include instruction in the methods, use of the LIMS system if applicable, correct documentation procedures, and all information necessary for adherence to the ARI QA Program. Analysts will be responsible for maintaining all instruments and equipment in optimum operating condition and documenting this maintenance as required by the QA Program.

It is the responsibility of each analyst to request the assistance of Supervisors or Managers in resolving out-of-control situations that cannot be corrected in a timely manner, and to perform the documentation of all corrective action activities.

Quality Assurance Program Manager (QAPM)

> *The QAPM will be responsible for controlling Company SOPs and other internal documents. The QAPM will oversee the scheduling and completion of detection limit studies and control charts. The QAPM will administer the training program, analyst's proficiency documentation and performance evaluation analyses as described in the QA Program. The QAPM will verify that QA policies and procedures are followed at all levels in the Company. The QAPM will produce a "Quality Assurance report to Management" each calendar year.*

The QAPM is responsible for the oversight of the QA Program as defined by the Board of Directors and interpreted by the Laboratory Director and Laboratory Managers.

Part of this oversight will be monitoring of the QA Program through submission of performance evaluation samples, blind QA samples and double-blind QA samples. It is the responsibility of the QAPM, along with the Laboratory Manager, Laboratory Director, Section Managers and Client Services, to determine in which QA Proficiency Programs the Laboratory will participate. The QAPM will be responsible for submitting these samples to the laboratory for analysis, overseeing submission of the results to the appropriate agencies, and for control of documented proficiency results.

The QAPM will be responsible for scheduling laboratory section SOP and procedural reviews and revisions, and section updates of the Quality Assurance Manual. It is the responsibility of the QAPM to work with each Section Manager to attempt to stagger these review schedules across the year within each laboratory section. The QAPM will also be responsible for

maintaining document control of all SOPs, bench sheets, logbooks, and other forms used within the laboratory.

All laboratory sections, on an annual basis, will perform detection limit studies for each method used within each section. It is the responsibility of the QAPM to schedule, review, compile, and distribute the results of these studies.

The QAPM is responsible for evaluation of the laboratories' adherence to defined protocols through periodic audits of completed projects and of the laboratory facilities. Following the audit schedule (Appendix K), the QA Manager will perform the scheduled audit and prepare an evaluation that will be submitted to the Board of Directors in the Annual QA Report to Management.

The QAPM will be responsible for evaluation of outside accreditation requested by Client Services. The QA Manager will deliberate with the Laboratory Managers and Laboratory Director on the feasibility of pursuing accreditation based on the scope of the accreditation, the effort required to pursue accreditation and the scope of work that might become available once the accreditation is obtained. If a decision is made to pursue an accreditation, it is the responsibility of the QAPM to coordinate laboratory efforts towards the accreditation.

The QAPM will produce an annual "Quality Assurance Report to Management" to be distributed to ARI management personnel as described in Section 13 of this LQAP.

The QAPM will serve as a resource for quality-related issues for all Laboratory Sections, and will serve management in an advisory capacity.

The QAPM will have documented training in elementary statistics and Quality Systems theory.

Data Reviewers

> *Data reviewers will be responsible for ensuring that all samples have been analyzed by the approved and requested methods, that data calculations are performed correctly, and that analyses meet the Data Quality Objectives of the client. They shall also be responsible for ensuring that the documentation from each laboratory section is intact and complete.*

Data reviewers shall ensure that all samples are analyzed according to approved methods by reviewing the data released by each laboratory section. The data will be evaluated for compliance with all Data Quality Objectives as defined in the method SOP or in the project-

specific quality assurance plan, including instrument tuning and calibration, holding time, spiking level, and spiking recovery criteria. Data reviewers will also verify 100% of manual calculations, spot check computer calculations, check electronic data for correct sample matching, and do a 100% check on any manually entered data. Analytical parameters, which have concentration interdependence, will be evaluated in relationship to each other.

Final reports generated will be evaluated to ensure that laboratories are using the current detection limit/reporting limit values and the current control limits. Data will be checked to ensure that all QA issues are addressed and fully documented. Reviewers are responsible for working with Laboratory Supervisors, Laboratory Managers and Project Managers when out-of-control events are incompletely documented, or if data is found to not meet Data Quality Objectives of a project without documentation.

It is the responsibility of data reviewers, the QAPM and section supervisors to work with Computer Services to ensure that the LIMS is updated to the current limits and methods used within the laboratory.

Computer Services

> *Computer Services is responsible for ensuring that the LIMS correctly reflects the preparations and analyses performed and that the LIMS is updated to include the current SOP, MDL, RL and QL data, as submitted by the QA Manager. Computer Services personnel are also responsible for ensuring that all electronic deliverables for clients are formatted correctly as requested by the Project Managers and that electronic data matches the hardcopy deliverables submitted.*

It is the responsibility of the Computer Services Manager to update, or to designate the task of updating, the LIMS as determined by Laboratory Management, including adjustment to current MDL/RL data, additions of analytes to methods, changes in method designations or changes in calculations for methodologies.

Computer Services will be responsible for generating the work list scripts required to allow analysts to enter data into the LIMS, and for generating the report scripts that produce final hardcopy or electronic reports for clients.

Computer Services Management and personnel are also responsible for generation and review of electronic data deliverables (EDD), as requested by clients through Project

Management. Computer Services personnel will review the EDD for compliance with the Software Quality Assurance SOP before it is released to the client.

Computer Services will be responsible for informing laboratory Section Managers and Project Managers of any discrepancies found between the EDD and the hardcopy, and for following up on corrections to hardcopy and EDD as required.

Client Services

> *Client Services (CS) (Project Managers, Sample Receiving, and Sales Management) personnel are the primary interface between ARI's clients and the laboratory sections. CS staff shall be responsible, with the assistance of the Section Managers and Supervisors, for ensuring that the laboratories understand and can meet the Data Quality Goals and Requirements of each Project before committing laboratory services to the project. CS will monitor the quality of sample processing after they are received.*

Client Services Management and Project Managers shall ensure that the laboratories can meet the data quality objectives for a project. The Project Managers are responsible for knowing the capabilities of the laboratory, in order to develop project proposals or accept samples without consultation with laboratory management. It is the responsibility of Client Services to consult with the Laboratory Manager and Section Managers, or supervisors designated by Management, when data quality goals are not included in standard Company policies. Clients may, at times, request modifications to methods that must be approved by the Supervisor and Section Manager. These modifications must be thoroughly documented and all pertinent information on modifications must be conveyed to the analysts, sample preparation sections, sample receiving, and computer services as needed for verification of feasibility. Laboratory Management may determine that a project should not be pursued based on the specific Data Quality Objectives and on current or projected laboratory capacity.

Project Managers shall be responsible for ensuring that project requirements and analytical requests are submitted correctly to all laboratory sections. Once samples have been logged into the laboratory, it is the responsibility of the Project Managers to ensure that all information is available to the laboratories concerning the Data Quality Objectives and deliverables requirements. It is also the responsibility of the Project Managers to convey changes in client

requirements to the laboratories and ensure that all paperwork reflects the changes if necessary.

It is the responsibility of Project Managers and Client Services Management to assure that specific EDD formats are submitted to Computer Services and approved as feasible before contracting with a client to provide the EDD.

It is the responsibility of Project Managers to notify clients of out-of-control events, “problem” samples, or anticipated turn-around time delays, as conveyed to them by Laboratory Management. It is also the responsibility of Project Management to work with Laboratory Management in setting priorities during times of heavy sample workloads.

Project Managers shall be responsible for coordinating data submissions and compiling hardcopy data for final submission to the client. This involves conducting a fourth level data review, from which any data which is found to contain errors that were not found earlier in the review process is returned to the Data Reviewer for correction and/or corrective action. The Project Manager will be responsible for compiling all analyst notes into a project narrative. This will include discussion of any sample receipt discrepancies, sample preparation and analysis difficulties or non-compliance, and any corrective actions that may have been required during processing. It will also discuss quality control analyses and results if applicable to the sample set.

Project Managers shall work with Laboratory Management in determination of the direction of growth for ARI, as the Project Managers are best able to define the analytical needs of clients based on new technologies and new environmental regulations.

SECTION 3: PERSONNEL QUALIFICATIONS AND TRAINING

The production of quality analytical data is dependent upon a laboratory staff with qualifications and training necessary to perform assigned tasks. All personnel employed by ARI will receive adequate training and instruction specific to their responsibilities. Prior to assigning a staff member full responsibility for performing a laboratory procedure, her/his skills will be evaluated and verified acceptable. It is the obligation of ARI′s supervisors and managers to ensure that personnel are qualified to successfully perform all assigned duties.

ARI′s training program is described in SOP 1017S (*Training and Demonstration of Proficiency*). The procedures described in this SOP assure that all ARI employees are proficient at the tasks required to produce quality analytical data. The SOP also provides for periodic review of each employees training and proficiency status, which may indicate any need for additional or remedial training. All training and review procedures are documented as described in the SOP.

Basic elements of ARI′s training program are:

1. All employees are required to read and document their knowledge of non-technical documents that describe general policies in place at ARI. These documents include ARI′s *Employee Manual* and ARI′s *Chemical Hygiene Plan*.
2. All technical employees are required to read and document their knowledge of ARI′s *Laboratory Quality Assurance Plan* and quality assurance policies.
3. All new employees must attend a Quality Assurance Orientation during which ARI′s general and specific requirements for the production of quality analytical data are emphasized.
4. All new technical employees will attend a laboratory specific technical orientation conducted by their laboratory supervisor or manager that provides specific information about laboratory operation.
5. All employees will complete an ‘on the job’ training program designated by their supervisor. The training program will be laboratory, SOP and employee specific. The training is

incremental with each step documented in an employee Training File. While an analyst is in the training period, her/his supervisor or trainer must approve all analytical work.

6. Upon completion of the training program a technical employee must complete an Initial Demonstration of Capability (IDOC) as described in ARI SOP 1017S. An analyst is considered proficient and may perform analytical procedures without supervision only after they have completed training and a successful IDOC.

7. The proficiency of each employee performing a given laboratory SOP will be continually monitored and documented as described SOP 1017S. An employee must continually generate data that meets all of ARI's published acceptance criteria for a given SOP to be considered proficient. Unacceptable results or insufficient number of analyses performed in a calendar quarter will result in revocation of proficiency. This will result in a remedial training program.

8. Each analyst is responsible for maintaining a training record as described in SOP 1017S. The training record will document an employee's experience, training and capability. The training file will be maintained in the analysts' laboratory.

SECTION 4: FACILITIES AND EQUIPMENT

4.1 Facilities

ARI's facilities have been designed to allow for efficient sample processing and analysis while maintaining consideration for the health and safety of the staff. The facility accommodates the following operations:

Sample receipt and storage
Sample container preparation and shipment
Sample preparation and analysis (organic and inorganic)
Project planning and management
Quality assurance
Data review and report generation
Computer programming and operations
Records storage
Instrument spare parts storage
Frozen sample archive
Short-term hazardous waste storage

A detailed description of ARI's facilities is included as Appendix C.

4.2 Security

Facilities

To ensure that security at ARI is maintained, access to the facilities is limited to employees and escorted visitors. Upon arrival, ARI visitors are required to register at the reception desk, and must sign out prior to leaving. Visitors will be escorted at all times. A receptionist constantly monitors the main entrance. Other laboratory entrances remain closed at all times and can only be opened from the outside by key. Key access to the facility is controlled; keys are issued on a limited basis depending on access needs.

As a result of controlled access and a monitored alarm system, the entire facility is considered a secure area. This eliminates the need for locked sample storage refrigerators, data storage areas or file cabinets.

Data Access

The Computer Services Manager controls security of, and access to, electronic data on the LIMS. Security measures are required to ensure data integrity, but must not be so restrictive

as to prevent data accessibility. The security measures taken at ARI are to prevent intentional intrusion by outside parties. These measures include building security, limited computer system access, password systems, encryption, firewalls and the use of virus protection programs. ARI′s Intranet is protected from outside tampering by a proxy server (firewall) connection to the Internet.

LIMS - System Security

Building/Computer Room Security

Access to the building is restricted to employees, vendors with security passes, and escorted visitors. Room 203 contains the computer and main console for the LIMS system. This room is closed and locked at all times. Access to this room is limited to Computer Services personnel, escorted repair technicians, and escorted visitors. Only Computer Services personnel will be allowed access to the main console.

System Password Policy

User name and password restrict access to the LIMS computer. Remote access to the LIMS server is not allowed.

Database Access Restrictions

Interaction with the database is menu-controlled and allows the LIMS Manager to restrict access. Technicians may be given the ability to fill a limited number of work lists, with no authorization to distribute data. Some users may be given “read only” access to the database.

Users will be given access to the database only to complete tasks for those analyses for which they are responsible. No users are to be given access to the shell or command prompt unless 1) they have completed the appropriate training and 2) administrative access to the computer systems is required by their job function

4.3 Safety

Ensuring that all sample processing and analysis procedures are performed under safe conditions is an important consideration at ARI. While safety is the responsibility of all staff members, ARI′s Safety Committee meets monthly to review the safety activities of all laboratory sections and to ensure that all operations and equipment meet safety criteria. *The*

Chemical Hygiene Plan details those safety procedures and requirements that must be followed at ARI. *The Chemical Hygiene Plan* is reviewed annually and updated as needed to incorporate any changes to ARI's safety program.

4.4 Instrumentation and Support Equipment

4.4.1 Instrumentation

Generation of quality data is dependent upon instrumentation and support equipment that is in optimum operating condition. All instrumentation and support equipment will be optimally maintained following method requirements and/or manufacturer's recommendations. Preventative maintenance is performed on a scheduled basis, with more frequent maintenance during periods of increased sample load or after analysis of highly contaminated samples. Separate, permanently bound logbooks are provided for and kept at or near each instrument. The logbooks are used to record all instrument maintenance, routine and non-routine. When non-routine maintenance is required the following information must be recorded:

1. A statement of the problem or symptom that requires correction.
2. Details of the maintenance procedure including listing the parts repaired or replaced.
3. Documentation that the instrument has returned to routine performance.

Spare parts are kept on hand when possible; necessary parts are ordered on an expedited basis to minimize downtime.

Currently available Laboratory Instrumentation is detailed in Appendix D.

4.4.2 Support Equipment

4.4.2.1 Thermometers in use at ARI are traceable to an NIST standard and are calibrated or verified annually. The procedures are described in SOP 1020S. When appropriate, thermometers are assigned a correction factor based upon the most recent calibration. ARI personnel must calculate and record corrected temperatures.

4.4.2.2 Water Bath temperatures are recorded before each use to assure the temperature is acceptable for its intended use.

4.4.2.3 Incubator temperatures (corrected) are recorded and at least twice a day while in use. The date and time of each observation is recorded.

4.4.2.3 Oven temperatures are recorded before and after each use.

4.4.2.4 Refrigerator and Freezer temperatures are recorded automatically every 30 minutes by ARI's "ThermoLogger" computer system. The temperature of several refrigerators and freezers not connected to "Thermologger" are recorded daily.

4.4.2.4 Balance accuracy is verified daily prior to use with two Class S weights that bracket the normal weighting range of the balance. A balance must be accurate to ±0.1% or ±0.5 mg whichever is greater. All analytical balances are professionally cleaned and calibrated annually by an outside contractor. Class S weights are calibrated every five years by an outside contractor. Calibration reports are filed in the QA Office.

4.4.2.5 pH Meters are standardized prior to each use with at least two standards, one at 4.0 and one at 7.0 pH units. The meters are checked prior to each use with a pH 7.0 buffer.

4.4.2.6 Variable Volume Pipette accuracy is verified monthly following the procedure in SOP 1015S.

4.4.2.7 Mechanical Burettes are calibrated quarterly following the procedure in SOP 1015S.

4.4.2.8 Sample Containers – Upon client request ARI supplies containers for collection of field samples. All containers supplied for organic and trace metals analyses are certified pre-cleaned by the manufacturer. When the manufacturer's certified concentration is greater than ARI's reporting limit for a specific project, a container is used to prepare a method (bottle) blank. ARI certifies that the containers from the same lot are suitable for sample collection when target analytes are not detected in the bottle blank. Containers for conventional analyses are not pre-cleaned and are certified internally by ARI following the procedures in Appendix 12.3 of ARI SOP 001S (Sample Receiving).

Container lot numbers are recorded when containers are sent to a client.

4.4.3 Chemical Standards and Reagents

4.4.3.1 Reagent Water Supply

ARI maintains a centralized water purification system. The quality of the water produced is monitored and documented daily in a bound logbook. All reagent / de-ionized water used within the laboratory meet or exceed ASTM Type II Standards. Water used in the Volatile Organic Laboratory is also filtered through activated charcoal to remove organic compounds.

4.4.3.2 Chemical Standards

Most standards used to determine the concentration of target analytes are purchased as certified solutions. In general the standards are traceable to a National Institute of Standards & Technology standard. A Certificate of Analysis and/or traceability for quantitative standards is filed in the QA Section when available. All standards (traceable, non-traceable and those prepared by ARI) are verified by comparison with standard reference materials or existing standards in use. ARI documents the source, date of receipt, required storage conditions and an expiration date for all standards. Containers used to store standards are labeled with an expiration date. Receiving, storage and preparation of calibration standards is described in SOPs 526S (Metals Analysis), 620S (Conventional Analysis), 704S (Volatile Organic Analysis) and 1012S (GC and GC-MS Analyses).

4.4.3.3 Chemical Reagents

Many of the analytical processes in use at ARI require chemical reagents that are not directly used in the calibration process. These reagents are used for analyte preservation, adjustment of pH, formation of colorimetric indicators, etc. The reagents are purchased in a grade and purity sufficient for their intended use. The receipt of all reagents is recorded in the Chemical Receiving Logbook where a unique Inventory Number is assigned to each reagent. Each original reagent container is labeled with an Inventory Number, the date it is opened and an expiration date as appropriate. A Certificate of Analysis is obtained for reagents when available and archived in the QA Office.

Solutions prepared from reagents are recorded in the Reagent Preparation Logbook. The logbook includes a unique Reagent Number that is traceable to the Chemical Receiving

Logbook. Reagent containers are labeled with Reagent Number, date of preparation, expiration date, and preparer's identification.

Procedures for Reagent Receiving and Preparation are detailed in SOP 1013S.

Trace Metals Acids

To ensure the quality of acids, nitric and hydrochloric, used for trace metals analyses, only the highest quality, certified "metals free" acids are purchased. Each lot received is analyzed for purity prior to use in the laboratory to assure that it is acceptable for use. Whenever possible, entire lots will be reserved for use exclusively by ARI. This minimizes the possibility of receiving contaminated or unacceptable acid.

Solvents

To ensure the quality of solvents used for sample preparation and analysis, the highest purity of solvents required for sample processing will be used. Purity checks are performed on solvent lots received by the laboratory. Only those solvent lots determined acceptable will be used for sample processing. Whenever possible, entire solvent lots will be reserved for use. This minimizes the possibility of receiving contaminated or unacceptable solvents.

Compressed Gases

To reduce the possibility of system contamination, compressed gases and liquids used for operating analytical instrumentation will be of a specified purity level. Any cylinder suspected of introducing contamination into a system will be promptly replaced.

4.5 Computer Systems

ARI maintains several data systems. These are used to automate such diverse functions as accounting, payroll, sales and marketing, sample receiving, instrument data collection, production of hardcopy and electronic data deliverables, intra- and internet applications and project management. Specific information about these systems is contained in Appendix D and various SOPs.

ARI maintains a Laboratory Information Management System (LIMS) that stores analytical data, calculates final results and produces final reports (both hardcopy and electronic). The LIMS

system is the major data system used at ARI. A separate Software Quality Assurance Plan outlines the QA/QC procedures for the LIMS system.

SECTION 5: LABORATORY DOCUMENTATION AND RECORDS

All laboratory operations and procedures performed during sample processing are documented in logbooks, notebooks and on laboratory forms and bench sheets. Analytical data and copies of paper documents are also stored electronically. Consistent use of standard documents throughout the laboratory ensures that all activities will be traceable and serves as objective evidence of the work performed.

All procedures performed at ARI will be detailed in Standard Operating Procedures (SOPs). Sample preparation and analysis SOPs will reference approved analytical methods and detail the actual procedures followed by ARI staff. SOPs for non-analytical activities will detail the procedures developed specifically for use at ARI.

5.1 Responsibilities

All staff members are responsible for complete and accurate documentation of laboratory activities. Each laboratory section develops a comprehensive set of documents (bench sheets, forms, etc.) to record all activities performed in that section. All staff members are responsible for reviewing and understanding SOPs, and must sign a record to document this fact. The QAPM is responsible for maintaining control of laboratory documents and ensuring their consistent use.

To ensure that all documents, SOPs in particular, accurately reflect the activities performed at ARI, section supervisors and managers are required to review all documents annually and recommend changes to the QAP. The QAPM is responsible for coordinating document revisions and ensuring that all staff members have access to the most current laboratory documents.

5.2 Document Control

ARI′s Quality Assurance Program requires that all forms and SOPs used within the laboratory be monitored to ensure that only the currently approved version of the documents are in use, centrally organized, and readily available to all staff members. All documents will include a revision date. The LQAP and SOPs will also have an effective date. The time between the revision and effective dates will be used for training and orderly implementation of changes.

Electronic copies of laboratory documents will be maintained as part of the quality assurance files. Each laboratory section maintains working copies of pertinent forms and SOPs. The QAPM coordinates the generation of new forms or SOPs and modifications to existing documents. Log number assignments will be as follows:

Laboratory Section	Form Number	SOP Number
Client Services	0001 - 0999	001 - 099
Computer Systems	1000 - 1999	100 - 199
Data Services	2000 - 2999	200 - 299
Extractions	3000 - 3999	300 - 399
GC Laboratory	4000 - 4999	400 - 499
Metals Laboratory	5000 - 5999	500 - 599
Conventional Laboratory	6000 - 6999	600 - 699
Volatile Organic Laboratory	8000 - 8999	700 - 799
Semi-volatile Laboratory	7000 - 7999	800 - 899
Quality Assurance Monitoring	10000 - 10999	1000 - 1099
GeoTech Laboratory	11000 - 11999	1100 - 1199

Document numbers will be include an F for forms and an S for SOPs i.e. 101F or 1234S. Document Control Logs of all forms and SOPs, detailing the form name and number, revision number and revision date will be maintained by the QA Officer. Outdated documents will be maintained in an electronic archive file.

The QAPM will distribute new and revised documents to the appropriate laboratory sections. Section staff will replace outdated copies of the document with the revised version. Laboratory forms and SOPs will be generated or revised on an “as needed” basis, and will be reviewed and revised as at least annually. Only the latest version of a form or SOP will be available in each laboratory. Section supervisors will periodically review these documents and recommend changes to be implemented by the QAPM. A comprehensive review of all laboratory documentation will be performed annually at the direction of the QAPM.

To maintain document security, release of documents to clients or other outside agencies will be controlled by the QAPM. The QAPM will record the document to be released, revision number, person and agency receiving the document, and the release date. All documents generated by the laboratory will be considered proprietary. ARI permission must be obtained by anyone releasing the document to other agencies or including the document in a project or quality assurance plan.

5.3 Reference Documentation

To provide an understanding of the procedures employed to generate quality data, a comprehensive set of reference materials is available to staff members. All activities performed within the laboratory can be referenced to a method or SOP. The laboratory maintains copies of the following method compilations:

Code of Federal Regulations (Section 40)
Test Methods for Evaluating Solid Waste (USEPA SW-846)
USEPA Contract Laboratory Program Statement of Work for Organics Analysis
USEPA Contract Laboratory Program Statement of Work for Inorganic Analysis
Methods for Chemical Analysis of Water and Waste (USEPA 500 and 600 series methods)
Standard Methods for the Examination of Water and Wastewater
Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound (PSEP)
US Naval Facilities Engineering Support Activity –NFESC (formerly NEESA).
Hazardous Waste Remedial Actions Program (HAZWRAP)
State of Alaska Department of Environmental Conservation (ADEC)
Oregon Department of Environmental Quality (DEQ) Petroleum Hydrocarbon Methods
Washington Department of Ecology (WDOE) Guidance for Remediation of Releases from Underground Storage Tanks (Appendix L)
Washington State SARA
AFCEE Project Quality Assurance Plan
Washington State EPH/VPH Methods
National Environmental Laboratory Accreditation Conference
Department of Defense Quality Systems Manual
Washington State Sediment Sampling and Analysis Plan

Other methods followed within the laboratory are also available. Published modifications to analytical methods will be reviewed and incorporated into laboratory SOPs. If a method for a parameter is developed by ARI, it will be detailed in an SOP. SOPs will be available for all laboratory activities. Each laboratory section will maintain a file or notebook of SOPs pertinent to that section. A compilation of all laboratory SOPs is maintained as part of the Quality Assurance Program files. A listing of laboratory SOPs is included as Appendix E.

The Quality Assurance Manual provides an overview of the laboratory-wide Quality Assurance program. A copy of the Quality Assurance Manual is distributed to all laboratory sections. Distribution of the QAP is coordinated by the QAPM.

ARI maintains a file of various laboratory and environmental publications and reference texts. These reference materials are available to all staff members. Operation and maintenance manuals are available for all equipment and instrumentation used within the laboratory. Additionally, senior level staff members are available to serve as reference sources. These staff members have numerous years of pertinent experience and can provide insight and guidance for all procedures and laboratory activities.

5.4 Quality Assurance Policies

Quality Assurance Policies provide standards and procedures to guide ARI employees in proper implementation of the QA Program. Appendix P includes current QA Policies.

5.5 Worksheets and Logbooks

Use of Laboratory Forms and Logbooks

All activities noted on laboratory forms and logs are recorded in blue ink. Initials of the staff member performing the activity, as well as the date the activity is performed are noted on all forms and logs. Any supplementary information about the activity, such as unusual observations or suspected procedural errors are noted on the forms and logs. The QAPM or his/her designee prepares and controls laboratory logbooks.

Changes to existing information is annotated by drawing a single line through the original entry and initialing and dating the deletion. Correct information is written above the deleted entry. When appropriate to clarify the intent of the change a note describing the reason for the change is added. The use of correction fluids or other techniques that cover an entry in its entirety is forbidden on laboratory documents.

Since sample processing within an analytical laboratory involves many detailed steps, documentation can be quite extensive and varied. The following guidelines will be followed to encourage consistency in laboratory record keeping:

Standard Logbooks

Preparation of all stock and working standards is documented in the appropriate standards logbook. Each entry includes preparation date, initial and final concentrations (including solute and solvent amounts), standard ID number, expiration date and the identity of the person preparing the standard. Stock solution entries include standard lot number and supplier. Working solution entries include the stock solution ID number. Commercially prepared stock standards are recorded in the stock standard logbook.

Sample Storage Temperature Logs

The temperature of all refrigerators and freezers used for sample and standards storage is monitored daily. The temperature and recorder's initials are recorded on the temperature log attached to each unit. The acceptable temperature range for each unit is noted on the log sheet. Any out of control temperatures and/or corrective actions, must be noted on the log sheet and reported to appropriate personnel (Lab Supervisor and QA Manager)

Balance Calibration Logs

The true and measured values for each calibration check weight are recorded, along with the date and recorder's initials. Any actions taken, such as notifying the QAPM of malfunctions is indicated alongside the entry for that date.

Instrument Logs

The Instrument Run Logs must detail all samples analyzed on a given instrument for a given parameter. Instrument conditions, analysis date and time for each sample, analyst initials and standard or sample identifications in the analytical sequence must be recorded in the log. Comments related to sample analysis and minor maintenance are noted on the instrument logs. For GC/MS analyses, instrument performance is documented by recording internal standard response alongside the sample identification.

Sample Preparation/Analysis Worksheets

Sample preparation and analysis activities are documented on appropriate worksheets. Sample identifications, weights or volumes used, intermediate cleanups, final volumes, preparation dates and analyst initials will be noted as well as any observations about

sample condition. Any issues encountered during sample preparation are also noted. Surrogate and spiking solution ID numbers, and concentrations added to the samples, must be indicated on the bench sheet.

For some parameters, analytical results are summarized on an analysis worksheet. Sample identifications, sample preparation information, sample results, quality control results, analysis date, analyst initials and reported detection limits must be indicated on the worksheet. Any necessary data qualifiers are also noted on the worksheet.

Maintenance Logs

All major maintenance performed on instrumentation or laboratory equipment must be documented. Maintenance performed, date and analyst performing the maintenance, and steps taken to verify that the maintenance was successful are detailed in the log. Routine maintenance of GC-MS instruments is documented on “maintenance cards” attached to each instrument. The demonstration that GC instruments are in-control following maintenance is documented in the instrument run log.

Individual Laboratory Notebooks

Staff members preparing USEPA CLP samples must maintain unique laboratory notebooks for these analyses. Each case submitted is documented on a separate, sequentially numbered page. A listing of all samples prepared as part of the case, the date and the preparer′s initials, and any notes specific to sample preparation must be annotated in the logbook. Individual notebooks are used only when required by a specific contract. All sample preparation information is recorded on a laboratory bench sheet.

5.5 Document /Data Storage and Archival

Logbooks

All active logbooks will remain in the appropriate laboratory sections. Completed logbooks will be forwarded to the QAPM for archival.

Magnetic Tapes and Diskettes

When instrument capabilities permit, all data generated is archived and stored on magnetic tapes or disks. The electronic media remains on file for five years.

Chromatograms and Instrument Documentation

Electronic or paper copies of chromatograms, instrument calibrations, quantification reports and any other printed documentation generated during sample analysis are maintained as part of the permanent data files. All hardcopy data remain on file at ARI for five (5) years or as specified by contract.

Project Data and Documentation

Project data and support documentation, electronic or paper copies, will be filed a minimum of five years, or as specified by contract.

SECTION 6: SAMPLE CONTROL

All samples analyzed by the laboratory will be monitored in accordance with sample control procedures. Sample control includes operations such as container preparation, sample collection, receipt and storage, and tracking of the sample throughout all processing steps. Documentation of all sample control activities and adherence to standard procedures is an important aspect of ensuring that data quality objectives are met.

6.1 Sample Collection

Production of quality analytical data begins with proper sample collection. Improper sampling procedures may result in inaccurate final results. Although the laboratory is not routinely involved with sample collection, it will minimize the possibility for error by providing clients with appropriate sample containers and sampling instructions for the requested parameters. If, upon receipt, sample integrity appears to be compromised, the client will be immediately notified to allow for re-sampling if necessary.

6.2 Sample Container Preparation and Shipment

To minimize the possibility of contamination from containers furnished by outside sources, the laboratory will furnish all necessary sample containers for client projects when requested by the client. Sample containers, pre-cleaned to EPA specifications, or certified clean by the manufacturer or ARI, are supplied for most parameters. Containers for special purposes may be acquired upon request. Lot numbers for containers are tracked to link bottle orders to lot numbers.

A blank sample label is affixed to each sample container prior sending the container to a client. The sample label allows for recording of the following information at the time of collection: client name, client sample identification, sampling site, date and time of sample collection, analytical parameters, and any preservatives used. Sample labels provided by ARI are coated to prevent bleeding of recorded information if labels become wet.

To ensure that the correct number of appropriate sample containers are prepared and submitted to the client, a Bottle Request is completed by a Client Services staff member or Project Manager at the time sample containers are ordered by the client. All necessary preservatives are also noted on the Bottle Request. The Bottle Request is then forwarded to

appropriate personnel in the Sample Receiving Section for order preparation. All required containers will be gathered and preservatives added as specified. A copy of the Bottle Request accompanies the sample containers to allow the client to verify that the order is properly filled. Additional containers will be supplied for quality control purposes and in case of container breakage or sampling complications. A complete listing of containers and preservatives used within the laboratory is included as Appendix F.

To facilitate transportation of containers to the sampling site, sample containers will be placed in coolers along with appropriate packing material. The inclusion of packing materials, such as vermiculite or “bubblewrap”, is provided to minimize the possibility of container breakage and cross-contamination. Sample containers will be organized in the coolers per analytical or client specifications. Depending on client preference and project requirements, coolers and sample containers will be shipped to a specified location, delivered by ARI courier, or held at the laboratory for pick up. To ensure that sample identification, analytical parameters, and sample custody are properly documented, Chain of Custody records will accompany all sample container shipments. When appropriate, as for drinking water source sampling events or for parameters that require preservation in the field, sample collection instructions will also be included with shipments.

6.3 Sample Admission

All samples received by the laboratory are processed in a central Sample Receiving area. To ensure the safety of staff members receiving samples, coolers will be opened under a hood or in a well-ventilated area. Appropriate protection, such as disposable gloves, safety glasses and laboratory coats will be worn during sample receipt and log-in. Additionally, all general safety practices as specified in ARI’s Chemical Hygiene Plan will be employed.

Upon receipt, sample coolers will be inspected for general condition and custody seals. Time and date of sample receipt, as well as identification of the staff member receiving the samples, will be indicated on each Chain of Custody record accompanying the shipment. Cooler temperatures will be determined using an IR temperature measuring device or by placing a thermometer in the cooler immediately after the cooler is opened. If samples cannot be logged-in within 30 minutes after receipt, the sample coolers will be tagged and placed in the walk-in sample storage refrigerator for short-term storage. Chain of Custody records for the

stored coolers will remain in Log-In to ensure that processing of the stored samples is not overlooked.

Samples to be processed will be removed from the coolers and organized by sample identification. The number and type of sample containers received will be verified against the Chain of Custody record. Each sample container will be examined to verify that the condition is acceptable and that sample integrity has not been compromised during shipment. Sample containers broken during shipment should be handled according to procedures detailed in the Chemical Hygiene Plan (Section 5, Waste Disposal Procedures).

After sample organization and initial inspection has been completed, sample information will be entered into the LIMS, and a Service Request will be generated for the sample set. The Service Request serves as a work order for the laboratory. The Service Request will contain the following information:

Client Name
Client Project Name and/or Number
Client Contact
Verified Time of Sample Receipt (VTSR)
Required Turnaround Time
Laboratory Job Number
Client Sample Identifiers(s)
Laboratory Sample Number(s)
Required Parameters
Additional Analytical Requirements/Comments

Also entered into the LIMS are the number of sample containers for each sample, sample conditions, and cooler temperatures.

A sequential laboratory job number will be assigned to each sample set. Laboratory sample numbers, determined by the job number and a sequential letter, will be assigned to each sample. Containers for each sample will also be numbered sequentially. The accuracy of sample container labeling is verified by a second person. These identifiers will be used to monitor the sample set and container throughout sample processing. All samples logged for the sample set and the analytical parameters required for each sample will be indicated on the Service Request. Client specific quality control requirements and any other pertinent information indicated on the Chain of Custody Record will also be noted. Discrepancies

between the Chain of Custody record and sample containers will be noted, as well as discrepancy resolutions. To reduce the possibility of inaccurate sample processing, the sample receiving staff working with the Project Manager will resolve all noted discrepancies prior to releasing the samples to the analytical sections.

Upon completion of sample log-in, all documentation will be placed in a master folder and forwarded to the assigned Project Manager for review and approval. The master folder will be color-coded as follows:

Master File Color	Designation
Red	Accelerated Turnaround (≤ week)
Blue	Accelerated Turnaround/Fuels
Clear	Routine Turnaround

The Project Manager will review all aspects of the documentation, specify any additional analytical requirements and resolve any remaining discrepancies before sample processing begins. After Project Manager final approval has been obtained (indicated by the Project Managers initials and the date on the Service Request and laboratory-specific parameter sheets), the master file will be returned to Log-In for preparation of laboratory job folders. A job folder will be created for each laboratory section involved in sample processing for a given project. Laboratory job folders are color-coded as follows:

Job Folder Color	Designation
Red	Accelerated Turnaround (≤ 10 days)
Manila	Normal Turnaround (11 to 14 days)
Blue	Accelerated Turnaround (≤ 7 days) for Fuels Analyses (NWTPH, AK103 etc.)
Yellow	Extended Turnaround (>14 day TAT)
Other (Green, Purple ,etc)	Client or Project Specific Analyzes

Copies of the Service Request and all pertinent laboratory-specific documentation required to accurately complete sample analysis will be placed in each laboratory job folder. Laboratory

job folders will then be distributed to appropriate laboratory sections for analysis and incorporation into the section tracking system.

Subcontracting Policies

ARI may be required to subcontract work to other laboratories. The following policies are followed to assure that data produced by a subcontractor is high quality, defensible and will meet the client's expectations.

1. ARI's client must be made aware that samples will be subcontracted and what laboratory will perform the analyses.
2. Subcontractor laboratories must qualify to perform the analyses using the same criteria applied to ARI. When appropriate, subcontracted laboratories must submit proof of certification or accreditation, quality assurance plans, standard operating procedures, results of method detection limit studies, control limits to ARI. ARI may at its discretion perform an on-site assessment of subcontracted laboratories. Failure to submit requested documents or refusal of an on-site assessment will disqualify laboratories from subcontracting ARI sample analyses.
3. ARI will not subcontract Department of Defense work to be performed under the Quality Systems Manual (DoD-QSM) unless the subcontract lab is approved to perform DoD-QSM analyzes.
4. The sample information and analytical requirements are first entered into the ARI LIMS in the same way that samples for in-house analyses are processed. Subcontractor laboratories are contacted to verify their preparedness, and samples are then submitted to them using ARI chain-of-custody forms. These chain-of-custody documents are included in the master folder for the project.
5. ARI may request that subcontract laboratories analyze, on double blind performance testing (PT) sample obtained from commercial vendors at the subcontractor's expense.
6. The laboratory must be willing to maintain an annual contract with ARI, and must list ARI as a co-insured on the subcontract laboratory's liability insurance policies.
7. Financial stability is also evaluated on a lab-by-lab basis.

6.4 Sample Custody

To ensure the traceability of sample possession, chain of custody is documented from sample collection to completion of final analysis, and is maintained during sample storage in archive prior to disposal. This is achieved through completion of a written chain of custody record. Custody of all samples and extracts processed by the laboratory is documented at each step of the analytical process.

The National Enforcement Investigations Center (NEIC) of EPA defines custody in the following ways:

It is in your actual possession, or
It is in your view, after being in your physical possession, or
It was in your possession, then you locked or sealed it up to prevent tampering, or
It is in a secure area.

Sample handling may vary and specific custody procedures have been developed for each laboratory section.

Custody at Sample Log-in

A Chain of Custody Record must accompany all samples received by the laboratory. This record documents all sampling activities as well as persons handling the samples prior to receipt by the laboratory. Sample receiving staff assumes custody of samples upon receipt from the client or courier. Samples will remain in the custody of Sample receiving until the samples are delivered to a laboratory section. Should samples require shipment to a subcontracting laboratory, a separate Chain of Custody Record will be completed to document the sample transfer. Chain of Custody records will be included with sample data reports in the final analytical package submitted to the client. Copies of these records will be filed with project data.

Custody of Volatile Organic Analysis (VOA) Samples

Upon completion of sample the sample receiving process, samples requiring analysis for volatile organic analysis will be placed in the VOA refrigerator designated for incoming samples and logged into the VOA sample receipt logbook. The samples are now in the custody of the VOA laboratory. To avoid possible cross-contamination of low level samples,

those samples known or suspected to contain high levels of contaminants, such as underground storage tank (UST) samples, will be stored in a separate refrigerator prior to analysis.

VOA Laboratory analysts complete the receiving process and move the samples to a refrigerator designated for “active” samples. Samples removed from storage for analysis are considered to be in the custody of the analyst responsible for sample processing. All samples to be analyzed will be listed in the analytical logbook for the selected instrument. Laboratory and client sample identifications, the bottle number and identification of the analyst performing the analysis will be indicated in the logbook. If it is necessary for sample custody to be transferred to another instrument or analyst, the second analyst will record this information. Thus, custody of a given sample can be traced throughout the analytical process, regardless of the number of instruments or analysts involved. Analysts will initial all raw data generated from sample analysis, to further document sample custody.

After completion of sample analysis, soil and intact water sample containers will be placed in the refrigerator designated for sample archival. Any water sample remaining in the container after completion of analysis will be considered compromised and will be discarded. The samples will remain in archive and in the custody of the VOA laboratory until final disposal.

Custody of Semi-volatile Organic Analysis (SVOA) Samples

Upon completion of sample log-in, samples requiring extraction for organic parameters will be placed in walk-in cooler number 5. All samples placed in the cooler will be logged into the *Walk-in Admission Logbook*. Removal of samples from the refrigerator for processing by Extractions or Conventional personnel must be indicated in the *Walk-in Admission Logbook*. Samples stored in this walk-in refrigerator remain in Log-In custody until removed to a laboratory for processing.

The analyst responsible for the custody and initial handling of samples within the sample preparation laboratory will be indicated on the Sample Preparation Worksheet. All analysts involved in the subsequent steps of sample processing will also be indicated on the worksheet. Residual sample volumes will be archived in the refrigerator designated for extractable organic samples. Transfer of residual samples to this refrigerator will be documented in the *Sample*

Archive Refrigerator Logbook. Transfer of prepared sample extracts to the appropriate analytical sections will be documented in the Extract Log in the preparation laboratory and in the Extract Log in the analytical section. Upon extract transfer, the analytical section receiving the extract assumes custody.

Extracts removed from storage for analysis are considered to be in the custody of the analyst responsible for analysis. Removal of extracts for analysis will be indicated in the Extract Log in the analytical section. All extracts to be analyzed will be indicated in the analytical logbook for the selected instrument. Laboratory and client sample identifications, as well as the analyst performing the analysis will be indicated in the logbook. Analysts will initial raw data generated from extract analysis to further document sample custody. After completion of analysis, extracts will be placed in the refrigerator designated for archive. Extracts will remain in storage and in the custody of the analytical section until final disposal.

Custody of Inorganic and Metals Samples

Upon completion of the sample receiving process, samples requiring preparation or analysis for inorganic parameters will be placed in the designated walk-in cooler. Selected samples such as those requiring a critical analysis are placed directly in the laboratory. Removal of samples from the refrigerators for digestion and/or analysis will be indicated in the *Walk-in Admission Logbook* for the appropriate refrigerator. Samples stored in the walk-in refrigerators remain in Log-In custody until the laboratory removes the samples for processing.

The analyst responsible for custody and initial handling of samples within the metals preparation laboratory will be indicated on the Sample Digestion Worksheet. All analysts involved in the subsequent steps of sample processing will also be indicated on the worksheet. Transfer of completed sample digests to the metals instrument (analysis) laboratory will be documented by the metals preparation laboratory. Upon transfer of digests, custody is considered to be the responsibility of the analytical section receiving the digests.

Digests removed from storage are considered to be in the custody of the responsible analyst. All digests to be analyzed will be indicated in the analytical logbook for the selected instrument. Laboratory sample identifications and the analyst performing the analysis will be indicated in the logbook. If it is necessary for digest custody to be transferred to another instrument or

analyst, the second analyst records this information. Thus, custody of a given digest can be traced throughout the analytical process, regardless of the number of instruments or analysts involved. Analysts will initial all raw data generated from digest and analysis to further document sample custody. After completion of analysis, digests will be stored by and remain in the custody of the analytical laboratory personnel until final disposal.

The analyst performing the sample analysis will remove samples requiring analysis for other inorganic (conventional) parameters from storage. Removal will be documented in the *Walk-in Admission Logbook*. Custody of the sample will be considered to be the responsibility of that analyst. All samples to be analyzed will be indicated on the worksheet for the required parameter. Laboratory sample identifications and the analyst performing the analysis will be indicated on the worksheet. If it is necessary for sample custody to be transferred to another instrument or analyst, the second analyst will record this information. Thus, custody of a given sample can be traced throughout the analytical process, regardless of the number of instruments or analysts involved. The analysts' initials will be indicated on the worksheet to further document sample custody.

Special Chain of Custody Requirements

Should a client project require additional or more detailed custody documentation, requirements will be incorporated into the procedures for that project. Samples processed as part of the USEPA Contract Laboratory Program require more stringent chain of custody procedures. For this program, removal of samples and extracts for analysis (or any reason) will be documented in the Sample Control Log. Date, time and reason for removal, and date and time of return, will be fully documented. Removal of samples or extracts for permanent archiving or disposal will also be fully documented in the Sample Control Log.

6.5 Sample Archival and Disposal

After completion of analysis, unused sample aliquots are routinely stored for a specified period of time: 30 days for water samples and 60 days for soil samples. Colored markers are placed on samples with specific storage requirements during the sample receiving process. The color-coding is defined in the following table:

Label Color	Storage Requirement
Red	Hold until further notice
Orange	Suspected Hazardous
Yellow	Shared Sample Containers
Blue	Samples to be frozen

Samples submitted for archival will be logged into the Sample Archive Logbook. Laboratory and client identifications, as well as archive date will be indicated in the logbook. The anticipated disposal date for the sample set will also be noted. The logbook will be reviewed several times during each week to determine samples scheduled for disposal. On or soon after the scheduled disposal date, the samples will be removed from archive storage and disposed.

In consideration of disposal requirements for hazardous samples, each sample processed by the laboratory will be evaluated for contamination levels based on final analytical results. Those samples containing analytes of interest at or above regulated disposal levels will be identified and handled as hazardous waste. A designated staff member coordinates periodic pickup and disposal of hazardous waste by an USEPA approved TSD (Treatment, Storage, and Disposal) Company and maintains hazardous waste disposal records. Specific guidelines for handling hazardous samples and waste are detailed in the Chemical Hygiene Plan (Section 5, Waste Disposal Procedures)

SECTION 7: PROJECT MANAGEMENT AND TRACKING

7.1 Project Management

Concise and accurate communication between a client and ARI, and within the laboratory, is an extremely important requirement for generating quality analytical results. All clients contracting with ARI will be assigned to a Project Manager. The Project Manager confirms that project requirements are consistent with laboratory capabilities, and coordinates with laboratory sections to provide analytical results within specified project timelines. Project organization, monitoring, and follow-up is the responsibility of Project Management staff.

Client project requirements and Project Managers' areas of expertise will be considered for client assignment. To ensure that all clients and projects receive the attention necessary for successful project completion, Project Manager workloads will also be considered. Project Managers will serve as the central focus for all project related activities and communications.

The Project Manager will review work plans and requirements for all pending projects. Any questions related to the work plan will be addressed prior to project commencement. The Project Manager will consult with appropriate analytical sections to clarify any issues regarding procedures and capabilities. Project deliverables requirements will also be addressed at this time. Upon receipt and log-in of project samples, the Project Manager will review all documentation to ensure that samples were properly logged in, and that analytical and QC requirements were correctly specified. The Project Manager will also provide any additional project related information that will assist the analytical sections with sample analysis. Laboratory sections will not process a sample until Project Manager approval has been given. Exceptions are parameters with critical (less than 48 hour) holding times or those that arrive on weekends or holidays when none of the Project Managers can be contacted.

Throughout the project, the Project Manager will monitor all analytical activities to help ensure that the project is completed and delivered on schedule. Any issues arising during sample processing will be promptly discussed with the client. Likewise, the analytical staff will be informed of any client concerns or project modifications. The Project Manager will also address any issues that arise during subsequent review of the analytical data by the client.

7.2 Project Tracking

Monitoring the laboratory workload ensures that adequate staffing and equipment will be available to produce quality analytical data and meet client needs. At the time a client project is tentatively scheduled, information regarding the project will be documented in the Project Management Database. Project particulars, sample quantities, parameters and anticipated sample delivery dates will be specified, as well as any prearranged analytical costs. Project work plans and any other project information will be kept on file with the Project Manager. Schedules for pending projects are communicated to the lab sections through periodic distribution of database printouts. Upon receipt of project samples, the project Inquiry number will be referenced to ensure project requirements are accurately specified. The original project documentation will be placed in the master folder as part of the project file.

Each laboratory section analyzing project samples will be responsible for ensuring that all analyses are accurately completed by the required date. All staff members are required to be aware of holding times, special analytical requirements, and required turnaround times. Analytical sections will remain in close communication with the Project Management staff so that any issues arising during sample analysis can be promptly addressed or discussed with the client.

Project Managers or their designee are responsible for monitoring project status. Sample status reports are generated as needed from LIMS and are distributed to lab sections and Project Managers. These reports allow the Project Managers to review project status and identify any samples which must be expedited to meet project timelines. Additionally, verbal communication between Project Managers and lab sections provides information about project status.

After sample analysis, report generation, and final review have been completed, data and final reports will be forwarded to the Project Manager. If requested, preliminary and interim results will be forwarded to the client. When all final data are available, the Project Manager will assemble the final package, verifying that all analyses were completed and project requirements met. A project narrative detailing the particulars of sample processing will be generated. After assembly and prior to shipment, the Project Manager will perform a final, cursory review of the package for any inconsistencies or incorrect information. The package will then be forwarded to clerical

personnel for photocopying and shipment. The Project Manager will determine final analytical costs and submit this information to the Accounting department for invoicing. Upon completion, all raw data and documentation associated with each client project will be compiled and stored as part of the laboratory project files. A chart detailing laboratory workflow as described in this section is included as Appendix G.

SECTION 8: ANALYTICAL METHODS

To ensure that all data generated are consistent and comparable, clearly defined procedures will be followed for all aspects of sample processing, control and management. Standard Operating Procedures (SOPs) provide detailed guidelines for completing a procedure. Document control procedures and periodic audits will ensure that operations are performed in accordance with the most current SOPs. All routine deviations from published will be noted in the SOPs. Analysis specific deviation will be noted in Analyst Notes and in the Analytical Narrative.

8.1 Responsibilities

It is the responsibility of staff members to perform all procedures in accordance with the guidelines specified in the Standard Operating Procedures. Laboratory management is responsible for ensuring that SOPs are followed throughout the laboratory. The QAPM is responsible for coordinating periodic review and revision of existing SOPs and generation of additional SOPs. The QAPM is also responsible for maintaining SOP document control and ensuring that the most current versions of all SOPs are available to staff members.

8.2 Methods

Laboratory procedures may reference any established methods specified in the following publications:

1. *Code of Federal Regulations (Section 40)*
2. *Test Methods for Evaluating Solid Waste (USEPA SW-846)*
3. *USEPA Contract Laboratory Program Statement of Work for Organic Analysis*
4. *USEPA Contract Laboratory Program Statement of Work for Inorganic Analysis*
5. *Methods for Chemical Analysis of Water and Waste (USEPA 500 and 600 series)*
6. *Standard Methods for the Examination of Water and Wastewater*
7. *Protocols for Measuring Selected Environmental Variables in Puget Sound (PSEP)*
8. *Navy Installation Restoration Laboratory Quality Assurance Guide(February 1996)*
9. *Hazardous Waste Remedial Actions Program (HAZWRAP)*
10. *State of Alaska Department of Environmental Conservation (ADEC)*
11. *Oregon Department of Environmental Quality (DEQ) Petroleum Hydrocarbon Methods*
12. *Washington Department of Ecology (WA-Ecology) Guidance for Remediation of Releases from Underground Storage Tanks (Appendix L)*
13. *The Department of Defense Quality Systems Manual (DoD-QSM)*
14. *Washington State Sediment Sampling and Analysis Plan*

The laboratory will adhere to established methods whenever possible. Occasionally, however, procedures determined to provide more accurate final results will be incorporated into the method. Should the laboratory procedures deviate from the established method, all modifications will be detailed in the associated SOP. A listing of laboratory SOPs is included as Appendix E.

8.3 Standard Operating Procedures

Standard Operating Procedures (SOPs) are detailed, step-by-step instructions for completing a laboratory operation. An SOP is available for all procedures within the laboratory, from initial project identification to final data archival. SOPs are generated for procedures developed within the laboratory and for those that follow established methods.

To ensure consistency in defining procedural guidelines, all SOPs that describe analytical procedures will contain the following sections:

1) Method, matrix or matrices, detection limit, scope & application, components to be analyzed
2) Summary of the test method
3) Definitions
4) Interferences
5) Safety
6) Equipment and supplies
7) Reagents and standards
8) Sample collection, preservation, shipment and storage
9) Quality control
10) Calibration and standardization
11) Procedure
12) Data analysis and calculations
13) Method performance
14) Pollution prevention
15) Data assessment and acceptance criteria for quality control measures
16) Corrective actions for out of control data
17) Contingencies for handling out-of-control or unacceptable data
18) Waste management
19) References
20) Appendices, tables, diagrams, flowcharts and validation data.

SOPs will be monitored through the laboratory document control system. Each SOP will be assigned a document control number as detailed in Section 5.2 of this LQAP. SOPs are revised whenever a laboratory procedure is changed or modified. All SOPs are reviewed and revised as necessary at least once a year. Personnel normally performing the procedure or

analysis perform the review. SOPs will be generated for each new procedure implemented within the laboratory. Review, modification, new SOP generation, and distribution will be coordinated through the QAPM. The QAPM will periodically audit the laboratory sections to verify that the most current versions of all SOPs are in use. Document release will be controlled as detailed in section 5.2.

8.4 Method Selection and Use

Method selection will be based on availability of analytical instruments and equipment, chemical standards, expected method performance and marketability. Methods that are defined and accepted by regulatory agencies and familiar to ARI's clients are preferred. The Laboratory Manager and QAPM in consultation with marketing, client service, and laboratory supervisory staff are responsible for selecting appropriate methods. Client or project-specific methods may be used when appropriate.

The most recently promulgated method will be used for all procedures. Non-promulgated methods will be investigated if requested by a client. Section supervisors and managers are responsible for ensuring that the procedures in use reflect the requirements of the promulgated methods. Any modifications made to the method must be documented in the SOPs. Method modifications may be acceptable, provided all acceptance criteria specified in the method are met.

Section supervisors and managers review newly promulgated methods. SOPs will be modified as necessary to reflect the new methods. When possible, the annual SOP review will be coordinated with anticipated method promulgation dates. This is especially useful for large method compilations, such as SW-846. If the annual SOP review and method promulgation cannot be coordinated, SOPs will be revised as soon as possible after a method has been promulgated, especially when method changes are significant.

SOPs will be generated to reflect the most commonly used methods and protocols. If more than one method is used for an analysis, separate SOPs should be generated. Several methods may be incorporated into one SOP, provided that each method is clearly identified and defined in the SOP. Method modifications or special requirements for ongoing projects, or for specific programs (Navy, CLP, etc.), will be incorporated into the SOP. These

requirements will be annotated to indicate that they are project/program specific. Analysts and technicians will be responsible for ensuring that, when required, project or program specific procedures are followed. SOPs will be controlled as specified in section 5.2.

8.5 Method Performance

Method performance must be demonstrated for all new methods prior to using methods for sample analysis. Section supervisors and managers are responsible for ensuring that method performance is demonstrated and support procedures have been performed.

Method performance will be demonstrated in the following manner:

A draft SOP will be generated for the method. The SOP must provide sufficient detail to perform the analysis and must accurately reflect the published method. Any steps in the method for which analyst discretion is allowed must be clearly defined.

A method detection limit (MDL) study must be performed for the method. Method detection limits must be verified to be at or lower than any method-specified detection limits. Method detection and reporting limits must be established.

Method precision and accuracy must be evaluated. This may be determined using an MDL or IDL study. Replicates will be evaluated for precision; analyte values will be compared with spike amounts to determine accuracy. Any method-specified precision and accuracy criteria must be met.

All method performance results will be reviewed and compiled by the section supervisor. Results will be filed with the QA section. A final SOP will be generated and distributed. MDL updates will be communicated to Computer Services for LIMS updates and distributed to laboratory sections as needed.

SECTION 9: INSTRUMENT CONTROL

9.1 Detection Limits

To verify that reported limits are within instrument and method capabilities, three levels of detection have been established: instrument detection limits, method detection limits, and reporting limits. Instrument and method detection limits are statistically based values, determined from replicate analyses of analytical standards. Reporting limits are based upon the experience and judgment of an analyst. Reported values will be qualified based on the established limits. All limits will be summarized and controlled by the QAPM and are included as Appendix I.

Instrument Detection Limits

The instrument detection limit (IDL) is considered to be the smallest signal above background noise that an instrument can reliably detect. This limit reflects whether or not the observed signal has been caused by a real signal or is only a random fluctuation of noise from the blank. The IDL does not take into consideration the performance or efficiency of analytical methods.

Instrument detection limits are determined annually, or when ever a major change has been made, for each instrument in the metals analysis laboratory. Seven replicates, of a blank, or standards containing analytes at levels three to five times the expected IDLs are analyzed on three non-consecutive days. The IDL value for an analyte is three times the average of the standard deviations from the three replicate sets of analyses.

Method Detection Limits

The method detection limit (MDL) is considered to be the lowest concentration of an analyte that a method can detect with 99% confidence. Method detection limits will be established for all analytical parameters according to the guidelines specified in the Code of Federal Regulations, Section 40. Seven replicate samples are fortified with target analytes at levels that are one to five times (but not exceeding 10 times) the expected detection limits. The MDL for an analyte is determined to be the standard deviation of the replicates times the appropriate

student's t-test value. More than seven replicates may be processed, but all replicates must be used in the MDL determination. MDLs are verified by analyzing a sample spiked at a concentration 3 to 5 times the calculated MDL concentration. When the analyte(s) are detected the MDL is verified. When the analytes is not detected, the concentration in the verification sample is increased until it is detected. The concentration at which the analytes is first detected then becomes the MDL.

Laboratory supervisors or managers review all statistically determined MDLs for accuracy and validity. The section supervisor or manager is responsible for ensuring that any unusable MDL studies are reprocessed. Once accepted, MDL study results and associated raw data will be forwarded to the QA section for further review and additional approval. MDLs approved by both section management and QA will be considered final and acceptable for use. Finalized MDL values are forwarded to Computer Services for incorporation into ARI's LIMS.

MDL studies will be conducted for all analyses performed by the laboratory on representative water, sediment and, tissue samples when appropriate and suitable sample matrices are available. MDL studies will be performed on all instruments used for sample analysis. To allow for reevaluation of method performance, MDL studies will be performed on an annual basis. The QAPM is responsible for ensuring that all MDL studies are performed at least annually. Section supervisors and managers are responsible for determining if and when additional MDL studies should be performed due to changes in analytical methods, instrumentation or personnel.

Reporting Limits

Reporting Limits (RL) are the lowest quantitative value routinely reported. Analytical results below the RL will be expressed as "less than" the reporting limit. RLs are estimated values based upon the MDLs, experience and judgment of the analyst, method efficiency, and analyte sensitivity. No reporting limit will be lower than its corresponding MDL. RLs will be verified on a regular basis either by having a calibration standard at the limit or by analyzing a standard at the RL immediately following initial calibration.

Analytical Standards

Generation of high quality results is dependent upon the use of accurately prepared analytical standards. Many stock standards used within the laboratory are commercially prepared solutions with certified analyte concentrations. Neat standards used for stock standard preparation are of the highest purity obtainable. Standard preparations are fully documented in appropriate logbooks.

Responsibilities

It is the responsibility of each laboratory employee involved with standards preparation to ensure that all standards are correctly and accurately prepared through the use of good laboratory practices and analytical verification. It is also the responsibility of these staff members to properly document the receipt and/or preparation of all standards. Management is responsible for ensuring that all staff members follow specified standards preparation and inventory procedures. The QAPM is responsible for periodically auditing standard preparation records to verify compliance with the laboratory Quality Assurance Program.

Organic Standards Preparation

Two types of standards are utilized for extractable organic compounds: neat standards from which stock solutions are prepared, and commercially prepared stock solutions from which working solutions are prepared. The type of standard depends upon availability. Commercially prepared standards are preferred when available.

Preparation of stock solutions will be documented in the Stock Solutions Log. To ensure traceability, commercially prepared stock solutions will also be documented in the Stock Standard Solutions Log. Each solution will be assigned a unique stock number determined by the page number and entry number on the page, preceded by “S” to indicate the solution is a stock, volatile stock standard are labeled “VS”. For example, the third entry on page 44 will be assigned the stock number S44-3. For stock solutions prepared from neat standards, the compound(s), supplier, lot number, preparation schematic, preparation date, expiration date, and analyst initials will be recorded. After preparing the standard, another analyst should review the preparation information to verify accuracy. For commercially prepared stock solutions, the compound, supplier, lot number and expiration date will be recorded. As a stock

solution is not actually prepared in-house for these commercial solutions, it is not necessary to record or verify a preparation schematic.

Preparation of working solutions (including spike and surrogate solutions) will be documented in the Working Standard Solutions Logbook. Each solution will be assigned a working standard number determined by the page number and entry number on the page. For example, the second entry on page 73 will be assigned the working standard number 73-2. For volatile organic standards, the working standard number is preceded by "VW". The compound, stock solution reference, preparation schematic, preparation date, expiration date, and analyst initials will be recorded. After preparing the standard, another analyst will review the preparation information to verify accuracy. After analyzing the standard and confirming that it is acceptable, analytical verification will be documented in the logbook.

Discarded or consumed standards will be annotated in the logbook by drawing a single line through the entry, indicating "discarded" or "consumed" above the line with confirming initial and date. Existing standard numbers will not be reused. Instead, each new stock or working solution made will be assigned a new number.

Standards preparation will be performed in accordance with good laboratory practices. Syringes, glassware and other preparation equipment will be thoroughly cleaned prior to and after use. Standard material weights and solution volumes will be accurate to ± 3%. Neat standards that are less than 97% pure must be corrected for concentration. Standard solutions will be stored in amber bottles with Teflon-lined caps. Each standard solution will be labeled with the solution number, compound, analyst initials and expiration date. Stock solutions will be stored in the appropriate standards freezer; working solutions will be stored in the appropriate standards refrigerator.

Metals Standard Preparation

Commercially prepared single element stock solutions are used for all elements. Preparation of working solutions from these single element stocks will be documented in the Solutions Logbook. Preparation of check standards will also be documented in the Solutions Logbook. The element, preparation schematic, preparation date, expiration date, and analyst initials will be recorded. Working calibration standards are prepared weekly for furnace and ICP analyses

and as needed for ICP-MS. Calibration verification standards are prepared daily for GFA analyses and as needed for ICP and ICP-MS analyses.

Standards preparation will be performed in accordance with good laboratory practices. All preparation equipment will be thoroughly cleaned prior to and after use.

Inorganic (Wet Chemistry) Standard Preparation

Working standards for wet chemistry parameters will be prepared on a daily basis, prior to starting an analysis. Stock and check standard solutions will be replaced as solutions expire or are consumed. Stock and check standard solutions will be labeled with the compound, preparation data (weight and volume), units of concentration, preparation date, expiration date, and analyst initials.

Standards preparation will be performed in accordance with good laboratory practices. Glassware and other preparation equipment will be thoroughly cleaned prior to and after use. Standard material weights and solution volumes will be accurate to ± 3%. Stock standards will be stored in containers appropriate for the parameter.

9.3 Calibration

Instrumentation and equipment used for sample processing and analysis must be operating optimally to ensure that accurate analytical results are generated. Verification of optimum operation is accomplished through various tuning and calibration procedures. Criteria for determining the accuracy of calibration are specified for all instrumentation and equipment. Prior to sample analysis, calibrations will be analyzed and evaluated against specified acceptance criteria. Acceptance criteria are either published as part of the method or generated at ARI using control charts. Calibration verifications will also be analyzed throughout an analytical sequence to ensure that instrument performance continues to meet acceptance criteria.

Gas Chromatography/Mass Spectrometry (GC/MS)

All GC/MS systems will be evaluated through analysis of an instrument performance check solution and calibration standards. The composition of the standards varies depending on the analysis performed on the system. System evaluation will be performed prior to sample

analysis. Evaluation criteria used for GC/MS analyses are as specified for the SW846 methods.

Instrument Performance Check Solution - Prior to analysis, the system will be evaluated to ensure that mass spectral ion abundance criteria are met. Bromofluorobenzene (BFB) is analyzed for volatile organic analyses and Decafluorotriphenylphosphine (DFTPP) is analyzed for semi-volatile organic analyses. All ions must meet method-specified criteria.

The instrument performance check solution will be analyzed at a minimum of every 12 hours during the analytical sequence. Each analysis of the check solution will be verified against the specified criteria.

Calibration - After instrument performance has been verified, each GC/MS system will be calibrated to verify response linearity. For volatile organic analyses, up to eight standards ranging from 1 to 200 µg/L will be analyzed. For semi-volatile organic analyses, five to seven standards ranging from 2 to 80 µg/L will be analyzed. The standard levels evaluated will vary depending on the compound. Initial calibration results will meet percent relative standard deviation acceptance criteria.

A continuing calibration verification standard at a mid-level concentration (routinely 50 µg/L for VOA and 250 µg/L for SVOA) will be analyzed at a minimum of every 12 hours during the analytical sequence. For continuing calibrations, minimum response factor and percent difference criteria will be considered in evaluating the acceptability of the calibration. Initial and continuing calibration acceptance criteria for volatile and semi-volatile organic analyses are presented in Appendix J. All calibration data printouts will include the following documentation:

Date of calibration,
Identification of standard used
Identification of person performing the calibration

The analyst performing the calibration will include documentation of any problems encountered during the calibration analyses with the data, and will also note any corrective actions taken. The calibration data will be tabulated, and summary statistics will be generated. These results will be kept on file with the raw data in the Data Services section.

Internal Standard Responses - Internal standard responses and retention times in all standards will be evaluated immediately after analysis. This will serve as a baseline from which all sample internal standard responses and retention times will be evaluated.

Gas Chromatography (GC)

Each GC and HPLC system will be calibrated to verify response linearity. Depending on the parameter, five to seven standards at concentrations covering the linear range of the

instrument will be analyzed. Percent relative standard deviations for initial calibrations will not exceed SW-846 limits or 25% when those limits are not applicable.

A continuing calibration standard at mid-range concentration will be analyzed after every 10 samples or more frequently if the method or conditions warrant. Percent differences between initial and continuing calibrations will not exceed SW-846 limits or 25% when those limits are not applicable.

Calibration for organochlorine pesticides will follow SW-846 guidelines. The initial calibration sequence specifies the analysis of Resolution Check, Performance Evaluation, five-point initial calibration, individual standards and instrument blanks. Criteria for evaluating these standards are as follows:

> Performance Evaluation - The Performance Evaluation standard will be analyzed immediately following the Resolution Check standard. All standard peaks will be completely resolved. Individual breakdowns of DDT and Endrin will be less than or equal to 15% on both columns. A Performance Evaluation standard will also be analyzed at the end of the calibration sequence.
>
> Initial Calibration - The percent relative standard deviation (RSD) will not exceed SW-846 guidelines or 20% on each column.
>
> Continuing Calibration - A midpoint Aroclor 1660 and or a midpoint pesticide standard along with a performance evaluation standard are analyzed after every ten (10) sample analyses. The continuing calibration standards will be within 85 - 115% of the initial calibration. The Performance Evaluation standard will meet previously specified criteria.

The analytical sequence may continue indefinitely, provided that calibration criteria are met throughout the sequence. Additionally, retention times for all compounds will fall within the retention time windows established by the initial calibration sequence of the three standard concentration levels.

All calibration data printouts will include the following documentation:

> *Date of calibration,*
> *Identification of standard used, and*
> *Identification of person performing the calibration.*

The analyst performing the calibration will include documentation of any problems encountered during the calibration analyses with the data, and will note any corrective actions taken. The calibration data will be tabulated, and summary statistics will be generated.

Metals

Analytical instrumentation for metals will be evaluated through the analysis of calibration standards, calibration blanks, and calibration verification standards. Initial calibrations will be performed prior to sample analysis.

Inductively Coupled Plasma Atomic Emission Spectrometry (ICP)

Initial standardization is performed daily, or more frequently as required, by analyzing a blank and four multiple element standards with a single concentration for each analytical wavelength. The calibration is immediately verified with the analysis of an initial calibration verification standard (ICV) obtained from a source independent from the IC standard. The calibration will then be verified throughout the analytical sequence by analyzing a continuing calibration verification standard (CCV) after every 10 sample analyses. The calibration check standard values will be within ± 10% of the true value.

After initial calibration, a calibration blank (ICB) will be analyzed to check for baseline drift or carryover. The level of analyte in the calibration blank should be ±2 RL. Calibration blanks (CCB) will be analyzed immediately following each calibration verification standard analysis.

Following calibration verification a standard at the reporting limit (CRI) is analyzed for all elements. Warning limits have been set at ±1RL and any sample determined to have a concentration below this standard will be reported as undetected.

The upper limit of the calibration range, linear dynamic range, is established for each analytical wavelength using standards of increasing concentrations. These standards are analyzed against the normal calibration curve and must be within 10% of their true value to verify linearity. At a minimum this upper range will be checked every six months or whenever major changes are made to the instrument. Any sample analyzed with a concentration above this linear dynamic range will be diluted and reanalyzed.

Also to verify the inter-element correction equations, inter-element correction standards (ICS) are analyzed both at the start and end of the analytic run. Both the major interfering and the interfered with elements are evaluated.

Atomic Absorption Spectroscopy (Graphite Furnace and Cold Vapor)

Atomic absorption instrumentation is initially calibrated using a minimum of three standards of varying concentrations and a calibration blank. Initial calibration is

performed daily or more frequently if conditions warrant. The calibration is immediately verified with the analysis of an independent source initial calibration verification standard (ICV). The calibration will then be verified throughout the analytical sequence by analyzing a continuing calibration verification standard (CCV) after every 10 sample analyses. The initial calibration verification standard value will be within ± 10% of the true value whereas the CCV will be considered in control if it is within ±10% for Graphite Furnace analysis or ±20% for Cold Vapor analysis.

After initial calibration, a calibration blank (ICB) will be analyzed to check for baseline drift or carryover. The level of analyte detected in the calibration blank should be ±1 RL. Calibration blanks (CCB) will be analyzed immediately following each calibration verification standard analysis.

Following calibration verification a standard at the reporting limit is analyzed for all elements. Warning limits have been set at ±1RL and any sample determined to have a concentration below this standard will be reported as undetected. Any sample determined to have a concentration above the high calibration standard will be diluted and reanalyzed.

Inductively Coupled Plasma Mass Spectrometry (ICP-MS)

Initial standardization is performed daily, or more frequently as required, by analyzing a blank and four multiple element standards. The calibration is immediately verified with the analysis of an independent source initial calibration verification standard (ICV). The calibration will then be verified throughout the analytical sequence by analyzing a continuing calibration verification standard (CCV) after every 10 sample analyses. The calibration check standard values will be within ± 10% of the true value.

After initial calibration, a calibration blank (ICB) will be analyzed to check for baseline drift or carryover. The level of analyte in the calibration blank should be ±1 RL. Calibration blanks (CCB) will be analyzed immediately following each calibration verification standard analysis.

Following calibration verification a standard at the reporting limit (CRI) is analyzed for all elements. Warning limits have been set at ±1RL and any sample determined to have a concentration below this standard will be reported as undetected.

The upper limit of the calibration range, linear dynamic range, is established for each analytical wavelength using high level standards. These standards are analyzed daily, or as necessary, against the normal calibration curve and must be within 10% of their true value to verify linearity. Any sample analyzed with a concentration above this linear dynamic range will be diluted and reanalyzed.

Also to verify the inter-element correction equations, inter-element correction standards (ICS) are analyzed both at the start and end of the analytic run. Both the major interfering and the interfered with elements are evaluated.

Inorganic Analyses other than Metals (Conventional Analyses)

Instrumentation and equipment used in analyzing samples for conventional wet chemical parameters (predominantly inorganic anions and aggregate organic characteristics) will be evaluated through the analysis of either internally prepared primary standards or externally derived Standard Reference Materials.

Depending upon the analysis, calibration is based upon direct stoichiometric relationships, regression analysis, or a combination of the two. Stoichiometry generally involves standardization of a titrant against a known primary standard and then the use of that titrant for determining the concentration of an unknown analyte (e.g. the use of sodium thiosulfate in the iodometric titration of dissolved oxygen). Regression analysis involves the determination of the mathematical relationship between analyte concentration and the response produced by the measurement being employed. Regression analysis is used for colorimetric determinations, ion specific electrode analysis and ion chromatography. The curve of response versus concentration is fit by the method of least squares using linear, polynomial or logarithmic regression dependant upon the pattern of response being measured.

Calibration is repeated for each analytical batch. Immediately following calibration, the standardized titrant or the calibration curve will be verified by the analysis of an Initial Calibration Verification standard (ICV) and Initial Calibration Verification Blank (ICB). The verification standard will be derived from a source other than that used for standardization or development of the standard curve. The ICV must return a value within 10% of its known concentration. The ICB must be less than the Reporting Limit (RL) or the lowest point on the standard curve, whichever is less. Initial calibration verification must be successfully completed prior to the analysis of any samples.

Calibration verification will be repeated after every ten samples processed during an analytical run. This Continuing Calibration Verification (CCV) will validate the method performance through an analytical sequence. If the continuing calibration values for either the standard or blank are out-of-control, the analyst will verify the outlying condition and, if verified, the analysis will stop and the method will be re-calibrated. All samples run between the outlying

CCV and the preceding in-control CCV will be re-analyzed. In-control verification standards and blanks must bracket all samples within an analytical run.

Initial calibration depending upon the analysis is based on a direct stoichiometric relationship, a linear regression analysis or a combination of the two. Stoichiometry generally involves standardization of a titrant and use of that titrant for determining the concentration of an unknown analyte (e.g. the use of thiosulfate in iodometric determination of dissolved oxygen). Regression analysis involves the determination of the mathematical relationship between the analyte concentration and the response produced by the measurement being employed. The curve is fit by the method of least squares using a linear, polynomial or logarithmic regression depending on the response being measured. The regression coefficient will be greater than or equal to 0.995 for the calibration to be considered acceptable.

Initial calibration curve is verified throughout the analytical sequence by analyzing a calibration verification standard after every 10 sample analyses. The calibration verification standard value will be within ± 10% of the initial calibration.

After initial calibration, a calibration blank will be analyzed to determine target analyte concentration levels. The level of analyte detected in the calibration blank will be less than the lowest standard concentration in the initial calibration.

SECTION 10: DATA VALIDATION and REVIEW

One hundred percent (100%) of laboratory data generated at ARI are subjected to a four level validation (review) process prior to release from the laboratory. The four levels of review are:

1. Analyst review
2. Peer review
3. Supervisory review
4. Administrative review

The data review process is outlined below and detailed in SOPs 200S through 206S.

In addition, Quality Assurance Personnel review 10% or more of all completed data packages for technical accuracy, project compliance and completeness. The data validation outlined below is completed in addition to the initial project review explained in Section 7 and QA specific reviews outlined in Section 11. If it is determined at any point during the analysis, reporting, or review process that data are unacceptable, prompt and appropriate corrective action must be taken. The corrective action will be determined by the situation. It is the responsibility of all staff members involved in data reporting and review to be aware of the quality control requirements and to be able to identify occurrences that require corrective action.

Analyst review:

Each analyst is responsible for producing quality data that meets ARI′s established requirements for precision and accuracy and is consistent with a client's expectation.

Prior to sample preparation or analysis an analyst will verify that:

1. Sample holding time has not expired.
2. The condition of the sample or extract is described accurately on the laboratory bench sheet.

3. Specified methods of analysis are appropriate and will meet project required Data Quality Objectives.
4. Equipment and Instrumentation are in proper operating condition.
5. Instrument calibration and/or calibration verification are in control.

During sample preparation or analysis an analyst will:

1. Verify that Method Blanks and Laboratory Control Samples are in control.
2. Verify that QC (replicate, matrix spike analyses, SRM, etc.) samples meet precision and accuracy requirements.
3. In addition to verifying that quality control requirements are met, the analyst will review each sample to determine if any compound of interest is present at levels above the calibrated range of the instrument.
5. Check for data translation or transcription errors
6. Record all details of the analysis in the appropriate bench sheet or logbook.
7. Note any unusual circumstances encountered.

Following the analysis or sample preparation an analyst will:

1. Examine each sample and blank to identify possible false positive or false negative results.
2. Determine whether any sample requires reanalysis due to unacceptable quality control.
3. Review data for any unusual observances that may compromise the quality of the data, such as matrix interference
4. Review and verify that data entry and calculations are accurate and no transcription errors have occurred.
5. Document anomalous results or other analytical concerns on the bench sheet, corrective action form or Analyst Notes for incorporation into the case narrative.
6. Note data with qualifying flags as necessary.

7. Enter reviewed data into LIMS as appropriate, incorporate all necessary sample and quality control information into the data package and forward it for further review.

Peer review:

A second analyst trained in the appropriate SOPs will complete a peer review. Peer review will include at a minimum:

1. Verification that all QA (holding times, calibrations, method blanks, LCS, spiked sample analyses, etc.) criteria are in control.
2. Examination the data for possible calculation and transcription errors.
3. Review bench sheets and analyst notes for completeness and clarity.
4. Approve the analytical results or recommend corrective action to the laboratory supervisor.

When a second trained analyst is not available a peer review is not completed.

Supervisory Review:

Following analyst and peer review the data is forwarded to the laboratory section supervisor for review. The supervisor will:

1. Review the data package for completeness and clarity.
2. Follow-up on the peer review recommendations.

Designated reviewers normally perform the peer and supervisory reviews for GC-MS data. The reviewers are identified on the organizational chart in Appendix A.

Administrative Review:

The results of all analyses are reviewed for compliance with quality control criteria and technical correctness before data is released to the Project Manager for distribution to clients. Designated reviewers in the Metals, Conventional and Organic laboratories perform administrative reviews. Personnel responsible for administrative reviews are noted in the Organizational Chart in Appendix A to this LQAP.

Administrative review is the final data validation process. Personnel performing the administrative review are responsible for the final sign-off and release of the data. Following administrative review the data is released to Project Managers for incorporation into the final data deliverable package.

Administrative review will:

1. Verify that the analytical package submitted for reporting is complete and contains all necessary information and documentation.
2. Verify that appropriate and necessary data qualifying flags (Listed in Appendix N) have been used.
3. Verify that method blank and LCS data are acceptable, quality control requirements were met for surrogates in all samples and blanks, and that all necessary re-analyses or dilutions were performed.
4. Check the technical validity (i.e. are total metal ≥ dissolved metals, is the cation/anion balance correct, etc.) of the complete data set.
5. Verify that all necessary final data reports have been generated and that all necessary data and documentation are included in the package.
6. Approve data reports for release.

10.2 Quality Assurance Review

10% (1 out each 10) final data packages are reviewed by ARI′s QA staff for compliance with ARI′s QA Program. This assessment includes, but is not limited to, review of the following areas:

1. Reporting and analysis requirements
2. Initial and continuing calibration records
3. Quality control sample results (method blank, LCS, spikes, replicates, reference materials)
4. Internal and surrogate standard results
5. Detection and reporting limits
6. Analyte identifications.

Data review activities are summarized and documented by the reviewer. The review notes are filed with the associated raw data in the project file. Any QA-related deficiencies identified during the data review will be forwarded to the QAPM for corrective action.

.

SECTION 11: QUALITY CONTROL SAMPLE ANALYSIS AND EVALUATION

Routine analysis of quality control (QC) samples is necessary to validate the quality of data produced in ARI's laboratory. ARI routinely utilizes the following quality control analyses as defined in Section 11.3:

1. method blank (MB)
2. holding blank (HB)
3. surrogate standard analyses (SS)
4. laboratory control sample (LCS)
5. laboratory control sample duplicate (LCSD)
6. standardized reference material (SRM)
7. sample(matrix) replicate (MD)

8 matrix spike (MS)

9. matrix spike duplicate (MSD)

The number and type of QC analyses depend on the analytical method and/or the QA/QC protocol required for a specific project. A range of acceptable result is defined for each type of QC analysis. When all quality control sample results are acceptable, the analysis is considered to be "in-control" and the data suitable for its intended use. Conversely, quality control sample results that do not meet the specified acceptance criteria indicate that the procedure may not be generating acceptable data and corrective action may be necessary to bring the process back "in-control".

Detailed information concerning sample preparation batches, QC analyses and surrogate standards follow:

11.1 Sample Preparation Batch

All QC samples will be associated with a discrete sample preparation batch. A preparation batch is defined as 20 or fewer field samples of similar matrix processed together by the same analysts, at the same time, following the same method and using the same lot of reagents. Additional batch requirements are detailed in ARI's method specific standard operating procedures. Each preparation batch will be uniquely identified. All samples, field and QC, will be assigned an ARI LIMS ID number and will be linked to their respective preparation batch. Each sample batch will contain all required QC samples in addition to a maximum of twenty field samples.

ARI will accommodate client, QC protocol or QAPP specific sample batching schemes.

11.2 QC Sample Requirements

Each preparation batch will include, at a minimum, a method blank (MB) and a laboratory control sample (LCS). Additional QC samples will be analyzed based upon the specific QC protocol required, data deliverable requirements or client request. ARI recommends that QC samples used to measure analytical precision also be included in each sample batch. These may include: a matrix spike and a matrix spike duplicate pair; a sample duplicate and a matrix spike pair or an LCS duplicate (LCSD) for comparison with the LCS.

11.3 QC Sample Definitions

11.3.1 Method Blank (MB)

A method blank is an aliquot of water or solid sample matrix that is free of target analytes and is processed as part of a sample batch. The method blank is used to verify that contaminants or compounds of interest are not introduced into samples during laboratory processing. Method blanks will be spiked with surrogate standards for all organic analyses.

ARI defines an acceptable method blank as one that contains no target analytes at a concentration greater than one-half ARI's reporting limit or 5% of an appropriate regulatory limit or 10% of the analyte concentration in the sample which ever is greatest.

A minimum of one method blank will be included in each preparation batch. A maximum of twenty samples may be associated with one method blank. An acceptable method blank is

required prior to analysis of field samples from a preparation batch. For methods not requiring pre-analysis sample preparation, a minimum of one method blank will be analyzed immediately prior to sample analysis, periodically throughout the analytical sequence, and also at the end of the sequence.

The results of the method blank analysis will be reported with the sample results.

11.3.2 Holding Blank (HB)

Holding blanks are organic-free water samples that are placed in each volatile organic sample storage refrigerator to monitor for possible cross-contamination of samples within the storage units. A holding blank from each refrigerator will be analyzed every 14 days. Holding Blank analyses will be reviewed by laboratory management and archived in ARI's electronic document archive.

11.3.3 Laboratory Control Sample (LCS)

An LCS is processed as part of each preparation batch, and is used to determine method efficiency. An LCS is an aliquot of water or solid matrix free of target analytes to which selected target analytes are added in known quantities. The analytes spiked into LCS samples are listed in ARI's method specific SOPs. LCS will be spiked with surrogate standards for all organic analyses.

Following analysis the percent recovery of each added analyte is calculated and compared to historical control limits. Current control limits are listed in Appendix K of this document. When calculated recovery values for all spiked analytes are within specified limits, the analytical process is considered to be in control. Any recovery value not within specified limits requires corrective action prior to analysis of any field samples from the associated preparation batch.

A minimum of one LCS will be prepared for each sample preparation batch. LCS analysis for those methods not requiring pre-analysis sample preparation will be performed after each continuing calibration. The results of all LCS performed will be reported with the sample results. A maximum of twenty samples may be associated with one LCS.

Specific clients or QA protocol may require the analysis of a duplicate LCS. When LCS duplicates are analyzed the failure of any analyte in either LCS to meet QC limits must trigger a corrective action.

11.3.4 Replicate Analysis

Replicate analyses are often used to determine method precision. Replicates are two or more identical analyses performed on subsamples of the same field sample at the same time. Replicate analyses should be performed on samples that are expected to contain measurable concentrations of target analytes.

The calculated percent difference between replicates must be within specified limits or corrective actions are required. Percent differences exceeding the specified limit signal the need for procedure evaluation unless the excessive difference between the replicate samples is clearly matrix related.

For inorganic analyses, a minimum of one replicate set should be processed for each analytical batch. Replicate sample analyses are not routinely performed for organic parameters. Instead, analytical precision is evaluated through the analysis of a duplicate matrix spike sample (MSD).

In order to perform replicate analyses, ARI's must receive sufficient volume to prepare the replicate aliquots.

Field replicates submitted to the laboratory will be analyzed as discrete samples.

11.3.5 Matrix Spike

A matrix spike is an environmental sample to which known quantities of selected target analytes have been added. The matrix spike is processed as part of an analytical batch and is used to measure the efficiency and accuracy of the analytical process for a particular sample matrix. The analytes spiked into MS samples are listed in ARI's method specific SOPs. MS samples will be spiked with surrogate standards for all organic analyses.

Following MS analysis the percent recovery of each spiked analyte is calculated and compared to historical control limits. If recovery values for the spiked compounds fall within specified

limits, the analytical process is considered to be in control. When calculated recovery is outside of historical limits corrective action is recommended.

Matrix spike duplicate (MSD) analyses are often used to measure method precision and accuracy. In this case the relative percent difference for recovery of spiked compounds is calculated and compared to established criteria.

Unless directed otherwise, ARI's policy is to prepare a matrix spike and a duplicate with each batch of samples for inorganic analysis and an MS/MSD set for each batch of samples for organic analyses. Analyte recovery and RPD values are reported with sample data.

11.3.6 Standardized Reference Material (SRM)

An SRM is material analyzed and certified by an outside organization to contain known quantities of selected target analytes independent of analytical method. SRMs are normally purchased from outside suppliers outside of ARI and are supplied with acceptance criteria. Analysis of SRM is used to assess the overall accuracy of ARI's analytical process. SRM are routinely analyzed with each batch of samples for wet chemistry (conventionals analysis) samples. External reference samples are analyzed after instrument calibration and prior to sample analysis. Compound recovery values not within the specified limit signal the need to evaluate either the calibration standards or instrumentation.

11.3.7 Other Quality Indicators

In addition to analyzing the quality control samples outlined previously, various indicators are added to environmental samples to measure the efficiency and accuracy of ARI's analytical process. Surrogate standards are added to extractable organic samples prior to extraction to monitor extraction efficiency. Surrogate standards will also be added to volatile organic samples prior to analysis to monitor purging efficiency. Internal standards are added to metals digestates for ICP-MS analyses and to organic samples or extracts prior to analysis to verify instrument operation.

The calculated recovery of surrogate analytes is compared to historical control limits to aid in assessing analytical efficiency for a given sample matrix.

11.4 Control Limits

To provide a means for evaluating whether or not a process is in control, acceptance limits have been established. These are based on internal, historical data for organic analyses and method specified limits for inorganic analyses. Samples associated with a specific program or contract (such as the USEPA Contract Laboratory Program) will be evaluated against program/contract-specified criteria. Routine samples will be evaluated against internally generated control limits. Project specific control limits will be used as required provided they have been reviewed for feasibility and approved by laboratory management.

Results of QA analyses are transferred from the LIMS to a control limit and chart generation program. The QAPM coordinates control chart and control limit generation. Control limits will be generated for LCS compound recoveries, surrogate recoveries, and matrix spike compound recoveries, on a method and matrix specific basis. Advisory control limits will be utilized for analyses performed on an infrequent basis until a sufficient number of usable data points are collected. Control limits are updated at least annually, but may be updated more frequently if method or instrument changes have been made. Laboratory control and acceptance limits are detailed in Appendix K.

Two levels of control limits are utilized in evaluating process control: warning limits and action limits. Limits are statistically determined from values obtained from LCSs or other control samples. Warning limits, within which 95% of all results are expected, equal ± two standard deviations from the average result. Action limits, within which 99.7% of all results are expected, are equal to ± three standard deviations from the average result. Mean values, warning limits, and action limits are necessary for thorough evaluation of process control.

11.5 Control Charts

Control charts, in conjunction with other control sample analyses, are useful in verifying that an analytical procedure is performing as expected. The control chart provides a pictorial representation of how closely control sample results approximate expected values, as well as showing analytical trends. Indicated on the control chart are the mean and upper and lower warning and action limits. The warning and action limits are used to determine whether or not an analytical process is in control. The mean is used to determine whether results obtained for

a procedure are trending upward or downward, which may ultimately affect the accuracy of sample results.

The QA Officer will coordinate generation of control charts based on laboratory data at least semi-annually. These control charts will be distributed to and reviewed by section supervisors and managers. Any significant trends or variations in results will be identified, and the source of the trend corrected. Copies of control charts will remain on file in the QA section. At the bench/instrument level, individual results from quality control samples are evaluated against the limits.

SECTION 12: CORRECTIVE ACTIONS AND REESTABLISHMENT OF CONTROL

To produce quality data, it is important that all aspects of the analytical process are under control and that all specified quality control criteria are met. On occasion, however, procedures, reagents, standards, and instrumentation can fail to meet specified criteria. Should any of those situations occur, the quality of data produced may be compromised. When procedures no longer appear to be in control, sample processing will be halted and appropriate actions will be taken to identify and rectify any instrument malfunctions or process-related issues. Prior to resuming sample analysis, verification of control will be made through the analysis of various control samples. Actions taken and observations made during reestablishment of control will be fully documented on the bench sheet or as an Analyst Note. Only when control has been regained and all actions documented will sample processing resume. This ensures that no results generated during the suspect period will be reported.

12.1 Responsibilities

It is the responsibility of all laboratory personnel involved with sample processing to be able to determine whether or not a procedure is in control and to verify that all data are produced under conditions that are “in control”. It is at the analytical level that unacceptable conditions are most easily detected and addressed. These personnel are also responsible for employing and documenting all necessary corrective actions taken to regain control of a procedure. Samples processed during suspect periods will be reprocessed, and suspect data will be appropriately annotated to indicate that it is of questionable quality. The analytical staff will verify that all data submitted for review has been generated under acceptable conditions. All anomalies will be documented on the Analyst Notes form and will include such information as: type and source of anomaly, reasons for the anomaly, and actions taken to correct the problem. All personnel involved with subsequent and final data review are responsible for verifying that data were generated under acceptable conditions. If suspect data are identified at the review level, responsible analysts should be contacted to determine whether additional actions (such as reanalysis) will be taken. In addition, reviewers will confirm that anomalies

noted by the analyst were indeed addressed and that appropriate corrective actions were taken.

On occasion, it is not possible to generate data that meet all Quality Control Standards. This may be due to sample volume limitations or sample matrix effects. It is the responsibility of the analytical and data review staff to document these situations and to maintain communication with the Project Management staff. The Project Management staff, in turn, is responsible for notifying the client or specifying additional actions to be taken. Project Managers are further responsible for ensuring that clients fully understand which data are questionable and the reasons why acceptable results could not be generated.

It is the responsibility of the QAPM to perform regular reviews of corrective action procedures to ensure that unacceptable conditions or suspect data will be identified prior to releasing results. Section managers and supervisors are responsible for ensuring that appropriate corrective action procedures are in place and that all staff members are trained to identify and act upon “out of control” situations.

12.2 Corrective Actions

There are various stages of the analytical process where the procedure may fall out of control and require corrective action. In general, all procedures and equipment will be monitored to verify that control is maintained during sample processing. The following details those stages as well as the actions taken to reestablish and verify control.

Sample Preparation

During sample preparation, all glassware associated with a specific sample will be clearly labeled to eliminate the possibility of sample mix-up or mislabeling. Laboratory staff will ensure that sample-identifying labels are accurately completed and that correct sample identification is maintained at all times. If a sample appears to have been misidentified or mixed with another sample during preparation, the suspect samples will be discarded and new aliquots taken. If there is insufficient sample for a second preparation, the situation will be documented on the bench sheet and the Project Manager will be immediately notified.

Addition of surrogate standards or matrix spiking solutions will be carefully monitored to ensure that all samples are accurately fortified. Volumes and standard solution numbers of all

standards added to samples will be recorded on the bench sheet. If there is suspicion that a sample has been incorrectly spiked a new sample aliquot should be prepared. If there is insufficient volume for re-preparation, the bench sheet will be annotated to indicate which samples may be inaccurately fortified.

If sample matrix hinders processing per standard procedures, the section supervisor or manager will be consulted for guidance on appropriate actions. Preparation of smaller sample aliquots or employment of different procedures may be necessary. Any deviations from normal protocols will be documented on the bench sheet.

If at any time during sample preparation sample integrity is compromised or a procedural error is noted, the sample will be discarded and re-prepared. If insufficient sample volume is available for re-preparation, the situation will be documented on the bench sheet and the Project Manager will be immediately notified.

Calibration and Tuning

Prior to sample analysis, all instrumentation will be calibrated and tuned to ensure that equipment meets all criteria necessary for production of quality data. Equipment must meet the calibration criteria specified in the section entitled “Calibrations”, per manufacturer specifications or per project/contract requirements. If these criteria are not met, corrective actions must be employed. Any corrective actions taken will be fully documented in the appropriate logbook, indicating the problem, the actions taken, and verification. Samples will not be analyzed until initial verification of system performance has been made. In the event that continuing calibration results do not meet criteria, sample analysis will not resume until corrective actions have been employed or the system has been re-calibrated.

GC/MS Analyses - Analysis of the instrument performance check solution (BFB or DFTPP) will meet the specified ion abundance criteria. Initial calibration standards at a minimum of five concentrations will meet specified response factor and percent relative standard deviation criteria. It criteria are not met for initial calibration, the system will be inspected for malfunction. The initial tuning and calibration will be repeated, with all necessary corrective actions taken, until calibration criteria are met.

A check of the calibration curve will be performed at a minimum of once every 12 hours. All response factor criteria will be met. Additionally, the percent difference between the initial and continuing calibrations will meet specified criteria. If criteria

are not met, the system will be inspected for malfunction. The initial tuning and calibration verification will be repeated, with all necessary corrective actions taken, until calibration criteria are met.

Internal standard responses and retention times for standards will meet specified criteria. Any sample not meeting internal standard criteria will be reanalyzed. If reanalysis yields the same response and the instrument is determined to be functioning correctly, the failure to meet criteria will be attributed to sample matrix interference. No further re-analyses will be required.

GC Analyses - Organochlorine pesticide calibrations will be evaluated using either USEPA CLP or SW-846 guidelines. The Resolution Check standard will meet resolution criteria and Endrin and DDT breakdown in the Performance Evaluation standard will meet breakdown criteria. Initial calibrations will meet percent relative standard deviation criteria. If, during the initial calibration sequence, criteria are not met, the system will be inspected for malfunction and the initial calibration be reanalyzed. Samples will not be analyzed until all initial calibration criteria are met.

Continuing calibrations of either the mid-level calibration standard or Performance Evaluation standard will be analyzed every 12 hours. If continuing calibration criteria are not met, the system will be inspected for malfunction and corrective actions will be taken to bring the system back into compliance. If, after corrective actions, the system is still not in compliance, re-calibration will be performed. After the system has been successfully corrected or re-calibrated, all samples previously analyzed between the acceptable and unacceptable continuing calibration will be reanalyzed.

If, during the analytical sequence, retention time shifting occurs, the system will be inspected for malfunction and corrective actions will be taken to bring the system back into compliance. If, after corrective actions, the system is still not in compliance, re-calibration will be performed. After the system has been successfully corrected or re-calibrated, all samples with retention times outside the specified windows will be reanalyzed.

For all other analyses, initial calibration standards analyzed at a minimum of five concentrations will meet percent relative standard deviation criteria. If criteria are not met for initial calibration, the system will be inspected for malfunction. The calibration will be repeated, with all necessary corrective actions taken, until calibration criteria are met.

A check of the calibration curve will be performed after every 10 samples. All percent differences between the initial and continuing calibrations will meet specified criteria. If criteria are not met, the system will be inspected for malfunction and re-calibration will be performed. Samples analyzed between an acceptable and unacceptable calibration check will be reanalyzed.

Metals and Inorganic Analyses - Initial calibrations will be verified by analyzing a calibration check standard immediately after calibration. The percent differences between the initial calibration and calibration check standard will meet specified percent difference criteria. If criteria are not met, the system will be inspected for

malfunction. The initial calibration and calibration check will be reanalyzed until acceptance criteria are met.

The calibration check standard analyzed after every 10 samples will meet percent difference criteria. If the calibration check standard is not acceptable, the system will be inspected for malfunction and re-calibration will be performed as necessary. Samples analyzed between acceptable and unacceptable calibration check standards will be reanalyzed.

Instrument Blanks

Prior to sample analysis, instrument and/or calibration blanks may be evaluated for the presence of target analytes. If analytes are detected, the concentrations must be below the reporting limits for those analytes. If analytes are detected at levels above the reporting limits, the source of contamination will be identified. Sample analysis will not commence until analyte levels in instrument and calibration blanks are below the reporting limits. Instrument and calibration blanks are analyzed for VOA analysis only if sample carryover is suspected.

Instrument and calibration blanks will also be analyzed throughout the analytical sequence. These will not contain target analytes at levels above the method detection limits for organic parameters or the reporting limit for inorganic parameters. If one or more analytes exceed the RL, an additional blank will be analyzed. If analyte levels are still above the method detection limits, the system will be inspected for malfunctions and the source of contamination will be identified. Sample analysis will not resume until instrument and calibration blank analyte levels are below the RL. Organic samples analyzed between acceptable and unacceptable blanks will be evaluated to determine the need for reanalysis per the following guidelines:

If no target analytes are detected in the samples, reanalysis will not be required.

If sample target analyte levels are above the method detection limits, samples will be reanalyzed at analyst discretion. Reanalysis will be dependent upon the analyte levels and whether or not there is likelihood that analytes detected are a direct result of system contamination.

If the analytes present at unacceptable levels in the instrument blank are not of interest or concern in the associated samples, reanalysis will not be required. This is often a consideration for ICP analyses where analytes of concern may be only a subset of the possible analytes.

Methods for the analysis of inorganic analytes require that all samples associated with an out of control blank be re-analyzed.

Method Blanks

Prior to sample analysis, method blanks will be evaluated for the presence of target analytes. Ideally, no target analytes should be present in the method blank. If analytes are detected at or above the Reporting Limit, the method blank will be reanalyzed to verify that the contamination is not a result of instrument carryover or malfunction. If the presence of target analytes is confirmed, the concentrations must be below the RL for those analytes.

Several volatile and semi-volatile compounds and certain elements are considered to be common laboratory contaminants. Concentrations of these common laboratory contaminants may exceed the method detection limits, but may not be present at concentrations greater than five times the method reporting limits. Target analytes considered to be common laboratory contaminants are:

Volatile Organic Compounds

Methylene Chloride
Acetone
2-Butanone

Semi-volatile Compounds

Dimethylphthalate
Diethylphthalate
Di-n-butylphthalate
Butylbenzylphthalate
bis-(2-Ethylhexyl) phthalate
Di-n-octylphthalate

If target analyte concentrations in the method blank exceed the acceptable levels and instrument malfunction or contamination has been ruled out, the method blank and all associated samples will be re-prepared and reanalyzed. If there is insufficient sample volume remaining for reprocessing, the Project Manager will be notified. If it is necessary to report results associated with an unacceptable method blank, the results will be qualified to indicate possible laboratory contamination.

In the event that an analyte detected in the samples ≥ 20 times the method blank levels re-preparation and reanalysis is not required. It is assumed that any contamination in the method blank is insignificant and will not affect final quantified results.

Laboratory Control Samples

Prior to sample analysis, the laboratory control sample (LCS) will be evaluated to verify that recovery values for all spiked compounds are within the specified acceptance limits. If LCS recoveries are out of control, corrective action is required. Corrective actions may include anything from a written explanation in the case narrative up to re-preparation and reanalysis of the entire sample batch.

Internal Standards

For volatile and semi-volatile organic analyses, internal standard results will be evaluated after each analytical run to verify that the values are within acceptance limits. Internal standard values will be within -50% to +100% of the internal standard values in the continuing calibration. If any internal standard does not meet the criteria, the system will be evaluated to confirm that all instrumentation is operating properly. The sample will then be reanalyzed. If the reanalysis results do not meet acceptance criteria, it will be assumed that the sample matrix is affecting internal standard values. Further reanalysis will not be required.

Surrogate

Surrogate recovery values will be evaluated after each analytical run to verify that the values are within acceptance limits. If recovery values are outside acceptance limits, the system will be evaluated to confirm that all instrumentation is operating properly. Documentation and bench sheets will be reviewed to verify that the concentrations of surrogate spike solutions added are accurate. For extractable organic analysis, bench sheets will be reviewed to determine if any additional dilutions or concentrations were performed. Bench sheets will also be reviewed for any explanatory notes about the sample.

If no system documentation, solution preparation or spiking errors are identified, the following considerations will be made:

When a volatile organic surrogate recovery value is outside of acceptable limits, the sample will be reanalyzed. If the reanalysis results are within acceptance limits, it will be assumed that the initial analysis was in error. If the reanalysis results are not within acceptance limits, it will be assumed that sample matrix is affecting surrogate recovery. Further reanalysis will not be required.

For semi-volatile organic analysis, one acid and one base/neutral surrogate recovery may be outside acceptance limits with no corrective action required provided the recoveries are at least 10%. If more than one acid or base surrogate standard is outside acceptance limits, or if any surrogate recovery value is less than 10%, the sample will be re-extracted and reanalyzed. If the reanalysis results are not within acceptance limits, it will be assumed that sample matrix is affecting surrogate recovery assuming all other QC analyses are acceptable. Further reanalysis will not be required. *Matrix spikes will not be re-extracted for unacceptable surrogate recovery values.*

For other extractable organic analysis, if a surrogate recovery value is outside of acceptance limits, the data will be reviewed to determine if the unacceptable surrogate is a result of matrix effect. If matrix interference is determined, the sample will be re-extracted or if re-extraction is not deemed useful, fully documented in the analytical narrative associated with the analyses. If a surrogate recovery is too low, based on the opinion of the final QA Data Reviewer, the sample will be re-extracted and reanalyzed.

Matrix Spikes

Matrix spikes will be evaluated to verify that recovery values for all spiked compounds are within the specified acceptance limits. If unacceptable results are obtained, the system will be evaluated to confirm that all instrumentation is operating properly. Documentation and bench sheets will be reviewed to verify that the concentrations of spike solutions added are accurate. Sample preparation bench sheets will be reviewed to determine if any additional dilutions or concentrations were performed. Bench sheets will also be reviewed for any explanatory notes about the sample.

If no system, documentation, solution preparation, or spiking errors are identified, the following considerations will be made:

Organic Analyses:

If a matrix spike recovery value is outside the acceptance limits, but the LCS meets recovery acceptance criteria, re-extraction will not be required. It will be assumed that the unacceptable recovery value is a result of matrix effect.

If both LCS and matrix spike recovery values are outside the acceptance limits, the sample batch will be re-extracted and reanalyzed. This indicates the possibility of a systematic error that may affect the accuracy of final results.

Inorganic analyses:

Matrix spikes with unacceptable recovery values will be re-prepared and reanalyzed. If the reanalysis results are not within acceptance limits, it will be assumed that the sample matrix is affecting the recovery values. Further reanalysis will not be required.

A post-digestion spike analysis will be performed for all metals analyses processed following EPA-CLP guidelines.

Sample and Matrix Spike Replicates

Sample and matrix spike replicates will be evaluated to verify that percent differences between the replicates are within acceptable limits. Percent differences for metals and inorganic sample replicates will be within ±20%. When percent difference criteria are not met, the system will be evaluated to confirm that all instrumentation is operating properly. Documentation and bench sheets will be reviewed to verify that the concentrations of spike solutions added are accurate. Sample preparation bench sheets will be reviewed to determine if any additional dilutions or concentrations were performed. Bench sheets will also be reviewed for any explanatory notes about the sample.

If no system, documentation, solution preparation, or spiking errors are identified, the following considerations will be made:

If percent difference values between sample replicates for metals and inorganic analyses do not meet acceptance criteria the Project Manager in consultation with ARI's client will determine whether to re-analyze the samples or flag the analytical results. If the samples are reanalyzed and results are not within acceptance limits, it will be assumed that the sample is not homogeneous, causing the poor analytical precision. Further re-analyses will not be required.

Replicate sample analyses are not routinely performed for organic parameters.

If percent difference values between matrix spike replicates do not meet acceptance criteria, but spike recovery values are acceptable, no re-extraction or analysis will be required. It will be assumed that the sample is not homogeneous, causing the poor analytical precision.

If percent difference values between matrix spike replicates do not meet acceptance criteria and recovery values in one or both replicates are not acceptable, the sample and associated matrix spike replicates will be re-prepared and reanalyzed. If the reanalysis results are not within acceptance limits, it will be assumed that the

sample is not homogeneous, causing the poor analytical precision. Further re-analyses will not be required.

Samples

In addition to monitoring sample quality control indicators, ARI evaluates samples to determine the need for reanalysis. Conditions considered while evaluating samples are:

If a target analyte detected in a sample exceeds the upper limit of the instrument calibration range, the sample is diluted and reanalyzed. Dilution and reanalysis continues until the analyte concentration falls within the linear range of calibration. If the sample requires dilution to such a level that surrogates are no longer detectable and analytical accuracy is questionable, the sample will be re-prepared using a smaller sample aliquot.

Samples will be evaluated for matrix interference that may affect analyte detection and quantification. Appropriate cleanup procedures will be employed to remove interference. Samples will be diluted and reanalyzed as required to minimize background interference. If it is not possible to remove all interference, reported results will be qualified as necessary.

If low-level analytes detected in a sample are suspected to be a result of instrument carryover, the sample will be reanalyzed. If analyte levels remain approximately the same the initial results will be considered valid. If analytes are not detected during reanalysis, it will be assumed that the initial detection was due to carryover, and the initial results will not be reported.

If an instrument malfunction or procedural error occurs during analysis, all affected samples will be reanalyzed. If the malfunction appears to be an isolated incident, it will not be necessary to inspect the analytical system. If the malfunction appears to be an ongoing problem, the system will be inspected and necessary maintenance/corrective actions will be taken prior to resuming analysis.

Sample Storage Temperatures

Every sample storage unit's temperature will be evaluated at the beginning of each day. Temperatures will be between 2 and 6 °C for refrigerators and < -10 °C for freezers. If a temperature is outside the specified range, the unit's temperature will be adjusted to bring the temperature back within limits. The Temperature Log will be annotated to document the adjustment.

If adjustment does not bring the temperature within range, or if adjustment is not possible, the Laboratory Supervisor will be notified and will take corrective action. The Temperature Log will be annotated to document the action. If the temperature fluctuation is chronic or extreme, the

samples will be removed from the unit and placed in another storage unit until the malfunctioning unit is repaired or replaced.

Balance Calibrations

Balances are serviced once a year by a certified technician. The service includes preventative maintenance and calibration.

Balance accuracy will be verified prior to balance use. The recorded weight will be within the acceptance criteria specified on the Calibration Log. If the recorded weight is not within the acceptance limits, the QAPM will be notified. The Calibration Log will be annotated to document the action. The balance will not be used until it can be verified that acceptance criteria can be met.

Water Supply System

The water supply for the volatile organic and inorganic laboratories will be monitored daily for the presence of contaminants through the analysis of method and/or instrument blanks. Organic contaminants, especially chloroform, are early indicators of the need for preventative maintenance. If organic or other contaminants are detected, the system filters will be changed. After filters have been changed, an additional aliquot of water will be analyzed to confirm that contaminants are no longer present.

The water supply for the metals laboratory will be monitored daily. When the resistivity falls below 18 megaohm, system maintenance will be performed.

Section 13: LABORATORY EVALUATION AND AUDITS

Routine evaluations of the laboratory ensure that all necessary quality control activities have been implemented and are being effectively utilized. It is the responsibility of the QAPM to ensure that quality control activities are periodically evaluated for compliance. Findings from these evaluations allow the laboratory to address and modify any procedures that are not in accordance with the laboratory Quality Assurance Program or accreditation program requirements.

A number of tools are available for monitoring laboratory performance. ARI evaluates the quality of laboratory performance through the use of

Internal QA Audits
Technical System Audits
Data Quality Reviews
Audits by Outside Agencies (External Audits)
Performance Evaluation Analyses
Annual Management Review

Each audit provides an objective evaluation of laboratory performance. All internal audits and reviews are conducted according to specified guidelines. In addition, a collective review of audit findings provides an overall evaluation of the laboratory. Deficiencies noted during the course of an audit or performance evaluation will be addressed, a root cause analysis performed, and appropriate corrective actions will be taken. Follow-up audits will be conducted to verify that corrective actions have been satisfactorily implemented.

Internal QA Audits

The Quality Assurance Officer regularly evaluates quality control activities within the laboratory to verify accuracy and compliance. The QAPM or designee routinely audits the following activities:

Balance verification records

Sample storage cooler temperature records

Oven, incubator and water bath temperature records

Chain of Custody records

Standard preparation records

Documentation and Response to Client Complaints

Chain of Custody Procedures

Documentation of Computer and Software Revisions

Checklists are utilized to ensure consistent and complete audits. The checklists are included in SOP 1005S. Internal QA audit results will be summarized and reported to both staff and management. Corrective actions will be initiated as necessary. A schedule of internal QA audits is provided in Appendix L.

When an audit finding indicates possible errors or deficiencies in analytical data, ARI will correct the error and notify all affected clients within 2 working days.

Technical System Audits

An audit of technical systems within the laboratory will be conducted at least annually. The audit will focus on the quality control and data generation/collection systems. The QAPM will conduct the audit with assistance from section managers and data reviewers. This evaluation will address areas such as:

Calibration records

Maintenance records

Control charts

Computer vs. hard copy data

Adherence to SOPs and methods

Support system records (DI water, balances, pipettes, etc.)

In addition, audit results from the past year will be reviewed to verify that all necessary corrective actions have been addressed and implemented.

Data Quality Reviews

Reviews of final data packages by the QAPM or his/her designee. The Data quality review verifies that the final data deliverables meet project and quality systems specifications

Audits by Outside Agencies (External Audits)

As a requirement for many accreditation programs, on-site review of laboratory facilities and operations are conducted by clients or other outside agencies. The laboratory may be periodically audited by the following agencies:

State of Washington Department of Ecology
A United States Department of Defense Agency (US Army, US Navy or US Air Force)
State of Oregon Environmental Laboratory Accreditation Program (ORELAP) as an Accrediting Body for The NELAP Institute.

External audits are beneficial in that they provide an independent evaluation of the laboratory without internal influence or bias. The laboratory will be available for evaluation at the convenience of the auditing agency. Laboratory personnel will be available during the audit to address questions or provide information regarding laboratory procedures. All comments, deficiencies, and areas of potential improvement noted by the auditor will be reviewed, and appropriate corrective actions will be taken to resolve the noted issues. A listing of laboratory accreditations is included as Appendix M.

Performance Evaluations

Performance Evaluation (PE) sample analysis is a means of evaluating individual performance as well as the overall analytical system. In addition to the external audit, PE sample (PES) analysis is a requirement of many certification and accreditation programs. The laboratory routinely participates in the following performance evaluation programs:

Analytical Standards, Inc.(ASI) Performance Evaluation Studies
USEPA Water Pollution (WP) Performance Evaluation Studies (Commercial Supplier)
USEPA Water Supply (WS) Performance Evaluation Studies (Commercial Supplier)
USEPA Contract Laboratory Program Quarterly Performance Evaluations (as required)
AASHTO (for geotechnical samples)

A PES is a sample containing specific analytes in concentrations unknown to analysts. Comparison of the laboratory result to the "true" value determines the accuracy of the

reported result and indicates the laboratory's ability to perform a given analysis. These results are also used to verify individual analyst proficiency. The QAPM will periodically submit internal “blind” performance evaluation samples to the laboratory sections for analysis. Values obtained by the laboratory will be compared to expected or true values. Parameters with reported values outside of the specified acceptable ranges will be evaluated by the analytical staff to determine the source of error. All necessary corrective actions will then be documented and implemented.

Quality Assurance Reports to Management and Staff

In order to ensure that laboratory managers are kept apprised of quality related activities and laboratory performance, a “Quality Assurance Report to Management” the QAPM will be produced annually and distributed to ARI management. The report will, at a minimum include:

1. Information concerning current and ongoing internal and external audits
2. Status and results of current or ongoing internal or external proficiency analyses
3. Identification of Quality Control problems in the laboratory
4. Information on all ongoing Corrective Actions
5. Current status of external certifications
6. Current status of the Staff Training Program
7. Outline of new and/or future Quality Assurance Program initiatives

The QAPM is responsible for follow-up and resolution of any deficiencies discussed in the report. Unresolved issues will remain on subsequent reports until addressed. Information such as performance evaluation results and audit reports will be distributed to the laboratory staff.

The application of these combined activities provides comprehensive monitoring and assessment of laboratory performance, and ensures that all data produced by ARI will be of the highest possible quality.

Annual Management Review

In the last quarter of each year, executive management will perform a comprehensive review of ARI quality system and analytical procedures to assess their continued suitability and effectiveness. Management will consider the following during the review process:

- Suitability of policies and procedures
- Reports fro management and supervisory personnel
- Results of internal audits
- Corrective and preventative actions
- Results of recent external quality systems audits
- PT results
- Changes in volume and type of analyzes performed
- Client Feedback
- Complaints
- Other relevant factors such as quality control activities, available resources and analyst training

Section 14: APPENDICES

A. Laboratory Organization and Key Personnel Resumes
B. Training and Demonstration of Proficiency
C. Laboratory Facilities
D. Laboratory Instrumentation and Computers
E. Standard Operating Procedures
F. Sample Collection Containers, Preservation and Holding Times
G. Laboratory Workflow
H. Analytical Methods
I. Method Detection Limits and Reporting Limits
J. Quality Control Recovery Limits
K. Internal Audit Schedule
L. Laboratory Accreditations
M. Data Reporting Qualifiers
N. Standards for Personal Conduct
O. QA Policies
P. Modifications to ARI's LQAP

Appendix A

Laboratory Organization Chart
and
Key Personnel Resumes

KEY PERSONNEL RESUMES

Mark Weidner

Laboratory Director

Profile

Mr. Weidner co-founded Analytical Resources, Inc., along with Brian Bebee, Sue Dunnihoo and David Mitchell. Prior to his co-founding of ARI in 1985, Mr. Weidner was the Head Mass Spectroscopist at Michigan State University and an instructor at the Finnigan Institute. As Laboratory Director, Mr. Weidner is responsible for overall laboratory performance, as well as facility expansion and major purchasing. Mr. Weidner is intimately familiar with all operational and analytical aspects of ARI and initiated many of the procedures currently in use.

Education:

M.S., Medicinal Chemistry, Purdue University, W. Lafayette, IN (1978).

B.S., Biochemistry, Michigan State University, E. Lansing, MI (1975).

Experience:

Laboratory Director/Co-founder, Analytical Resources, Inc., Seattle, WA (1985 to present).

Senior Chemist, City of Seattle, Seattle, WA (1981 to 1985).

Instructor, Finnigan Institute, Cincinnati, OH (1979 to 1981).

Mass Spectroscopist, Michigan State University (1978 to 1979).

Brian Bebee

Laboratory Manager

Administrative Services Manager

Profile:

Mr. Bebee co-founded Analytical Resources, Inc., along with Mark Weidner, Sue Dunnihoo, and David Mitchell. Prior to his co-founding of ARI, Mr. Bebee had gained extensive GC/MS experience as a GC/MS Chemist at the Municipality of Metropolitan Seattle, (METRO). When he co-founded ARI in 1985, Mr. Bebee became the Organics Division Manager until 1993, when he assumed the position of Laboratory Manager. As Laboratory Manager, Mr. Bebee is responsible for the day to day flow of all laboratory operations, including personnel, instrument, and procedural concerns. He is also responsible for the direct supervision of the Volatile and Semivolatile Laboratories.

Education:

A.A., Oceanography, Marine Biology, Biology, Shoreline Community College (1973).

Experience:

Laboratory Manager, Analytical Resources, Inc., Seattle, WA (1987 to present).

Organics Division Manager/Co-founder, Analytical Resources, Inc., Seattle, WA (1985 to 1987).

GC/MS/DS Operator, Municipality of Metropolitan Seattle, Seattle, WA (1980 to 1985).

Senior Water Quality Technician, Municipality of Metropolitan Seattle (METRO), Seattle, WA (1976 to 1980).

Water Quality Technician, Municipality of Metropolitan Seattle (METRO), Seattle, WA (1973 to 1976)

David Mitchell

Quality Assurance Program Manager

Profile:

Mr. Mitchell co-founded Analytical Resources, Inc., along with Mark Weidner, Sue Dunnihoo, and Brian Bebee. Prior to his co-founding of ARI, Mr. Mitchell had gained extensive experience in the environmental chemistry field as Senior Chemist and Trace Organics Laboratory Supervisor at the Municipality of Metropolitan Seattle (METRO). His responsibilities include the management of ARI's Quality Assurance/Quality Control Program.

Education:

Graduate Work in Chemistry (Organic/Biological), University of Wyoming, Laramie, WY (1970 to 1974).

B.S., Chemistry, Upper Iowa College, Fayette, IA (1970).

Experience:

Quality Assurance Manager, Analytical Resources Inc., Seattle, WA (1998 to Present)

Client Services Manager, Analytical Resources Inc., Seattle WA (1987 to 1998)

Vice President/Co-founder of Analytical Resources, Inc., Seattle, WA (1985 to 1987).

Senior Chemist, METRO Trace Organics Laboratory, Seattle, WA (1979 to 1985).

Research Associate, Northwestern University Medical School (1974 to 1979).

Susan Dunnihoo

Director, Client Services

Profile:

Ms. Dunnihoo co-founded Analytical Resources, Inc., along with Mark Weidner, Brian Bebee, and David Mitchell. Prior to her co-founding of ARI, Ms. Dunnihoo had gained extensive experience in the environmental chemistry field through her work at Laucks Testing Laboratories, the City of Tacoma, and the Municipality of Metropolitan Seattle (METRO). As Director of Client Services, Ms. Dunnihoo is responsible for assisting project managers in responding to the needs of ARI clients, and for communicating to the laboratory the analytical capabilities that should be added to satisfy future client needs. Ms. Dunnihoo also acts as project manager for a number of projects.

Education

Graduate work in Chemical Oceanography, University of Washington (1976-1980)

ACS Certified BA, Chemistry, Augsburg College, Minneapolis, MN (1976)

Experience

Director, Client Services, Analytical Resources, Inc., Seattle, WA (2007-present)

Client Services Manager, Analytical Resources, Inc., Seattle, WA (1998-2007)

Computer Services Manager, Analytical Resources, Inc., Seattle, WA (1985 to 2000)

Corporate Secretary, Analytical Resources, Inc., Seattle, WA (1985 to present)

Chemist, Laucks Testing Laboratories, Seattle, WA (1983 to 1985)

Chemist, City of Tacoma, Plant II, Tacoma, WA (1982 to 1983)

GC/MS/DS Operator, METRO TPSS Lab, Seattle, WA (1980 to 1982)

Jay Kuhn

Inorganic Division Manager

Profile:

Mr. Kuhn oversees ARI's Inorganic Division, which includes the Metals Sample Preparation, Metals Analysis, and Conventional Wet Chemistry sections. He has extensive experience in the environmental chemistry field, with an emphasis in inorganic analyses. Mr. Kuhn is experienced with in-house and EPA standard methods and protocols, as well as the operation, maintenance, and repair of ICP-MS, ICAP, CVAA, and Graphite Furnace instruments.

Education

Graduate work in Environmental Chemistry, University of Washington, Seattle, WA.

B.S. Chemistry, University of California at Santa Barbara (1980)

Experience

Inorganic Division Manager, Analytical Resources, Inc., Seattle, WA (1992 to present)

Metals Division Manager, Analytical Resources, Inc., Seattle, WA (1990 to 1992)

Research Technologist III and Laboratory Manager, UW College of Forest Resources Chemical Analysis Cost Center (1985-1990)

Research Technologist, UW College of Forest Resources Chemical Analysis Cost Center (1981 to 1985)

Appendix B

Training

Qualification Requirements

In addition to on-the-job training, ARI recommends a specific level of education and experience for the following positions:

GC/MS Laboratory Supervisor

A Bachelor's degree in chemistry or scientific/engineering discipline, three years experience operating GC/MS systems and one year supervisory experience.

GC Laboratory Supervisor

A Bachelor's degree in chemistry or scientific/engineering discipline, three years experience operating GC systems and one year supervisory experience.

Sample Preparation Laboratory Supervisor

A Bachelor's degree in chemistry or scientific/engineering discipline, three years experience in organic sample preparation and one year supervisory experience.

Data Systems/LIMS Manager

A Bachelor's degree with four or more computer-related courses and three years experience in systems management or programming. A minimum of one year experience with software utilized for laboratory report generation is also recommended.

Programmer Analyst

A Bachelor's degree with four or more computer-related courses and two years experience in systems or application programming. A minimum of one year experience with software utilized for laboratory report generation is also recommended.

Quality Assurance Officer

A Bachelor's degree in chemistry or a scientific/engineering discipline and three years of laboratory experience, including one year of applied experience with quality assurance.

Project Manager

A Bachelor's degree in chemistry or a scientific/engineering discipline and three years of laboratory experience, including one year of applied experience with quality assurance.

GC/MS Chemist

A Bachelor's degree in chemistry or a scientific/engineering discipline and at least one year experience operating a GC/MS system. Three years of GC/MS operations and spectral interpretation experience may be substituted in lieu of educational requirements.

Mass Spectral Interpretation Specialist

A Bachelor's degree in chemistry or a scientific/engineering discipline and participation in training course(s) in mass spectral interpretation. Also, at least two years of experience in mass spectral interpretation is recommended.

Purge and Trap Expert

A Bachelor's degree in chemistry or a scientific/engineering discipline and one year experience operating a purge and trap type liquid concentrator interfaced to a GC/MS system.

GC Chemist

A Bachelor's degree in chemistry or a scientific/engineering discipline and at least one year experience operating a GC system. Three years of GC operations and maintenance experience may be substituted in lieu of educational requirements.

Pesticide Analysis Expert

A Bachelor's degree in chemistry or a scientific/engineering discipline and at least one year experience operating a GC system. Three years of GC operations and spectral interpretation experience may be substituted in lieu of educational requirements.

ICP Spectroscopist

A Bachelor's degree in chemistry or a scientific/engineering discipline and Four years of applied experience with ICP analysis of environmental samples. Four years of ICP experience may be substituted in lieu of educational requirements.

ICP Operator

A Bachelor's degree in chemistry or a scientific/engineering discipline and one year of experience operating and maintaining ICP instrumentation. Three years of ICP experience may be substituted in lieu of educational requirements.

Atomic Absorption (AA) Operator

A Bachelor's degree in chemistry or a scientific/engineering discipline and one year of experience operating and maintaining graphite furnace and cold vapor AA instrumentation. Three years of AA experience may be substituted in lieu of educational requirements.

Conventionals (Classical Chemistry) Analyst

A Bachelor's degree in chemistry of a scientific/engineering discipline and one year of experience with classical chemistry procedures. Three years of classical chemistry experience may be substituted in lieu of educational requirements.

Sample Preparation Expert

A high school diploma and one college level course in chemistry. One year of experience in sample preparation is also recommended.

Appendix C

Laboratory Facilities

ANALYTICAL RESOURCES INC. occupies a total of 23,500 square feet of floor space located at 4611 S. 134th Place in Tukwila, Washington. The laboratory facility, constructed between September 2001 and June 2002, includes:

- State-of-the-art heating, ventilation and air conditioning (HVAC) systems to assure a clean comfortable working environment while maintaining air flow balance designed to minimize the possibility of sample cross contamination between laboratory areas.
- A central service area provides space for three walk-in coolers (356 sq. ft. total), two walk-in freezers (760 cubic ft.), metals archive storage, and sample cooler storage. A 400 sq. ft. walk-in freezer covered by a mezzanine for storage was added in 2005.
- A data network linking all workstations to a centralized server room. All connections are made to managed switches and hubs and are protected by the latest firewall technology and uninterruptible power supplies.
- Distribution systems to deliver pressurized Air, Zero Grade Air, Argon, Helium, Hydrogen, Nitrogen and Argon/Hydrogen to the laboratory areas from a central location.
- A system to deliver ASTM Type 1 water directly to sinks in each laboratory area. Water is purified by filtration, ion exchange and reverse osmosis and continuously re-circulated through a filtration + ion exchange + UV radiation polishing loop that delivers water directly to the laboratories.
- An isolated and ventilated hazardous waste storage area.
- An electronic repair shop and storage room.
- Alarm monitored fire sprinkler and intrusion detection systems

The facilities are divided into five functionally-distinct sections as detailed below:

1) The Organics Division features three main laboratory areas as described below:
   - The Organics Extraction Laboratory (2400 sq. ft.) is utilized to isolate and concentrate organic compounds from various environmental sample matrices. The laboratory contains approximately 200 linear feet of bench space and nine fume hoods. It is equipped with two gel permeation chromatographs, an accelerated solvent extractor (ASE) and a gas chromatograph for extract screening purposes. The laboratory includes a separate area for extraction of aqueous samples, a glassware cleaning area and individual workstations for the laboratory supervisor and analyst.
   - The Semivolatile Organics Analysis Laboratory (3000 sq. ft) has 124 linear feet of instrument bench space plus personal workstations. The Laboratory is equipped with seven Gas Chromatographs (GCs) with six GC-MS instruments, one High Resolution GC/MS (HRGC-MS) and a fume hood for preparation of standard solutions and dilution of samples. Each gas chromatograph is individually vented to the outside for removal of heat and potentially contaminated GC exhaust gases.
   - The Volatile Organics Analysis (VOA) Laboratory (2500 sq. ft) houses seven GC-MS and two GC-PID instruments dedicated to volatile organics analysis. Each instrument is vented to the outside. The laboratory area includes two fume hoods, a sample/standards preparation area, a TCLP preparation/tumbler room and sample holding refrigerators. The HVAC system maintains a positive air pressure in the laboratory using filtered air from outside of the building. This eliminates the possibility of cross contamination of samples with solvents from other areas of the laboratory.

2) The Inorganic Division includes a Trace Metals Laboratory and the Conventional Analyses Laboratory:
   - Trace Metals Laboratory (3000 square feet)
     - The Metals Preparation Laboratory (1200 sq. ft) contains five fume hoods including two 8-foot polypropylene. An additional eight foot polypropylene laminar flow fume hood is housed in a separate class 1000 clean room. The lab is equipped with tumblers, hot-plates, digestion blocks, facilities for glassware cleaning, and a spectrophotometer for cold vapor analysis of mercury, a TCLP tumbler room, and storage areas.
     - The Metals Instrument Laboratory (1300 sq. ft) features two atomic absorption spectrometers for graphite furnace analyses, two inductively coupled argon plasma spectrometers (ICP) for simultaneous analysis of metals species, and an ICP-mass spectrometer for analysis of metals species at low detection levels.
     - A 500 sq. ft. Office provides desk area for Trace Metals laboratory personnel.
   - The Conventional Analyses (Wet Chemistry) Laboratory (2500 sq. ft.) contains approximately 200 linear feet of bench space, eight fume hoods and includes a separate microbiology room. Instruments in this lab include two Rapid-Flow Analyzers, two TOC analyzers, an ion chromatograph, two uv/visible spectrophotometers, and various other equipment necessary for the evaluation of inorganic parameters.

3) The Geotechnical Laboratory includes 2500 square feet of space with special areas and equipment for soil testing, treatability studies, and soil/sediment leaching studies. The Laboratory includes approximately 50 feet of linear bench space and 5 fume hoods.

4) The Sample Receiving Facility consists of an area to accept and log-in samples to ARI's Laboratory Information Management System (LIMS) and an area to prepare and ship sampling supplies.
   - The Sample Receiving Facility (1000 sq. ft.) is equipped with two fume hoods, and 70 feet of bench space. Four computer terminals are available to log samples into ARI's LIMS.
   - The Sampling Containers Facility (500 sq. ft.) is used to prepare sampling containers for shipment to ARI's client designated locations.

4) Administrative Areas (8600 sq. ft.) include:
   - The Quality Assurance Section
   - Executive Offices
   - Project Management Section
   - The Human Resources Section
   - The Computer Services Section
   - One Conference Room
   - A Lunch Room
   - Several Storage Areas

Appendix D

Laboratory Instrumentation and Computers

LABORATORY INSTRUMENTATION and COMPUTERS

Organic Extractions Laboratory Equipment

(MARS 1) CEM MARS™ (2008) – Microwave extraction apparatus.

(MARS 2) CEM MARS™ (2010) – Microwave extraction apparatus.

(MARS 3) CEM MARS™ (2011) – Microwave extraction apparatus.

(GPC 1) Gel Permeation Chromatograph (1985) – Fluid Metering Inc. pump and ISCO UA-5 UV detector equipped with a 16 position autosampler used for clean-up of samples prior to final analysis.

(GPC 2) Gel Permeation Chromatograph (2003) – Fluid Metering Inc. pump and ISCO UA-5 UV detector equipped with a 16 position autosampler used for clean-up of samples prior to final analysis.

Zymark Turbo-Vap LV (1999) - 24 place

Zymark Turbo-Vap LV (2002) - 24 place

Zymark Turbo-Vap LV (2007) - 24 place

Zymark Rapid Trace Solid Phase Extraction Workstations (2007) - 5 each

Horizon Technology – DryVap Concentrator System Model 5000 – 2 each

Dioxin Extractions Laboratory Equipment

(MARS 1) CEM MARS™ Express (2010) – Microwave extraction apparatus.

Zymark Turbo-Vap LV (2010) - 24 place

Rotovap R-205 with V-805 Vacuum Controller (2010) – 2 each

Glas-Col Combo Heating Mantle (2010) – 6 place – 3 each

Vacuum Manifold – 6Place (2010) – for SPE

Gas Chromatograph - High Resolution Mass Spectrometer (GC/HRMS)

(HR1) Waters Autospec Premier (2009) – A GC-HRMS system with Masslynx Version 4.1 data acquisition & quantitation software. System includes an Agilent 7890A GC and 7683B autosampler.

Gas Chromatograph - Mass Spectrometers (GC/MS)

(FINN5) Finnigan MAT Incos 50 (1989) - A GC-MS system networked with a Hewlett Packard Unix Server running Thruput Target 3.5 data analysis software. System includes an HP 5890 GC, a Tekmar LSC 2000 Purge & Trap and a Dynatech PTA-30 autosampler for VOA analysis of either aqueous or solid samples.

(NT2) Hewlett Packard (1999) – A GC-MS system networked with a Hewlett Packard Unix Server running Thruput Target 3.5 data analysis software. System includes Agilent 6890 GC, 5973 MSD, and 7683 autosampler.

(NT3) Hewlett Packard (1999) – A GC-MS system networked with a Hewlett Packard Unix Server running Thruput Target 3.5 data analysis software. System includes an HP 6890 Plus GC, an HP 5973 MSD, an OI Analytical Eclipse 4660 and a Varian Archon autosampler for VOA analysis of aqueous or solid samples.

(NT4) Hewlett Packard (2001) – A GC-MS system networked with a Hewlett Packard Unix Server running Thruput Target 3.5 data analysis software. The system includes HP 6890-Plus GC, 5973 MSD and 6890 autosampler

(NT5) Hewlett Packard (2002) – A GC-MS system networked with a Hewlett Packard Unix Server running Thruput Target 3.5 data analysis software. The system is equipped with an HP 6890N GC, an HP 5973N MSD, a Tekmar LCS 2000 Purge and Trap and a Dynatech PTA 30 autosampler for VOA analysis of aqueous or solid samples.

(NT6) Hewlett Packard (2002) – A GC-MS system networked with a Hewlett Packard Unix Server running Thruput Target 3.5 data analysis software. The system includes an HP 6890 Plus GC, an HP 5973 MSD and an HP 7683 autosampler.

(NT7) Hewlett Packard (2007) – A GC-MS system networked with a Hewlett Packard Unix Server running Thruput Target 3.5 data analysis software. The system is equipped with an HP 6890N GC, an HP 5973N MSD, a Tekmar LCS 2000 Purge and Trap and a Dynatech PTA 30 autosampler for VOA analysis of aqueous or solid samples.

(NT8) Agilent (2008) – A GC-MS system networked with a Hewlett Packard Unix Server running Thruput Target 3.5 data analysis software. The system is equipped with Agilent 6890N GC, 5975C MSD, and 7683 autosampler.

(NT9) Agilent (2008) – A GC-MS system networked with a Hewlett Packard Unix Server running Thruput Target 3.5 data analysis software. The system is equipped with Agilent 6890 GC and 5973 MSD, a Tekmar LSC 2000 Purge and Trap and a Dynatech PTA-30 autosampler for VOA analysis of either aqueous or solid samples.

(NT10) Agilent (2008) – A GC-MS system networked with a Hewlett Packard Unix Server running Thruput Target 3.5 data analysis software. The system is equipped with Aglient 6850GC,an Agilent 5975C inert MSD GC, an OI Analytical Eclipse 4660 and a Varian Archon autosampler for VOA analysis of aqueous samples.

(NT11) Hewlett Packard (2009) - A GC-MS system networked with a Hewlett Packard Unix Server running Thruput Target 3.5 data analysis software. The system includes an Agilent 6890 N GC, an HP 5973 MSD and a Combi-pal SPME autosampler.

Gas Chromatographs

Hewlett Packard 5890 Series II (2003) – A GC system equipped with both FID and ECD detectors, capillary injectors, an autosampler and Chemstation. Used for screening samples before full extraction.

(ECD1) Hewlett Packard 5890 Series II (2004) - A GC system equipped with dual ECD detectors, an Agilent 6890 autosampler and HP Chem Station data system.

(ECD3) Hewlett Packard 5890 Series II (1991) – A GC system equipped with Dual ECD detectors, two Cool on column capillary injectors, an HP7673 autosampler and ChromPerfect data system.

(FID2) Hewlett Packard 5890 Series II (2004) – A GC system equipped with an FID detector, a capillary injector, an HP 7673A autosampler and HP Chem Station data system.

(FID3 A, B) Hewlett Packard 6890 (1996) – A GC system equipped with dual FID detectors, two capillary injectors, a dual tower HP 6890 autosampler, and HP Chem Station data system. A Restek GC Racer has been added to enhanced performance.

(FID4 A, B) Hewlett Packard 6890 (1996) – A GC system equipped with dual FID detectors, two capillary injectors, a dual tower HP 6890 autosampler, and HP Chem Station data system. A Restek GC Racer has been added to enhanced performance.

(PID1) Hewlett Packard 5890 Series II (2002) – A GC system equipped PID and FID detectors in series, an Dynatech PT30 autosampler and Tekmar LCS 2000 Sample Concentrator and Chemstation data system.

(PID2) Hewlett Packard 5890 Series II – (2005) –A GC system equipped with dual PID detectors, one in series with an FID, a Dynatech PT30 autosampler, a Tekmar 2000 sample concentrator and HP Chem Station data system.

(PID 3) Hewlett Packard 5890 Series II – (2006) –A GC system equipped with PID and FID detectors in series, a Dynatech PT30 WS autosampler, a Tekmar 2000 sample concentrator and HP Chem Station data system.

(ECD5) Hewlett Packard 6890 Plus Micro – (2002) – A GC system equipped with dual ECD detectors, an HP 7683 autosampler and an HP Chem Station data system.

(ECD6) Hewlett Packard 6890 Plus Micro – (2008) – A GC system equipped with dual ECD detectors, an Agilent 6890 autosampler and an HP Chem Station data system.

(FID5) Hewlett Packard 5890E Series II (2005) – A GC system equipped with dual FID detectors, an HP 7683 autosampler and HP Chem Station data acquisition system.

(FID6) Hewlett Packard 5890 Series II (2005) – A GC system equipped with an FID detector, an HP 7694 Headspace Sampler and HP Chem Station data acquisition system.

(FID7) Agilent 6850 (2008) – A GC system equipped with a single FID detectors, an Agilent 6850 autosampler and HP Chem Station data acquisition system.

(ECD7) Hewlett Packard 6890 Plus Micro – (2008) – A GC system equipped with dual ECD detectors, an Agilent 6890 autosampler, and HP Chem Station data system.

(FID8) Agilent 6890N (2008) – A GC system equipped with a dual FID detectors, an Agilent 7683B autosampler and HP Chem Station data acquisition system.

(FID9) Agilent 6850 (2009) – A GC system equipped with a single FID detector, an Agilent 6850 autosampler and HP Chem Station data acquisition system.

Inorganic Instrumentation

Perkin-Elmer SCIEX ELAN 6000 ICP-MS (1996) - A completely automated ICP-Mass Spectrometer with autosampler and multitasking software.

Perkin-Elmer NexIon 300 ICP-MS (2010) - A completely automated ICP-Mass Spectrometer with autosampler and multitasking software.

Perkin-Elmer Optima 7300DV ICP (2009) – Automated dual view simultaneous ICP with an Elemental Scientific SC-2 fast autosampler system

Perkin-Elmer Optima 4300 ICP (2001) - A completely automated dual view simultaneous ICP with auto-sampler and multitasking software.

Varian 300Z (1992) - A single channel atomic absorption graphite furnace instrument equipped with Zeeman background correction, and an auto-sampler

Varian 300Z (1991) - A single channel atomic absorption graphite furnace instrument with Zeeman background correction, equipped with an auto-sampler

CETAC M-6000A Mercury Analyzer (2000) – A fully automated high sensitivity cold vapor atomic absorption instrument dedicated to trace and ultratrace Mercury analysis. System is computer controlled with windows base software and an auto-sampler

Dionex Ion Chromatography DX 500 (1997) – A fully automated system with an auto-sampler for quantitative anion analyses. The system is computer controlled using Peaknet software.

Dionex Ion Chromatography 2100 (2009) – A fully automated system with an auto-sampler for quantitative anion analyses. The system is computer controlled using Chromeleon CHM-2 Version 7.0 software.

Thermo Genesys 10 (2003) - UV-VIS Spectrophotometer used for quantitative conventionals analysis.

Thermo Genesys 10 (2005) - UV-VIS Spectrophotometer used for quantitative conventionals analysis.

Lachat QuickChem 8000 Flow Injection Analyzer (2003) – Automated flow injection instrument dedicated to low level nutrient analysis

Lachat QuickChem 8500 Flow Injection Analyzer (2007) – Automated flow injection instrument dedicated to low level nutrient analysis

Dohrmann Apollo 9000 (2001) - Total Organic Carbon (TOC) Analyzer. Includes an autosampler for water analysis and a boat sampler for solids analysis.

Dohrmann Apollo 9000 (2009) - Total Organic Carbon (TOC) Analyzer. Includes an autosampler for water analysis and a boat sampler for solids analysis.

Kontes Midi-Vap Cyanide Distillation Systems (3 each)(1995-2008) – Each of the systems is capable of simultaneously distilling up to 10 samples for cyanide analysis using small sample aliquots.

Centrifuge (1987) - Beckman Model GP with swinging bucket rotor and inserts for 250 ml bottles and scintillation vials

Aim 500 Block Digestion System (2006) with Controller

Environmental Express Hot Block digestion blocks (10 ea) (1999-2008) for digestion of samples prior to trace metals analysis.

Hach COD Digestion Blocks (2)

Hach Ratio Nephelometer

Incubators: Lab-Line Ambi Hi-Lo Chamber and **Thermolyne 41900.**

GeoTech Laboratory Equipment

Trautwein Sigma 1 (2008) – Triaxial loading system

Sedigraph III Model 5120 (2007) – Automatic particle size analyzer

Beckman Coulter LS 13320 (2008) – Laser diffraction particle size analyzer with microliquid and universal liquid modules

Trautwein Soil Equipment – 12 position flexible wall permeability station

Soil Test Load Frame – with 500, 2,000 and 10,000 pound load cells for QU, UU, and CU triaxial tests, with pore pressure.

Soil Consolidation Apparatus – 16 tsf

Biosciences BI-1000 – 8 position electrolytic respirometer

Microtox – photo-luminescence toxicity test instrument

Beckman JP-21 – refrigerated centrifuge with 6 x 500 ml fixed angle head

IEC DRP-6000 – refrigerated centrifuge with a 4 x 1,000 ml swinging bucket head

Plas-Labs Anaerobic Test Chambers – 3 each

U.S. Army Corps of Engineers – column settling; column and batch leaching apparatus

Network Servers

ARI's central laboratory computer is a Dell PC Server, PowerEdge 2300/450, running Microsoft Windows NT 4.0 SP6. This system is home to ARI's Laboratory Information Management System (LIMS) database developed by Northwest Analytical of Portland, OR. The LIMS receives electronic data from all lab sections and produces hardcopy and electronic deliverables. In addition, the LIMS stores sample demographic data while providing a common tracking mechanism for all laboratory information.

The LIMS is connected to two sub-networks. Most data, with the notable exception of Conventionals and Geotech, is transferred electronically as text files from other data systems to the LIMS. This key process enhances data integrity by reducing manual entry and manipulation of instrument output.

The metals section uses an Intel PC Server with the Windows 2000 Server operating system. This system runs as a file server for dBASE IV and MS Access 2000 database applications.

Once data is collected by the metals instrument computers, dBASE is used to aggregate and process the results and transfer it to the LIMS. The MS Access software has been customized by ARI's metals data supervisor to generate metals CLP forms and other internal reports. This server also provides additional services such as DHCP, WSUS, and the corporate vacation calendar.

The organics section uses an HP-UX Server with the HP-UX 10.20 operating system. This system runs Target 3.4 data analysis software. All GC/MS and other GC instruments are networked to this system. In addition to providing one common platform for organics data processing, the Target software produces CLP forms for organics data packages.

The conventional analysis laboratory uses individual PC Workstations with MS Excel for data reduction. Filled spreadsheets are saved to Server3. Data is manually copied from the MS Excel spreadsheet into the LIMS systems using LIMS worklists specific to a test method.

Server2 is the primary internal/external interface and provides email, NTP, web (internet and intranet), DHCP, proxy, document (Geotech), CVS, database, and authentication services. Access to Server2 is limited to authorized users and only IT personal have access to the shell.

Server3, running Windows 2000 Advanced Server, is the primary document server for ARI and is used to warehouse all scanned (pdf) data packages. The hardware for Server3 consists of a generic box with a 2.4 MHz Intel Pentium 4 processor. Packages saved to this server are indexed using the CI service of Windows and are available for searching via the ARI intranet.

All servers are secured in a locked room where only management and IT staff have access. Some users have external access to the network but this is limited to current employees and only through an end-to-end encrypted VPN (OpenVPN).

Note: Extensive in-house replacement parts are available for lab instruments and computers, including spare circuit boards. A majority of all service maintenance is performed by ARI employees.

Appendix E

ARI Active Standard Operating Procedures (SOP)

A list of ARI's current Standard Operating Procedures (SOPs) is available on ARI's web site at:

http://www.arilabs.com/portal/downloads/ARI-SOPs.zip

SOPs are updated periodically. Assure that you have ARI's current SOPs by downloading the files at the time of use.

Appendix F

Sample Containers, Preservation and Holding Times

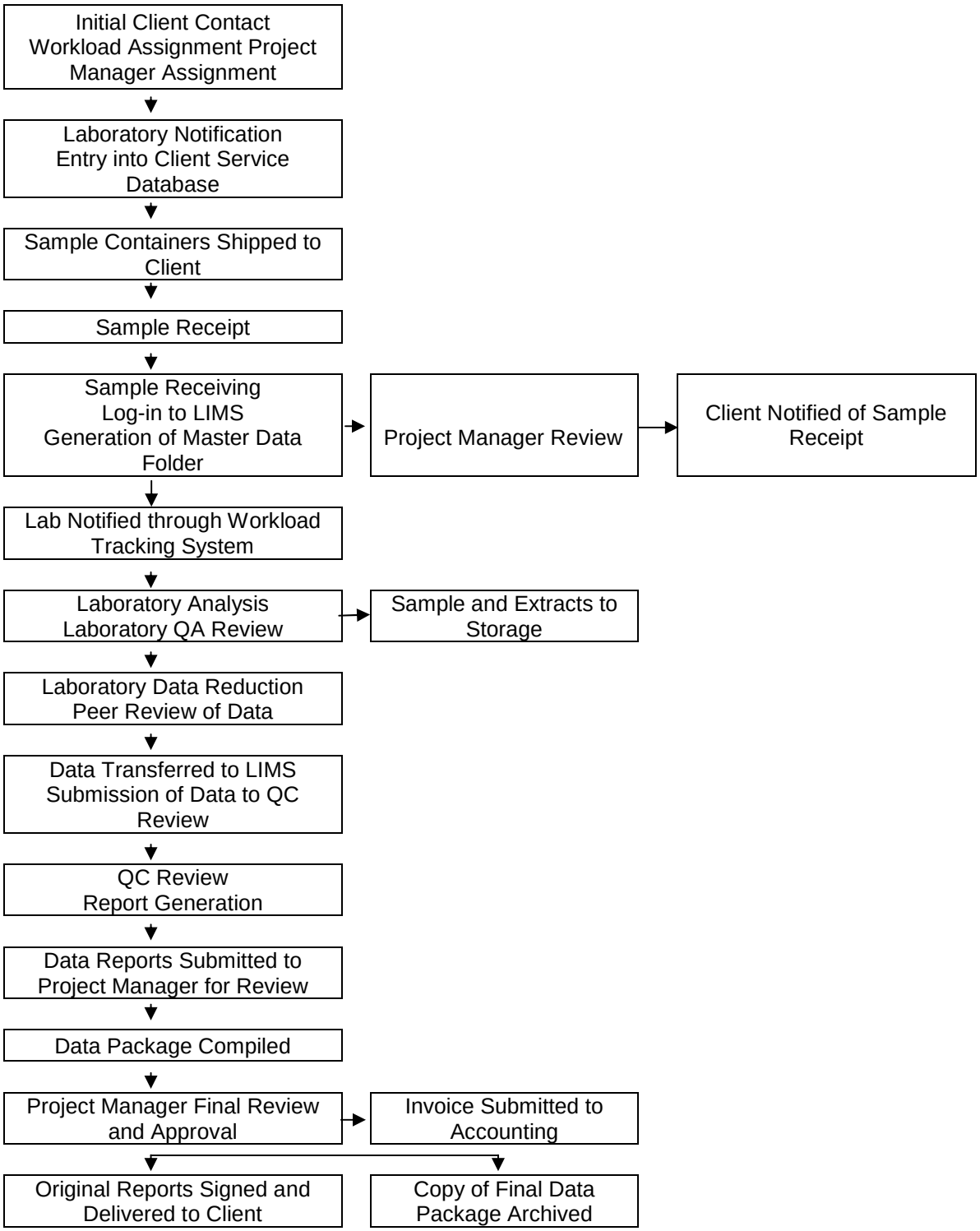
A summary of sample containers, preservatives and holding times is available on ARI's web site at:

http://www.arilabs.com/portal/downloads/

The summary is updated periodically. Assure that you have ARI's current document by downloading the files at the time of use.

Appendix G

Laboratory Workflow


Initial Client Contact
Workload Assignment Project Manager Assignment
Laboratory Notification
Entry into Client Service Database
Sample Containers Shipped to Client
Sample Receipt
Sample Receiving
Log-in to LIMS
Generation of Master Data Folder
Project Manager Review
Client Notified of Sample Receipt
Lab Notified through Workload Tracking System
Laboratory Analysis
Laboratory QA Review
Sample and Extracts to Storage
Laboratory Data Reduction
Peer Review of Data
Data Transferred to LIMS
Submission of Data to QC Review
QC Review
Report Generation
Data Reports Submitted to Project Manager for Review
Data Package Compiled
Project Manager Final Review and Approval
Invoice Submitted to Accounting
Original Reports Signed and Delivered to Client
Copy of Final Data Package Archived

Appendix H

Analytical Methods

ORGANIC ANALYSES

Parameter	Methods	Technique
Volatiles (GC/MS)	524.2/624/8260B	GC/MS
	Low Level Vinyl Chloride & 1,1 – Dichloroethene	GC-MS-SIM
Volatiles (GC)		
Volatile Aromatics	602/8021B	GC/PID
Semivolatiles (GC/MS)		
Semivolatile Organics	625/8270D	GC/MS
Polynuclear Aromatic Hydrocarbons (PNA/PAH)	625/8270D	GC/MS (SIM)
Isotope Dilution Semivolatiles	1625	GC/MS
Butyl Tin Species	Krone (1988)	GC/MS-SIM
Pesticides/GC Analyses		
Chlorinated Pesticides	608/8081A	GC/ECD
Aroclors/PCBs	608/8082	GC/ECD
PCB Congeners	ARI Method	GC/ECD
Phenols	604/8041	GC/FID
Chlorinated Phenols	8041 (mod)	GC/ECD
Pentachlorophenol	8151A (mod)	GC/ECD
Organophosphorous Pesticides	614/8141A	GC/NPD
Polynuclear Aromatic Hydrocarbons (PNA/PAH)	610/8100	GC/FID
Chlorinated Hydrocarbons	612/8121	GC/ECD
Herbicides	615/8151A	GC/ECD
Glycols	ARI Method(SOP 426S R2)	GC/FID
Hydrocarbon ID	NWTPH-HCID	GC/FID
Gasoline Range Hydrocarbons	(N)WTPH-G/AK101/WI-GRO	GC/FID
Diesel Range Hydrocarbons	(NWTPH-D/AK102/WI-DRO)	GC/FID
Extractable Petroleum Hydrocarbons	ARI Method	GC/FID
Volatile Petroleum Hydrocarbons	ARI Method	GC/PID
Organic Sample Preparation and Clean Up		
TCLP / SPLP Extraction		1311 / 1312
Sonication		3550B
Soxhlet		3540C
Accelerated Solvent Extraction (ASE)		3545B
Separatory Funnel		3510C
Continuous Liquid-Liquid		3520C
Alumina Clean-up		3610B

Florisil Clean-up	3620B
Gel Permeation (GPC)	3640A
Silica Gel	3630C
Sulfur Clean-up	3660B
Sulfuric Acid Clean-up	3665A

INORGANIC ANALYSES

Parameter	Methods	Technique
Wet Chemistry		
Acidity	2310/305.1	Titrimetric
Alkalinity	2320/310.1	Titrimetric
Ammonia	4500NH_3H/350.1	AutomatedPhenate/ISE
Biological Oxygen Demand-BOD		
Carbonaceous – BOD	5210.B/405.1	5-day Winkler Titration
Bromide	4500Br.B	Phenol Red Colorimetric
Anions	300.0	Ion Chromatography
Cation Exchange Capacity	9080	Neutral Ammonium Acetate
Chemical Oxygen Demand	5220.D/410.4	Closed Reflux, Colorimetric
Chromium Hexavalent (Cr6+)	3500Cr-D/7196A	Diphenylcarbazide
Chloride	4500CI.E/325.2	Automated Ferricyanide
Chlorophyll a	10200.H	Spectrophotometric
Coliform, Total / Fecal	9222.B/D	Membrane Filtration
Color	2120.B/110.2	Visual Comparison
Conductivity	2510/120.1	Electrometric
Corrosivity (CaCO3 Saturation)	2330	Calc. (pH, Alk, TDS, Ca)
Cyanide, Total	4500CN.C/335.2/9010	PBA, Colorometric
Cyanide, Amenable	4500CN.G/335.1	Alkaline Chlorination
Cyanide, WAD	4500CN.I	Weak Acid Distillation
Dissolved Oxygen	4500-O.C/360.2	Winkler Titration
Fats/Oils/Grease	5520.B/413.1/9070A	Gravimetric
Fluoride	4500F.C/340.2	Ion Specific Electrode
	300.0	Ion Chromatography
Formaldehyde	ASTM D-19 P216	Colorimetric
Hardness, Calculation	2340.B/6010B	Ca, Mg Calculation
Heterotrophic Plate Count	9215.D	Membrane Filtration
Iron (II) ferrous	3500Fe.D	Phenanthrolene
Nitrate + Nitrite	4500NO_3F/353.2	Automated Cd Reduction
Nitrate	4500NO_3F/353.2	Calculated
	300.0	Ion Chromatography
Nitrite	4500NO_3.F/353.2mod	Automated Colorimetric
	300.0	Ion Chromatography
Oil & Grease, Solids	5520.D/907	Gravimetric
Oil & Grease, Polar/Non Polar	5520.F	Gravimetric
PH	150.1	Electrometric
Phenols	5530.D/420.1/9065	4-AAP w/ Distillation
Phosphorous, Total	4500P.B/365.2	Colorimetric w/ digestion

Phosphorous, Ortho (SRP)	4500P.B/365.2	Colorimetric
	300.0	Ion Chromatography
Salinity	2520	Conductimetric
Silicate	4500Si.E/370.1	Heteropoly Blue
Total Kjeldahl Nitrogen (TKN)	4500N.org/351.4	Block Digest/ISE
Total Solids	2540.B/160.3	Gravimetric, 104°C
Total Suspended Solids (TSS)	2540.D.160.2	Gravimetric, 104°C
Total Dissolved Solids (TDS)	2540.C/160.1	Gravimetric, 180°C
Total Volatile Solids (TVS)	2540.E/160.4	Gravimetric, 550°C
Settleable Solids	2540.F	Volumetric
Streptococcus, Fecal	9230.C	Membrane Filtration
Sulfide	4500S^2.E/376.1/9034	Iodometric
Sulfide, Low Level	4500S^2.D/376.2	Methylene Blue
Sulfide, Acid Volatile	4500S^2.D/376.2	Methylene Blue
Sulfate	4500SO_4^2.F/375.2/9036	Auto. Methylthymol Blue
	300.0	Ion Chromatography
Sulfite	4500SO_3^2.B.377.1	Iodometric
Total Organic Carbon (TOC)	5310.B415.1/PSEP	Combustion NDIR
Turbidity	2130.B/180.1	Nephelometric
Total Lipids in Tissue	Bligh & Dyer (mod)	Gravimetric

Trace Metals Analyses

Inductively Coupled Plasma (ICP):

Ag, Al, As, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, Pb, Sb, Se, Si, Sn, Sr, Th, Ti, Tl, V, (Li, Th, U, W - special request only)	Zn200.7 / 6010B	ICP

Graphite Furnace (GFAA):

Ag, As, Cd, Sb, Pb, Se, Tl	200 Series / 7000 Series	GFAA

Cold Vapor (CVAA):

Hg	7470A/7471A	CVAA

Inductively Coupled Plasma/Mass Spectroscopy (ICP-MS):

Ag, Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, Pb, Sb, Se, Th, Tl, U, V, Zn	200.8/ 6020 Mod.	ICP/MS

Trace Metals Sample Preparation

Toxicity Characteristic Leaching Procedure	1311
Synthetic Precipitation Leaching Procedure	1312
Digestion for Total Recoverable or Dissolved Metals	3005A
Digestion of Aqueous Samples for Total Metals by ICP	3010A
Digestion of Aqueous Samples for Total Metals by GFAA	3020A
Digestion of Sediment, Sludge and Soil	3050B

Appendix I

Method Detection Limits and Reporting Limits

Summaries of method specific MDL studies and reporting limits are available on ARI's web site at:

http://www.arilabs.com/portal/downloads/ARI-MDLs.zip

MDL's and reporting are updated periodically. Assure that you have ARI's current detection limit data by downloading the files at the time of use.

Appendix J

Quality Control Recovery Limits

Method specific control limits are available on ARI's web site at:

http://www.arilabs.com/portal/downloads/ARI-CLs.zip

Control limits are updated periodically. Assure that you have ARI's current control limits by downloading the files at the time of use.

Appendix K

Internal Audit Schedule

Schedule of Laboratory Quality Assurance Audits

Process To Be Audited	Frequency
Verify Effectiveness of Corrective Actions	Monthly
Verify Refrigerator and Freezer Temperature Logs	Monthly*
Verify Oven and Incubator Temperature Logs	Monthly*
Verify That Balance Records Are Complete	Quarterly*
Verify That Standard Records are Complete	Monthly#
Verify That Logbooks Are Reviewed	Monthly#
Verify That SOPs Are Current and Available in Labs	Monthly#
Review Chain of Custody Documentation	Monthly#
Audit Internal Technical Systems	Annually
Post-Completion Project Review	Monthly**

* all sections will be audited

one section will be audited each month

** frequency may be contract specific i.e. 10% of NFESC projects must be audited

Appendix L

Laboratory Accreditations

Laboratory Accreditations

Analytical Resources Inc. is currently certified to perform environmental analysis by the National Environmental Laboratory Accreditation Program (NELAP), the State of Washington Department of Ecology and the State of Alaska Department of Environmental Conservation. ARI is approved to perform analyzes for the US Navy and the US Army Corps of Engineers following the Department of Defense Quality Systems Manual (DoD-QSM)

ARI's laboratory QA/QC Program has been audited and approved by The Boeing Company and Battelle Pacific Northwest Laboratories.

ARI analyzes drinking water, waste water and solid matrix performance testing (PT) samples semiannually.

List of Accreditations

1) National Environmental Laboratory Accreditation Conference (NELAC) – Accrediting authority is Oregon Environmental Laboratory Accreditation Program (ORELAP).
2) State of Washington, Department of Ecology - Environmental Laboratory Accreditation Program
3) The Alaska State Department of Environmental Conservation - Laboratory Approval Program
4) United States Army Corps of Engineers (USACE)
5) United States Naval Facilities Engineering Service Center (NFESC) (formerly known as NEESA)

Continuing Contracts Resulting from On-Site Laboratory Audits

1) The Boeing Company Corporate Environmental Affairs Division
2) The City of Seattle
3) The Port of Seattle

Appendix M

Data Reporting Qualifiers

Data Reporting Qualifiers

Effective 7/10/2009

Inorganic Data

U Indicates that the target analyte was not detected at the reported concentration

* Duplicate RPD is not within established control limits

B Reported value is less than the CRDL but ≥ the Reporting Limit

N Matrix Spike recovery not within established control limits

NA Not Applicable, analyte not spiked

H The natural concentration of the spiked element is so much greater than the concentration spiked that an accurate determination of spike recovery is not possible

L Analyte concentration is ≤5 times the Reporting Limit and the replicate control limit defaults to ±1 RL instead of the normal 20% RPD

Organic Data

U Indicates that the target analyte was not detected at the reported concentration

* Flagged value is not within established control limits

B Analyte detected in an associated Method Blank at a concentration greater than one-half of ARI's Reporting Limit or 5% of the regulatory limit or 5% of the analyte concentration in the sample.

J Estimated concentration when the value is less than ARI's established reporting limits

D The spiked compound was not detected due to sample extract dilution

E Estimated concentration calculated for an analyte response above the valid instrument calibration range. A dilution is required to obtain an accurate quantification of the analyte.

Q Indicates a detected analyte with an initial or continuing calibration that does not meet established acceptance criteria (<20%RSD, <20%Drift or minimum RRF).

S Indicates an analyte response that has saturated the detector. The calculated concentration is not valid; a dilution is required to obtain valid quantification of the analyte

NA The flagged analyte was not analyzed for

NR Spiked compound recovery is not reported due to chromatographic interference

NS The flagged analyte was not spiked into the sample

M Estimated value for an analyte detected and confirmed by an analyst but with low spectral match parameters. This flag is used only for GC-MS analyses

M2 The sample contains PCB congeners that do not match any standard Aroclor pattern. The PCBs are identified and quantified as the Aroclor whose pattern most closely matches that of the sample. The reported value is an estimate.

N The analysis indicates the presence of an analyte for which there is presumptive evidence to make a "tentative identification"

Y The analyte is not detected at or above the reported concentration. The reporting limit is raised due to chromatographic interference. The Y flag is equivalent to the U flag with a raised reporting limit.

EMPC Estimated Maximum Possible Concentration (EMPC) defined in EPA Statement of Work DLM02.2 as a value "calculated for 2,3,7,8-substituted isomers for which the quantitation and /or confirmation ion(s) has signal to noise in excess of 2.5, but does not meet identification criteria" **(Dioxin/Furan analysis only)**

C The analyte was positively identified on only one of two chromatographic columns. Chromatographic interference prevented a positive identification on the second column

P The analyte was detected on both chromatographic columns but the quantified values differ by ≥40% RPD with no obvious chromatographic interference

X Analyte signal includes interference from polychlorinated diphenyl ethers. **(Dioxin/Furan analysis only)**

Z Analyte signal includes interference from the sample matrix or perfluorokerosene ions. **(Dioxin/Furan analysis only)**

Geotechnical Data

A The total of all fines fractions. This flag is used to report total fines when only sieve analysis is requested and balances total grain size with sample weight.

F Samples were frozen prior to particle size determination

SM Sample matrix was not appropriate for the requested analysis. This normally refers to samples contaminated with an organic product that interferes with the sieving process and/or moisture content, porosity and saturation calculations

SS Sample did not contain the proportion of “fines” required to perform the pipette portion of the grain size analysis

W Weight of sample in some pipette aliquots was below the level required for accurate weighting

Appendix N

Standards for Personal Conduct

Standards of Conduct

Since effective working relationships depend upon each of us, ARI expects certain minimum standards of personal conduct.

This list highlights general Company expectations and standards and does not include all possible offenses or types of conduct which may result in discipline or discharge. Management reserves the absolute right to determine the appropriate degree of discipline, including discharge, warranted in individual cases.

Employees engaged in the following activities, or similar activities deemed equally serious, will normally be terminated:

theft or embezzlement
disclosure of trade secrets or industrial espionage;
willful violation of safety or security regulations;
conviction of a felony;
working for a competitor or establishing a competing business.

In addition, dismissal may result from other serious offenses such as:

being intoxicated, under the influence or in possession of illegal drugs on the job;
falsification of records;
abuse, destruction, waste or unauthorized use of equipment, facilities or materials;
gambling on the premises;
chronic tardiness or absenteeism;
insubordination;
unwillingness to perform the job;
unauthorized requisition of materials from vendors.

There may be no alcoholic beverages on the Company premises, other than at times designated as Company functions. At such times, non-alcoholic beverages will be provided as well.

Personal and corporate honesty and integrity have built the character of ARI. This good character is fundamental to our well-being, future growth and progress. It is vitally important that we avoid both the fact and the appearance of conflicts of personal interest with that of the firm, its clients, and any other professional contacts.

This policy requires that ARI employees have no relationships or engage in any activities that might impair their independence of judgment. Employees must not accept gifts, benefits, or hospitality that might tend to influence them in the performance of their duties. It is expected that there will be no employment by any competing company, nor any employment by any outside interest or engagement in outside activity which might impair an employee's ability to render the full-time service to the company that employment involves.

If any possible conflict of interest situation arises, the individual concerned must make prior disclosure of the facts so that action may be taken to determine whether a problem exists and,

Standards of Personnel Conduct – continued

if so, how best to eliminate it. Likewise, any financial interest in an organization doing business with ARI or which competes with us should be revealed to Company management. (Excluded from this requirement is ownership of securities traded in major stock exchanges or other recognized trading markets.)

Our standards are those generally expected of employees in any well-regarded, ethical business organization.

ARI further expects that each employee will:

Be dressed and groomed appropriately for a business office. Employees in the laboratory areas are expected to dress in compliance with established safety procedures. Specific standards will be discussed with each employee during Health and Safety orientation. Your supervisor and the Administrative Services Manager always are available to answer questions.

Maintain the confidential nature of Company information. Removal of Company documents, records, stored materials, computer printouts, or any similar information, or copies of such material or information from the office without specific permission is prohibited. Likewise, revealing confidential information to an unauthorized person or using such information in an unauthorized way is prohibited. If there could be any possible question about the applicability of this requirement to a given circumstance, ask your supervisor.

Use Company computer capabilities and facilities only for authorized business at authorized times and locations; observe strictly all computer security measures and precautions; enter, alter or delete no computer instructions or stored material apart from that required by faithful performance of assigned duties; remove, copy, use or permit to be used no computer software developed for, purchased by, or otherwise used by ARI except as required by faithful performance of assigned duties.

Conduct business dealings with clients and members of the public in a courteous manner.

Appendix O

Quality Assurance Policies

QUALITY ASSURANCE POLICY

POLICY NUMBER: **1**

SUBJECT: **CORRECTIONS TO DATA/BENCHSHEETS**

DATE: **8/2/96**

Manual corrections made on any raw data, bench sheet, logbook or document used during sample processing will be made in the following manner:

1. Draw a single line through the information to be deleted or corrected. The original information must remain readable.

2. Enter any new information, preferably above the original information.

3. Initial and date the correction.

QUALITY ASSURANCE POLICY

POLICY NUMBER: **2**

SUBJECT: **LINING OUT UNUSED BENCHSHEET PORTIONS**

DATE: **8/2/96**

All unused portions of logbook pages and benchsheets will be lined through so that information cannot be added at a later date. This will be completed in the following manner:

1. Line out unused portions of a logbook page or benchsheet by drawing a single line or "Z" through the unused portions.

2. Initial and date the page beside the lineout.

3. Do not line out a page or section until it is certain that no additional information will be added to the unused portions.

QUALITY ASSURANCE POLICY

POLICY NUMBER: 3

SUBJECT: STOP WORK ORDERS

DATE: 8/28/96

It is the responsibility of all staff members to address situations that may require the issuance of a "stop work order". Potential and actual "stop work orders" will be handled as follows:

1. If an analyst or technician observes a situation which will or may have a negative impact on data quality, that person will notify her/his section supervisor immediately.

2. The section supervisor will assess the situation. If it appears that a "stop work order" may be required, the section supervisor will notify the appropriate manager (inorganic or organic).

3. The supervisor and manager will then decide if a "stop work order" should be issued. The manager will make a final decision on whether or not to issue a "stop work order". The incident will be reported to the Quality Assurance Program Manager using a Corrective Action Request form.

4. If a "stop work order" is issued, the manager will inform the Project Managers and the QA section. The section supervisor will notify section staff of the order.

5. The laboratory manager involved will oversee the development and implementation of a Corrective Action Plan (CAP). Upon completion of the CAP the "stop work order" may be rescinded.

6. Prior to rescinding a "stop work order", verification must be made that control has been regained and that work may begin. Only the inorganic or organic manager may rescind a "stop work order".

7. When the "stop work order" is rescinded, the Project Managers, analytical staff and QA section will be notified. The QA section will require documentation verifying that the procedure is back in control.

QUALITY ASSURANCE POLICY

POLICY NUMBER:	**4**
SUBJECT:	**SOP Review**
DATE:	**9/3/96**

All Standard Operating Procedure (SOP) documents will be reviewed and updated at least annually by qualified staff members. Laboratory management will review and approve all modifications to the SOPs.

QUALITY ASSURANCE POLICY

POLICY NUMBER: **5**

SUBJECT: **Reporting Dilutions**

DATE: **9/11/96**

Dilution factors will be recorded as whole numbers followed by "X" (i.e., 5X, 10X, etc.). This reporting convention will be used on run logs, bench sheets, raw data and final reports for all diluted samples, extracts or digestates or standards.

QUALITY ASSURANCE POLICY

POLICY NUMBER: 6

SUBJECT: Formatting for SOPs – Computer Related

DATE: 1/31/00

Conventions for formatting computer-related instructions in SOPs

Commands should be indented and formatted as **`bold courier`** and one or two font sizes smaller:

```
USE PARAMS ORDER PARAMS
BROW
```

Many systems and languages are *case-sensitive*, and case should match the syntax and/or stylistic standards of the language.

If only one command, like ***`SET CENTURY ON`***, is needed, it can be included in the rest of the text, so long as it is also italicized.

If the user must substitute a particular value in place of a general descriptor, italicize the descriptor, make it lowercase, and *do not make it bold*:

```
USE PARAMS ORDER PARAMS
COPY TO TEMPARM FOR JOB = 'job' .AND. SAMPLE = 'sample'
```

In general, keywords, variable names, formatting codes, and descriptors should be in *`courier`* and *`italicized`*.

QUALITY ASSURANCE POLICY

POLICY NUMBER:	**7**
SUBJECT:	**Manual Adjustment of Data**
DATE of IMPLEMENTATION:	**1/1/01**

Modern chromatographic instruments include computer software to identify a detector response as a chromatographic peak, characterize that peak and determine the relative height or area of the signal. The software utilizes parameters (threshold, slope, etc) that are adjusted by the instrument operator to optimize the results.

A single set of operator controlled settings that determine peak characteristics for an entire data file is defined as an "automated procedure". An automated procedure often characterizes chromatographic peaks incorrectly. ARI requires that trained analysts identify and resolve these errors using an alternate automated procedure or a "manual adjustment" of the data. Manual adjustment is defined as the process used by an analyst to adjust an individual peak or a subset of data in a chromatographic file.

1. The settings for a routine automated procedure normally used to process chromatographic data must be described in the method Standard Operating Procedure (SOP).

2. Trained analysts may substitute one automated procedure for another in order to optimize peak characteristics. The use of an alternate automated procedure must be permanently documented using either a software generated log file or analyst notes.

3. Manual adjustment of chromatographic peak characteristics will be used to correct the results of an automated procedure that, in a trained analyst's opinion, are clearly incorrect and will result in erroneous peak identification, integration or quantification.

4. Manual adjustment will be implemented in a reasonable and consistent manner. Guidelines for performing manual adjustment will be documented in method SOPs.

5. All manually adjusted data will be clearly identified for approval in the data review process. A permanent record of all manual adjustments will be maintained in both electronic and hardcopy versions of the raw data.

6. Manual adjustment of chromatographic files will not be used to falsify data for any purpose. Falsification of data through the use of manual peak adjustment is unethical, unlawful and will result in termination of the offending analyst.

Approval:

_____

Quality Assurance Program Manager Date

QUALITY ASSURANCE POLICY

POLICY NUMBER:	**8**
SUBJECT:	**Performance Evaluation Samples**
IMPLEMENTATION DATE:	**1/1/01**

Performance Evaluation Samples (PES) will be analyzed on a periodic basis to monitor laboratory performance and/or meet the requirements of an external accreditation program. PES samples contain target analytes in concentrations unknown to laboratory personnel. PES may be submitted by a third party or prepared internally under the direction of ARI's QA personnel.

PES will be submitted blind to the laboratory whenever possible.

PES will be logged-in, prepared, analyzed and reported as a routine sample without special consideration.

QUALITY ASSURANCE POLICY

POLICY NUMBER:	**9**
SUBJECT:	**Modifications to Analytical Methods Procedures or Reports**
DATE of IMPLEMENTATION:	**8/24/05**

This Policy defines the processes used to initiate and validate modifications to analytical processes, QA/QC protocol, data processing programs and algorithms, data reporting formats or other changes to analytical procedures or SOPs at Analytical Resources Inc. (ARI). The procedures outlined will also be used to validate project specific changes to analytical protocol and new analytical methods.

Changes to analytical procedures must be approved by ARI's Management (Managers and/or Supervisors) and be well documented using the following procedure:

1. Modification may be requested by any staff member. The modification must be requested using ARI's Corrective Actions Tracking System. Corrective Action requests for changes to analytical protocol or reports will assigned to the appropriate manager or supervisor by the initiator. As an alternative the request may be assigned to the QA Section. The Corrective Actions assignee may approve the project or re-assign the request for approval to a third party. The QA Section will monitor the progress of all requests.

2. The requestor must detail and justify the proposed modifications or additions when initiating a Corrective Action issue. Modifications must be approved by ARI management prior to any work performed to establish the modification.

3. The following must be in place before final approval and/or implementation of the proposed modification.

A. A new or revised SOP as appropriate including the modification or new protocol.
B. An Initial Demonstration of Proficiency as defined in ARI SOP 1018S for new or modified analytical procedures.
C. An MDL study following the procedure in ARI SOP 1018S for new or modified analytical procedure.
D. When appropriate, successful analysis of a blind Performance Evaluation Sample using new or modified procedures or data processing protocol.
E. Documentation that new or modified software provides the desired result.

4. ARI staff must have sufficient training to implement the procedural changes.

5. Notification of the modifications must be distributed to all affected personnel including appropriate client personnel.

QUALITY ASSURANCE POLICY

POLICY NUMBER:	**10**
SUBJECT:	**Reporting of Target and Spiked Analytes For Dual Column GC Analyses**
DATE of IMPLEMENTATION:	**8/24/05**

Analytical Resources Inc. uses single injection, dual column gas chromatographs to simultaneously identify and confirm the presence of target or spiked analytes in some GC analyses. Only one quantitative value is reported for each target or spiked analyte. ARI's policy for deciding which value to report is outlined as follows:

1. ARI considers each column equally valid for compound identification and quantification. Both GC columns must be compliant with all quality assurance parameters outlined in ARI's SOPs and LQAP. Both GC columns must produce valid initial and continuing calibrations using the same calibration model.

2. The analytical value reported will be determined by comparison of the quantitative results of confirmed analytes as follows.

a. The relative percent difference (RPD) between the results on the two columns (R_1 & R_2) is calculated using the formula:

$$RPD = \frac{|R_1 - R_2|}{\left(\frac{R_1 + R_2}{2}\right)} \times 100$$

b. If the RPD is less than 40% the greater of the two values is reported for both target analytes and spiked compounds. When required by specific QA protocol, by contract or client request the lower value will be reported for target analytes.

c. If the RPD is greater than 40%, ARI's analyst must examine the chromatogram for anomalies (overlapping peaks, incorrect integration, negative peaks) and either correct the anomalies (i.e. perform manual integrations) or report the most appropriate target analyte value. The higher value will be reported for spiked analytes. ARI's analyst must provide a written evaluation of all analyses where an RPD exceeds 40% and this information must be passed on to ARI's client or the data user.

QUALITY ASSURANCE POLICY

POLICY NUMBER:	**11**
SUBJECT:	**Calculation of Analytical Uncertainty**
DATE of IMPLEMENTATION:	**8/31/06**

Analytical Resources Inc. will use the procedure[1] proposed by Thomas Georgian, PhD to estimate analytical uncertainty. Dr. Georgian's proposes using the formulae below to calculate uncertainty:

For biased corrected analytical results:

100 (c/R)(1± L / R)
Where:
c = Measured concentration of the analyte
R = Average LCS spike recovery
L = ½ the warning or control range

And for unbiased results i.e. R = 100

c (± L / 100)

Example:

For a 10 ppb analytical result when the mean LCS recovery is 50% and the control limits are 20% to 80% an interval for the analytical results is calculated as follows:

100 (10 ppb / 50)(1±30 / 50) = 20 ± 12 ppb

[1] Estimation of Laboratory Analytical Uncertainty Using Laboratory Control Samples, Thomas Georgian, Ph.D., *Environmental Testing & Analysis*, November/December 2000.

QUALITY ASSURANCE POLICY

POLICY NUMBER:	**12**
SUBJECT:	**Rounding of Numbers and Reporting Limits**
DATE of IMPLEMENTATION:	**8/24/05**

I. ARI reports analytical results in concentration units as follows:

A. Values expressed as a concentration (mg/L, µg/Kg etc.)

1. Values less than or equal 10 are reported using 2 significant figures.
2. Values greater than 10 are reported using 2 or 3 significant figures.

B. Values expressed as percent (control limits, RSD etc.) are reported using the appropriate whole number. Examples: 6.38 rounds to 6, 9.95 rounds to 10, 99.93 rounds to 100, 145.48 rounds to 145.

II. ARI rounds numbers to the appropriate level of precision using the following rules:

A. If the figure following those to be retained is greater than or equal to 5, the absolute value of the result is to be rounded up: otherwise, the absolute value of the result is rounded down. Examples: -0.4365 rounds to -0.437 and 2.3564 rounds to -2.356; 11.443 is rounded down to 11.44 and 11.455 is rounded up to 11.46.

B. When a series of multiple operations is performed (add, subtract, divide, multiply), all significant figures are carried through the calculations and the final result is rounded to the appropriate number of significant figures.

III. ARI compares concentration values to reporting limits prior to rounding final concentration values. Example: with an RL of 0.50, 0.499 is undetected at 0.50 (0.50U) and 0.504 is detected at 0.50.

III. ARI will round quality control results prior to determining if the value is in control. Example: for spike recovery limits of ± 10% (90 – 110%), a recovery of 110.47is in control at 110% and a calculated recovery of 110.50 is out of control at 111%.

QUALITY ASSURANCE POLICY

POLICY NUMBER:	**12**
SUBJECT:	**Use of "J" Flag when Reporting Analytical Data**
DATE of IMPLEMENTATION:	**3/1/09**

1. ARI uses a "J" flag to indicate that a quantitative result chemical analysis is an estimated value. In general, "J" flags note positively identified compounds that are not in an instrument's verified calibrated range.
2. A "J" indicates quantitative values with a high degree of uncertainty. Data users must consider the greater uncertainty when using "J" flagged quantitative values.
3. ARI will not use "J" flags when reporting the results of metals analyses. Instrumental analysis of metals is subject to inter-element interference, non-specific absorption and sample-to-sample carryover that make quantification of elements below the reporting limit difficult. MDL studies performed on clean sample matrices are not subject to these interferences.
4. ARI will not report analytes below the RL ("J" flag is not used) for any single column GC analysis. (HCID, TPH-D, BTEX, TPH-G, RSK-175, Direct Aqueous Injection)
5. ARI uses "J" flags when reporting results of GC-MS (VOA and SVOA) and dual column GC analyses using the following criteria:
   A. All analyses must meet ARI established QA criteria for calibration and spike recovery.
   B. Analytes must meet method specific identification criteria (i.e. spectral match, retention time and/or relative retention time).
   C. The analyte concentration must exceed the greater of either the MDL or ½ the reporting limit before a "J" flag is applied.
   D. An analyte in a method blank will be "J" flagged only when any associated sample contains the same analyte.
   E. The application of a "J" flag is discretionary, depending on the professional judgment of ARI's data reviewers. GC-MS parameters such as ion ratios, spectral match, background contamination and instrument noise are weighted when considering the application of "J" flags.
6. Some typical circumstances that may warrant the use of a "J" flag:
   A. A compound identified at a concentration between the MDL or ½ RL and ARI's reporting limit (normally the low concentration used to calibrate the instrument).
   B. The quantified values in a dual column GC analysis differ by > 40% with obvious interference on one column. ARI may report the value with the lowest concentration or the least interference.
   C. The analyte is present at low concentration due to extract dilution and identified in a previous analysis of less dilute extract.
   D. Analytes < the RL and reported in previous analyses from the same sampling site.
   E. An analyte is < the RL in a sample and greater than the RL a duplicate or replicate analysis. This often applies to Matrix Spike and Laboratory Control Samples and their duplicates.

Appendix P

Modifications to ARI's LQAP

Modifications to ARI's LQAP

New Revision	Date	Modifications
		1. Updated Appendix D – Instrument/Equipment List 2. Specified length of data archive in Section 5.5
12-010	1/4/08	1. Edit Sections 4.4.1, 4.4.2, 4.4.3.2, 5.5, 6.3 (subcontracting), 8.3, 9.1 (MDLs) and 13 for Navy CAP. 2. Transferred Containers, Preservative & HT Table from Appendix F to Web
12-009	7/21/07	1. Updated SOP list in Appendix E 2. Updated Instrument List in Appendix D 3. Updated Accreditations Appendix L 4. Removed SOP table to web-site
12-008	12/20/06	1. Added Methane, Ethane & Ethene Info to Appendix F Table 2. Updated SOP Table in Appendix E 3. Modified Internal Audit Schedule 4. Archived SOP 355S and removed it from list in Appendix E 5. Updated Instrument / Equipment List in Appendix D
12-007	4/11/06	1. Removed Appendix J – Tuning Criteria are in the SOP 2. Changed BOD RL from 1 to 2 ppm 3. Integrated all SVOA Soil/Sediment MDLs into One Table 4. Added SIM Analysis to Soil/Sediment SVOA MDL Table 5. Added SIM Analysis to Water SVOA MDL Table 6. Updated MDL for SVOA in Water 7. Updated MDLV for Pesticides in Soil (25g to 5mL) 8. Updated MDLV for Pesticides in Soil (12g to 4mL) 9. Updated MDLV for PCB in Water (500 to 1mL) 10. Updated MDLV for PCB in Water (500 to 5mL) 11. Updated MDLV for Chlorinated Phenols in Water (500 to 50mL) 12. Removed Appendix I – MDL & RL Summaries 13. Updated MDL for SIM-PNA 14. Updated MDLV for SIM-PNA 15. Removed Appendix K – Control Limits
12-006	1/16/06	1. Updated MDL for TBT in Pore Water 2. Updated MDL and MDLV for Toxaphene in Soil/Sediment 3. Updated MDLV for VOA 8260B 20 mL Purge 4. Added IDL, MDL & RL for Low RL Mercury 5. Updated all Metals MDL Verifications 6. Updated MDLV for Water VOA using 5 mL purge 7. Updated MDLV for PCB in Soil with Soxhlet Extraction 8. Updated MDLV for SVOA (8270D) Analysis of Water using SepFunnel 9. Updated MDL for GC-MS-SIM Analysis of Skydrol & BHT in Water 10. Updated MDL for Chlorophenols (8041) in Soil 11. Modified RL for Chlorophenols in Soil & Tissue 12. Added Headspace GC (FID5) to Instrument List 13. Updated Footnotes on Glycols RL Table 14. Modified RL for 1,4-Dioxane in Water Method 8270D 15. Updated MDL for Analysis of Soil for VOA 16. Updated MDL for Analysis of Soil for JP-8 17. Updated MDL for Analysis of Sediment for TBT 18. Updated MDLV for Analysis of TBT in Water and Tissue 19. Added MDL for Analysis of PCB in Tissue with 4 ppb RL 20. Updated MDLV for PCB Analysis of Soil (Soxhlet) and Tissue (4 ppb) 21. Updated MDLV for Manchester Analysis of PCB in Water 22. Updated MDLV for Analysis of Gasoline in Soil and Water 23. Updated MDLV for Analysis of BTEX in Soil and Water 23. Updated MDLV for Analysis of Motor Oil in Soil and Water

		24. Updated MDLV for Analysis of VOA-SIM in Water 25. Updated MDLV for Analysis of VOA (20 mL) in Water 26. Updated MDL Table for Conventionals 27. Updated MDLV for Pesticides in Water (500 to .5 mL) 28. Updated MDLV for PCB Analysis of Soil 29. Updated MDLV for Chlorophenols (8041) in Soil 30. Updated MDLV for JP4 in Water and Soil 31. Updated MDLV for JP8 in Soil 32. Updated MDLV for VOA (8260B) in Water 5 mL & 20 mL Purge Volumes 33. Updated MDL for PCB in Soil – Standard Analysis & Medium Level 34. Updated MDL for Pesticides in Water – Standard Analysis 35. Updated MDL for SVOA in Water – Liq-Liq Extraction 36. Updated MDLV for Chlorophenols in Water
12-005	10/24/05	1. Added MDL for Chlorinated Phenol Analysis of Tissue (Method 8041) 2. Modified QA Policy 10 3. Established Implementation Date for QA Policies 09 & 10 4. Updated MDLV for TBT in Water 5. Corrected MDL Value for bis-(2-Ethylhexyl)-phthalate in SVOA Tissue 6. Updated MDL for Pesticides in Soil 7. Modified Title Format of Selected MDL Tables 8. References to 8270 or 8270C changed to 8270D 9. Deleted MDL Tables for SVOA Analyses of Tissue 10. Updated MDLs for SIM-PNA in Water (SepFunnel) and Soil 11. Updated MDLV for Metals 12. Updated MDLV for Manchester Pesticides 13. Updated MDLV for TPH-D In Soil 14. Updated MDLV for SIM-PNA in Water with Liq-Liq Extraction 15. Updated MDLV for JP-4 in Soil 16. Updated MDLV for VOA Water 5 mL Purge 17. Corrected MTCA RL for Methoxyclor & Manchester RL for all Pesticides 18. Updated MDL for Manchester Beta-BHC to reflect latest MDLV 19. Corrected Tissue Pesticide RLs 20. Updated MDLV for LVI-SIM-PNA in Water with Liq-Liq Extraction 21. Updated MDL for VOA-SIM Analysis of Aqueous Samples 22. Updated MDLV for PCB in Water (500 to 5 mL) 23. Updated MDLV for Diesel in Water (NWTPH-D & AK102) 24. Updated MDLV for Chlorophenols in Aqueous Samples 25. Updated MDLV for Chlorophenols in Tissue Samples 26. Removed & Archived Modifications to LQAP for 2002 & 2003 27. Updated MDL for Skydrol/BHT Analysis in Water Using 8270-SIM 28. Removed Direct Aqueous Injection MDLs RL Table. 29. Updated SOP Table (Appendix E)
12-004	8/19/05	1. Added “A” Flag for GeoTech to Appendix N. 2. Updated MDL for JP-4 in Soil 3. Updated MDL for Pesticides in Tissue 4. Updated MDLV for JP-4 in Soil 5. Updated MDLV for Pesticides in Soil 6. Updated MDLV for Pesticides in Water 7. Updated MDLV for PCB in Soil (25g to 1 mL) 8. Updated MDLV for PCB in Water (500 to 5 mL) 9. Updated MDLV for TPH-D in Water 10. Updated MDLV for PNA-SIM in Water (Liq-Liq Extraction) 11. Updated MDLV for VOA in Water (5 mL 8260B) 12. Updated MDLV for VOA in Water (20 mL 8260B) 13. Updated MDL for PSDDA SVOA in Sediment 14. Updated Appendix E – SOP List 15. Corrected MDL for Pesticides in Soil Information (IA-80 not GU-32)

		16. Corrected Reporting Limits for TBT in Water, Sediment & Tissue 17. Added Control Limits for 1,4-Dioxane to SVOA List 18. Added low level RLs for BTEX Compounds 19. Updated MDLV for TBT in Pore Water 20. Updated MDLV for BTEX Water & Soil 21. Updated MDLV for TPH-G in Water & Soil 22. Updated Appendix E SOP Table 23. Updated MDLV for Motor Oil in Soil Using ASE 24. Updated MDLV for Motor Oil in Soil Using MicroTip 25. Updated MDLV for Motor Oil in Water Using SepFunnel 26. Updated MDLV for JP-4 in Water Using SepFunnel
12-003	7/15/05	1. Added MDLV for 5 mL VOA Analysis of Water – Method 8260B 2. Updated MDL for MTCA PCB in Water Samples 3. Added MDL for Soxhlet Extraction of PCBs 4. Removed Aroclor 1242 from MDL Table 5. Control Limits for HEM Changed to Equal Those in SOP 648S 6. Updated MDL for PSDDA PCB Analysis. 7. Added MDL for TBT in Tissue 8. Updated MDL for 20 mL 8260B 9. Updated MDLV for SIM-VOA 10. Updated MDL for Pesticides in Soil 11. Updated MDLV for TPH-D in Soil 12. Added MDLV for PSEP Level Pesticides in Sediment 13. Updated (added missing compounds) PSDDA SVOA MDLs 14. Updated & Corrected Appendix F (Containers & Preservatives) 15. Added “A” Flag for GeoTech to Appendix N.
12-002	6/9/05	1. Updated Motor Oil MDL (NWTPH-Dext & AK103) for Soil 2. Documented MDLV for Gasoline in Soil (Methods NWTPH-G & AK101) 3. Corrected units for DRO & RRO MDL for water from mg/kg to mg/L 4. Added MDL for JP-4 in Water using Sep Funnel Extraction 5. Updated MDL for Sediment Analysis (Krone) of TBT using Sonication 6. Updated MDL for SVOA Water SepFunnel 7. Noted that BTEX –SIM MDL in Table was Medium Level Extraction 8. Added MDL Verification Information for ICP Metals 9. Updated MDL for TBT in Water and Pore Water – SepFunnel 10.Updated MDLV for TPH-D Water – SepFunnel 11. Added EPH and VPH RL Tables 12. Added MDLV for JP-4 Analysis of Water – Sep Funnel 13. Added MDLV for BTEX analysis of Soil 14. Added MDLV for SVOA Water - SepFunnel 15. Added MDLV for TBT Sediment 16. Updated MDL for PSEP Pesticides in Sediment/Soil 17. Updated MDL for Chlorinated Phenols in Water 18. Updated MDL for Pesticides in Water – SepFunnel 19. Added MDLV for 524.5 20. Added MDLV for Metals 21. Updated MDL for Manchester Pesticides 22. Added Appendices to the Table of Contents 23. Added MDL for PCB Analysis of Tissue
12-001	4/5/05	1. List of SOPs (Appendix E) Modified & Updated as Appropriate 2. MDL Verification for DRO in Soil Added 3. MDL Verification for PCB Water Standard Analysis (HO-24) Added 4. AK-101 Removed from BTEX MDL Table for Water 5. Metals IDLs & MDLs Updated 6. BTEX MDL for Analysis of Water and Soil Updated 7. RL for 1,4-Dioxane in SVOA Analysis of Water Changed from 1.0 to 5.0 8. Control Limits for BTEX and Gasoline updated

		9. MDL for Gasoline in Soil Updated 10.MDL for Diesel and Motor Oil in Soil Updated. 11. Split TPH-G Table into Aqueous and Soil Table & added MDLV for Water 12. Entered updated MDLs for SIM-LVI-PNA 13. Changed RL for 20 mL 1,2-Dibromo-3-Chloropropane from 2 to 0.5 ppb 14. Updated MDLs for 524.2 15. Updated Conventionals MDLs 16. Updated MDLs for 5 mL VOA analysis of Water Samples (8260B) 17. Modified MDL Table for TPH-D Analysis of Water 18. Updated TPH-D and TPH-Dext MDL for Water Analyses. 19. Removed EPH and VPH MDLs from the LQAP
11-028	12/31/04	1. Modified definition of "Y" flag in Appendix N 2. Updated MDL for TPH-D Soil 3. Updated Appendix M - Laboratory Certification and Accreditation
11-027	12/15/04	1. Updated SOP List in Appendix E. 2. Added AK-101 to BTEX/GRO Control Limit Table. 3. Lowered RL for Benzene in MDL Summary for Method 8021B 4. Added Additional Surrogates to VOA-SIM BTEX Control Limit Table 5. Corrected BTEX MDLs for 8260-SIM to Reflect Sample Conc. Not On-Column values 6. Updated SOP Table in Appendix E 7. Modified VOA 5 mL Water RLs - Acrylonitrile & 1,2,3-Trichloropropane 8. Modified VOA mL Soil RL – 4-Methyl-2-Pentanone 9. Corrected MDL Value for Methoxychlor in PSDDA Sediment Analysis. 10.Modified definition of "Y" Flag in Appendix N 11.Updated MDL for BTEX Water PID-2 12.Updated MDL for Pesticides MTCA Analysis of Water 13.Updated MDL for PSDDA SVOA Analysis 14.Updated MDL for VOA Soil 15.Updated MDL for SVOA, Water, Liq-Liq 16.Updated MDL for Various PCB (1660) Analyses 17.Updated MDL for TPH-G – Water & Soil 18.Updated MDL for SVOA Soil Micro Sonication 19.Added MDL for Manchester Aroclor 1254 20.Modified Control Limits for EPH Analyses 21.Deleted MDL Table for SVOA, Soil, MacroTIp Extraction 22.Deleted MDL for Soil Skydrol/BHT, GC-MS-SIM 23.Updated Instrumentation Listing (Appendix D)
11-026	11/02/04	1. Updated Control Limits for SIM-PNA 2. Added Control Limit Table for Full Scan PNA Analysis (Method 8270D) 3. Updated SIM-PNA Water MDL for NT-1 4. Updated Appendix E – SOPs 5. Modified PCB MDL Table –Remove Manchester & Combine PSEP/Low Level Sediment MDLs 6. Updated MDL for VOA SIM Water NT3 7. Updated MDL Table for SIM Skydrol/BHT in Water 8. Updated SOP Table in Appendix E.
11-025	9/16/04	1. Added new Appendix N listing Data Qualifiers & changed designations for Appendices N, O & P to O,P & Q respectively 2. Updated MDL Table for PCB Analyses. 3. Combined MDL tables for SVOA Water & Deleted Sep Funnel Table 4. Updated PCB & TPH-D MDL Tables 5. Updated Equipment List (Appendix D) & added GeoTech Equipment 6. Revised MDL Table for FID Analysis of Polar SVOA (EPA Method 8015) 7. Updated MDLs for Pesticide analysis of soil. 8. Sediment Pesticide MDLs added to Soil Table, Sediment Table Deleted 9. Control Limit for MS Recovery of Pyrene in Sediment Corrected

		10.Updated Cyclohexanone MDL (Finn 1, 20 mL purge) 11.Updated SIM-PNA Soil MDL for NT-1 12. Edited MDL Tables for SVOA for consistency and accuracy 13. Modified EPH Reporting Limits 14. Revised formatting on most MDL tables. 15. Corrected dates for VOA Control Limit data 16. Deleted analytes except cyclohexanone from VOA MDL Table for Project Specific Analytes. 17. Added BTEX in Soil to VOA-SIM MDL Table 18. Added Manchester MDL to PCB Table 19. Updated Skydrol/BHT Control Limits
11-024	7/19/04	1. Revised and Updated MDL Tables for TPH Analyses of Soil/Sediment. 2. Revised and Updated MDL Tables for PCB Analyses. Combined All PCB MDL into One Table. 3. Deleted all other MDL tables 4. Updated MDL for VOA analysis of Soil using ARI's In-house Method. 5. Added 1-Methylnaphthalene to SIM-PNA MDL Tables for Water & Soil 6. Updated Appendix D (Lab Equipment) and added GeoTech Section 7. Combined Water & Soil SIM-PNA MDL Tables into One Table 8. Deleted Water-SF & Soil SIM-PNA MDL Tables 9. Updated MDLs for Pesticide – Manchester Extraction 10. Revised VOA Water Control Limits Table 11. Updated MDLs for VOA analysis of Water-8260B-5mL purge
11-023	7/6/04	1. Corrected Conventionals MDL/RL Table 2. Corrected Control Limit for TPH-D MS Recovery in Water Samples. 3. Updated MDLs for NWTPH-D Soil ASE & MicroTip. 4. Removed HPLC MDL Table for analysis of PNA. 5. Removed MDL Table for HCID 6. Removed FID-3B from TPH MDL Tables 7. Updated MDLs & Modified Table for SVOA-PSEP analysis of Sediments 8. Revised Section 11 9. Updated MDL for VOA (524.2) analysis of Water 10. Removed MDLs for VOA-SIM analysis of Soil 11. Updated MDL Table for VOA-Water 20 mL 12. Updated MDL Table for VOA-Water 5 mL
11-022	5/17/04	1. Corrected Extract Final Volume in MDL table for Sediment PCB 2. Deleted FINN 8 from all MDL Tables 3. Corrected RL for Hg in Water.
11-021	5/07/04	1. Implemented default control limits for EPA Method 524.2 2. Decreased RL for Aroclor 1221 to level of other Aroclors 3. Eliminated Control Limits for VOA using ARI SOP 804S. 4 Updated VOA 8260B full scan control limits for water & sediment/soil 5. Updated 10 mL purge VOA-SIM control limits for water 6. Changed effective date for VOA-SIM BTEX control limits 7. Updated 8270-SIM-PNA control limits for water & sediment/soil 8. Updated BTS control limits for water & soil.
11-020	4/26/04	1. Updated MDL (PID1 & 2) for BTEX in water 2. Updated MDL (PID 1) for gasoline in water 3. Deleted MDL Table for ASE extraction of chlorinated pesticides 4. Updated MDL for VOA water 5 mL purge 8260B on NT3 5. Updated MDL for pesticide in water separatory funnel on ECD3 6. Added MDL Table for VPH in water and soil 7. Deleted Control Limit Table for HPLC PNA 8. Updated PCB control limits 9. Updated Herbicide control limits 10. RL for Sulfate to 2.0 & 20.0 ppm for water & solids respectively 11. Updated TPH-D Control Limits

		12. Updated Chlorinated Phenols Control Limits 13. Updated BTEX & TPH-G Control Limits 14. Corrected Pesticide MTCA MDL Table 15. Corrected RL for GC-ECD analyses of HCBD & HCB
11-019	3/11/04	1. Revised holding time for Total Solids in soil & sediment from 7 days to 14 days. 2. Updated MDLs for SVOA water L/L NT4 & NT 6. 3. Updated Metals IDLs and MDLs 4. Added QA Policy 9 – Modifications to method, protocol or reports 5. Updated Conventionals MDLs 6. Added QA Policy 10 – Reporting of dual column GC analytes
11-018	1/21/04	1. Revised Control Limits for GC-MS analysis of SVOA 2. Revised Control Limits for Chlorinated pesticides 3. Updated Appendix E – Table of SOPs 4. Updated and Revised Appendix F – Sample Containers, Preservation and Holding Times 5. Modified Sign-of Sheet to include only QA manager
11-017	1/4/04	1. Minor revisions to Section 13 2. Revisions to subcontracting language in Section 6.3

ATTACHMENT B

LABORATORY CHAIN OF CUSTODY FORM

CHAIN OF CUSTODY FORM

Project: _____

Samplers: _____

integral consulting inc.

Integral Contact:
Office _____
Phone _____

Ship to:
Lab Name _____
Address _____
_____
_____
Contact _____
Phone _____

Sample No.	Tag No.	Date	Time	Matrix	ANALYSES REQUESTED						Extra Container	Archive	Comments

Analysis Turn Time: Normal Rush **Rush Results Needed By:**

Shipped by: **Shipping Tracking No.**

Condition of Samples Upon Receipt: **Custody Seal Intact?**

Matrix Code: GW - Groundwater
SL - Soil SW - Surface water
SD -Sediment Other:

Relinquished by: _____ *(signature)* **Date/Time:** _____ **Received by:** _____ *(signature)* **Date/Time:** _____

Relinquished by: _____ *(signature)* **Date/Time:** _____ **Received by:** _____ *(signature)* **Date/Time:** _____

Special Instructions:

Annapolis
2661 Riva Road
Building 500, Suite 120
Annapolis, MD 21401

Denver
12300 Airport Way
Suite 270
Broomfield, CO 80021

Portland
319 SW Washington St
Suite 1150
Portland, OR 97204

Bellingham
1201 Cornwall Ave
Suite 208
Bellingham, WA 98225

Mercer Island
7900 SE 28th St
Suite 410
Mercer Island, WA 98040

Olympia
1205 West Bay Drive NW
Olympia, WA 98502

APPENDIX H

HEALTH AND SAFETY PLAN

HEALTH AND SAFETY PLAN
FOR
STORMWATER SOURCE CONTROL MEASURES

Former Arkema Inc. Facility
Portland, Oregon

Prepared for
Legacy Site Services, LLC
468 Thomas Jones Way
Exton, PA 19341

Prepared by

integral consulting inc.
319 SW Washington Street
Suite 1150
Portland, OR 97204

September 30, 2011

CONTENTS

LIST OF ATTACHMENTS ..... **IV**

ACRONYMS AND ABBREVIATIONS ..... **V**

HEALTH AND SAFETY PLAN APPROVAL ..... **VI**

HEALTH AND SAFETY PLAN ACKNOWLEDGEMENT ..... **VII**

1 INTRODUCTION **1-1**
- 1.1 OBJECTIVES AND METHODS 1-2
- 1.2 ORGANIZATION 1-2
- 1.3 ROLES AND RESPONSIBILITIES 1-3
  - 1.3.1 Site Safety and Health Officer/Site Supervisor 1-3
  - 1.3.2 Site Workers 1-4
  - 1.3.3 Buddy System 1-4
- 1.4 SITE BACKGROUND 1-4
- 1.5 PROJECT MANAGER AND OTHER KEY CONTACTS 1-5
- 1.6 DEFINITIONS 1-5

2 CHEMICAL HAZARD EVALUATION **2-1**
- 2.1 CHEMICAL CHARACTERISTICS AND EXPOSURE ROUTES 2-4

3 PHYSICAL HAZARD EVALUATION AND GUIDELINES **3-1**
- 3.1 GENERAL PHYSICAL HAZARDS 3-1

4 PERSONAL PROTECTIVE EQUIPMENT AND SAFETY EQUIPMENT **4-1**
- 4.1 PERSONAL PROTECTIVE EQUIPMENT 4-1
  - 4.1.1 Respirator and Respirator Cartridge Information 4-1
- 4.2 SAFETY EQUIPMENT 4-1

5 AIR MONITORING **5-1**

6 HEALTH AND SAFETY TRAINING **6-1**
- 6.1 HEALTH AND SAFETY TRAINING 6-1
  - 6.1.1 Training Requirements 6-1
  - 6.1.2 Medical Monitoring 6-1
- 6.2 SITE SAFETY MEETINGS 6-2

7 EMERGENCY RESPONSE PLAN **7-1**
- 7.1 EMERGENCY RECOGNITION AND PREVENTION 7-1
- 7.2 EMERGENCY RESPONSE AND NOTIFICATION 7-1

7.3 EMERGENCY DECONTAMINATION PROCEDURES 7-2
7.4 SITE COMMUNICATIONS 7-3

8 WORK ZONES 8-1

9 DECONTAMINATION AND PERSONAL HYGENE 9-1
9.1 DECONTAMINATION PROCEDURES 9-1
9.2 PERSONAL HYGIENE 9-1

10 VEHICLE SAFETY, SPILL CONTAINMENT, AND SHIPPING INSTRUCTIONS 10-1
10.1 VEHICLE SAFETY 10-1
10.2 SPILL CONTAINMENT 10-2
10.3 SHIPPING INFORMATION 10-2

11 TASK-SPECIFIC SAFETY PROCEDURES 11-1

LIST OF ATTACHMENTS

Attachment 1. Site Map and Hospital Route
Site Map
Hospital Route Map

Attachment 2. Regulatory Notices
Federal OSHA Right to Know Posters

Attachment 3. Safety Procedures
OSHA Cold Stress Information Card
OSHA Heat Stress Information Card

Attachment 4. Material Safety Data Sheets
Alconox®
Hydrogen
Liquinox®
Methane (500 ppm)
Isobutylene (100 ppm)

ACRONYMS AND ABBREVIATIONS

CFR	Code of Federal Regulations
COPC	constituent of potential concern
DOT	U.S. Department of Transportation
DDT	dichloro-diphenyl-trichloroethane
FID	flame ionization detector
HASP	health and safety plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
IDLH	immediately dangerous to life and health
Integral	Integral Consulting Inc.
MCB	monochlorobenzene
OSHA	Occupational Safety and Health Administration
PEL	permissible exposure level
PID	photo-ionization detector
PPE	personal protective equipment
SCM	source control measure
SSHO	site safety and health officer
STEL	short-term exposure level

HEALTH AND SAFETY PLAN APPROVAL

This health and safety plan has been reviewed and approved for the stormwater source control measure construction oversight work at the Arkema site in Portland, Oregon.

Project Manager	Date
Corporate Health and Safety Manager	Date

HEALTH AND SAFETY PLAN ACKNOWLEDGEMENT

In the absence of an appropriate subcontractor or consultant health and safety plan, and with the express approval of the corporate health and safety officer, the subcontractor or consultant may utilize the Integral Consulting Inc. (Integral) site health and safety plan (HASP), provided there is written concurrence from the subcontractor that it will directly administer the plan for its employees. The Integral HASP is a minimum standard for the site and will be strictly enforced for all Integral personnel and subcontractors where applicable. This HASP does not cover construction activities.

I have reviewed the HASP prepared by Integral, dated December 2, 2010, for the Arkema site stormwater source control measure construction oversight work. I understand the purpose of the plan, and I consent to adhere to its policies, procedures, and guidelines while an employee of Integral or its subcontractors or consultants. I have had an opportunity to ask questions regarding this plan, which have been answered satisfactorily by Integral.

Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date

1 INTRODUCTION

On behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc., Integral Consulting Inc. has prepared this site-specific health and safety plan (HASP) in support of the implementation of the stormwater source control measures (SCMs) at the former Arkema Portland Plant (the site) located at 6400 NW Front Avenue, Portland, Oregon. This HASP is prepared pursuant to the Order on Consent, requiring SCMs, issued by the Oregon Department of Environmental Quality (DEQ), signed October 31, 2008 (DEQ No. LQVC-NWR-08-04), and the new stormwater Mutual Agreement and Order No. WQ/I-NWR-10-175, executed by DEQ and LSS on August 4, 2010. Refer to the contract documents for all locations and details of the work.

It is the policy of Integral Consulting Inc. (Integral) to provide a safe and healthful work environment that is compliant with applicable regulations. No aspect of the work is more important than protecting the health and safety of all workers.

This HASP provides general health and safety provisions to protect workers from potential hazards during SCMs construction oversight activities at the Arkema site (the site) located in Portland, Oregon. This HASP has been prepared in accordance with Oregon Occupational Safety and Health Division safety regulations (OAR 437-004) and federal Occupational Safety and Health Administration (OSHA) safety regulations (29 CFR [Code of Federal Regulations] 1910 and 29 CFR 1926). Attachments to the HASP provide specific routes to the hospital from the site (Attachment 1), OHSA regulatory notices (Attachment 2), safety procedures for heat and cold (Attachment 3), and material safety data sheets (Attachment 4).

This HASP does not cover construction activities associated with the stormwater SCMs. Subcontractors that are contracted to perform field work associated with the stormwater SCMs will develop and follow their own HASPs. However, these plans must be consistent with the provisions outlined in this plan.

This HASP has been prepared to identify potential site hazards to the extent possible based on information available to Integral. Integral cannot guarantee the health or safety of any person entering this site. Because of the potentially hazardous nature of this site and the activity occurring thereon, it is not possible to discover, evaluate, and provide protection for all possible hazards that may be encountered. Strict adherence to the health and safety guidelines set forth herein will reduce, but not eliminate, the potential for injury and illness at this site. The health and safety guidelines in this plan were prepared specifically for this site and should not be used on any other site without prior evaluation by trained health and safety personnel.

A copy of this HASP will be in the custody of the field crew during field activities. All individuals performing field work must read, understand, and comply with this plan before undertaking field activities. Once the information has been read and understood, the

individual must sign the Acknowledgment Form provided above, which will become part of the project file.

This plan may be modified at any time based on the judgment of the Integral site safety and health officer (SSHO) in consultation with the corporate health and safety officer and Integral project manager or principal-in-charge. Any modification will be presented to the onsite team during a safety briefing and will be recorded in the field logbook.

1.1 OBJECTIVES AND METHODS

The selected stormwater SCMs for the site includes the following elements:

- Erosion control measures of capping portions of the drainage basins that discharge to Outfalls 001 and 002, which historically have had the highest surface soil concentrations of constituents of potential concern (COPCs), to prevent the potential migration of COPCs in these soil to the river via the stormwater drainage system
- Eliminating the potential for migration of COPCs to the river in the existing stormwater collection system by decommissioning this system
- Rerouting stormwater via a new surface conveyance system and treating stormwater runoff from the site using filtration and discharge of the treated stormwater through an existing outfall equipped with a diffuser (Outfall 004).

The stormwater SCMs will be implemented using a variety of construction equipment, such as excavators, bulldozers, and dump trucks, and may require the use of other heavy equipment, such as fork-lifts and cranes, for certain operations.

Additional details on the objectives of the SCMs are presented in the stormwater Final Design Report.

1.2 ORGANIZATION

This HASP covers the stormwater SCMs construction oversight activities. Specific health and safety guidelines associated with the oversight work are discussed in Section 11. General health and safety guidelines associated with all field activities at the site (e.g., physical and chemical hazard evaluation) are combined.

1.3 ROLES AND RESPONSIBILITIES

All personnel and visitors on this site must comply with the requirements of this HASP. The specific responsibilities and authority of management, safety and health personnel, and other personnel on this site are detailed in the following paragraphs.

1.3.1 Site Safety and Health Officer/Site Supervisor

The SSHO and site supervisor have full responsibility and authority to develop and implement this HASP and to verify compliance. They report to the project manager and are onsite or readily accessible to the site during all work operations. They have the authority to suspend site work if unsafe conditions are detected and are responsible for assessing site conditions and directing and controlling emergency response activities. The specific responsibilities of the SSHO include:

- Managing the safety and health functions on this site
- Serving as the site's point of contact for safety and health matters
- Assessing site conditions for unsafe acts and conditions and providing corrective action
- Ensuring that all Integral employees and subcontractors know and follow the HASP
- Ensuring that daily work schedules and tasks are appropriate for the required levels of effort and weather conditions
- Confirming local emergency response phone numbers and locations
- Conducting and documenting the initial and daily or periodic health and safety briefings
- Evaluating and modifying the level of protective apparel and safety equipment, as necessary and appropriate, based on site conditions
- Ensuring that the field team observes all necessary decontamination procedures
- Inspections on a weekly basis to determine the effectiveness of the HASP.

If the site supervisor determines that site conditions are unsafe, he or she has the authority to suspend field operations until the problem is corrected. The site supervisor can modify HASP procedures in consultation with the SSHO. Any changes must be documented in the field logbook, and field staff must be immediately informed of the change. The project manager and Integral's corporate health and safety officer must be notified within 12 hours of any changes to the HASP.

1.3.2 Site Workers

Site workers are responsible for complying with this HASP, using the proper personal protective equipment (PPE), reporting unsafe acts and conditions, and following the work and safety and health instructions of the project manager and SSHO. All site workers have the authority and are encouraged to suspend field operations and leave the environment if they feel conditions have become unsafe.

1.3.3 Buddy System

The buddy system will be used at the site at all times. The buddy system is a system of organizing employees into field teams in such a manner that each employee of the field team is designated to be observed by at least one other employee in the field team. The purpose of the buddy system is to provide rapid assistance to employees in the event of an emergency.

1.4 SITE BACKGROUND

The Arkema facility is located in Portland, Oregon, on the northwest bank of the lower Willamette River between approximately river mile 6.9 and 7.6. The upland portion of the site encompasses approximately 54 acres of land. The in-water portion of the site is defined as the land below mean high water (18.1 ft City of Portland Datum).[1] The facility is located within the heavy industrial sanctuary of northwest Portland. Specific information on the site is presented below:

- **Owners/tenants:** Arkema Inc.
- **Current site use:** Inactive industrial, environmental remediation and monitoring are ongoing
- **Industrial waste site:** Yes
- **Topography:** Generally level with steep banks along river
- **Site access:** Private, access gate off Front Avenue
- **Site activity:** Inactive, except for environmental remediation and monitoring
- **Nearest drinking water/sanitary facilities:** Office building at Front Avenue gate
- **Nearest telephone:** Cell phone coverage is available across the site.

[1] The in-water portion of the site below mean low tide is leased from the Oregon Division of State Lands.

1.5 PROJECT MANAGER AND OTHER KEY CONTACTS

	Name (affiliation)	Work Telephone	Cell Phone
Project manager	Mike Martin (Integral)	303-404-2944	303-818-3285
Facility contact	Larry Patterson (ERM)	503-225-7210	503-539-5112
Client contact	Todd Slater (LSS)	610-594-4430	610-804-0506
Site Safety and Health Officer/Site Supervisor	Jane Sund (Integral)	503-943-3615	TBD

1.6 DEFINITIONS

Contamination reduction zone Area between the exclusion and support zones that provides a transition between contaminated and clean zones.

Exclusion zone Any portions of the site where hazardous substances are present[2], or are reasonably suspected to be present, and pose an exposure hazard to personnel

Support zone All areas of the site outside the exclusion and contaminant reduction zones.

HAZWOPER Hazardous Waste Operations and Emergency Response standard, as described in 29 CFR Part 1910.120.

OSHA Occupational Safety and Health Administration.

[2] In general, the site does not have areas with exposed hazardous substances. However, when field activities are conducted, there is the potential that hazardous substances may be brought to the ground surface and potential contact with hazardous substances could occur.

2 CHEMICAL HAZARD EVALUATION

Potentially hazardous chemicals known to exist at the site in soil, sediment, and groundwater are primarily organochlorine pesticides (dichloro-diphenyl-trichloroethane [DDT] and its metabolites), monochlorobenzene (MCB), chromium, and perchlorate associated with the former chemical manufacturing operation at the site. The chemicals of concern, applicable chemical properties, and exposure routes are presented in the following sections.

The following table lists the historical site maximum constituent concentrations in soil at the site. The table also lists the chemical properties and OSHA's permissible exposure level (PEL), short-term exposure level (STEL), and immediately dangerous to life and health (IDLH) level. Some chemicals in soil may volatilize or become airborne dust and enter the field crew's breathing zone and be inhaled. Breathing zone air can be monitored to ensure that the chemicals do not exceed the PEL. If any of the chemicals exceed the PEL, immediate action is required (e.g., don respirators, leave site) as designated in the "Air Monitoring" section (Section 5).

Chemical Properties

Chemical of Concern	Upland Concentration (site maximum)	Medium	OSHA PEL	OSHA STEL	OSHA IDLH	Odor Threshold	IP(eV)	Carcinogen or Other Hazard
Monochlorobenzene	66,600 mg/kg	Soil	75 ppm	--	1,000 ppm	--	9.07	--
Perchlorate	168 mg/kg	Soil	--	--	--	--	--	--
Total chromium	1,640 mg/kg	Soil	0.5 mg/m^3	--	250 mg/m^3	--	--	--
2,3,7,8-TCDD	0.000003 mg/kg	Soil	--	--	--	--	--	Ca
Dioxin/Furan TCDD TEQ	0.0691 mg/kg	Soil	--	--	--	--	--	--
Chloride	1,648 mg/kg	Soil	--	--	--	--	--	--
Chloroform	0.35 mg/kg	Soil	2 ppm	--	500 ppm	--	11.42	Ca
Tetrachloroethylene	14 mg/kg	Soil	100 ppm	--	150 ppm	4.68–50 ppm	9.32	Ca
Lindane (gamma hexachlorocyclohexane)	0.55 mg/kg	Soil	0.5 mg/m^3	--	50 mg/m^3	--	--	--
4-4'-DDD	690 mg/kg	Soil	--	--	--	--	--	--
4-4'-DDT	150,000 mg/kg	Soil	0.5 mg/m^3	--	500 mg/m^3	--	--	Ca
4,4'-DDE	18,200 mg/kg	Soil	--	--	--	--	--	Ca
Acetone	1,300 mg/kg	Soil	250 ppm	--	2,500 ppm	13–100 ppm	9.69	--
Trichloroethene	0.083 mg/kg	Soil	100 ppm	--	1,000 ppm	21.4–28 ppm	9.45	Ca
Total xylenes	0.036 mg/kg	Soil	100 ppm	--	900 ppm	--	8.44–8.56 (based on isomers)	--
1,2-Dicholorobenzene	15 mg/kg	Soil	50 ppm C	--	200 ppm	--	9.06	--
Methylene chloride	0.055 mg/kg	Soil	25 ppm	--	2,300 ppm	25–250 ppm	11.32	Ca
1,4-Dichlorobenzene	51 mg/kg	Soil	75 ppm	--	150 ppm	--	8.98	Ca
1,3-Dichlorobenzene	1.2 mg/kg	Soil	--	--	--	--	--	--
2-Butanone	0.016 mg/kg	Soil	200 ppm	--	3,000 ppm	--	9.54	--

Chemical of Concern	Upland Concentration (site maximum)	Medium	OSHA PEL	OSHA STEL	OSHA IDLH	Odor Threshold	IP(eV)	Carcinogen or Other Hazard
beta-Endosulfan	0.033 mg/kg	Soil	--	--	--	--	--	--
1,1,1-Trichlorethane	18 mg/kg	Soil	350 ppm	--	700 ppm	20–400 ppm	11.00	--
Toluene	0.043 mg/kg	Soil	200 ppm	--	500 ppm	0.17–2.9 ppm	8.82	--

Notes:

--	none established
Ca	carcinogen
C	ceiling (value that should not be exceeded at any time)
IDLH	immediately dangerous to life and health
IP(eV)	ionization potential (electron volts)
mg/kg	milligrams per kilogram
mg/m^3	milligrams per cubic meter
OSHA	Occupational Safety and Health Administration
PEL	permissible exposure level
ppm	parts per million
STEL	short-term exposure level
TCDD	tetrachloro-dibenzo-p-dioxin
TEQ	toxic equivalence

2.1 CHEMICAL CHARACTERISTICS AND EXPOSURE ROUTES

The table below summarizes the chemical characteristics and potential chemical exposure routes at the site.

	Likely	Possible	Unlikely
Potential Chemical Exposure Routes at the Site:			
Inhalation		X	
Ingestion			X
Skin absorption		X	
Skin contact		X	
Eye contact		X	
Chemical Characteristics:			
Corrosive			X
Flammable			X
Ignitable			X
Reactive			X
Volatile	X		
Radioactive			X
Explosive			X
Biological agent			X
Particulates or fibers	X		
If likely, describe:	MCB is volatile. All construction oversight activities will be conducted in well-ventilated areas, and air monitoring for organic vapors will be conducted periodically with an organic vapor monitor (see Air Monitoring section). Dust containing DDT and its metabolites may become airborne if the soils are dry. Air monitoring will be conducted periodically with an aerosol meter (see Air Monitoring section).		

3 PHYSICAL HAZARD EVALUATION AND GUIDELINES

The following sections present general physical hazards that are expected during construction oversight activities.

3.1 GENERAL PHYSICAL HAZARDS

The table below presents possible physical hazards that are expected to be present during the stormwater SCMs construction oversight field activities.

Potential Hazard	Yes	No	Proposed Safety Procedure
Uneven terrain/tripping	X		Use caution, wear properly fitting shoes or boots, keep work area orderly.
Heat stress	X		Follow heat stress information (Attachment 3). *Note:* potential for heat stress will depend on season.
Cold/hypothermia	X		Keep warm and dry; bring changes of clothes; do not work in extreme conditions without proper equipment or training. Follow cold stress information (Attachment 3). *Note*: potential for cold/hypothermia will depend on season.
Falling objects	X		Wear hard hat; stay away from overhead hazards.
Noise	X		Wear ear protection when working around heavy equipment and other noise sources.
Excavations	X		Do not enter excavations greater than 3 ft in depth without evaluation by a qualified person and implementing applicable trenching and excavation safeguards as required by law.
Heavy equipment	X		Stay back from operating equipment; wear safety vest and hard hat; coordinate with operator.
Compressed air equipment	X		Equipment must be equipped with pressure release valves, drains, and gauges.
Adverse weather	X		Seek shelter during electrical storms; work in adverse weather conditions only with proper training and equipment.

Note: If confined space entry is required, personnel must first obtain a confined space entry permit. Integral personnel are not trained or authorized for confined space entry.

Summary of potential physical hazards posed by proposed site activities:

Activity	Potential Hazard
Construction Oversight	Uneven terrain/tripping, heat stress, cold/hypothermia, excavations, compressed air equipment, falling objects, heavy equipment, noise, adverse weather

4 PERSONAL PROTECTIVE EQUIPMENT AND SAFETY EQUIPMENT

The following sections address PPE and safety equipment required for completing the field activities.

4.1 PERSONAL PROTECTIVE EQUIPMENT

Based on the hazards identified above, the following table identifies the personal protective equipment required for the site activities.

	Level of Protection	
	Initial	**Contingency**
Construction Oversight	D	Leave Site

Each level of protection will incorporate the following PPE:

Level D: X Long pants and shirt or work coveralls, hard hat, safety glasses, traffic safety vest, latex or nitrile gloves, and steel-toed boots are required at all times. Hearing protection is required as needed.

Level MD: X Same as Level D with the addition of a personal floatation device and chemical protective coveralls (coated Tyvek) or rain slicks.

Level C: X Same as Level D with half-face or full-face air purifying respirator with **organic vapor/particulate cartridge.**

4.1.1 Respirator and Respirator Cartridge Information

Is there potential for a respirator to be donned during fieldwork? **No**[3]

4.2 SAFETY EQUIPMENT

The following safety equipment will be onsite during the proposed field activities. One automated external defibrillator will be onsite at all times during field sampling activities.

Air Monitoring (check the items required for this project)

- [X] Organic vapor monitor (OVM)
- [ ] Lower explosive limit/O_2 meter
- [ ] Air sampling pumps
- [X] Aerosol meter

[3] If action level specified in Section 5 is exceeded, personnel will evacuate the site instead of donning a respirator.

- [ ] H_2S meter
- [x] Detector pump and tubes (benzene)
- [ ] Radiation meter
- [ ] Other: _____

First Aid Kit (mandatory, including adhesive band-aids, gauze, tape, gloves, cardiopulmonary resuscitation [CPR] shield, triangle bandage; check additional items required for the site)

- [x] Emergency blanket
- [x] Insect repellent
- [x] Sunscreen
- [ ] Other: _____

Other (check the items required for this project)

- [x] Eyewash
- [x] Drinking water
- [ ] Stopwatch for monitoring heart rate
- [ ] Thermoscan® thermometer for heat stress monitoring
- [ ] Survival kit
- [ ] Personal flotation device
- [ ] Cool vests
- [ ] Fit test supplies
- [x] Fire extinguisher (Heavy equipment, drill rigs and boats)
- [ ] Windsock
- [x] Cellular phone
- [ ] Radio sets
- [ ] Global positioning system
- [ ] Other: _____

5 AIR MONITORING

Air monitoring will be conducted when entering previously uncharacterized sites, when working in the vicinity of uncontained chemicals or spills, when opening containers and well casings, and prior to opening and entering confined spaces (Integral personnel are not trained or authorized to enter confined spaces). Air monitoring must be conducted to identify potentially hazardous environments and determine reference or background concentrations. Air monitoring can be used to augment judgment in defining exclusion zones. Air monitoring may also be conducted to evaluate the concentration of chemicals in samples.

Periodic air monitoring will be performed with a photo-ionization detector (PID) equipped with an 11.7 eV lamp and/or a flame ionization detector (FID) and an aerosol meter during stormwater SCMs construction oversight activities. Specifications and response factors for the selected PID and FID meters are presented in Attachment A of the CMM plan (Appendix B of the Design Report). The constituents of concern at the site are primarily DDT and its metabolites, MCB, chromium, and perchlorate. Of these constituents, only MCB is volatile. Dust containing DDT and its metabolites, chromium, and perchlorate may become airborne during excavation activities.

Monitoring Instrument	Calibration Frequency	Parameters of Interest	Monitoring Frequency
PID or FID	Daily	Volatile organic compounds	15 minutes
Aerosol meter	Daily	Dust	15 minutes

The following action levels have been established to determine the appropriate level of personal protection to be used during site investigation activities:

Instrument	Reading	Action	Comments
PID or FID	Sustained at or above 2 ppm over background for over 1 minute	Retreat to upwind direction and assess situation. Pull Drager tube for benzene. If less than 1 ppm, continue working.	If readings do not decrease, leave site and reassess situation. Might be able to employ engineering controls (e.g., fans, etc.) to reduce volatiles in breathing zone.
Aerosol meter	Sustained at or above 0.5 mg/m^3 for 1 minute.	Retreat to upwind direction and assess situation.	If possible, use engineering controls (i.e., water application) to suppress dust. If readings do not decrease, leave site and reassess situation.

The air monitoring equipment will be maintained and calibrated in accordance with the manufacturer's recommendations.

6 HEALTH AND SAFETY TRAINING

6.1 HEALTH AND SAFETY TRAINING

State and federal laws establish training requirements for workers at uncontrolled hazardous waste sites (including areas where accumulations of hazardous waste create a threat to the health and safety of an individual, the environment, or both). Integral and subcontractor personnel are required to complete the following training requirements prior to working at the site.

6.1.1 Training Requirements

Integral and subcontractor personnel will be required to complete the following training requirements prior to working at the site.

Task	No Training	24-hour	40-hour[a]	Supervisor[b]	First Aid/CPR[c]	Medical Monitoring
Construction Oversight			X	X	X	X

Notes:

[a] Must have current 8-hour refresher if it has been more than a year since the 40-hour training.
[b] At least one person onsite must be OSHA HAZWOPER supervisor trained if this is a hazardous waste site.
[c] At least one member of each team of two or more people onsite must be first aid/CPR trained.

Note that non-Integral subcontractors and personnel may have requirements that are more stringent than those listed above. These are minimum training and monitoring requirements to work on this site.

6.1.2 Medical Monitoring

OSHA requires medical monitoring for personnel potentially exposed to chemical hazards in concentrations in excess of the PEL for more than 30 days per year and for personnel who must use respiratory protection for more than 30 days per year. Integral requires medical monitoring for all employees potentially exposed to chemical hazards.

Will personnel working at this site be enrolled in a medical monitoring program? Yes ___X___ No _____

6.2 SITE SAFETY MEETINGS

Site safety meetings must be held before beginning new tasks or when new staff enter the site. Site safety meetings should be held at a minimum of once a week and should be held daily on large projects. Tailgate safety meetings should occur every morning during the review of the day's work plan, covering specific hazards that may be encountered. Additional meetings will be held anytime health and safety concerns are raised by any of the personnel. The emergency response plan will be discussed in detail at the kick-off health and safety meeting on the first day of fieldwork. Attendance and topics covered are to be documented in the field logbook.

7 EMERGENCY RESPONSE PLAN

The following sections discuss emergency recognition and prevention, emergency response, and site communications.

7.1 EMERGENCY RECOGNITION AND PREVENTION

It is the responsibility of all employees to monitor work at the site for potential safety hazards. All employees are required to immediately report any unsafe conditions to the SHSO. The SHSO is responsible to take steps to remedy any unsafe conditions observed at the work site.

The following are examples of some emergency situations that could occur during the Arkema stormwater SCMs construction oversight field activities:

- During air monitoring, the air monitoring action level is exceeded
- Serious injury or illness (e.g., physical injury, heart attack, etc.)
- Severe thunderstorm with lightning.

Immediate actions will be taken by the field crew under the leadership of the SHSO in response to these emergencies.

7.2 EMERGENCY RESPONSE AND NOTIFICATION

In case of any emergency at the site, all affected personnel must immediately evacuate the work area and report to the site safety officer at the following predetermined location.

The gated site entrance on Front Avenue (see site map in Attachment 1).

In case of injury, field personnel should take precautions to protect the victim from further harm and notify local or facility emergency services. In remote areas, it will be necessary to have first-aid-trained personnel on the field team. The victim may require decontamination prior to treatment—requirements will vary based on site conditions.

Emergency medical care will be provided by:

- [X] Local emergency medical provider (i.e., fire department)
- [ ] Facility emergency medical provider
- [ ] First-aid-trained field staff (for remote areas only)

A hospital route map and directions to the hospital are provided in Attachment 1.

Local Resources	Name	Telephone	Notified Prior to Work (Yes/No)?
Fire	--	911	No
Police	Emergency	911	
Oregon DEQ	Matt McClincy	503-229-5263	Yes
Ambulance	--	911	No
Hospital	Legacy Good Samaritan	503-413-7711	No
Site phone	Field cell phone	TBD	N/A
Directions to hospital:	Consult attached maps in Attachment 1.		

Corporate Resources	Name	Telephone
Integral Consulting Corporate Health and Safety Officer	Eron Dodak	(503) 284-5545 (office) (503) 407-2933 (cell)
Medical consultant	Health Force Partners	(425) 806-5700

The SHSO (Jane Sund or designee) and the project manager (Mike Martin) are the only people **that may call the phone numbers listed above, with the exception of 911. In case of serious** injuries, death, or other emergency, the Integral health and safety officer must be notified immediately. To contact the Integral health and safety officer (or delegate), try calling the phone numbers listed above.

7.3 EMERGENCY DECONTAMINATION PROCEDURES

In case of an emergency, gross decontamination procedures will be speedily implemented, if possible. If a life-threatening injury occurs and the injured person cannot undergo decontamination procedures, the medical facility will be informed that the injured person has not been decontaminated and given information regarding the most probable chemicals of concern.

Decontamination procedures will only be used if practical and if they will not further injure the person. The SHSO will make the determination on whether or not to decontaminate the injured person. The following steps will be followed for decontaminating injured personnel:

- Wash the gross contamination from the injured person's PPE (e.g., Tyvek® coveralls, work boots, etc.) with a Liquinox® or Alconox® solution followed by a rinse with tap or deionized/distilled water
- Remove PPE if feasible without further injuring the person.

7.4 SITE COMMUNICATIONS

Each field team will carry a cell phone and an air horn that are in good working order. Cell phone coverage is good at the site. Site communications will be done with either a cell phone or the air horn. If there is any type of emergency that requires the site to be evacuated (e.g., severe thunderstorm), the field team leader will blow the air horn three times. When the horn sounds, all personnel will meet at the emergency meeting location (the gated site entrance on Front Avenue). All other notifications will be conducted using a cell phone. Emergency phone numbers are listed in Section 7.2.

8 WORK ZONES

Site control measures in work zones are described below for the stormwater SCMs construction oversight field activities.

Exclusion zone: The area immediately around the construction activities. Where practical, the exclusion zone will be delineated with caution tape or orange traffic safety cones.

Contamination reduction zone: The contamination reduction zone will consist of an area surrounding the exclusion zone where decontamination of both personnel and equipment will occur. Where practical, the exclusion zone will be delineated with caution tape or orange traffic safety cones.

Support zone: All areas of the site outside the exclusion and contaminant reduction zones.

Controls to be used to prevent entry by unauthorized persons: Sampling staff will instruct unauthorized personnel to stay outside the exclusion and contaminant reduction zones.

9 DECONTAMINATION AND PERSONAL HYGENE

To prevent the distribution of contaminants outside the exclusion zone and to prevent the cross-contamination of different areas of the site, the following procedures will be used to decontaminate sampling equipment. In addition, personal hygiene guidelines should be followed to prevent personnel from coming into contact with contaminants during or after leaving the site.

9.1 DECONTAMINATION PROCEDURES

The decontamination procedures described in the stormwater SCMs design plan will be used during construction activities.

Construction equipment that contacts site soils will be decontaminated with potable water using a hot pressure washer on a water-tight decontamination pad that will capture the decontamination waters and soil. All excess soil will be contained in properly labeled, U.S. Department of Transportation (DOT)-approved 55-gallon drums for waste characterization sampling and disposal. Decontamination fluids will be containerized in properly labeled, DOT-approved 55-gallon drums pending analytical results for proper disposal.

To minimize or prevent personal exposure to hazardous materials, all personnel working in the exclusion zone and contamination reduction zone will comply with the following decontamination procedures. Gross contamination will be removed from PPE with solution of Alconox® or Liquinox® and potable water. PPE will be removed and placed in a garbage sack for proper disposal at a solid waste landfill.

9.2 PERSONAL HYGIENE

The following personal hygiene practices will be used at the site to reduce exposure to chemicals:

- Long hair will be secured away from the face so it does not interfere with any activities.
- All personnel leaving potentially contaminated areas will wash their hands, forearms, and faces prior to entering any clean areas or eating areas.
- Personnel leaving potentially contaminated areas will shower (including washing hair) and change to clean clothing as soon as possible after leaving the site.

- No person will eat, drink, or chew gum or tobacco in potentially contaminated areas. Drink containers and drinking of replacement fluids for heat stress control will be permitted only in support areas. Smoking is prohibited in all areas of the site because of the potential for contaminating samples and for health and safety reasons.

10 VEHICLE SAFETY, SPILL CONTAINMENT, AND SHIPPING INSTRUCTIONS

10.1 VEHICLE SAFETY

Integral's vehicle safety program requires the following:

- All vehicles are to be operated in a safe manner and in compliance with statutory traffic regulations and ordinances.
- Operators are to practice defensive driving and drive in a courteous manner.
- Operators are required to have a valid driver's license and liability insurance (per local state laws).
- Seat belts are to be worn by the driver and all passengers.
- No persons are allowed to ride in the back of any trucks or vans, unless equipped with seat belts.
- Vehicles are to be driven in conformance with local speed limits.
- Personnel who are impaired by fatigue, illness, alcohol, illegal or prescription drugs, or who are otherwise physically unfit, are not allowed to drive.
- Personnel are to avoid using cellular phones (including hands-free devices) or engaging in other distractions while driving.
- All Integral-owned field vehicles are to be maintained in a safe and clean condition.
- All Integral-owned field vehicles are to be equipped with the following:
  - First-aid kit
  - Fire extinguisher
  - Flares
  - Spare tire and jack
  - Other equipment as required for the project (e.g., tire chains, towing cable, tools, cellular phone or radio).
- Motor vehicle accidents are to be reported to the responsible law enforcement agency, the Integral human resources manager, and Integral's corporate health and safety officer on the same day of occurrence.
- Employees who have experienced work-related vehicle accidents or citations may be required to complete a defensive driving program.

10.2 SPILL CONTAINMENT

Provisions must be made for spill containment at any site where bulk liquids will be handled.

Will the proposed fieldwork include the handling of bulk liquids, oil, or chemicals (other than water)? Yes _____ No X

If yes, describe spill containment provisions for the site: _____

Bundles of oil sorbent pads will be onsite at all times.

In case of a significant bulk liquid spill, the National Response Center (800-424-8802) and Oregon Emergency Response System (800-452-0311) will be notified by the SSHO (Jane Sund or designee) or the project manager (Mike Martin).

10.3 SHIPPING INFORMATION

Federal laws and international guidelines place restrictions on what materials may be shipped by passenger and cargo aircraft. In addition, 49 CFR regulates labeling, manifesting, and shipment of all packages containing potentially hazardous materials. In the course of this field investigation, the following items will be shipped to and from the site in the following manner:

Item	Hazardous Constituent	Quantity	Packaging	How Shipped
Samples				
Solvents (name)				
Calibration gas (name)	Isobutylene (100 ppm)	17 liter cylinder	Cooler	Field vehicle
Preservatives (name)				
Other:				

A 24-hour emergency response number (on any shipping documents such as a Uniform Hazardous Waste Manifest, Shipper's Declaration of Dangerous Goods, etc.) is required for shipments of all dangerous or hazardous goods. Integral does not have a 24-hour emergency contact number for dangerous or hazardous goods shipment. No dangerous or hazardous goods may be shipped by Integral until an account is set up with a 24-hour emergency response service such as CHEM-TEL (1-813-248-0573). If any hazardous or dangerous goods need to be shipped for a project, they must be shipped directly to the site by the supplier. Any hazardous or dangerous goods that are not used in the course of the field effort must remain at the site.

11 TASK-SPECIFIC SAFETY PROCEDURES

The following are safety procedures associated with the stormwater SCMs construction oversight fieldwork. Oversight personnel will wear appropriate PPE including steel-toed boots, safety glasses, traffic safety vest, and a hard hat (see Section 4.1 for additional details on PPE). Note that Integral personnel are not authorized to operate heavy equipment under any circumstances.

Confirm the absence of underground and overhead utilities prior to moving to an excavation area. The areas slated for excavation must be cleared by the facility manager, Larry Patterson. Be sure that all utilities are marked or have a designation that they are not present in the area. The one-call (1-800-332-2344) utility locating representatives of Oregon should have notified you of all utilities present in the area. Take a few minutes to examine the locations of fire hydrants, gas meters, etc. to make sure that the utility locating marks make sense. If there is any doubt as to the location of underground utilities, call the public or a private utility locator. Finally, check for overhead utilities and other obstructions.

Avoid all heavy equipment pinch points and stay a safe distance from the equipment. Always wear a traffic safety vest and be sure the heavy equipment operator is in visual contact with you at all times. Do not ride on the excavating equipment or ride in the backhoe bucket to inspect an excavation. If materials need to be closely examined, ask the equipment operator to collect a sample of the material with the excavator. Do not enter any excavations greater than 3 ft deep. Stand clear of all loads that are lifted by a crane or forklift.

The Arkema site is a secure fenced facility. However, it is still critical to police the exclusion zone and keep all unauthorized individuals a safe distance away from the work.

ATTACHMENT 1

SITE MAP AND HOSPITAL ROUTE

Dock #2

Dock #1

Salt Dock

Former Salt Storage Area

Chlorate Plant Area

Acid Plant Area

Office

Emergency Assembly Area

Map Document: (P:\Projects\C250_Arkema_Stormwater\Production_MXDs\HSP_FSP.mxd)
11/1/2010 -- 3:39:44 PM

integral consulting inc.

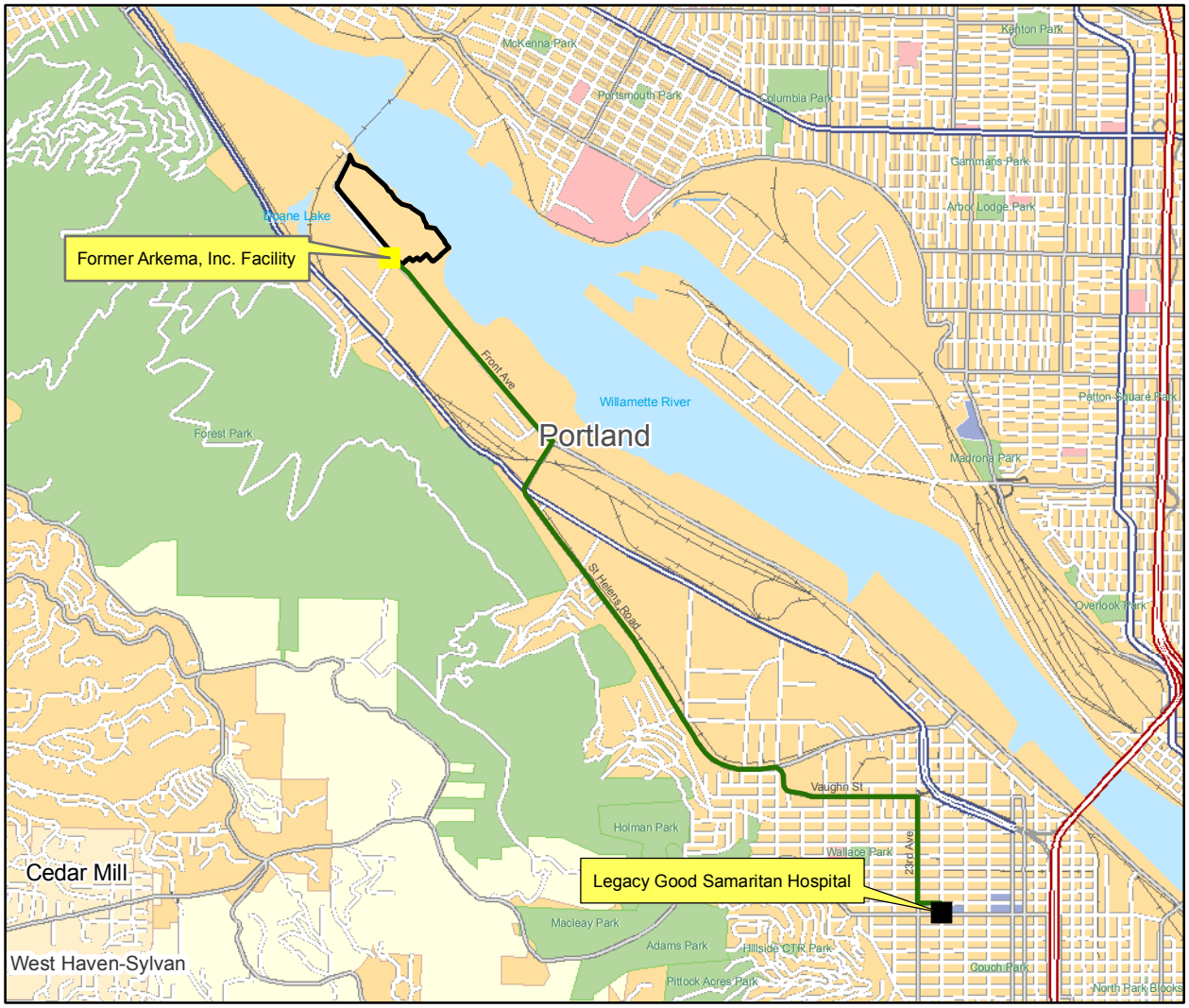
200 100 0 200 Feet

FEATURE SOURCES:
Bathymetric Information: Multibeam bathymetric survey conducted by David Evans and Associates, Inc. from February 6 - March 6, 2004.
Contours were derived from a Digital Terrain Model (DTM) based on a three-foot grid of multibeam data.
Vertical Datum: North American Vertical Datum of 1988(NAVD88).
Horizontal Datum: North American Datum of 1983 - 91 adjusted (NAD83/91), State Plane Coordinate System (SPCS), Oregon North Zone.
Units: International Feet.
Basemap: Basemap features updated in 2006 by David Evans and Associates. Ordinary high water line, top of bank, and other site features surveyed in April 2006.
Most buildings and structures on the Arkema site have been demolished or removed.
OHW and Top of Slope lines were created from the April 2006 DEA survey, the +12ft contour line was derived from the combined lidar/bathymetry grid.
Lot Lines: Created by importing pdf file from ERM, georeferencing to CAD lines (RMS error = 2.3042) and heads-up digitizing the lot lines.

E-Sewer-L
Storm Drain
12ft_Contour
Navigation Channel
Bridges
River
Outfalls

DRAFT

Arkema Stormwater SCM
Health and Safety Plan
Site Map



Directions to Legacy Good Samaritan Hospital

1. Go South East on NW Front Avenue toward NW 61st Avenue.
2. Turn right on NW Kittridge Avenue.
3. Bear left on NW Saint Helens Road.
4. Continue on NW Nicolai Street.
5. Bear right on NW Wardway Street.
6. Bear left on NW Vaughn Street.
7. Turn right on NW 23rd Avenue.
8. Turn left on NW Marshall Street.
9. Turn right on NW 22nd Avenue.
10. Arrive at Legacy Good Samaritan Hospital, on the right.

ATTACHMENT 2

REGULATORY NOTICES

You Have a Right to a Safe and Healthful Workplace.

IT'S THE LAW!

- You have the right to notify your employer or OSHA about workplace hazards. You may ask OSHA to keep your name confidential.
- You have the right to request an OSHA inspection if you believe that there are unsafe and unhealthful conditions in your workplace. You or your representative may participate in the inspection.
- You can file a complaint with OSHA within 30 days of discrimination by your employer for making safety and health complaints or for exercising your rights under the *OSH Act*.
- You have a right to see OSHA citations issued to your employer. Your employer must post the citations at or near the place of the alleged violation.
- Your employer must correct workplace hazards by the date indicated on the citation and must certify that these hazards have been reduced or eliminated.
- You have the right to copies of your medical records or records of your exposure to toxic and harmful substances or conditions.
- Your employer must post this notice in your workplace.

The *Occupational Safety and Health Act of 1970 (OSH Act)*, P.L. 91-596, assures safe and healthful working conditions for working men and women throughout the Nation. The Occupational Safety and Health Administration, in the U.S. Department of Labor, has the primary responsibility for administering the *OSH Act*. The rights listed here may vary depending on the particular circumstances. To file a complaint, report an emergency, or seek OSHA advice, assistance, or products, call 1-800-321-OSHA or your nearest OSHA office: • Atlanta (404) 562-2300 • Boston (617) 565-9860 • Chicago (312) 353-2220 • Dallas (214) 767-4731 • Denver (303) 844-1600 • Kansas City (816) 426-5861 • New York (212) 337-2378 • Philadelphia (215) 861-4900 • San Francisco (415) 975-4310 • Seattle (206) 553-5930. Teletypewriter (TTY) number is 1-877-889-5627. To file a complaint online or obtain more information on OSHA federal and state programs, visit OSHA's website at **www.osha.gov**. If your workplace is in a state operating under an OSHA-approved plan, your employer must post the required state equivalent of this poster.

1-800-321-OSHA
www.osha.gov

U.S. Department of Labor • Occupational Safety and Health Administration • OSHA 3165

Usted Tiene el Derecho a un Lugar de Trabajo Seguro y Saludable.

¡LO ESTABLECE LA LEY!

- Tiene el derecho de notificar a su empleador o a la OSHA sobre cualquier peligro en su lugar de trabajo. Puede pedir a la OSHA que mantenga su nombre en reserva.
- Tiene el derecho de solicitar una inspección de la OSHA si considera que existen condiciones peligrosas y poco saludables en su lugar de trabajo. Usted o su representante puede participar en la inspección.
- Puede presentar un reclamo a OSHA durante un plazo de 30 días si su empleador lo discrimina por presentar reclamos de seguridad y sanidad o por ejercer sus derechos de acuerdo con la Ley.
- Tiene el derecho de ver las citaciones de la OSHA enviadas a su empleador. Su empleador debe colocar las citaciones en un lugar visible en el sitio de la supuesta infracción o cerca de él.
- Su empleador debe corregir los peligros en el lugar de trabajo dentro del plazo indicado en la citación y debe certificar que dichos peligros se hayan reducido o eliminado.
- Tiene el derecho de recibir copias de su historial médico o de los registros de su exposición a sustancias o condiciones tóxicas y peligrosas.
- Su empleador debe colocar este aviso en un lugar visible de su lugar de trabajo.

La Ley de Seguridad y Salud Ocupacionales de 1970 (la Ley), P.L. 91-596, garantiza condiciones ocupacionales seguras y saludables para los hombres y las mujeres que desempeñen algún trabajo en toda la Nación. La Administración de Seguridad y Salud Ocupacionales (OSHA), dependiente del Departamento del Trabajo de los Estados Unidos, es la responsable principal de supervisar la Ley. Los derechos que se indican en este documento pueden variar según las circunstancias particulares. Para presentar un reclamo, informar sobre una emergencia o pedir consejo, asistencia o productos de la OSHA, llame al 1-800-321-OSHA o a la oficina de la OSHA más cercana a usted: • Atlanta (404) 562-2300 • Boston (617) 565-9860 • Chicago (312) 353-2220 • Dallas (214) 767-4731 • Denver (303) 844-1600 • Ciudad de Kansas (816) 426-5861 • Nueva York (212) 337-2378 • Filadelfia (215) 861-4900 • San Francisco (415) 975-4310 • Seattle (206) 553-5930. El número TTY es 1-877-889-5627. Para presentar un reclamo en línea u obtener más información sobre los programas federales y estatales de la OSHA, visite el sitio Web de la OSHA en www.osha.gov. Si su lugar de trabajo se encuentra en un estado que funciona según un plan aprobado por la OSHA, su empleador debe colocar en un sitio visible el equivalente estatal de este afiche.

1-800-321-OSHA

www.osha.gov

Departmento del Trabajo de los E.E. UU. • Administracíon de Seguridad y Salud Ocupacionales • OSHA 3167

ATTACHMENT 3

SAFETY PROCEDURES

FROSTBITE

What happens to the body:

Freezing in deep layers of skin and tissue; pale, waxy-white skin color; skin becomes hard and numb; usually affects fingers, hands, toes, feet, ears, and nose.

What to do: (land temperatures)

- Move the person to a warm, dry area. Don't leave the person alone.
- Remove wet or tight clothing that may cut off blood flow to the affected area.
- **Do not** rub the affected area because rubbing damaged the skin and tissue.
- Gently place the affected area in a warm water bath (105°) and monitor the water temperature to **slowly** warm the tissue. Don't pour warm water directly on the affected area because it will warm the tissue too fast, causing tissue damage. Warming takes 25-40 minutes.
- After the affected area has been warmed, it may become puffy and blister. The affected area may have a burning feeling or numbness. When normal feeling, movement, and skin color have returned, the affected area should be dried and wrapped to keep it warm. **Note:** If there is a chance the affected area may get cold again, do not warm the skin. If the skin is warmed and then becomes cold again, it will cause severe tissue damage.
- Seek medical attention as soon as possible.

How to Protect Workers

- Recognize the environmental and workplace conditions that lead to potential cold-induced illnesses and injuries.
- Learn the signs and symptoms of cold-induced illnesses/injuries and what to do to help the worker.
- Train workers about cold-induced illnesses and injuries.
- Select proper clothing for cold, wet, and windy conditions. Layer clothing to adjust to changing environmental temperatures. Wear a hat and gloves, in addition to underwear that will keep water away from the skin (polypropylene.)
- Take frequent short breaks in warm, dry shelters to allow the body to warm up.
- Perform work during the warmest part of the day.
- Avoid exhaustion or fatigue because energy is needed to keep muscles warm.
- Use the buddy system (work in pairs.)
- Drink warm, sweet beverages (sugar water, sports-type drinks.) **Avoid drinks with caffeine** (coffee, tea, or hot chocolate) **or alcohol**.
- Eat warm, high-calorie foods like hot pasta dishes.

Workers are at increased risk when…

- They have predisposing health conditions such as cardiovascular disease, diabetes, and hypertension.
- They take certain medications. Check with your doctor, nurse, or pharmacy and ask if medicines you take affect you while working in cold environments.
- They are in poor physical condition, have a poor diet, or are older.

HYPOTHERMIA - (Medical Emergency)

What happens to the body:

Normal body temperature (98.6°F/37°C) drops to or below 95°F/35°C; fatigue or drowsiness; uncontrolled shivering; cool, bluish skin; slurred speech; clumsy movements; irritable, irrational, or confused behavior.

What to do: (land temperatures)

- Call for emergency help (i.e., ambulance or 911).
- Move the person to a warm, dry area. Don't leave the person alone.
- Remove wet clothing and replace with warm, dry clothing or wrap the person in blankets.
- Have the person drink warm, sweet drinks (sugar water or sports-type drinks) if he is alert. **Avoid drinks with caffeine** (coffee, tea, or hot chocolate) **or alcohol**.
- Have the person move his arms and legs to create muscle heat. If he is unable to do this, place warm bottles or hot packs in the armpits, groin, neck, and head areas. **Do not** rub the person's body or place him in a warm water bath. This may stop his heart.

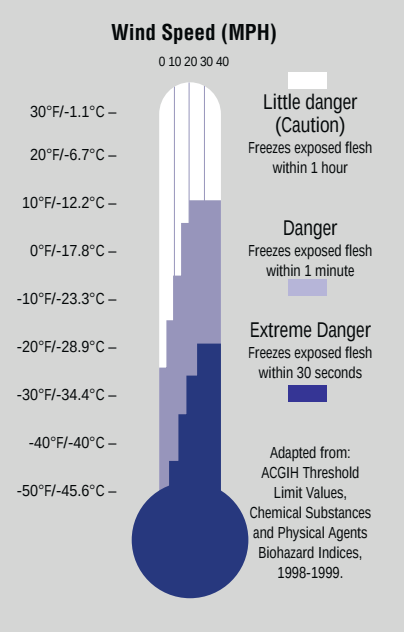
What to do: (water temperatures)

- Call for emergency help (i.e., ambulance or 911). Body heat is lost up to 25 times faster in water.
- **Do not** remove any clothing. Button, buckle, zip, and tighten any collars, cuffs, shoes, and hoods because the layer of trapped water closest to the body provides a layer of insulation that slows the loss of heat. Keep the head out of the water and put on a hat or hood.
- Get out of the water as quickly as possible or climb on anything floating. **Do not** attempt to swim unless a floating object or another person can be reached because swimming or other physical activity uses body heat and reduces survival time by about 50 percent.
- If getting out of the water is not possible, wait quietly and conserve body heat by folding arms across the chest, keeping thighs together, bending knees, and crossing ankles. If another person is in the water, huddle together with chests held closely.

THE COLD STRESS EQUATION

LOW TEMPERATURE + WIND SPEED + WETNESS = INJURIES & ILLNESS

When the body is unable to warm itself, serious cold-related illnesses and injuries may occur, and permanent tissue damage and death may result. **Hypothermia** can occur when *land temperatures* are **above** freezing or *water temperatures* are below 98.6°F/37°C. Cold-related illnesses can slowly overcome a person who has been chilled by low temperatures, brisk winds, or wet clothing.



Oregon Occupational Safety & Health Division
440-3336E-S (9/03)

HEAT EXHAUSTION

What happens to the body:

Headaches, dizziness, or light-headedness, weakness, mood changes, irritability or confusion, feeling sick to your stomach, vomiting, fainting, decreased and dark-colored urine, and pale, clammy skin.

What should be done:

- Move the person to a cool shaded area. Don't leave the person alone. If the person is dizzy or light-headed, lay him on his back and raise his legs about 6-8 inches. If the person is sick to his stomach, lay him on his side.
- Loosen and remove heavy clothing.
- Have the person drink some cool water (a small cup every 15 minutes) if he is not feeling sick to his stomach.
- Try to cool the person by fanning him. Cool the skin with a cool spray mist of water or wet cloth.
- If the person does not feel better in a few minutes call for emergency help (ambulance or call 911.)

(If heat exhaustion is not treated, the illness may advance to heat stroke.)

HEAT STROKE - A Medical Emergency

What happens to the body:

Dry, pale skin (no sweating); hot red skin (looks like a sunburn); mood changes; irritability, confusion, and not making any sense; seizures or fits, and collapse (will not respond).

What should be done:

- Call for emergency help (i.e., ambulance or 911.)
- Move the person to a cool, shaded area. Don't leave the person alone. Lay him on his back and if the person is having seizures, remove objects close to him so he won't hit them. If the person is sick to his stomach, lay him on his side.
- Remove heavy and outer clothing.
- Have the person drink some cool water (a small cup every 15 minutes) if he is alert enough to drink anything and not feeling sick to his stomach.
- Try to cool the person by fanning him or her. Cool the skin with a cool spray mist of water, wet cloth, or wet sheet.
- If ice is available, place ice packs in armpits and groin area.

How to Protect Workers

- Learn the signs and symptoms of heat-induced illnesses and what to do to help the worker.
- Train workers about heat-induced illnesses.
- Perform the heaviest work during the coolest part of the day.
- Slowly build up tolerance to the heat and the work activity (usually takes up to 2 weeks.)
- Use the buddy system (work in pairs.)
- Drink plenty of cool water (one small cup every 15-20 minutes.)
- Wear light, loose-fitting, breathable (like cotton) clothing.
- Take frequent short breaks in cool, shaded areas (allow your body to cool down.)
- Avoid eating large meals before working in hot environments.
- Avoid caffeine and alcoholic beverages (these beverages make the body lose water and increase the risk of heat illnesses.)

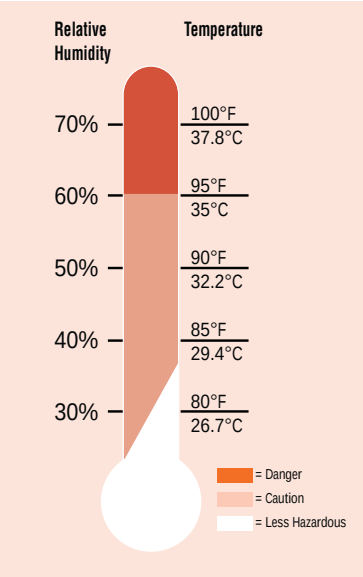
Workers are at increased risk when…

- They take certain medications. Check with your doctor, nurse, or pharmacy to see if medicines you take affect you when working in hot environments.
- They have had a heat-induced illness in the past.
- They wear personal protective equipment.

THE HEAT EQUATION

HIGH TEMPERATURE + HIGH HUMIDITY + PHYSICAL WORK = HEAT ILLNESS

When the body is unable to cool itself through sweating, **serious** heat illnesses may occur. The most severe heat-induced illnesses are **heat exhaustion** and **heat stroke**. If actions are not taken to treat heat exhaustion, the illness could progress to heat stroke and **death**.



Oregon Occupational Safety & Health Division
440-3333E-S(9/03)

ATTACHMENT 4

MATERIAL SAFETY DATA SHEETS

ALCONOX MSDS

Section 1 : MANUFACTURER INFORMATION

Product name: Alconox

Supplier: Same as manufacturer.

Manufacturer: Alconox, Inc.
30 Glenn St.
Suite 309
White Plains, NY 10603.

Manufacturer emergency phone number: 800-255-3924.
813-248-0585 (outside of the United States).

Manufacturer: Alconox, Inc.
30 Glenn St.
Suite 309
White Plains, NY 10603.

Supplier MSDS date: 2005/03/09

D.O.T. Classification: Not regulated.

Section 2 : HAZARDOUS INGREDIENTS

C.A.S.	CONCENTRATION %	Ingredient Name	T.L.V.	LD/50	LC/50
25155-30-0	10-30	SODIUM DODECYLBENZENESULFONATE	NOT AVAILABLE	438 MG/KG RAT ORAL 1330 MG/KG MOUSE ORAL	NOT AVAILABLE
497-19-8	7-13	SODIUM CARBONATE	NOT AVAILABLE	4090 MG/KG RAT ORAL 6600 MG/KG MOUSE ORAL	2300 MG/M3/2H RAT INHALATION 1200 MG/M3/2H MOUSE INHALATION
7722-88-5	10-30	TETRASODIUM PYROPHOSPHATE	5 MG/M3	4000 MG/KG RAT ORAL 2980 MG/KG MOUSE ORAL	NOT AVAILABLE
7758-29-4	10-30	SODIUM PHOSPHATE	NOT AVAILABLE	3120 MG/KG RAT ORAL 3100 MG/KG MOUSE ORAL >4640 MG/KG RABBIT DERMAL	NOT AVAILABLE

Section 2A : ADDITIONAL INGREDIENT INFORMATION

Note: (supplier).
CAS# 497-19-8: LD50 4020 mg/kg - rat oral.
CAS# 7758-29-4: LD50 3100 mg/kg - rat oral.

Section 3 : PHYSICAL / CHEMICAL CHARACTERISTICS

Physical state: Solid

Appearance & odor: Almost odourless.
White granular powder.

Odor threshold (ppm): Not available.

Vapour pressure (mmHg): Not applicable.

Vapour density (air=1): Not applicable.

By weight: Not available.

Evaporation rate (butyl acetate = 1): Not applicable.

Boiling point (°C): Not applicable.

Freezing point (°C): Not applicable.

pH: (1% aqueous solution).
9.5

Specific gravity @ 20 °C: (water = 1).
0.85 - 1.10

Solubility in water (%): 100 - > 10% w/w

Coefficient of water\oil dist.: Not available.

VOC: None

Section 4 : FIRE AND EXPLOSION HAZARD DATA

Flammability: Not flammable.

Conditions of flammability: Surrounding fire.

Extinguishing media: Carbon dioxide, dry chemical, foam.
Water
Water fog.

Special procedures: Self-contained breathing apparatus required.
Firefighters should wear the usual protective gear.

Auto-ignition temperature: Not available.

Flash point (°C), method: None

Lower flammability limit (% vol): Not applicable.

Upper flammability limit (% vol): Not applicable.

Not available.

Sensitivity to mechanical impact: Not applicable.

Hazardous combustion products: Oxides of carbon (COx).
Hydrocarbons.

Rate of burning: Not available.

Explosive power: None

Section 5 : REACTIVITY DATA

Chemical stability: Stable under normal conditions.

Conditions of instability: None known.

Hazardous polymerization: Will not occur.

Incompatible substances: Strong acids.
Strong oxidizers.

Hazardous decomposition products: See hazardous combustion products.

Section 6 : HEALTH HAZARD DATA

Route of entry: Skin contact, eye contact, inhalation and ingestion.

Effects of Acute Exposure

Eye contact: May cause irritation.

Skin contact: Prolonged contact may cause irritation.

Inhalation: Airborne particles may cause irritation.

Ingestion: May cause vomiting and diarrhea.
May cause abdominal pain.
May cause gastric distress.

Effects of chronic exposure: Contains an ingredient which may be corrosive.

LD50 of product, species & route: > 5000 mg/kg rat oral.

LC50 of product, species & route: Not available for mixture, see the ingredients section.

Exposure limit of material: Not available for mixture, see the ingredients section.

Sensitization to product: Not available.

Carcinogenic effects: Not listed as a carcinogen.

Reproductive effects: Not available.

Teratogenicity: Not available.

Mutagenicity: Not available.

Synergistic materials: Not available.

Medical conditions aggravated by exposure: Not available.

First Aid

Skin contact: Remove contaminated clothing.
Wash thoroughly with soap and water.
Seek medical attention if irritation persists.

Eye contact: Check for and remove contact lenses.
Flush eyes with clear, running water for 15 minutes while holding eyelids open: if irritation persists, consult a physician.

Inhalation: Remove victim to fresh air.
Seek medical attention if symptoms persist.

Ingestion: Dilute with two glasses of water.
Never give anything by mouth to an unconscious person.
Do not induce vomiting, seek immediate medical attention.

Section 7 : PRECAUTIONS FOR SAFE HANDLING AND USE

Leak/Spill: Contain the spill.
Recover uncontaminated material for re-use.
Wear appropriate protective equipment.
Contaminated material should be swept or shoveled into appropriate waste container for disposal.

Waste disposal: In accordance with municipal, provincial and federal regulations.

Handling procedures and equipment: Protect against physical damage.
Avoid breathing dust.
Wash thoroughly after handling.
Keep out of reach of children.
Avoid contact with skin, eyes and clothing.
Launder contaminated clothing prior to reuse.

Storage requirements: Keep containers closed when not in use.
Store away from strong acids or oxidizers.
Store in a cool, dry and well ventilated area.

Section 8 : CONTROL MEASURES

Precautionary Measures

Gloves/Type:

Neoprene or rubber gloves.

Respiratory/Type:

If exposure limit is exceeded, wear a NIOSH approved respirator.

Eye/Type:

Safety glasses with side-shields.

Footwear/Type: Safety shoes per local regulations.

Clothing/Type: As required to prevent skin contact.

Other/Type: Eye wash facility should be in close proximity.
Emergency shower should be in close proximity.

Ventilation requirements: Local exhaust at points of emission.

SCIENTIFIC GAS PRODUCTS INC/SCOTT SPECIALITY GASES -- HYDROGEN -- 6830-00-965-2492

========== Product Identification ==========

Product ID:HYDROGEN
MSDS Date:10/16/1996
FSC:6830
NIIN:00-965-2492
MSDS Number: CDGHC
=== Responsible Party ===
Company Name:SCIENTIFIC GAS PRODUCTS INC/SCOTT SPECIALITY GASES
Address:2330 HAMILTON BLVD
City:SOUTH PLAINFIELD
State:NJ
ZIP:07080
Country:US
Info Phone Num:908-754-7700
Emergency Phone Num:908-754-7700
CAGE:54262
=== Contractor Identification ===
Company Name:SCOTT SPECIALTY GASES
Address:2330 HAMILTON BLVD
Box:City:SOUTH PLAINFIELD
State:NJ
ZIP:07080
Country:US
Phone:908-754-7700
CAGE:54262

========== Composition/Information on Ingredients ==========

Ingred Name:HYDROGEN
CAS:1333-74-0
RTECS #:MW8900000
Fraction by Wt: >99%
Other REC Limits:NONE RECOMMENDED

========== Hazards Identification ==========

LD50 LC50 Mixture:LD50 (ORAL RAT) IS NOT RELEVANT.
Routes of Entry: Inhalation:YES Skin:NO Ingestion:NO
Reports of Carcinogenicity:NTP:NO IARC:NO OSHA:NO
Health Hazards Acute and Chronic:TARGET ORGANS:LUNGS AND CNS. ACUTE- HYDROGEN IS DEFINED AS A SIMPLE ASPHYXIANT. INHALATION OF HIGH CONCENTRATIONS OF HYDROGEN MAY CAUSE DIZZINESS, HEADACHE, DEEPER BREATHING DUE TO AIR HUNGER, POSSIBL E NAUSEA AND EVENTUAL UNCONSCIOUSNESS. EYES/SKIN/ORAL:NOT LIKELY TO OCCUR. CHRONIC- NONE.
Explanation of Carcinogenicity:NONE
Effects of Overexposure:HYDROGEN IS INACTIVE BIOLOGICALLY AND ESSENTIALLY NONTOXIC. IF THE EXCLUSION OF AN ADEQUATE SUPPLY OF OXYGEN TO THE LUNGS OCCUR: HEADACHE, DIZZINESS, DROWSINESS, NAUSEA, VOMITING, EXCITATION, EXCESS S ALIVATION, UNCONSCIOUSNESS
Medical Cond Aggravated by Exposure:NONE

========== First Aid Measures ==========

First Aid:PROMPT MEDICAL ATTENTION IS MANDATORY IN ALL CASES OF OVEREXPOSURE TO HYDROGEN. RESCUE PERSONNEL SHOULD BE EQUIPPED WITH

SCBA. CONSCIOUS PERSONS SHOULD BE REMOVED TO AN UNCONTAMINATED AREA AND INHALE FRESH AIR. QUICK REMOVAL FROM CONTAMINATED AREA IS MOST IMPORTANT. UNCONSCIOUS PERSONS SHOULD BE MOVED TO AN UNCONTAMINATED AREA, GIVEN MOUTH-TO-MOUTH RESUSCITATION & SUPPLEMENTAL OXYGEN.

Fire Fighting Measures

Flash Point:FLAMMABLE GAS
Autoignition Temp:Autoignition Temp Text:752F
Lower Limits:4%
Upper Limits:75%
Extinguishing Media:HALOGENATED GAS, CARBON DIOXIDE, DRY CHEMICAL. WATER SPRAY MAY BE USED TO KEEP FIRE EXPOSED CONTAINERS COOL.
Fire Fighting Procedures:ONLY SAFE WAY TO EXTINGUISH FIRE IS TO STOP FLOW OF GAS. IF FLOW CANNOT BE STOPPED, LET FIRE BURN ITSELF OUT WHILE COOLING CONTAINERS WITH WATER. STAY UPWIND.
Unusual Fire/Explosion Hazard:EXTREMELY FLAMMABLE AND EXPLOSIVE. HYDROGEN BURNS WITH AN ALMOST INVISIBLE FLAME. HYDROGEN IS VERY LIGHT AND RISES VERY RAPIDLY IN AIR. INCREASE VENTILATION.

Accidental Release Measures

Spill Release Procedures:WEAR PROTECTIVE EQUIPMENTS. VENTILATE AREA. REMOVE ALL SOURCES OF IGNITION. STOP LEAK AND REMOVE LEAKING CONTAINERS TO A SAFE OUTDOOR AREA OR TO EXHAUST HOOD IF YOU CAN DO WITHOUT RISK. ALLOW GAS TO D ISSIPATE.
Neutralizing Agent:NOT RELEVANT

Handling and Storage

Handling and Storage Precautions:STORE CYLINDERS SECURED, IN UPRIGHT POSITION. STORE AWAY FROM FLAMES, OXYGEN & OTHER OXIDIZERS. DO NOT STORE ABOVE 130F. PROTECT CYLINDERS FROM DAMAGE
Other Precautions:EXTREMELY FLAMMABLE. STORE AND USE WITH ADEQUATE VENTILATION. CLOSE VALVE WHEN NOT IN USE. NEVER WORK ON A PRESSURIZED SYSTEM. GAS CAN CAUSE RAPID SUFFOCATION. KEEP OUT OF REACH OF CHILDREN. POST NO S MOKING OR OPEN FLAMES SIGNS.

Exposure Controls/Personal Protection

Respiratory Protection:IF AIRBORNE CONCENTRATIONS ARE HIGH, A NIOSH-APPROVED POSITIVE PRESSURE AIR SUPPLIED RESPIRATOR OR SELF-CONTAINED BREATHING APPARATUS MUST BE WORN.
Ventilation:MECHANICAL (GENERAL AND/OR LOCAL EXHAUST, EXPLOSION-PROOF) VENTILATION TO MAINTAIN EXPOSURE BELOW TLV.
Protective Gloves:PLASTIC OR RUBBER RECOMMENDED
Eye Protection:SAFETY GLASSES OR GOGGLES RECOMMENDED
Other Protective Equipment:SAFETY SHOWER AND EYE WASH FOUNTAIN SHOULD BE LOCATED NEARBY. WEAR APPROPRIATE PROTECTIVE CLOTHING FOR RISK OF EXPOSURE.
Work Hygienic Practices:OBSERVE GOOD PERSONAL HYGIENE PRACTICES AND RECOMMENDED PROCEDURES.
Supplemental Safety and Health

Physical/Chemical Properties

HCC:G2
NRC/State Lic Num:NOT RELEVENT
Boiling Pt:B.P. Text:-422F,-252C
Melt/Freeze Pt:M.P/F.P Text:-435F,-259C

Vapor Pres:GAS
Vapor Density:0.07
Spec Gravity:GAS
Viscosity:NOT RELEVANT
Evaporation Rate & Reference:GAS
Solubility in Water:1.82% @ 20C/68F
Appearance and Odor:COLORLESS, ODORLESS GAS
Percent Volatiles by Volume:100

Stability and Reactivity Data

Stability Indicator/Materials to Avoid:YES
OXIDIZING AGENTS, SOME METALS, ALKALINE MATERIALS, HALOGENS
Stability Condition to Avoid:STORAGE IN POORLY VENTILATED AREA OR HEAT SOURCE
Hazardous Decomposition Products:NONE

Disposal Considerations

Waste Disposal Methods:ALLOW GAS TO DISCHARGE AT MODERATE RATE, IF ALLOWED. RETURN IN THE SHIPPING CONTAINER PROPERLY LABELED, WITH ANY VALVE OUTLET PLUGS OR CAPS SECURED AND VALVE PROTECTION CAP IN PLACE TO SUPPLIER.

Disclaimer (provided with this information by the compiling agencies): This information is formulated for use by elements of the Department of Defense. The United States of America in no manner whatsoever, expressly or implied, warrants this information to be accurate and disclaims all liability for its use. Any person utilizing this document should seek competent professional advice to verify and assume responsibility for the suitability of this information to their particular situation.

ALDRICH CHEMICAL CO INC. -- LIQUI-NOX PHOSPHATE-FREE DETERGENT, 24302-7 -- 6810-00N016648

========== Product Identification ==========

Product ID:LIQUI-NOX PHOSPHATE-FREE DETERGENT, 24302-7
MSDS Date:01/09/1990
FSC:6810
NIIN:00N016648
MSDS Number: BQTFQ
=== Responsible Party ===
Company Name:ALDRICH CHEMICAL CO INC.
Address:1001 W. ST. PAUL AVE
Box:355
City:MILWAUKEE
State:WI
ZIP:53201
Country:US
Info Phone Num:414-273-3850/FAX -4979
Emergency Phone Num:414-273-3850
CAGE:60928
=== Contractor Identification ===
Company Name:ALDRICH CHEMICAL CO INC
Address:1001 WEST ST PAUL AVE
Box:355
City:MILWAUKEE
State:WI
ZIP:53233
Country:US
Phone:414-273-3850
CAGE:60928

========== Composition/Information on Ingredients ==========

Ingred Name:LIQUI-NOX, PHOSPHATE-FREE DETERGENT

========== Hazards Identification ==========

LD50 LC50 Mixture:NONE SPECIFIED BY MANUFACTURER.
Routes of Entry: Inhalation:YES Skin:YES Ingestion:YES
Reports of Carcinogenicity:NTP:NO IARC:NO OSHA:NO
Health Hazards Acute and Chronic:ACUTE: MAY BE HARMFUL BY INHALATION, INGESTION, OR SKIN ABSORPTION. MAY CAUSE EYE IRRITATION. MAY CAUSE SKIN IRRITATION. TO THE BEST OF OUR KNOWLEDGE, THE CHEMICAL, PHYSICAL, AND TOXICOLOGICAL PROPERT IES HAVE NOT BEEN THOROUGHLY INVESTIGATED.
Explanation of Carcinogenicity:NOT RELEVANT
Effects of Overexposure:SEE HEALTH HAZARDS.
Medical Cond Aggravated by Exposure:NONE SPECIFIED BY MANUFACTURER.

========== First Aid Measures ==========

First Aid:EYE: IMMEDIATELY FLUSH EYES WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MIN. SKIN: IMMEDIATELY WASH SKIN WITH SOAP AND COPIOUS AMOUNTS OF WATER. INHAL: REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ART F RESP. IF BREATHING IS DIFFICULT, GIVEOXYGEN. CALL A PHYSICIAN. WASH CONTAMINATED CLOTHING BEFORE REUSE. INGEST: GET MD IMMEDIATELY .

Fire Fighting Measures

Extinguishing Media:WATER SPRAY, CARBON DIOXIDE, DRY CHEMICAL POWDER, ALCOHOL OR POLYMER FOAM.
Fire Fighting Procedures:WEAR NIOSH/MSHA APPROVED SCBA AND FULL PROTECTIVE EQUIPMENT TO PREVENT CONTACT WITH SKIN AND EYES.
Unusual Fire/Explosion Hazard:NONE SPECIFIED BY MANUFACTURER.

Accidental Release Measures

Spill Release Procedures:WEAR NIOSH/MSHA APPROVED RESP, CHEMICAL SAFETY GOGGLES, RUBBER BOOTS AND HEAVY RUBBER GLOVES. ABSORB ON SAND OR VERMICULITE AND PLACE IN CLOSED CONTAINERS FOR DISPOSAL. VENTILATE AREA AND WASH SPILL S ITE AFTER MATERIAL PICKUP IS COMPLETE.
Neutralizing Agent:NONE SPECIFIED BY MANUFACTURER.

Handling and Storage

Handling and Storage Precautions:KEEP TIGHTLY CLOSED. STORE IN A COOL DRY PLACE. AVOID INHALATION. AVOID CONTACT WITH EYES, SKIN AND CLOTHING. AVOID PROLONGED OR REPEATED EXPOSURE.
Other Precautions:NONE SPECIFIED BY MANUFACTURER.

Exposure Controls/Personal Protection

Respiratory Protection:NIOSH/MSHA APPROVED RESPIRATOR.
Ventilation:MECHANICAL EXHAUST REQUIRED.
Protective Gloves:COMPATIBLE CHEMICAL-RESISTANT GLOVES.
Eye Protection:CHEMICAL SAFETY GOGGLES.
Other Protective Equipment:SAFETY SHOWER AND EYE BATH.
Work Hygienic Practices:WASH THOROUGHLY AFTER HANDLING.
Supplemental Safety and Health
WASTE DISP: AND NEUTRALIZATION REACTIONS MAY GENRATE HEAT & FUMES WHICH CAN BE CONTROLLED BY THE RATE OF ADDITION. OBSERVE ALL FEDERAL, STATE AND LOCAL LAWS.

Physical/Chemical Properties

HCC:N1
Spec Gravity:1.051
Appearance and Odor:NONE SPECIFIED BY MANUFACTURER.

Stability and Reactivity Data

Stability Indicator/Materials to Avoid:YES
STRONG OXIDIZING AGENTS.
Stability Condition to Avoid:NONE SPECIFIED BY MANUFACTURER.
Hazardous Decomposition Products:NATURE OF DECOMPOSITION PRODUCTS NOT KNOWN.

Disposal Considerations

Waste Disposal Methods:SML QTYS: CAUTIOUSLY ADD TO A LRG STIRRED EXCESS OF WATER. ADJUST THE PH TO NEUTRAL, SEPARATE ANY INSOLUBLE SOLIDS OR LIQUIDS & PACKAGE THEM FOR HAZARDOUS-WASTE DISP. FLUSH THE AQUEOUS SOLN DOWN THE D RAIN W/PLENTY OF WATER. THE HYDROLYSIS (SUPP DATA)

Disclaimer (provided with this information by the compiling agencies):
This information is formulated for use by elements of the Department

of Defense. The United States of America in no manner whatsoever, expressly or implied, warrants this information to be accurate and disclaims all liability for its use. Any person utilizing this document should seek competent professional advice to verify and assume responsibility for the suitability of this information to their particular situation.

BACHARACH INC -- CALIBRATION GAS, METHANE 500 PPM IN AIR, 51-1816 -- 6630-00N048469

========== Product Identification ==========

Product ID:CALIBRATION GAS, METHANE 500 PPM IN AIR, 51-1816
MSDS Date:12/13/1990
FSC:6630
NIIN:00N048469
MSDS Number: BTYRS
=== Responsible Party ===
Company Name:BACHARACH INC
Address:625 ALPHA DR
City:PITTSBURGH
State:PA
ZIP:15238
Country:US
Info Phone Num:412-963-2223
Emergency Phone Num:800-424-9300(CHEMTREC)
CAGE:05083
=== Contractor Identification ===
Company Name:BACHARACH INC
Address:625 ALPHA DRIVE
Box:City:PITTSBURGH
State:PA
ZIP:15238
Country:US
Phone:412-963-2130
CAGE:05083

========== Composition/Information on Ingredients ==========

Ingred Name:METHANE. BP:-260F,-162C. MP:-296F,-182C. FL PT:-306F,-188C.
CAS:74-82-8
RTECS #:PA1490000
Fraction by Wt: 0.05%
OSHA PEL:N/K
ACGIH TLV:ASPHYXIANT

Ingred Name:AIR, REFRIGERATED LIQUID; (AIR)
RTECS #:AX5271000
Fraction by Wt: 99.95%
OSHA PEL:N/K
ACGIH TLV:N/K

========== Hazards Identification ==========

LD50 LC50 Mixture:NONE SPECIFIED BY MANUFACTURER.
Routes of Entry: Inhalation:NO Skin:NO Ingestion:NO
Reports of Carcinogenicity:NTP:NO IARC:NO OSHA:NO
Health Hazards Acute and Chronic:ACUTE:EYE/SKIN:NONE KNOWN OR EXPECTED.
INHAL:NONE. METHANE IS NON-TOXIC SIMPLE ASPHYXIANT. CONCENTRATION OF METHANE IN THIS GAS IS TOO LOW TO DEPRESS OXYGEN CONCENTRATION. INGEST:NOT APPLICABLE. THIS MATERIAL IS A GAS. METHANE IS BIOLOGICALLY INACTIVE & ESSENTIALLY NON TOXIC. CHRONIC:NONE KNOWN OR EXPECTED.
Explanation of Carcinogenicity:NOT RELEVANT
Effects of Overexposure:NONE SPECIFIED BY MANUFACTURER.
Medical Cond Aggravated by Exposure:NONE SPECIFIED BY MANUFACTURER.

First Aid Measures

First Aid:INGEST:CALL MD IMMEDIATELY . INHAL:REMOVE TO FRESH AIR. SUPPORT BREATHING (GIVE O*2/ARTF RESP) . EYES:IMMEDIATELY FLUSH W/POTABLE WATER FOR A MINIMUM OF 15 MINUTES, SEEK ASSISTANCE FROM MD . SKIN:FLUSH W/COPIOUS AMOUNTS OF WATER. CALL MD . NONE NEEDED (MFR).

Fire Fighting Measures

Flash Point Method:CC
Flash Point:SEE ING 1
Lower Limits:5%
Upper Limits:15%
Extinguishing Media:MEDIA SUITABLE FOR SURROUNDING FIRE . THIS GAS IS NOT FLAMMABLE. COOL EXPOSED CONTAINERS W/WATER.
Fire Fighting Procedures:USE NIOSH/MSHA APPROVED SCBA & FULL PROTECTIVE EQUIPMENT . USE SHIELDING TO PROTECT FROM CYLINDER EXPLOSION.
Unusual Fire/Explosion Hazard:THIS MIXT IS BELOW LEL OF METHANE & NON-FLAMM. COMPRESSED AIR/METHANE MIXTS AT HIGH PRESS WILL ACCELERATE BURNING OF OTHER MATLS. GAS CYLS EXPOS TO HEAT(SUPDAT)

Accidental Release Measures

Spill Release Procedures:NONE NEEDED. THIS MATERIAL IS NON TOXIC & NON-FLAMMABLE.
Neutralizing Agent:NONE SPECIFIED BY MANUFACTURER.

Handling and Storage

Handling and Storage Precautions:DO NOT STORE CYLS NEAR HEAT/OPEN FLAME. EXPOS TO TEMPS >130F MAY CAUSE RUPTURE. SECURE CYLS - DO NOT DROP. CONTENTS UNDER PRESS.
Other Precautions:DO NOT PUNCTURE. NEVER THROW CNTNR INTO FIRE/INCIN. KEEP CYLS SECURED. DO NOT DROP/DMG. USE PRESS REGULATOR WHEN CONNECTING TO LOWER PRESS PIPING SYS. USE CHECK VALVE TO PVNT BACKFLOW. KEEP CYLS AWAY FROM HEAT & FLAMES. FOR ADDNL (SUPDAT)

Exposure Controls/Personal Protection

Respiratory Protection:NONE NEEDED. SELECTION OF NIOSH/MSHA APPROVED RESPIRATORY PROTECTION DEPENDS ON CONTAMINANT TYPE, FORM & CONCENTRATION. SELECT I/A/W OSHA 1910.134 & GOOD INDUSTRIAL HYGIENE PRACTICE.
Ventilation:NO SPECIAL VENTILATION REQUIRED.
Protective Gloves:LEATHER GLOVES.
Eye Protection:SAFETY GLASSES.
Other Protective Equipment:NONE NEEDED.
Work Hygienic Practices:NONE SPECIFIED BY MANUFACTURER.
Supplemental Safety and Health
EXPLO HAZ:OR FLAME MAY VENT RAPIDLY/EXPLODE. OTHER PREC:HNDLG RECS ON COMPRESSED GAS CYLS, CONSULT COMPRESSED GAS ASSOC PAMPHLET P-1. PROTECT FROM HEAT & PHYSICAL DMG.

Physical/Chemical Properties

Boiling Pt:B.P. Text:SEE ING 1
Melt/Freeze Pt:M.P/F.P Text:SEE ING 1
Vapor Pres:(GAS)

Vapor Density:0.991
Spec Gravity:0.673
Solubility in Water:NEGLIGIBLE
Appearance and Odor:COLORLESS, ODORLESS, TASTELESS COMPRESSED GAS IN CYLINDERS.
Percent Volatiles by Volume:100

Stability and Reactivity Data

Stability Indicator/Materials to Avoid:YES
NONE KNOWN.
Stability Condition to Avoid:AVOID HEAT OR FLAMES.
Hazardous Decomposition Products:NONE KNOWN.

Disposal Considerations

Waste Disposal Methods:DISPOSE I/A/W ALL LOCAL, STATE & FEDERAL REGULATIONS. DO NOT INCINERATE CYLINDER.

Disclaimer (provided with this information by the compiling agencies): This information is formulated for use by elements of the Department of Defense. The United States of America in no manner whatsoever, expressly or implied, warrants this information to be accurate and disclaims all liability for its use. Any person utilizing this document should seek competent professional advice to verify and assume responsibility for the suitability of this information to their particular situation.

LIQUID AIR CORP -- ISOBUTYLENE IN AIR,0.01 %,DC 102573,101-350-N

==========

MSDS Safety Information

==========

FSC: 6665
NIIN: 01-214-8247
MSDS Date: 01/01/1992
MSDS Num: CFKHB
Product ID: ISOBUTYLENE IN AIR,0.01 %,DC 102573,101-350-N
MFN: 01
Responsible Party
Cage: 18197
Name: LIQUID AIR CORP
Address: 2700 POST OAK BLVD 18TH FLOOR
City: HOUSTON TX 77056
Info Phone Number: 713-624-8000
Emergency Phone Number: 800-231-1366/800-424-9300(CHEMTREC)
Preparer's Name: UNKNOWN
Review Ind: Y
Published: Y

==========

Contractor Summary

==========

Cage: 24274
Name: AIR LIQUID AMERICA CORP
Address: 2700 POST OAK DR
City: HOUSTON TX 77056-8229
Phone: 716-868-0440
Cage: 57631
Name: HNU SYSTEMS INC
Address: 160 CHARLEMONT ST
City: NEWTON HIGHLANDS MA 02161
Phone: 617/964-6690
Cage: 18197
Name: LIQUID AIR CORP
Address: 2121 N CALIFORNIA BLVD, STE 296
City: WALNUT CREEK CA 94596
Phone: 415-977-6500

==========

Item Description Information

==========

Item Manager: S9G
Item Name: CALIBRATION GAS CYL
Specification Number: NONE
Type/Grade/Class: NONE
Unit of Issue: EA
UI Container Qty: 1
Type of Container: CYLINDER

==========

Ingredients

==========

RTECS #: AX5275000
Name: AIR
% Wt: 100
Other REC Limits: NONE RECOMMENDED
OSHA PEL: NOT ESTABLISHED
ACGIH TLV: NOT ESTABLISHED

Cas: 115-11-7
RTECS #: UD0890000

Name: ISOBUTYLENE (DDRV PROVIDED % FOR ISOBUTYLENE)
% Wt: 0.01
Other REC Limits: NONE RECOMMENDED
OSHA PEL: NOT ESTABLISHED
ACGIH TLV: NOT ESTABLISHED

==========

Health Hazards Data

==========

LD50 LC50 Mixture: NOT RELEVANT
Route Of Entry Inds - Inhalation: YES
Skin: NO
Ingestion: NO
Carcinogenicity Inds - NTP: NO
IARC: NO
OSHA: NO
Effects of Exposure: TARGET ORGANS:NONE. ACUTE AND CHRONIC- NONE. THESE MIXTURES SHOULD BE CONSIDERED SIMILAR TO AIR AND WOULD THEREFORE CAUSE NO SYMPTOMS OF EXPOSURE.
Explanation Of Carcinogenicity: NONE
Signs And Symptions Of Overexposure: NONE
Medical Cond Aggravated By Exposure: NONE.
First Aid: NONE NEEDED.

==========

Handling and Disposal

==========

Spill Release Procedures: NOT RELEVANT
Neutralizing Agent: NOT RELEVANT
Waste Disposal Methods: NOT RELEVANT
Handling And Storage Precautions: STORE CYLINDERS SECURE, IN COOL, DRY, VENTILATED AREA BELOW 125F. PROTECT CYLINDERS FROM PHYSICAL DAMAGE. FULL & EMPTY CYLINDERS SHOULD BE SEGREGATED.
Other Precautions: VENTING OF AIR FROM CYLINDER MUST BE ACCOMPLISHED SLOWLY. USE A "FIRST IN-FIRST OUT" INVENTORY SYSTEM. CLOSE VALVE AFTER EACH USE AND WHEN EMPTY.

==========

Fire and Explosion Hazard Information

==========

Flash Point Text: NONE
Lower Limits: NOT RELEVANT
Upper Limits: NOT RELEVANT
Extinguishing Media: USE WATER FOG, CARBON DIOXIDE, FOAM, OR DRY CHEMICAL FOR SURROUNDING FIRE. KEEP FIRE-EXPOSED CYLINDERS COOL WITH WATER.
Fire Fighting Procedures: AS WITH ANY FIRE, WEAR PROTECTIVE CLOTHING AND NIOSH-APPROVED SELF-CONTAINED BREATHING APPARATUS IF NEEDED.
Unusual Fire/Explosion Hazard: AIR AT HIGH PRESSURES WILL ACCELERATE THE BURNING OF MATERIALS TO A GREATER RATE THAN THEY BURN AT ATMOSPHERIC PRESSURE.

==========

Control Measures

==========

Respiratory Protection: NONE NEEDED.
Ventilation: NONE
Protective Gloves: LEATHER WHEN HANDLING CYLINDERS
Eye Protection: GOGGLES RECOMMENDED
Other Protective Equipment: EAR PROTECTION WHEN VENTING AIR
Work Hygienic Practices: OBSERVE GOOD INDUSTRIAL HYGIENE PRACTICES AND RECOMMENDED PROCEDURES.

==========

Physical/Chemical Properties

==========

HCC: G3
NRC/State LIC No: NOT RELEVANT
B.P. Text: -318F (AIR)
Vapor Pres: UNKNOWN
Vapor Density: 1
Spec Gravity: NOT RELEVANT
Viscosity: NOT RELEVANT
Evaporation Rate & Reference: NOT RELEVANT (GAS)
Solubility in Water: SLIGHTLY
Appearance and Odor: COLORLESS, ODORLESS GAS
Percent Volatiles by Volume: 100
==========
Reactivity Data
==========
Stability Indicator: YES
Stability Condition To Avoid: HEATING CYLINDER
Materials To Avoid: NONE
Hazardous Decomposition Products: NONE
Hazardous Polymerization Indicator: NO
Conditions To Avoid Polymerization: NOT RELEVANT
==========
Toxicological Information
==========
==========
Ecological Information
==========
==========
MSDS Transport Information
==========
==========
Regulatory Information
==========
==========
Other Information
==========
==========
Transportation Information
==========
Responsible Party Cage: 18197
Trans ID NO: 115758
Product ID: ISOBUTYLENE IN AIR,0.01 %,DC 102573,101-350-N
MSDS Prepared Date: 01/01/1992
Review Date: 07/13/1998
MFN: 1
Tech Entry NOS Shipping Nm: 0.01% ISOBUTYLENE IN AIR.
Radioactivity: NOT RELEVANT
Net Unit Weight: 0.6 LB
Multiple KIT Number: 0
Review IND: Y
Unit Of Issue: EA
Container QTY: 1
Type Of Container: CYLINDER
==========
Detail DOT Information
==========
DOT PSN Code: DQQ
Symbols: G
DOT Proper Shipping Name: COMPRESSED GASES, N.O.S.
Hazard Class: 2.2
UN ID Num: UN1956

Label: NONFLAMMABLE GAS
Special Provision: B13
Non Bulk Pack: 302,305
Bulk Pack: 314,315
Max Qty Pass: 75 KG
Max Qty Cargo: 150 KG
Vessel Stow Req: A
==========
Detail IMO Information
==========
IMO PSN Code: EQH
IMO Proper Shipping Name: COMPRESSED GAS, N.O.S. o
IMDG Page Number: 2124
UN Number: 1956
UN Hazard Class: 2(2.2)
IMO Packaging Group: -
Subsidiary Risk Label: -
EMS Number: 2-04
MED First Aid Guide NUM: 620
==========
Detail IATA Information
==========
IATA PSN Code: HDO
IATA UN ID Num: 1956
IATA Proper Shipping Name: COMPRESSED GAS, N.O.S. *
IATA UN Class: 2.2
IATA Label: NON-FLAMMABLE GAS
Packing Note Passenger: 200
Max Quant Pass: 75KG
Max Quant Cargo: 150KG
Packaging Note Cargo: 200
==========
Detail AFI Information
==========
AFI PSN Code: HDO
AFI Symbols: *
AFI Proper Shipping Name: COMPRESSED GAS, N.O.S.
AFI Hazard Class: 2.2
AFI UN ID NUM: UN1956
Special Provisions: P5
Back Pack Reference: A6.3, A6.5,A6.6
==========
HAZCOM Label
==========
Product ID: ISOBUTYLENE IN AIR,0.01 %,DC 102573,101-350-N
Cage: 18197
Company Name: LIQUID AIR CORP
Street: 2121 N CALIFORNIA BLVD, STE 296
City: WALNUT CREEK CA
Zipcode: 94596
Health Emergency Phone: 800-231-1366/800-424-9300(CHEMTREC)
Date Of Label Review: 09/19/1997
Status Code: C
Label Date: 09/19/1997
==========
Disclaimer (provided with this information by the compiling agencies): This information is formulated for use by elements of the Department of Defense. The United States of America in no manner whatsoever expressly or implied warrants, states, or intends said information to have any application, use or viability by or to any person or persons outside the Department of Defense

nor any person or persons contracting with any instrumentality of the United States of America and disclaims all liability for such use. Any person utilizing this instruction who is not a military or civilian employee of the United States of America should seek competent professional advice to verify and assume responsibility for the suitability of this information to their particular situation regardless of similarity to a corresponding Department of Defense or other government situation.

APPENDIX I

WINTR-55 MODELING REPORTS

Integral Consulting Inc.
285 Century Place
Suite 190
Louisville, CO 80027

telephone: 303.404.2944
facsimile: 303.404.2945
www.integral-corp.com

MEMORANDUM

To:	Project File
From:	Michael J. Martin
Date:	September 30, 2011
Subject:	Arkema Stormwater Source Control Measures – Hydrological Modeling
Project No.:	C250

A hydrologic analysis was conducted to evaluate site stormwater runoff that must be captured and treated to satisfy the stormwater source control measures (SCMs) design criteria. The Natural Resources Conservation Service (NRCS) Technical Release 55 (TR-55) within the Win TR-55 software package was used to develop runoff hydrographs for a range of storm events. Two separate hydrographs were developed: 1) one for the inlet to the detention basin, which provides the flow to the HydroCAD modeling (Appendix J); and, 2) one for direct precipitation onto the sand filter. Section 6.3 of the Final Design Report discusses the modeling methodology, including both a discussion of the drainage analysis (Section 6.3.1) and the runoff calculations (Section 6.3.2). Results of the modeling for the detention basin inlet are summarized in Table 6-3 and Figure 6-3 in the Final Design Report. Detailed information on modeling runs, including model inputs, are provided with this memorandum as Attachment A for the outlet (i.e., the detention basin inlet) and Attachment B for precipitation directly on the sand filter.

Table 6-1 of the Final Design Report provides a summary of the subcatchment input parameters for the TR-55 model. Tables 1 and 2, attached to this memorandum, provide additional input parameters for determination of the time of concentration. Table 1 provides detailed information on the flow path as determined from the ArcHydro program (see the Final Design Report, Section 6.3.1). For flow within the channel in a specific subcatchment, the average velocity within each channel for the 2-yr, 5-yr, 10-yr, 25-yr, and 100-yr storms was used (Table 2). Reach input data is provided as attached Table 3.

TABLES

Table 1. Time of Concentration Inputs

Basins	Length	Type	Surface	Slope (ft/ft)	Velocity (ft per sec)
Basin 1	100	1st 100 ft	Impervious, Gravel	0.017184792	
Basin 1	325	Past 1st 100 ft 2 Channel	Impervious, Gravel	0.005496048	
Basin 1	125	Longest Path Channel			1.15
Routes to Reach 1					
Basin 2	100	1st 100 ft	Impervious, Paved	0.00500103	
Basin 2	685	Past 1st 100 ft 2 Channel	Impervious, Paved	0.002188085	
Basin 2	195	Past 1st 100 ft 2 Channel	Pervious, Graded	0.00655062	
Basin 2	129	Longest Path Channel			1.15
Routes to Reach 2					
Basin 3	100	1st 100 ft	Impervious, Paved	0.006265182	
Basin 3	783	Past 1st 100 ft 2 Channel	Impervious, Paved	0.003150234	
Basin 3	174	Longest Path Channel			1.47
Routes to Reach 3					
Basin 4	607	Longest Path Channel			
Routes to Reach 6					
Basin 5	100	1st 100 ft	Impervious, Paved	0.000263367	
Basin 5	253	Past 1st 100 ft 2 Channel	Pervious, Graded	0.011843323	
Basin 5	480	Longest Path Channel			1.66
Routes to Reach 4					
Basin 6	100	1st 100 ft	Impervious, Paved	0.005063934	
Basin 6	435	Past 1st 100 ft 2 Channel	Pervious, Graded	0.007703385	
Basin 6	134	Longest Path Channel			1.07
Routes to Reach 5					
Basin 7	100	1st 100 ft	Pervious, Brush	0.015851822	
Basin 7	510	Past 1st 100 ft 2 Channel	Pervious, Brush	0.00973794	
Basin 7	205	Past 1st 100 ft 2 Channel	Pervious, Graded	0.007103892	
Basin 7	478	Longest Path Channel			1.07
Routes to Reach 6					
Basin 8	100	1st 100 ft	Pervious, Brush	0.013459892	
Basin 8	303	Past 1st 100 ft 2 Basin	Pervious, Brush	0.010395449	
Routes to Outlet					
Basin 9		N/A Entire Basin is Sand Filter			
Basin 9					
Basin 9					
Separate hydrograph for specific input to Sand Filter					

Table 2. TR-55 Velocity for Travel in Channel

Velocities - 2 Year Storm

Reach	Modeled Discharge (Q, cfs)	Slope (S_o, ft/ft)	Bottom (b, ft)	Side Slope (Z, H:1V)	Lining Type ($D_{b,\ 50}$, ft)	Estimated Depth (d_i, ft)	Mannings (η)	Area (A, ft^2)	Hydraulic Radius (R, ft)	Calculated Discharge (Q_i)	Is Q_i with 5% of Q?	Velocity (V, ft/s)
Reach 1	2.15	0.001	2	2.5	0.17	0.60	0.025	2.10	0.40	2.15	Yes	1.02
Reach 2	5.54	0.001	2	2.5	0.17	0.96	0.025	4.19	0.59	5.54	Yes	1.32
Reach 3	8.99	0.001	2	2.5	0.17	1.20	0.025	6.00	0.71	8.99	Yes	1.50
Reach 4	1.73	0.001	2	2.5	0.17	0.54	0.025	1.79	0.37	1.73	Yes	0.97
Reach 5	4.04	0.001	2	2.5	0.17	0.82	0.025	3.32	0.52	4.04	Yes	1.22
Reach 6	14.65	0.001	4	2.5	0.17	1.24	0.025	8.83	0.83	14.65	Yes	1.66

Velocities - 5 Year Storm

Reach	Modeled Discharge (Q, cfs)	Slope (S_o, ft/ft)	Bottom (b, ft)	Side Slope (Z, H:1V)	Lining Type ($D_{b,\ 50}$, ft)	Estimated Depth (d_i, ft)	Mannings (η)	Area (A, ft^2)	Hydraulic Radius (R, ft)	Calculated Discharge (Q_i)	Is Q_i with 5% of Q?	Velocity (V, ft/s)
Reach 1	2.74	0.001	2	2.5	0.17	0.68	0.025	2.50	0.44	2.74	Yes	1.10
Reach 2	7.06	0.001	2	2.5	0.17	1.07	0.025	5.02	0.65	7.06	Yes	1.41
Reach 3	11.3	0.001	2	2.5	0.17	1.33	0.025	7.11	0.77	11.30	Yes	1.59
Reach 4	2.16	0.001	2	2.5	0.17	0.60	0.025	2.10	0.40	2.16	Yes	1.03
Reach 5	5.08	0.001	2	2.5	0.17	0.92	0.025	3.93	0.57	5.08	Yes	1.29
Reach 6	18.7	0.001	4	2.5	0.17	1.40	0.025	10.55	0.91	18.70	Yes	1.77

Velocities - 10 Year Storm

Reach	Modeled Discharge (Q, cfs)	Slope (S_o, ft/ft)	Bottom (b, ft)	Side Slope (Z, H:1V)	Lining Type ($D_{b,\ 50}$, ft)	Estimated Depth (d_i, ft)	Mannings (η)	Area (A, ft^2)	Hydraulic Radius (R, ft)	Calculated Discharge (Q_i)	Is Q_i with 5% of Q?	Velocity (V, ft/s)
Reach 1	3.33	0.001	2	2.5	0.17	0.75	0.025	2.88	0.48	3.33	Yes	1.15
Reach 2	8.49	0.001	2	2.5	0.17	1.17	0.025	5.75	0.69	8.49	Yes	1.48
Reach 3	13.59	0.001	2	2.5	0.17	1.45	0.025	8.15	0.83	13.59	Yes	1.67
Reach 4	2.59	0.001	2	2.5	0.17	0.66	0.025	2.40	0.43	2.59	Yes	1.08
Reach 5	6.11	0.001	2	2.5	0.17	1.00	0.025	4.51	0.61	6.11	Yes	1.36
Reach 6	22.78	0.001	4	2.5	0.17	1.55	0.025	12.19	0.99	22.78	Yes	1.87

Table 2. TR-55 Velocity for Travel in Channel

Velocities - 25 Year Storm

Reach	Modeled Discharge (Q, cfs)	Slope (S_o, ft/ft)	Bottom (b, ft)	Side Slope (Z, H:1V)	Lining Type ($D_{b,\ 50}$, ft)	Estimated Depth (d_i, ft)	Mannings (η)	Area (A, ft^2)	Hydraulic Radius (R, ft)	Calculated Discharge (Q_i)	Is Q_i with 5% of Q?	Velocity (V, ft/s)
Reach 1	3.92	0.001	2	2.5	0.17	0.81	0.025	3.25	0.51	3.92	Yes	1.21
Reach 2	9.95	0.001	2	2.5	0.17	1.26	0.025	6.47	0.74	9.95	Yes	1.54
Reach 3	15.88	0.001	2	2.5	0.17	1.56	0.025	9.16	0.88	15.88	Yes	1.73
Reach 4	3.01	0.001	2	2.5	0.17	0.71	0.025	2.68	0.46	3.01	Yes	1.12
Reach 5	7.13	0.001	2	2.5	0.17	1.08	0.025	5.05	0.65	7.13	Yes	1.41
Reach 6	26.86	0.001	4	2.5	0.17	1.68	0.025	13.75	1.05	26.86	Yes	1.95

Velocities - 100 Year Storm

Reach	Modeled Discharge (Q, cfs)	Slope (S_o, ft/ft)	Bottom (b, ft)	Side Slope (Z, H:1V)	Lining Type ($D_{b,\ 50}$, ft)	Estimated Depth (d_i, ft)	Mannings (η)	Area (A, ft^2)	Hydraulic Radius (R, ft)	Calculated Discharge (Q_i)	Is Q_i with 5% of Q?	Velocity (V, ft/s)
Reach 1	4.5	0.001	2	2.5	0.17	0.86	0.025	3.60	0.54	4.50	Yes	1.25
Reach 2	11.41	0.001	2	2.5	0.17	1.34	0.025	7.16	0.78	11.41	Yes	1.59
Reach 3	18.15	0.001	2	2.5	0.17	1.65	0.025	10.12	0.93	18.15	Yes	1.79
Reach 4	3.43	0.001	2	2.5	0.17	0.76	0.025	2.95	0.49	3.43	Yes	1.16
Reach 5	8.15	0.001	2	2.5	0.17	1.15	0.025	5.58	0.68	8.15	Yes	1.46
Reach 6	30.94	0.001	4	2.5	0.17	1.80	0.025	15.26	1.12	30.94	Yes	2.03

Average Velocity for Use in TR-55

	Ave	St Dev	
Reach 1	1.15	0.0892143	Basin 1 and Basin 2
Reach 2	1.47	0.1072344	Basin 3
Reach 3	1.66	0.1167749	Basin 4
Reach 4	1.07	0.0782754	Basin 5 and Basin 6
Reach 5	1.35	0.0969412	Basin 7
Reach 6	1.86	0.1455257	No Basin

Table 3. Reach Data

Reach Name	Receiving Reach	Reach Length (ft)	Manning (η)	Friction Slope (ft/ft)	Bottom Width (ft)	Side Slope
Reach 1	Reach 2	366	0.025	0.001	2.0	2.5H:1V
Reach 2	Reach 3	441	0.025	0.001	2.0	2.5H:1V
Reach 3	Reach 6	675	0.025	0.001	2.0	2.5H:1V
Reach 4	Reach 5	296	0.025	0.001	2.0	2.5H:1V
Reach 5	Reach 6	678	0.025	0.001	2.0	2.5H:1V
Reach 5	Outlet	62	0.025	0.001	4.0	2.5H:1V

Notes
H = horizontal
V = vertical

ATTACHMENT A

OUTLET WINTR-55 REPORT

WinTR-55 Current Data Description

--- Identification Data ---

User: M. Martin
Project: Arkema Stormwater
SubTitle: 09-27-2011 FINAL
State: Oregon
County: Multnomah
Filename: C:\Documents and Settings\mmartin\Desktop\Final Model\WinTR-55 Runs\09-27-2011 Runs\09-27-2011 F

Date: 9/28/2011
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Basin 1		Reach 1	4.7	94	.188
Basin 2		Reach 2	7.34	95	.313
Basin 3		Reach 3	6.97	97	.259
Basin 4		Reach 6	2.92	94	.102
Basin 5		Reach 4	3.51	96	.29
Basin 6		Reach 5	4.94	95	.16
Basin 7		Reach 6	4.77	85	.445
Basin 8		Outlet	3.93	88	.143

Total area: 39.08 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

1-Yr (in)	2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	100-Yr (in)	-Yr (in)
1.0	2.4	2.9	3.4	3.9	4.4	.0

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type IA
Dimensionless Unit Hydrograph: <standard>

M. Martin

Arkema Stormwater
09-27-2011 FINAL
Multnomah County, Oregon

Storm Data

Rainfall Depth by Rainfall Return Period

1-Yr (in)	2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	100-Yr (in)	-Yr (in)
1.0	2.4	2.9	3.4	3.9	4.4	.0

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type IA
Dimensionless Unit Hydrograph: <standard>

M. Martin

Arkema Stormwater
09-27-2011 FINAL
Multnomah County, Oregon

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period ANALYSIS: (cfs)	2-Yr (cfs)	5-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS						
Basin 1	0.55	2.15	2.74	3.33	3.92	4.50
Basin 2	0.96	3.42	4.31	5.20	6.08	6.96
Basin 3	1.24	3.64	4.49	5.33	6.17	7.00
Basin 4	0.35	1.35	1.72	2.09	2.46	2.83
Basin 5	0.54	1.73	2.16	2.58	3.01	3.43
Basin 6	0.68	2.40	3.02	3.64	4.26	4.88
Basin 7	0.06	1.04	1.51	2.01	2.52	3.05
Basin 8	0.15	1.23	1.69	2.17	2.65	3.15
REACHES						
Reach 1	0.55	2.15	2.74	3.33	3.92	4.50
Down	0.54	2.12	2.71	3.29	3.87	4.45
Reach 2	1.50	5.54	7.01	8.49	9.95	11.41
Down	1.46	5.43	6.89	8.35	9.80	11.25
Reach 3	2.64	8.99	11.30	13.59	15.88	18.15
Down	2.54	8.75	11.01	13.26	15.50	17.72
Reach 4	0.54	1.73	2.16	2.58	3.01	3.43
Down	0.53	1.71	2.13	2.55	2.97	3.39
Reach 5	1.19	4.04	5.07	6.10	7.12	8.14
Down	1.14	3.93	4.94	5.94	6.95	7.96
Reach 6	3.90	14.64	18.70	22.77	26.85	30.93
Down	3.89	14.61	18.65	22.71	26.78	30.84
OUTLET	4.01	15.73	20.23	24.75	29.29	33.83

M. Martin

Arkema Stormwater
09-27-2011 FINAL
Multnomah County, Oregon

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period ANALYSIS: 2-Yr (cfs) (hr)	5-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS					
Basin 1	0.55 8.02	2.15 7.97	2.74 7.95	3.33 7.95	3.92 7.95	4.50 7.95
Basin 2	0.96 8.06	3.42 8.04	4.31 8.03	5.20 8.03	6.08 8.02	6.96 8.02
Basin 3	1.24 8.02	3.64 8.01	4.49 8.00	5.33 8.00	6.17 7.99	7.00 8.00
Basin 4	0.35 7.94	1.35 7.92	1.72 7.92	2.09 7.91	2.46 7.91	2.83 7.91
Basin 5	0.54 8.04	1.73 8.03	2.16 8.02	2.58 8.01	3.01 8.01	3.43 8.02
Basin 6	0.68 7.98	2.40 7.94	3.02 7.94	3.64 7.93	4.26 7.93	4.88 7.93
Basin 7	0.06 8.99	1.04 8.14	1.51 8.14	2.01 8.13	2.52 8.13	3.05 8.12
Basin 8	0.15 8.03	1.23 7.96	1.69 7.96	2.17 7.95	2.65 7.94	3.15 7.94
REACHES						
Reach 1	0.55 8.02	2.15 7.97	2.74 7.95	3.33 7.95	3.92 7.95	4.50 7.95
Down	0.54 8.08	2.12 8.03	2.71 8.02	3.29 8.01	3.87 8.01	4.45 8.01
Reach 2	1.50 8.06	5.54 8.04	7.01 8.02	8.49 8.03	9.95 8.02	11.41 8.02
Down	1.46 8.15	5.43 8.09	6.89 8.08	8.35 8.07	9.80 8.07	11.25 8.07
Reach 3	2.64 8.08	8.99 8.05	11.30 8.05	13.59 8.05	15.88 8.04	18.15 8.04
Down	2.54 8.18	8.75 8.12	11.01 8.11	13.26 8.10	15.50 8.10	17.72 8.10
Reach 4	0.54 8.04	1.73 8.03	2.16 8.02	2.58 8.01	3.01 8.01	3.43 8.02
Down	0.53 8.10	1.71 8.07	2.13 8.06	2.55 8.06	2.97 8.06	3.39 8.06
Reach 5	1.19 8.02	4.04 8.00	5.07 8.00	6.10 7.99	7.12 7.99	8.14 7.99
Down	1.14 8.14	3.93 8.08	4.94 8.07	5.94 8.07	6.95 8.06	7.96 8.05
Reach 6	3.90 8.16	14.64 8.07	18.70 8.06	22.77 8.05	26.85 8.05	30.93 8.05
Down	3.89 8.17	14.61 8.09	18.65 8.07	22.71 8.06	26.78 8.06	30.84 8.05
OUTLET	4.01	15.73	20.23	24.75	29.29	33.83

Hydrograph Peak/Peak Time Table (continued)

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period ANALYSIS: 2-Yr (cfs) (hr)	5-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

M. Martin

Arkema Stormwater
09-27-2011 FINAL
Multnomah County, Oregon

Structure Output Table

Reach Identifier / Structure Identifier	Peak Flow (PF), Storage Volume (SV), Stage (STG) by Rainfall Return Period ANALYSIS:	2-Yr	5-Yr	10-Yr	25-Yr	100-Yr

M. Martin

Arkema Stormwater
09-27-2011 FINAL
Multnomah County, Oregon

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Basin 1	4.70	0.188	94	Reach 1	
Basin 2	7.34	0.313	95	Reach 2	
Basin 3	6.97	0.259	97	Reach 3	
Basin 4	2.92	0.102	94	Reach 6	
Basin 5	3.51	0.290	96	Reach 4	
Basin 6	4.94	0.160	95	Reach 5	
Basin 7	4.77	0.445	85	Reach 6	
Basin 8	3.93	0.143	88	Outlet	

Total Area: 39.08 (ac)

Arkema Stormwater
09-27-2011 FINAL
Multnomah County, Oregon

Reach Summary Table

Reach Identifier	Receiving Reach Identifier	Reach Length (ft)	Routing Method
Reach 1	Reach 2	366	CHANNEL
Reach 2	Reach 3	441	CHANNEL
Reach 3	Reach 6	676	CHANNEL
Reach 4	Reach 5	296	CHANNEL
Reach 5	Reach 6	678	CHANNEL
Reach 6	Outlet	62	CHANNEL

Arkema Stormwater
09-27-2011 FINAL
Multnomah County, Oregon

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
Basin 1							
SHEET	100	0.0172	0.050				0.083
SHALLOW	325	0.0055	0.050				0.075
CHANNEL	125					1.150	0.030
					Time of Concentration		.188
							========
Basin 2							
SHEET	100	0.0050	0.011				0.041
SHALLOW	685	0.0022	0.025				0.200
SHALLOW	195	0.0066	0.050				0.041
CHANNEL	129					1.150	0.031
					Time of Concentration		.313
							========
Basin 3							
SHEET	100	0.0063	0.011				0.037
SHALLOW	783	0.0032	0.025				0.189
CHANNEL	174					1.470	0.033
					Time of Concentration		.259
							========
Basin 4							
CHANNEL	607					1.660	0.102
					Time of Concentration		.102
							========
Basin 5							
SHEET	100	0.0003	0.011				0.125
SHALLOW	253	0.0118	0.050				0.040
CHANNEL	480					1.070	0.125
					Time of Concentration		.29
							========
Basin 6							
SHEET	100	0.0051	0.011				0.040
SHALLOW	435	0.0077	0.050				0.085
CHANNEL	134					1.070	0.035
					Time of Concentration		.16
							========
Basin 7							
SHEET	100	0.0159	0.150				0.207
SHALLOW	510	0.0097	0.050				0.089
SHALLOW	205	0.0071	0.050				0.042
CHANNEL	521					1.350	0.107
					Time of Concentration		.445
							========
Basin 8							
SHEET	100	0.0135	0.050				0.092
SHALLOW	303	0.0104	0.050				0.051

Sub-Area Time of Concentration Details (continued)

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

Time of Concentration .143

Arkema Stormwater
09-27-2011 FINAL
Multnomah County, Oregon

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Basin 1	CN directly entered by user	-	4.7	94
	Total Area / Weighted Curve Number		4.7	94
			===	==
Basin 2	CN directly entered by user	-	7.34	95
	Total Area / Weighted Curve Number		7.34	95
			====	==
Basin 3	CN directly entered by user	-	6.97	97
	Total Area / Weighted Curve Number		6.97	97
			====	==
Basin 4	CN directly entered by user	-	2.92	94
	Total Area / Weighted Curve Number		2.92	94
			====	==
Basin 5	CN directly entered by user	-	3.51	96
	Total Area / Weighted Curve Number		3.51	96
			====	==
Basin 6	CN directly entered by user	-	4.94	95
	Total Area / Weighted Curve Number		4.94	95
			====	==
Basin 7	CN directly entered by user	-	4.77	85
	Total Area / Weighted Curve Number		4.77	85
			====	==
Basin 8	CN directly entered by user	-	3.93	88
	Total Area / Weighted Curve Number		3.93	88
			====	==

Arkema Stormwater
09-27-2011 FINAL
Multnomah County, Oregon

Reach Channel Rating Details

Reach Identifier	Reach Length (ft)	Reach Manning's n	Friction Slope (ft/ft)	Bottom Width (ft)	Side Slope
Reach 1	366	0.025	0.001	2	2.5 :1
Reach 2	441	0.025	0.001	2	2.5 :1
Reach 3	676	0.025	0.001	2	2.5 :1
Reach 4	296	0.025	0.001	2	2.5 :1
Reach 5	678	0.025	0.001	2	2.5 :1
Reach 6	62	0.025	0.001	4	2.5 :1

Reach Identifier	Stage (ft)	Flow (cfs)	End Area (sq ft)	Top Width (ft)	Friction Slope (ft/ft)
Reach 1	0.0	0.000	0	2	0.001
	0.5	1.506	1.6	4.5	
	1.0	6.079	4.5	7	
	2.0	27.978	14	12	
	5.0	251.450	72.5	27	
	10.0	1450.979	270	52	
	20.0	8756.312	1040	102	
Reach 2	0.0	0.000	0	2	0.001
	0.5	1.506	1.6	4.5	
	1.0	6.079	4.5	7	
	2.0	27.978	14	12	
	5.0	251.450	72.5	27	
	10.0	1450.979	270	52	
	20.0	8756.312	1040	102	
Reach 3	0.0	0.000	0	2	0.001
	0.5	1.506	1.6	4.5	
	1.0	6.079	4.5	7	
	2.0	27.978	14	12	
	5.0	251.450	72.5	27	
	10.0	1450.979	270	52	
	20.0	8756.312	1040	102	
Reach 4	0.0	0.000	0	2	0.001
	0.5	1.506	1.6	4.5	
	1.0	6.079	4.5	7	
	2.0	27.978	14	12	
	5.0	251.450	72.5	27	
	10.0	1450.979	270	52	
	20.0	8756.312	1040	102	
Reach 5	0.0	0.000	0	2	0.001
	0.5	1.506	1.6	4.5	
	1.0	6.079	4.5	7	
	2.0	27.978	14	12	
	5.0	251.450	72.5	27	
	10.0	1450.979	270	52	
	20.0	8756.312	1040	102	
Reach 6	0.0	0.000	0	4	0.001
	0.5	2.644	2.6	6.5	
	1.0	9.564	6.5	9	
	2.0	38.602	18	14	
	5.0	298.278	82.5	29	
	10.0	1596.608	290	54	
	20.0	9213.141	1080	104	

Reach Channel Rating Details (continued)

Reach Identifier	Reach Length (ft)	Reach Manning's n	Friction Slope (ft/ft)	Bottom Width (ft)	Side Slope

Structure Description - User Entered

Reach Identifier	Surface Area @ Crest (ac)	Height Above Crest (ft)	Surface Area @ Ht Above (ac)	Pipe Diameter (in)	Head on Pipe (ft)	Weir Length (ft)

Arkema Stormwater
09-27-2011 FINAL
Multnomah County, Oregon

Structure Rating Details - Computed

ATTACHMENT B

SAND FILTER WINTR-55 REPORT

WinTR-55 Current Data Description

--- Identification Data ---

User: M. Martin
Project: Arkema Stormwater
SubTitle: 09-27-2011 FINAL SAND FILTER
State: Oregon
County: Multnomah
Filename: C:\Documents and Settings\mmartin\Desktop\Final Model\WinTR-55 Runs\09-27-2011 Runs\09-27-2011 F

Date: 9/28/2011
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Basin 9		Outlet	0.99	98	0.100

Total area: .99 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

1-Yr (in)	2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	100-Yr (in)	-Yr (in)
1.0	2.4	2.9	3.4	3.9	4.4	.0

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type IA
Dimensionless Unit Hydrograph: <standard>

M. Martin

Arkema Stormwater
09-27-2011 FINAL SAND FILTER
Multnomah County, Oregon

Storm Data

Rainfall Depth by Rainfall Return Period

1-Yr (in)	2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	100-Yr (in)	-Yr (in)
1.0	2.4	2.9	3.4	3.9	4.4	.0

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type IA
Dimensionless Unit Hydrograph: <standard>

M. Martin

Arkema Stormwater
09-27-2011 FINAL SAND FILTER
Multnomah County, Oregon

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period ANALYSIS: (cfs)	2-Yr (cfs)	5-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS						
Basin 9	0.21	0.55	0.68	0.80	0.92	1.04
REACHES						
OUTLET	0.21	0.55	0.68	0.80	0.92	1.04

M. Martin

Arkema Stormwater
09-27-2011 FINAL SAND FILTER
Multnomah County, Oregon

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period ANALYSIS: 2-Yr (cfs) (hr)	5-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS					
Basin 9	0.21 7.91	0.55 7.84	0.68 7.84	0.80 7.84	0.92 7.84	1.04 7.84
REACHES					
OUTLET	0.21	0.55	0.68	0.80	0.92	1.04

M. Martin Arkema Stormwater
09-27-2011 FINAL SAND FILTER
Multnomah County, Oregon

Structure Output Table

Reach Identifier / Structure Identifier	Peak Flow (PF), Storage Volume (SV), Stage (STG) by Rainfall Return Period ANALYSIS:	2-Yr	5-Yr	10-Yr	25-Yr	100-Yr

M. Martin

Arkema Stormwater
09-27-2011 FINAL SAND FILTER
Multnomah County, Oregon

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Basin 9	.99	0.100	98	Outlet	

Total Area: .99 (ac)

M. Martin

Arkema Stormwater
09-27-2011 FINAL SAND FILTER
Multnomah County, Oregon

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
Basin 9							
User-provided							0.100
						Time of Concentration	0.100

Arkema Stormwater
09-27-2011 FINAL SAND FILTER
Multnomah County, Oregon

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Basin 9	CN directly entered by user	-	.99	98
	Total Area / Weighted Curve Number		.99	98

Arkema Stormwater
09-27-2011 FINAL SAND FILTER
Multnomah County, Oregon

Structure Description - User Entered

Reach Identifier	Surface Area @ Crest (ac)	Height Above Crest (ft)	Surface Area @ Ht Above (ac)	Pipe Diameter (in)	Head on Pipe (ft)	Weir Length (ft)

Arkema Stormwater
09-27-2011 FINAL SAND FILTER
Multnomah County, Oregon

Structure Rating Details - Computed

APPENDIX J

HYDROCAD MODELING REPORTS

Integral Consulting Inc.
285 Century Place
Suite 190
Louisville, CO 80027

telephone: 303.404.2944
facsimile: 303.404.2945
www.integral-corp.com

MEMORANDUM

To:	Project File
From:	Michael J. Martin
Date:	September 30, 2011
Subject:	Arkema Stormwater Source Control Measures – Hydraulic Modeling
Project No.:	C250

Stormwater hydraulics through the treatment system (i.e., detention basin and sand filter) were modeled using HydroCAD Version 9.1.[1] Inflow hydrographs were imported from the WinTR-55 software package for each of the modeled storms and passed through each of the treatment facilities (i.e., first the detention basin and then the sand filter) to evaluate system design and determine maximum discharge flow rates and water elevations. This memorandum discusses the input parameters and presents the output from the hydraulics modeling.

For the Arkema stormwater source control measures (SCMs), channels will collect stormwater flow from across the site and direct it to a treatment system. The treatment system will consist of two basic components, a detention basin used for controlling flow rates and for settling, and a sand filter used for filtration treatment of the stormwater. The detention basin is divided into two distinct components: a sediment forebay and a settling basin. Flow from the stormwater channels will first flow to the sediment forebay where larger sediments can settle out. The flow will then pass over a broad-crested weir to the settling basin where further settling can occur. Discharge from the detention basin will be routed to the sand filter, which is divided into three distinct components: an influent area, a sand filtration area, and an effluent clear well. Discharge from the detention basin will be routed to the influent area, which will be used for spreading flow across the surface of the sand filter. Flow will pass over a broad-crested weir into the sand filtration area. In the filtration area, flow will either

[1] HydroCAD 9.10 (Build 21). Copyright ® 2010 HydroCAD Software Solutions LLC. www.hydrocad.net.

pass downward through the sand to be filtered or, if flows are high enough, over a broad-crested weir as a bypass. Both flows will be collected in the effluent clear well. Flow from the effluent clear well will be discharged to the existing stormwater collection system onsite and to the Willamette River through an existing discharge.

To model the stormwater treatment system, the Dynamic Storage-Indication Pond Routing Method was chosen within the HydroCAD program. This methodology uses the same equations as the Storage-Indication Method (based on the conservation of mass); however, this method re-evaluates the storage-indication curve at each time step, allowing such variables as downstream tailwater to be taken into consideration.

DETENTION BASIN

The detention basin was modeled as two separate pond nodes within the HydroCAD model. The initial (i.e., upgradient) pond node includes the sediment forebay. The second pond node includes the remainder of the detention basin. Inputs for the HydroCAD model include storage and outlet characteristics. Note that construction access entrances were not included in the modeling of the detention basin. As-designed, construction access entrances would increase volumes and, thus, are conservatively left out of the modeled basin (see SCM Drawings[2]).

Sediment Forebay

Sediment forebay characteristics are depicted in Figure 1. Physical characteristics were determined from the SCM Drawings to calculate storage. Figure 1 also presents the custom storage data as entered into to the hydraulic model. The outlet characteristics for the sediment forebay are also required for the hydraulic model. The outlet will be an overflow weir (constructed by ultrablock LOCK-BLOCK® units, Ultrablock Inc.) at an elevation of 31.75 ft. Outlet parameters were as follows:

- Invert elevation: 31.75 ft
- Crest length: 5.0 ft
- Crest breadth: 2.5 ft
- Discharge multiplier: 1.0.

[2] Attachment to the *Final Design Report, Stormwater Source Control Measures, Former Arkema Inc. Facility, Portland, Oregon* (Integral 2011).

Default values of C, the coefficient of discharge, provided by the HydroCAD program were used for calculating discharge from the sediment forebay. Sediment forebay discharge was routed directly to the detention basin.

Detention Basin

The detention basin characteristics are depicted in Figure 1 and were determined from the SCM Drawings to calculate storage. Figure 1 also presents the custom storage data as entered into the hydraulic model.

Outlet characteristics are also required for the hydraulic model. The as-designed outlet will include 5 individual, 8-in.-diameter riser pipes to promote flow across the width of the basins. The riser pipes will each have two, 1-in. diameter holes in them centered at the following elevations: 31.5 ft, 32.0 ft, 32.5 ft, and 33 ft. The riser pipes will also be open at the top to allow free flow into them. Each of the riser pipes will be routed to a 24-in.-diameter PVC pipe which will route flow to the sand filter. Table 1 presents the input parameters for the outlet devices for the detention basin.

SAND FILTER

The sand filter was modeled as two separate pond nodes within the HydroCAD model, the volume directly above the sand filter (filtration area) and the effluent clear well (i.e., the volume on the discharge side of the overflow weir). For the purposes of modeling, the volume within the influent area for spreading flow across the sand filter was not modeled. The volume within this area is effectively a part of the sand filter and is too small to be accurately modeled (causes significant oscillations in the routing equations). Further, to simulate flow through the sand filter by exfiltration (see below), the storage volume not directly above the sand filter was also not modeled. Exclusion of this volume allowed for more accurate modeling of flow rates through the sand filter.

Inputs for the HydroCAD model include storage and outlet characteristics. Construction access entrances were not included in the modeling of the sand filter. As-designed, construction access entrances would increase volumes and, thus, are conservatively left out of the modeled basin (see SCM Drawings).

Also included in the modeling of the sand filter was a direct input hydrograph from the TR-55 hydrology model. This input hydrograph was developed to model precipitation directly on the sand filter basin.

Filtration Area (Sand Filter)

Sand filter characteristics are depicted in Figure 2. Physical characteristics were determined from the SCM Drawings to calculate storage. Figure 2 also presents the custom storage data as entered into to the hydraulic model. As discussed previously, outlet from the sand filter can occur through one of two methods: filtration through the sand filter (modeled through exfiltration) or over the bypass overflow weir. Further filtration through the sand filter was modeled as a three step process: exfiltration through the sand to the perforated underdrain (perforations modeled as an orifice/grate), through perforations in the underdrain pipe, then through the underdrain pipe (modeled as a culvert) to the effluent clear well. Discharge from the overflow weir is routed directly to the effluent clear well. Table 2 presents the input parameters for the outlet devices for the sand filter.

The discharge from the perforated pipe was routed through a 206 minute lag to mimic the delay through the sand filter and then to the effluent clear well. The lag through the sand filter was calculated as:

Lag (hours) = depth of sand/velocity through sand filter

Depth of sand = 18 inches

Velocity through sand filter = conductivity x gradient

Conductivity = 1.75 in./hour

Gradient = (depth of water above sand + depth of sand)/depth of sand filter. Average depth of water above the sand was assumed to be 3 ft (36 in.)[3]

Effluent Clear Well

The effluent clear well characteristics are also depicted in Figure 2 and were determined from the SCM Drawings to calculate storage. Figure 2 also presents the custom storage data as entered into the hydraulic model. The outlet characteristics for the effluent clear well are also required for the hydraulic model. The outlet will be a 24-in.- diameter PVC pipe. Outlet parameters were entered as follows:

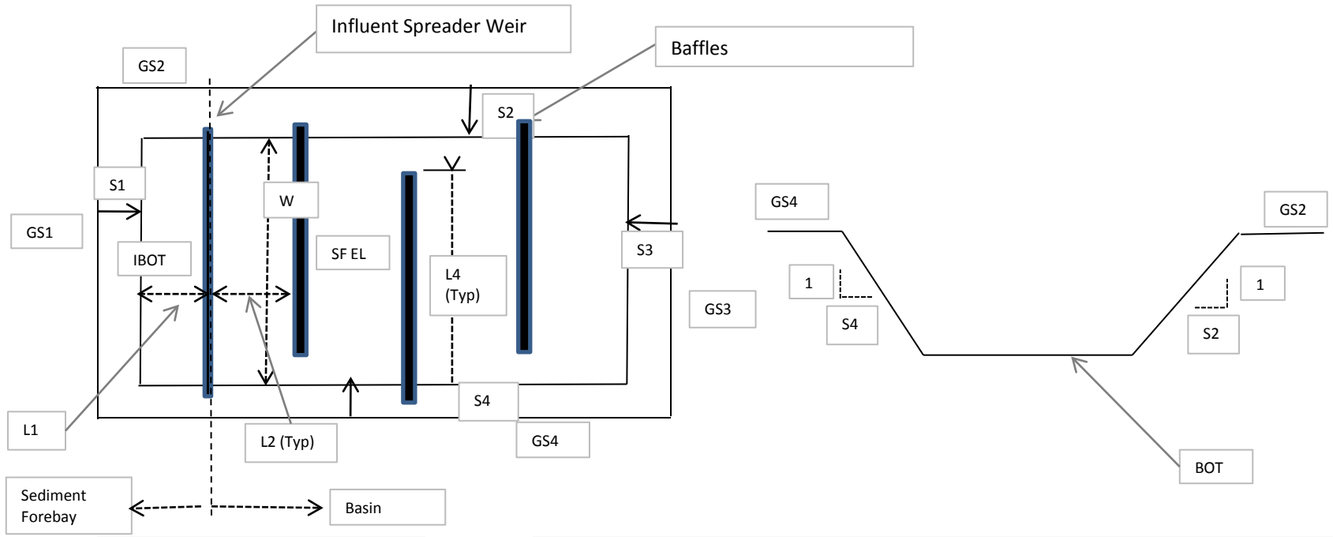
[3] In practice, the velocity through the sand filter (and thus the lag) will not be a constant, but will vary with the depth of water above the sand filter. However, this lag cannot be modeled with HydroCAD, so an average lag was calculated.

- Invert elevation: 28.00 ft
- Discharge multiplier: 1.00
- Outlet elevation: 27.26 ft
- Length: 148 ft
- Slope: 0.005 ft/ft
- Diameter: 24 in.
- Manning's number: 0.013
- Contraction coefficient: 0.5
- Ke: 0.7 (default value for CPP, mitered to conform to fill).

RESULTS

The 2-year, 5-year, 10-year, 25-year, and 100-year design storms were modeled through the treatment system. Table 3 summarizes the results of the hydraulic modeling and the HydroCAD reports are provided as Attachment A to this memorandum. Tables 4 and 5 present time-step elevation data for the 2-year and the 25-year storm (design storm), respectively.

FIGURES



Ground Surface El. (NAVD88)	
GS1 =	37 ft
GS2 =	37 ft
GS3 =	37 ft
GS4 =	37 ft

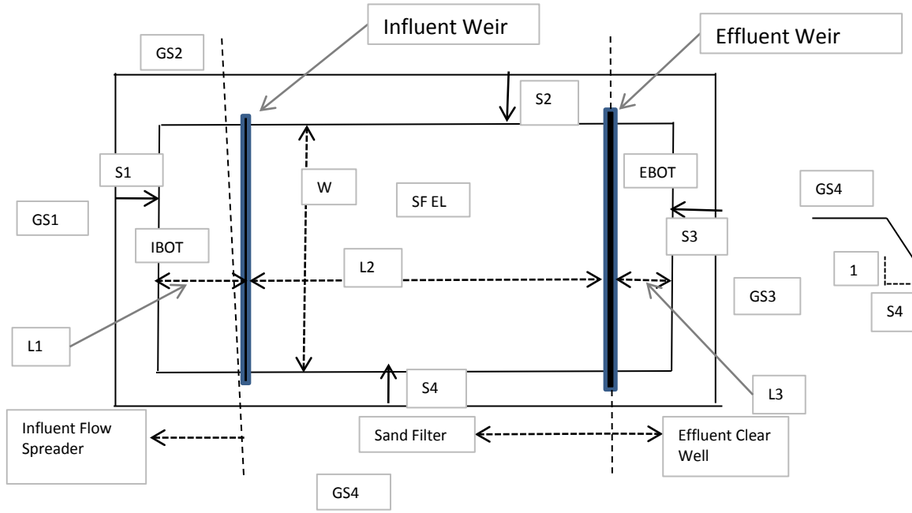
Bottom El. (NAVD88)		Slopes		Lengths (at BOT)	
BOT =	30 ft	S1 =	4 ft H:1 ft V	L1 =	60 ft
		S2 =	4 ft H:1 ft V	L2 =	60 ft
IBOT =	30 ft	S3 =	4 ft H:1 ft V	L2 T =	240
		S4 =	4 ft H:1 ft V	L T =	300 ft

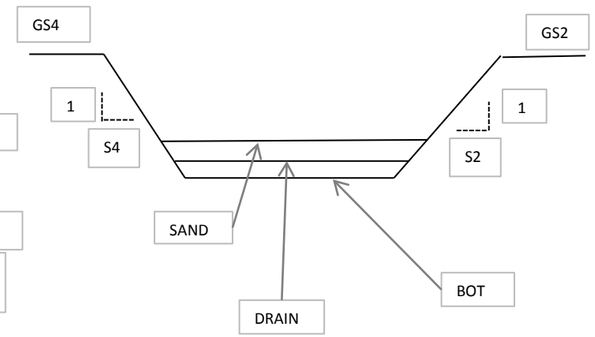
Width (at BOT)	
W =	150 ft
L4 =	120 ft

Sediment Forebay			Detention Basin		
Elevation	Volume (ft^3)	Volume (acre-ft)	Elevation	Volume (ft^3)	Volume (acre-ft)
30	0	0	30	0	0
30.5	4447	0.102089	30.25	8897.125	0.20425
31	9171	0.210537	30.5	17949.5	0.412064
31.5	14184	0.32562	31	36526	0.838522
31.75	16802.625	0.385735	31.5	55741.5	1.279649
32	19498	0.447612	32	75608	1.735721
32.5	25125	0.576791	32.5	96137.5	2.207013
33	31077	0.71343	33	117342	2.693802
33.5	37366	0.857805	33.5	139233.5	3.196361
34	44004	1.010193	34	161824	3.714968
34.5	51003	1.170868	34.5	185125.5	4.249897
35	58375	1.340106	35	209150	4.801423
35.5	66132	1.518182	35.5	233909.5	5.369823
36	74286	1.705372	36	259416	5.955372
36.5	82849	1.901951	36.5	285681.5	6.558345

All elevations are in ft NAVD88.

Figure 1
Detention Basin Size and Volume Calculations
Technical Memorandum
Arkema Stormwater Source Control Measures





Ground Surface El. (NAVD88)		
GS1 =	36.5	ft
GS2 =	36.5	ft
GS3 =	36.5	ft
GS4 =	36.5	ft

Slopes		
S1 =	4	ft H:1 ft V
S2 =	4	ft H:1 ft V
S3 =	4	ft H:1 ft V
S4 =	4	ft H:1 ft V

Bottom El. (NAVD88)		
BOT =	28	ft *
SF EL =	30.5	ft
IBOT =	29	ft
EBOT =	29	ft

Lengths (at BOT)		
L1 =	9	ft
L2 =	160	ft
L3 =	14	ft
Weirs =	5	ft
	188	ft

Width (at BOT)		
W =	80	ft

Drain Layer (thickness)	12	inches
DRAIN =	29	ft NAVD88
Sand Layer (thickness)	18	inches
SAND =	30.5	ft NAVD88
Influent Weir Elevation	30.75	ft NAVD88

All elevations are in ft NAVD88.

* This is the bottom below the drain layer. Refer to Arkema SCM Drawings.

** Not used in model

Total Storage Directly Above Sand Filter
For Exfiltration-> HydroCAD

El.	L	W	Volume (acre-ft)	Surface Area (acres)
30.5	160	100	0	0.36730946
30.75	160	100	0.091827	0.36730946
31.25	160	100	0.275482	0.36730946
31.75	160	100	0.459137	0.36730946
32.25	160	100	0.642792	0.36730946
32.75	160	100	0.826446	0.36730946
33.25	160	100	1.010101	0.36730946
33.75	160	100	1.193756	0.36730946
34.25	160	100	1.37741	0.36730946
34.75	160	100	1.561065	0.36730946
35.25	160	100	1.74472	0.36730946
35.75	160	100	1.928375	0.36730946
36.25	160	100	2.112029	0.36730946

Sand Filter - Actual Volume**

Elevation	Volume (ft^3)	Volume (acre-ft)
30.5	0	0
30.75	4040	0.092746
31.25	12360	0.283747
31.75	21000	0.482094
32.25	29960	0.687787
32.75	39240	0.900826
33.25	48840	1.121212
33.75	58760	1.348944
34.25	69000	1.584022
34.75	79560	1.826446
35.25	90440	2.076217
35.75	101640	2.333333
36.25	113160	2.597796
Surface Area =	16000	ft^3

Effluent Clear Well

Elevation	Volume (ft^3)	Volume (acre-ft)
29	0	0
29.5	616	0.014141
30	1352	0.031038
30.5	2220	0.050964
31	3232	0.074197
31.5	4400	0.10101
32	5736	0.13168
32.5	7252	0.166483
33	8960	0.205693
33.5	10872	0.249587
34	13000	0.298439
34.5	15356	0.352525
35	17952	0.412121
35.5	20800	0.477502
36	23912	0.548944

Influent Area for Flow Spread**

Elevation	Volume (ft^3)	Volume (acre-ft)
30.75	0	0
31.25	411	0.00944
31.75	932	0.0214
32.25	1575	0.03616
32.75	2352	0.05399
33.25	3275	0.07518
33.75	4356	0.1
34.25	5607	0.12872
34.75	7040	0.16162
35.25	8667	0.19897
35.75	10500	0.24105
36.25	12551	0.28813

integral consulting inc

Figure 2
Sand Filter Size and Volume Calculations
Technical Memorandum
Arkema Stormwater Source Control Measures

TABLES

Table 1. Model Parameters for Detention Basin Outlets, Arkema Stormwater SCMs

Outlet	Type	Discharge	Invert Elevation (ft)
Riser Pipes Vertical Orifices	Orifice/Grate	To 24" diameter pipe	31.50
Opening in:	Vertical plane		
Row spacing (in.)	6		
Rows	4		
Columns	10		
Diameter (in.)	1		
Discharge coefficient	0.6		
Riser Pipes Horizontal Orifices	Orifice/Grate	To 24" diameter pipe	33.75
Opening in:	Horizontal plane		
Discharge multiplier	5		
Rows	1		
Diameter (in.)	8		
Discharge coefficient	0.6		
Set to use weir flow at low head			
24" Diameter Pipe	Culvert	To Sand Filter	31.00
Discharge multiplier	1		
Inlet elevation (ft)	31		
Outlet elevation (ft)	29.45		
Geometry	Round		
Length (ft)	310		
Diameter (in.)	24		
Slope (ft/ft)	0.005		
Manning's number	0.013		
Entrance	CPP, end-section conforming to fill		
Ke	0.5	(Default value given entrance assumption)	
Contraction coefficient	0.5	Assumed	

Notes:
SCM = source control measure

Table 2. Model Parameters for Sand Filter Outlets, Arkema Stormwater SCMs

Outlet	Type		Discharge	Invert Elevation (ft)
Overflow Weir[a]	Broad-Crested Rectangular Weir		To Effluent Clear Well	35.25
Crest length	130			
Crest breadth	2.5			
Discharge multiplier	1			
Discharge coefficient	Defaults as set by HydroCAD			
Sand Filtration	Exfiltration		To perforated pipe (perforations)	30.5
Routing	To perforated pipe (perforations)			
Discharge multiplier	1			
Conductivity	1.75 in/hr	(Equal to 3.5 ft/day)		
Apply exfiltration to:	Horizontal area			
Allow exfiltration	At all elevations			
Groundwater elevation	29	(Elevation of under-drain pipe)		
Phase-in depth	0.01 ft			
Perforated Pipe (perforations)	Orifice/Grate		To perforated pipe (pipe)	29.00
Columns	8	(8 discharge pipe, 10 ft on center)		
Rows	150	(150 LF of perforated pipe)		
Opening in:	Horizontal plane			
Geometry	Round			
Diameter	0.5	(Equates to minimum opening of 0.2 sq. in. per LF of pipe)		
Do not use weir flow at low head.				
Perforated Pipe (pipe)	Culvert		To Effluent Clear Well	28.76
Discharge multiplier	8	(8 discharge pipes, 10 ft on center)		
Inlet elevation (ft)	28.76			
Outlet elevation (ft)	28			
Geometry	Round			
Length (ft)	165			
Diameter (in.)	4			
Slope (ft/ft)	0.005			
Manning's number	0.011			
Ke	0.9	Assumed		
Contraction coefficient	0.5	Assumed		

Notes:
[a]Default values of C, the coefficient of discharge, provided by the HydroCAD program were used for calculating discharge from the sediment forebay.

LF = linear foot
SCM = source control measure

Table 3. Summary of Hydraulic Modeling Results, Arkema Stormwater SCMs

Characteristic	2-Year	5-Year	10-Year	25-Year	100-Year
Sediment Forebay					
Peak elevation (ft)	33.77	33.89	34.35	34.98	35.47
Max storage (acre-ft)	0.94	0.978	1.121	1.333	1.508
Max inflow (cfs)	15.72	20.21	24.72	29.25	33.77
Max outflow (cfs)	14.36	18.63	22.44	25.63	28.75
Detention Basin					
Peak elevation (ft)	33.77	33.89	34.35	34.98	35.47
Max storage (acre-ft)	3.476	3.604	4.085	4.777	5.339
Max inflow (cfs)	14.36	18.63	22.44	25.63	28.75
Max outflow (cfs)	1.35	3.12	4.43	5.96	7.34
Sand Filter					
Peak elevation (ft)	31.45	33.52	34.27	34.89	35.27
Max storage (acre-ft)	0.349	1.108	1.386	1.611	1.753
Max inflow (cfs)	1.35	3.2	4.56	6.13	7.56
Max filtration outflow (cfs)	1.06	1.95	2.28	2.54	2.71
Max bypass outflow (cfs)	0.00	0	0	0	1.14
Effluent Clear Well					
Peak elevation (ft)	29.00	29	29	29	29.25
Max storage (acre-ft)	0.00	0	0	0	0.007
Max inflow (cfs)	1.06	1.95	2.28	2.54	3.83
Max outflow (cfs)	1.06	1.95	2.28	2.54	3.83

Notes:
cfs = cubic feet per second
SCM = source control measure

Table 4. Time-Step Elevation Data, 2-Year Storm

Time (hours)	Sediment Forebay Elevation (ft)	Detention Basin Elevation (ft)	Sand Filter Elevation (ft)	Effluent Clear Well Elevation (ft)
0	30.00	30.00	30.50	29.00
1	30.00	30.00	30.50	29.00
2	30.00	30.00	30.50	29.00
3	30.00	30.00	30.50	29.00
4	30.10	30.00	30.50	29.00
5	30.55	30.00	30.50	29.00
6	31.35	30.00	30.50	29.00
7	32.14	30.11	30.50	29.00
8	32.68	30.65	30.51	29.00
9	32.44	31.72	30.50	29.00
10	32.34	32.18	30.51	29.00
11	32.50	32.46	30.51	29.00
12	32.68	32.67	30.51	29.00
13	32.84	32.84	30.52	29.00
14	32.99	32.99	30.55	29.00
15	33.12	33.12	30.60	29.00
16	33.24	33.24	30.67	29.00
17	33.34	33.34	30.74	29.00
18	33.44	33.44	30.82	29.00
19	33.52	33.52	30.90	29.00
20	33.59	33.59	30.99	29.00
21	33.65	33.65	31.07	29.00
22	33.70	33.70	31.15	29.00
23	33.74	33.74	31.22	29.00
24	33.77	33.77	31.28	29.00
25	33.72	33.72	31.35	29.00
26	33.64	33.64	31.39	29.00
27	33.57	33.57	31.42	29.00
28	33.50	33.50	31.44	29.00
29	33.43	33.43	31.45	29.00
30	33.36	33.36	31.45	29.00
31	33.30	33.30	31.44	29.00
32	33.23	33.23	31.43	29.00
33	33.17	33.17	31.40	29.00
34	33.12	33.12	31.37	29.00
35	33.06	33.06	31.33	29.00
36	33.01	33.01	31.29	29.00
37	32.96	32.96	31.23	29.00
38	32.92	32.92	31.18	29.00
39	32.87	32.87	31.13	29.00
40	32.82	32.82	31.08	29.00
41	32.78	32.78	31.03	29.00
42	32.74	32.74	30.98	29.00
43	32.70	32.70	30.92	29.00
44	32.66	32.66	30.87	29.00
45	32.62	32.62	30.82	29.00
46	32.59	32.59	30.76	29.00
47	32.55	32.55	30.71	29.00

Table 4. Time-Step Elevation Data, 2-Year Storm

Time (hours)	Sediment Forebay Elevation (ft)	Detention Basin Elevation (ft)	Sand Filter Elevation (ft)	Effluent Clear Well Elevation (ft)
48	32.52	32.52	30.65	29.00
49	32.49	32.49	30.59	29.00
50	32.46	32.46	30.53	29.00
51	32.44	32.43	30.51	29.00
52	32.41	32.41	30.51	29.00
53	32.38	32.38	30.51	29.00
54	32.35	32.35	30.51	29.00
55	32.33	32.33	30.51	29.00
56	32.30	32.30	30.51	29.00
57	32.28	32.28	30.51	29.00
58	32.25	32.25	30.51	29.00
59	32.23	32.23	30.51	29.00
60	32.21	32.21	30.50	29.00
61	32.19	32.19	30.50	29.00
62	32.17	32.17	30.50	29.00
63	32.15	32.15	30.50	29.00
64	32.13	32.13	30.50	29.00
65	32.11	32.11	30.50	29.00
66	32.09	32.09	30.50	29.00
67	32.07	32.07	30.50	29.00
68	32.06	32.06	30.50	29.00
69	32.04	32.04	30.50	29.00
70	32.03	32.03	30.50	29.00
71	32.02	32.02	30.50	29.00
72	32.00	32.00	30.50	29.00
73	31.99	31.99	30.50	29.00
74	31.98	31.98	30.50	29.00
75	31.97	31.97	30.50	29.00
76	31.95	31.95	30.50	29.00
77	31.94	31.94	30.50	29.00
78	31.93	31.93	30.50	29.00
79	31.92	31.92	30.50	29.00
80	31.91	31.91	30.50	29.00
81	31.90	31.90	30.50	29.00
82	31.88	31.88	30.50	29.00
83	31.87	31.87	30.50	29.00
84	31.86	31.86	30.50	29.00
85	31.85	31.85	30.50	29.00
86	31.84	31.84	30.50	29.00
87	31.83	31.83	30.50	29.00
88	31.82	31.82	30.50	29.00
89	31.81	31.81	30.50	29.00
90	31.80	31.80	30.50	29.00
91	31.79	31.79	30.50	29.00
92	31.78	31.78	30.50	29.00
93	31.78	31.77	30.50	29.00
94	31.77	31.76	30.50	29.00
95	31.76	31.75	30.50	29.00

Table 4. Time-Step Elevation Data, 2-Year Storm

Time (hours)	Sediment Forebay Elevation (ft)	Detention Basin Elevation (ft)	Sand Filter Elevation (ft)	Effluent Clear Well Elevation (ft)
96	31.76	31.74	30.50	29.00
97	31.76	31.73	30.50	29.00
98	31.75	31.72	30.50	29.00
99	31.75	31.71	30.50	29.00
100	31.75	31.71	30.50	29.00
101	31.75	31.70	30.50	29.00
102	31.75	31.69	30.50	29.00
103	31.75	31.68	30.50	29.00
104	31.75	31.67	30.50	29.00
105	31.75	31.66	30.50	29.00
106	31.75	31.65	30.50	29.00
107	31.75	31.65	30.50	29.00
108	31.75	31.64	30.50	29.00
109	31.75	31.63	30.50	29.00
110	31.75	31.62	30.50	29.00
111	31.75	31.62	30.50	29.00
112	31.75	31.61	30.50	29.00
113	31.75	31.60	30.50	29.00
114	31.75	31.60	30.50	29.00
115	31.75	31.59	30.50	29.00
116	31.75	31.59	30.50	29.00
117	31.75	31.58	30.50	29.00
118	31.75	31.58	30.50	29.00
119	31.75	31.57	30.50	29.00
120	31.75	31.57	30.50	29.00
121	31.75	31.57	30.50	29.00
122	31.75	31.56	30.50	29.00
123	31.75	31.56	30.50	29.00
124	31.75	31.56	30.50	29.00
125	31.75	31.55	30.50	29.00
126	31.75	31.55	30.50	29.00
127	31.75	31.55	30.50	29.00
128	31.75	31.55	30.50	29.00
129	31.75	31.54	30.50	29.00
130	31.75	31.54	30.50	29.00
131	31.75	31.54	30.50	29.00
132	31.75	31.54	30.50	29.00
133	31.75	31.54	30.50	29.00
134	31.75	31.54	30.50	29.00
135	31.75	31.54	30.50	29.00
136	31.75	31.53	30.50	29.00
137	31.75	31.53	30.50	29.00
138	31.75	31.53	30.50	29.00
139	31.75	31.53	30.50	29.00
140	31.75	31.53	30.50	29.00
141	31.75	31.53	30.50	29.00
142	31.75	31.53	30.50	29.00
143	31.75	31.53	30.50	29.00

Table 4. Time-Step Elevation Data, 2-Year Storm

Time (hours)	Sediment Forebay Elevation (ft)	Detention Basin Elevation (ft)	Sand Filter Elevation (ft)	Effluent Clear Well Elevation (ft)
144	31.75	31.53	30.50	29.00
145	31.75	31.53	30.50	29.00
146	31.75	31.52	30.50	29.00
147	31.75	31.52	30.50	29.00
148	31.75	31.52	30.50	29.00
149	31.75	31.52	30.50	29.00
150	31.75	31.52	30.50	29.00
151	31.75	31.52	30.50	29.00
152	31.75	31.52	30.50	29.00
153	31.75	31.52	30.50	29.00
154	31.75	31.52	30.50	29.00
155	31.75	31.52	30.50	29.00
156	31.75	31.52	30.50	29.00

Note:
All elevations in ft NAVD88.

Table 5. Time-Step Elevation Data, 25-Year Storm

Time (hours)	Sediment Forebay Elevation (ft)	Detention Basin Elevation (ft)	Sand Filter Elevation (ft)	Effluent Clear Well Elevation (ft)
0	30.00	30.00	30.50	29.00
1	30.00	30.00	30.50	29.00
2	30.03	30.00	30.50	29.00
3	30.45	30.00	30.50	29.00
4	31.27	30.00	30.50	29.00
5	32.13	30.09	30.50	29.00
6	32.30	30.52	30.50	29.00
7	32.43	31.14	30.50	29.00
8	33.25	32.17	30.54	29.00
9	33.62	33.58	30.66	29.00
10	33.99	33.98	31.12	29.00
11	34.06	34.06	32.19	29.00
12	34.07	34.07	33.19	29.00
13	34.10	34.09	33.91	29.00
14	34.23	34.22	34.12	29.00
15	34.36	34.35	34.25	29.00
16	34.47	34.47	34.37	29.00
17	34.58	34.58	34.48	29.00
18	34.67	34.67	34.57	29.00
19	34.75	34.75	34.65	29.00
20	34.82	34.82	34.72	29.00
21	34.87	34.87	34.78	29.00
22	34.92	34.92	34.82	29.00
23	34.95	34.95	34.86	29.00
24	34.98	34.98	34.88	29.00
25	34.89	34.89	34.83	29.00
26	34.77	34.77	34.72	29.00
27	34.66	34.66	34.61	29.00
28	34.55	34.55	34.50	29.00
29	34.44	34.44	34.39	29.00
30	34.33	34.33	34.29	29.00
31	34.23	34.23	34.18	29.00
32	34.12	34.12	34.08	29.00
33	34.02	34.02	33.98	29.00
34	33.92	33.92	33.88	29.00
35	33.83	33.83	33.73	29.00
36	33.78	33.78	33.47	29.00
37	33.73	33.73	33.21	29.00
38	33.68	33.68	33.00	29.00
39	33.63	33.63	32.82	29.00
40	33.57	33.57	32.66	29.00
41	33.51	33.51	32.53	29.00
42	33.45	33.45	32.41	29.00
43	33.39	33.39	32.29	29.00
44	33.33	33.33	32.19	29.00
45	33.27	33.27	32.09	29.00
46	33.21	33.21	32.00	29.00
47	33.16	33.16	31.91	29.00

Table 5. Time-Step Elevation Data, 25-Year Storm

Time (hours)	Sediment Forebay Elevation (ft)	Detention Basin Elevation (ft)	Sand Filter Elevation (ft)	Effluent Clear Well Elevation (ft)
48	33.10	33.10	31.82	29.00
49	33.05	33.05	31.74	29.00
50	33.00	33.00	31.64	29.00
51	32.95	32.95	31.56	29.00
52	32.91	32.91	31.47	29.00
53	32.86	32.86	31.40	29.00
54	32.82	32.82	31.32	29.00
55	32.77	32.77	31.24	29.00
56	32.73	32.73	31.17	29.00
57	32.69	32.69	31.10	29.00
58	32.65	32.65	31.03	29.00
59	32.61	32.61	30.96	29.00
60	32.58	32.58	30.89	29.00
61	32.55	32.55	30.82	29.00
62	32.52	32.52	30.75	29.00
63	32.49	32.49	30.68	29.00
64	32.46	32.46	30.62	29.00
65	32.43	32.43	30.56	29.00
66	32.40	32.40	30.51	29.00
67	32.37	32.37	30.51	29.00
68	32.35	32.35	30.51	29.00
69	32.32	32.32	30.51	29.00
70	32.30	32.30	30.51	29.00
71	32.27	32.27	30.51	29.00
72	32.25	32.25	30.51	29.00
73	32.23	32.23	30.51	29.00
74	32.20	32.20	30.50	29.00
75	32.18	32.18	30.50	29.00
76	32.16	32.16	30.50	29.00
77	32.14	32.14	30.50	29.00
78	32.12	32.12	30.50	29.00
79	32.10	32.10	30.50	29.00
80	32.09	32.09	30.50	29.00
81	32.07	32.07	30.50	29.00
82	32.05	32.05	30.50	29.00
83	32.04	32.04	30.50	29.00
84	32.03	32.03	30.50	29.00
85	32.01	32.01	30.50	29.00
86	32.00	32.00	30.50	29.00
87	31.99	31.99	30.50	29.00
88	31.98	31.98	30.50	29.00
89	31.96	31.96	30.50	29.00
90	31.95	31.95	30.50	29.00
91	31.94	31.94	30.50	29.00
92	31.93	31.93	30.50	29.00
93	31.92	31.92	30.50	29.00
94	31.90	31.90	30.50	29.00
95	31.89	31.89	30.50	29.00

Table 5. Time-Step Elevation Data, 25-Year Storm

Time (hours)	Sediment Forebay Elevation (ft)	Detention Basin Elevation (ft)	Sand Filter Elevation (ft)	Effluent Clear Well Elevation (ft)
96	31.88	31.88	30.50	29.00
97	31.87	31.87	30.50	29.00
98	31.86	31.86	30.50	29.00
99	31.85	31.85	30.50	29.00
100	31.84	31.84	30.50	29.00
101	31.83	31.83	30.50	29.00
102	31.82	31.82	30.50	29.00
103	31.81	31.81	30.50	29.00
104	31.80	31.80	30.50	29.00
105	31.79	31.79	30.50	29.00
106	31.78	31.78	30.50	29.00
107	31.77	31.77	30.50	29.00
108	31.77	31.76	30.50	29.00
109	31.76	31.75	30.50	29.00
110	31.76	31.74	30.50	29.00
111	31.76	31.73	30.50	29.00
112	31.75	31.72	30.50	29.00
113	31.75	31.71	30.50	29.00
114	31.75	31.70	30.50	29.00
115	31.75	31.69	30.50	29.00
116	31.75	31.68	30.50	29.00
117	31.75	31.68	30.50	29.00
118	31.75	31.67	30.50	29.00
119	31.75	31.66	30.50	29.00
120	31.75	31.65	30.50	29.00
121	31.75	31.64	30.50	29.00
122	31.75	31.64	30.50	29.00
123	31.75	31.63	30.50	29.00
124	31.75	31.62	30.50	29.00
125	31.75	31.62	30.50	29.00
126	31.75	31.61	30.50	29.00
127	31.75	31.60	30.50	29.00
127.1	31.75	31.60	30.50	29.00
128	31.75	31.60	30.50	29.00
129	31.75	31.59	30.50	29.00
130	31.75	31.59	30.50	29.00
131	31.75	31.58	30.50	29.00
132	31.75	31.58	30.50	29.00
133	31.75	31.57	30.50	29.00
134	31.75	31.57	30.50	29.00
135	31.75	31.57	30.50	29.00
136	31.75	31.56	30.50	29.00
137	31.75	31.56	30.50	29.00
138	31.75	31.56	30.50	29.00
139	31.75	31.55	30.50	29.00
140	31.75	31.55	30.50	29.00
141	31.75	31.55	30.50	29.00
142	31.75	31.55	30.50	29.00

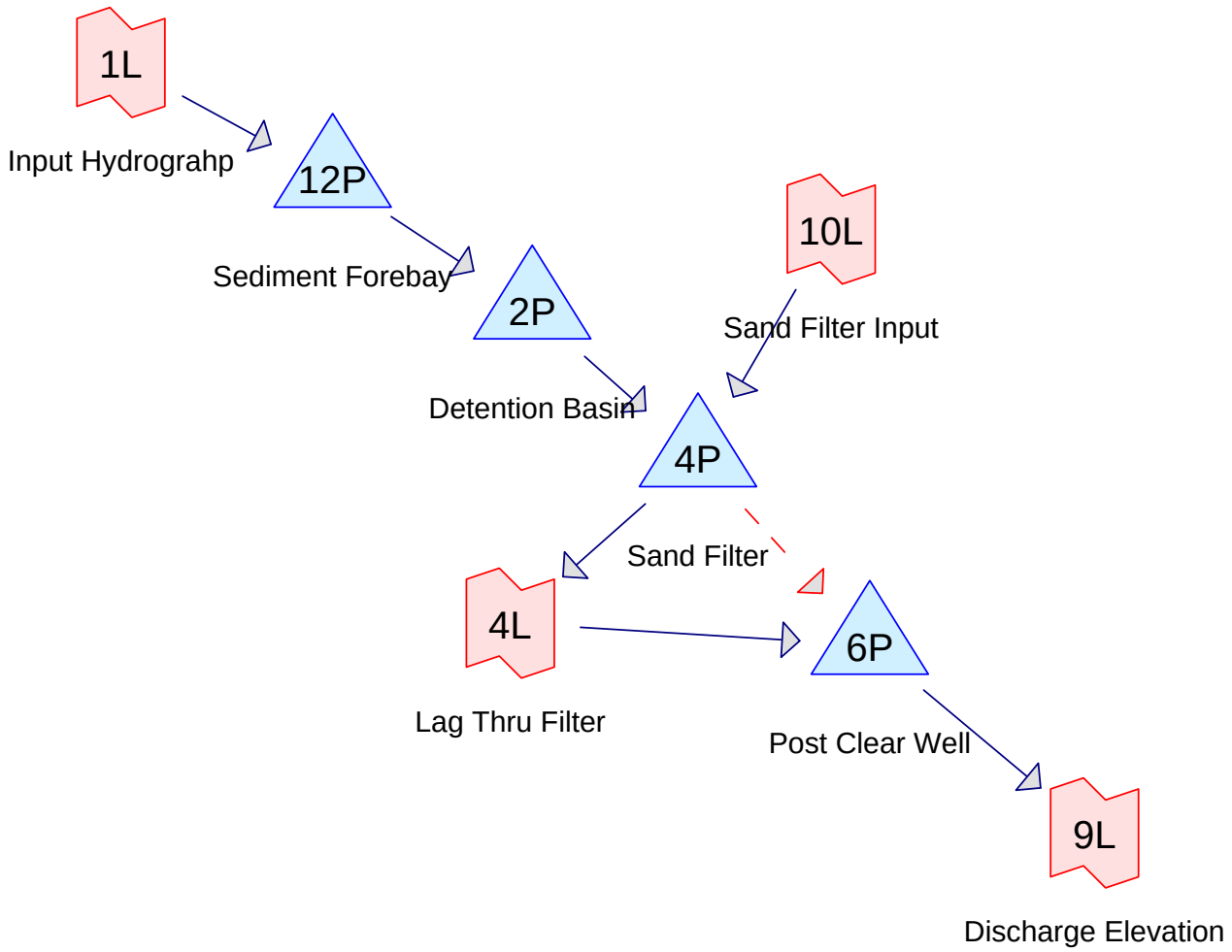
Table 5. Time-Step Elevation Data, 25-Year Storm

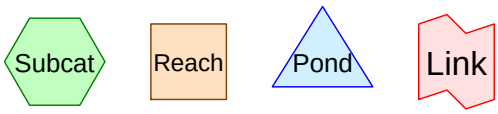
Time (hours)	Sediment Forebay Elevation (ft)	Detention Basin Elevation (ft)	Sand Filter Elevation (ft)	Effluent Clear Well Elevation (ft)
143	31.75	31.54	30.50	29.00
144	31.75	31.54	30.50	29.00
145	31.75	31.54	30.50	29.00
146	31.75	31.54	30.50	29.00
147	31.75	31.54	30.50	29.00
148	31.75	31.54	30.50	29.00
149	31.75	31.53	30.50	29.00
150	31.75	31.53	30.50	29.00
151	31.75	31.53	30.50	29.00
152	31.75	31.53	30.50	29.00
153	31.75	31.53	30.50	29.00
154	31.75	31.53	30.50	29.00
155	31.75	31.53	30.50	29.00
156	31.75	31.53	30.50	29.00

Note:
All elevations in ft NAVD88.

ATTACHMENT A

HYDROCAD MODEL REPORTS





Drainage Diagram for 2-Year Model
Prepared by Integral Consulting Inc., Printed 9/28/2011
HydroCAD® 9.10 s/n 06683 © 2010 HydroCAD Software Solutions LLC

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Fill (inches)
1	2P	31.00	29.45	310.0	0.0050	0.013	24.0	0.0	0.0
2	4P	28.76	28.00	152.0	0.0050	0.011	4.0	0.0	0.0
3	6P	28.00	27.22	156.0	0.0050	0.013	24.0	0.0	0.0

Time span=0.00-156.00 hrs, dt=0.02 hrs, 7801 points x 3
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Pond 2P: Detention Basin Peak Elev=33.77' Storage=3.476 af Inflow=14.36 cfs 5.169 af
Outflow=1.35 cfs 3.871 af

Pond 4P: Sand Filter Peak Elev=31.45' Storage=0.349 af Inflow=1.35 cfs 4.040 af
Primary=1.06 cfs 4.040 af Secondary=0.00 cfs 0.000 af Outflow=1.06 cfs 4.040 af

Pond 6P: Post Clear Well Peak Elev=29.00' Storage=0.000 af Inflow=1.06 cfs 4.038 af
24.0" Round Culvert n=0.013 L=156.0' S=0.0050 '/' Outflow=1.06 cfs 4.038 af

Pond 12P: Sediment Forebay Peak Elev=33.77' Storage=0.940 af Inflow=15.72 cfs 5.555 af
Outflow=14.36 cfs 5.169 af

Link 1L: Input Hydrograhp Flow Rate Imported from 2-Year Input.csv Inflow=15.72 cfs 5.555 af
Primary=15.72 cfs 5.555 af

Link 4L: Lag Thru Filter delayed by 206.0 min Inflow=1.06 cfs 4.040 af
Primary=1.06 cfs 4.038 af

Link 9L: Discharge Elevation Inflow=1.06 cfs 4.038 af
Primary=1.06 cfs 4.038 af

Link 10L: Sand Filter Input Flow Rate Imported from 2-YEAR SAND FILTER.csv Inflow=0.55 cfs 0.169 af
Primary=0.55 cfs 0.169 af

Summary for Pond 2P: Detention Basin

Inflow	=	14.36 cfs @	8.22 hrs,	Volume=	5.169 af
Outflow	=	1.35 cfs @	24.13 hrs,	Volume=	3.871 af, Atten= 91%, Lag= 954.6 min
Primary	=	1.35 cfs @	24.13 hrs,	Volume=	3.871 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 33.77' @ 24.13 hrs Surf.Area= 0.000 ac Storage= 3.476 af

Plug-Flow detention time= 1,795.9 min calculated for 3.871 af (75% of inflow)
Center-of-Mass det. time= 1,487.4 min (2,476.3 - 988.9)

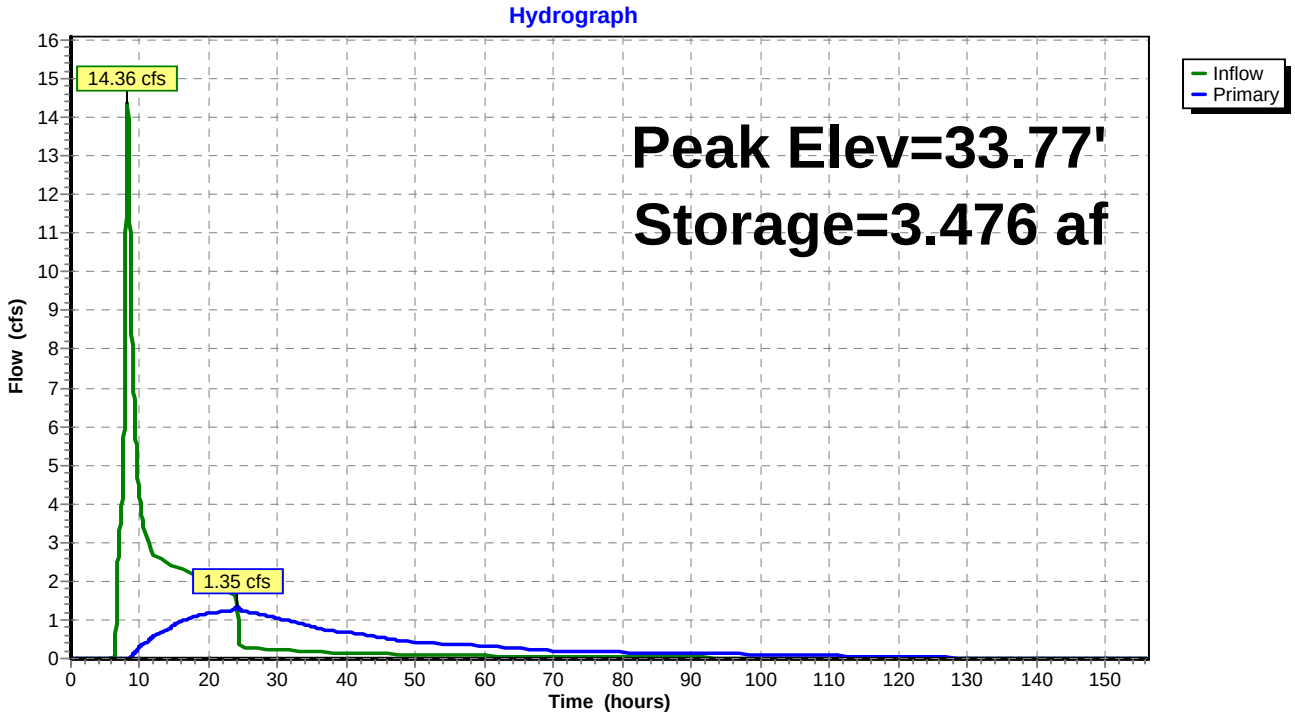
Volume	Invert	Avail.Storage	Storage Description
#1	30.00'	6.558 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
30.00	0.000
30.25	0.204
30.50	0.412
31.00	0.839
31.50	1.280
32.00	1.736
32.50	2.207
33.00	2.694
33.50	3.196
34.00	3.715
34.50	4.250
35.00	4.801
35.50	5.370
36.00	5.955
36.50	6.558

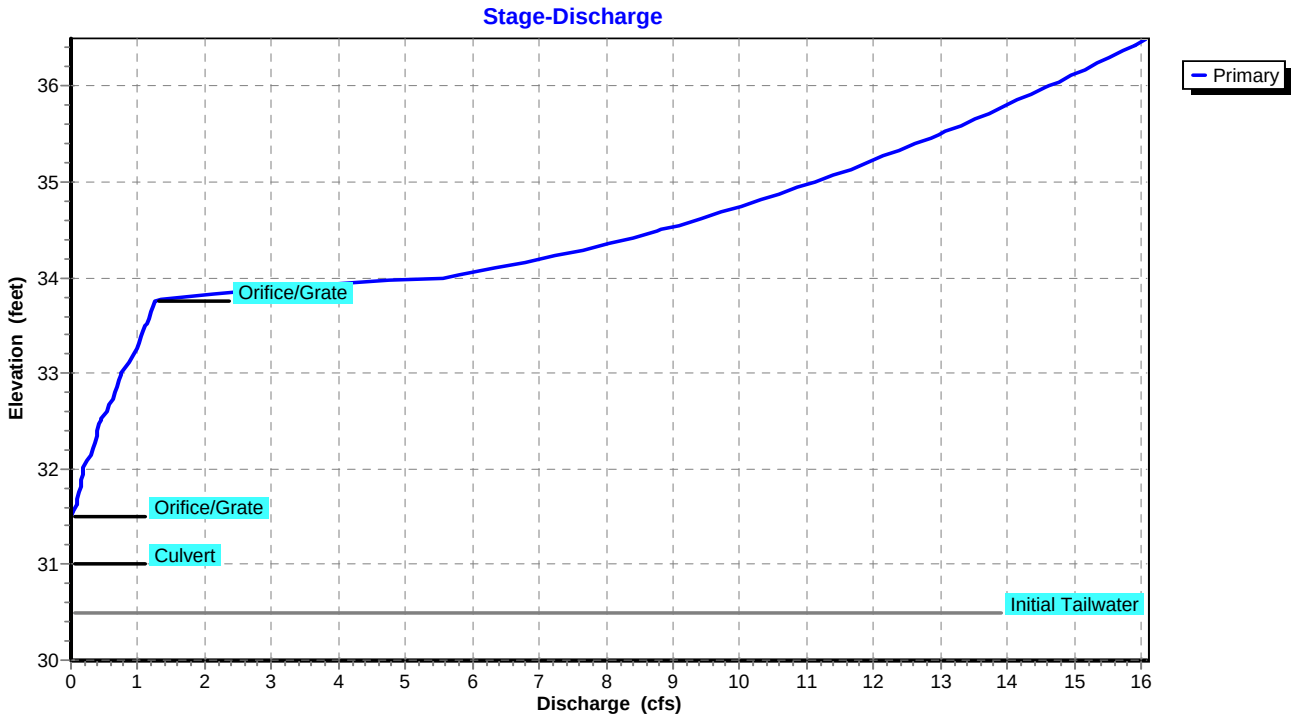
Device	Routing	Invert	Outlet Devices
#1	Device 3	31.50'	**1.0" Vert. Orifice/Grate X 10.00 columns** X 4 rows with 6.0" cc spacing C= 0.600
#2	Device 3	33.75'	**8.0" Horiz. Orifice/Grate X 5.00** C= 0.600 Limited to weir flow at low heads
#3	Primary	31.00'	**24.0" Round Culvert** L= 310.0' CPP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 31.00' / 29.45' S= 0.0050 '/' Cc= 0.500 n= 0.013

Primary OutFlow Max=1.35 cfs @ 24.13 hrs HW=33.77' TW=31.30' (Dynamic Tailwater)
└─**3=Culvert** (Passes 1.35 cfs of 11.18 cfs potential flow)
  ├─**1=Orifice/Grate** (Orifice Controls 1.25 cfs @ 5.74 fps)
  └─**2=Orifice/Grate** (Weir Controls 0.10 cfs @ 0.46 fps)

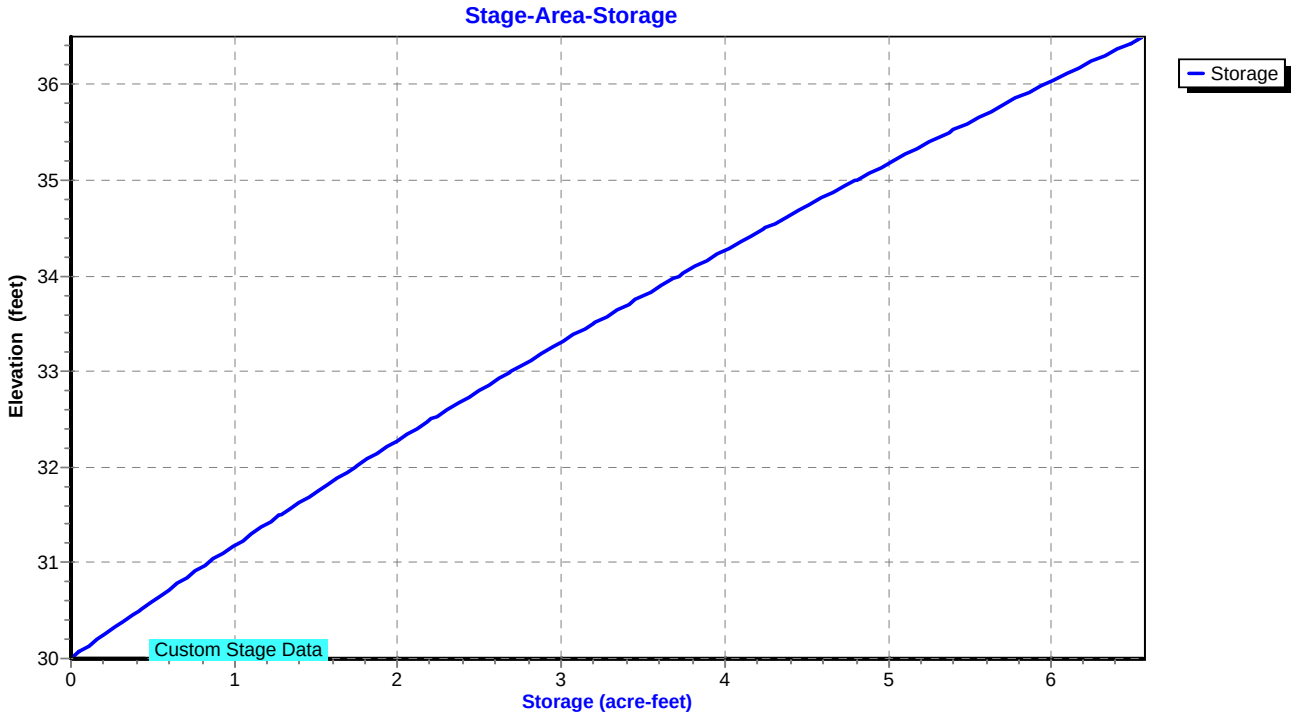
Pond 2P: Detention Basin



Pond 2P: Detention Basin



Pond 2P: Detention Basin



Hydrograph for Pond 2P: Detention Basin

Time (hours)	Inflow (cfs)	Storage (acre-feet)	Elevation (feet)	Primary (cfs)
0.00	0.00	0.000	30.00	0.00
4.00	0.00	0.000	30.00	0.00
8.00	**11.86**	0.541	30.65	0.00
12.00	**2.66**	2.370	32.67	0.58
16.00	2.31	2.932	33.24	0.96
20.00	1.97	3.286	33.59	1.16
24.00	1.62	**3.474**	**33.77**	**1.34**
28.00	0.25	**3.196**	**33.50**	**1.12**
32.00	0.22	2.929	33.23	0.96
36.00	0.17	2.707	33.01	0.76
40.00	0.15	2.522	32.82	0.67
44.00	0.13	2.362	32.66	0.57
48.00	0.10	2.229	32.52	0.45
52.00	0.09	2.119	32.41	0.40
56.00	0.08	2.021	32.30	0.36
60.00	0.07	1.932	32.21	0.32
64.00	0.06	1.855	32.13	0.28
68.00	0.05	1.790	32.06	0.22
72.00	0.04	1.740	32.00	0.18
76.00	0.03	1.694	31.95	0.17
80.00	0.03	1.651	31.91	0.16
84.00	0.03	1.611	31.86	0.15
88.00	0.03	1.573	31.82	0.14
92.00	0.02	1.538	31.78	0.13
96.00	0.01	1.503	31.74	0.12
100.00	0.00	1.467	31.71	0.11
104.00	0.00	1.434	31.67	0.09
108.00	0.00	1.406	31.64	0.08
112.00	0.00	1.381	31.61	0.07
116.00	0.00	1.360	31.59	0.06
120.00	0.00	1.343	31.57	0.04
124.00	0.00	1.331	31.56	0.03
128.00	0.00	1.322	31.55	0.02
132.00	0.00	1.316	31.54	0.02
136.00	0.00	1.311	31.53	0.01
140.00	0.00	1.307	31.53	0.01
144.00	0.00	1.304	31.53	0.01
148.00	0.00	1.302	31.52	0.01
152.00	0.00	1.300	31.52	0.01
156.00	0.00	1.298	31.52	0.00

Stage-Discharge for Pond 2P: Detention Basin

Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)
30.00	0.00	32.12	0.27	34.24	7.33	36.36	15.69
30.04	0.00	32.16	0.30	34.28	7.58	36.40	15.80
30.08	0.00	32.20	0.32	34.32	7.83	36.44	15.92
30.12	0.00	32.24	0.34	34.36	8.06	36.48	**16.03**
30.16	0.00	32.28	0.35	34.40	8.29		
30.20	0.00	32.32	0.37	34.44	8.51		
30.24	0.00	32.36	0.39	34.48	8.72		
30.28	0.00	32.40	0.40	34.52	8.93		
30.32	0.00	32.44	0.41	34.56	9.13		
30.36	0.00	32.48	0.43	34.60	9.33		
30.40	0.00	32.52	0.45	34.64	9.53		
30.44	0.00	32.56	0.49	34.68	9.72		
30.48	0.00	32.60	0.53	34.72	9.90		
30.52	0.00	32.64	0.56	34.76	10.09		
30.56	0.00	32.68	0.59	34.80	10.26		
30.60	0.00	32.72	0.61	34.84	10.44		
30.64	0.00	32.76	0.64	34.88	10.61		
30.68	0.00	32.80	0.66	34.92	10.78		
30.72	0.00	32.84	0.68	34.96	10.95		
30.76	0.00	32.88	0.70	35.00	11.11		
30.80	0.00	32.92	0.72	35.04	11.28		
30.84	0.00	32.96	0.73	35.08	11.44		
30.88	0.00	33.00	0.75	35.12	11.59		
30.92	0.00	33.04	0.79	35.16	11.75		
30.96	0.00	33.08	0.84	35.20	11.90		
31.00	0.00	33.12	0.88	35.24	12.05		
31.04	0.00	33.16	0.91	35.28	12.20		
31.08	0.00	33.20	0.94	35.32	12.35		
31.12	0.00	33.24	0.97	35.36	12.50		
31.16	0.00	33.28	0.99	35.40	12.64		
31.20	0.00	33.32	1.02	35.44	12.78		
31.24	0.00	33.36	1.04	35.48	12.92		
31.28	0.00	33.40	1.06	35.52	13.06		
31.32	0.00	33.44	1.09	35.56	13.20		
31.36	0.00	33.48	1.11	35.60	13.33		
31.40	0.00	33.52	1.13	35.64	13.47		
31.44	0.00	33.56	1.15	35.68	13.60		
31.48	0.00	33.60	1.17	35.72	13.73		
31.52	0.00	33.64	1.19	35.76	13.86		
31.56	0.04	33.68	1.21	35.80	13.99		
31.60	0.06	33.72	1.23	35.84	14.12		
31.64	0.08	33.76	1.28	35.88	14.25		
31.68	0.10	33.80	1.65	35.92	14.37		
31.72	0.11	33.84	2.21	35.96	14.50		
31.76	0.12	33.88	2.91	36.00	14.62		
31.80	0.13	33.92	3.72	36.04	14.75		
31.84	0.14	33.96	4.63	36.08	14.87		
31.88	0.15	34.00	5.56	36.12	14.99		
31.92	0.16	34.04	5.90	36.16	15.11		
31.96	0.17	34.08	6.21	36.20	15.23		
32.00	0.18	34.12	6.51	36.24	15.34		
32.04	0.20	34.16	6.80	36.28	15.46		
32.08	0.24	34.20	7.07	36.32	15.58		

Stage-Area-Storage for Pond 2P: Detention Basin

Elevation (feet)	Storage (acre-feet)
30.00	0.000
30.10	0.082
30.20	0.163
30.30	0.246
30.40	0.329
30.50	0.412
30.60	0.497
30.70	0.583
30.80	0.668
30.90	0.754
31.00	0.839
31.10	0.927
31.20	1.015
31.30	1.104
31.40	1.192
31.50	1.280
31.60	1.371
31.70	1.462
31.80	1.554
31.90	1.645
32.00	1.736
32.10	1.830
32.20	1.924
32.30	2.019
32.40	2.113
32.50	2.207
32.60	2.304
32.70	2.402
32.80	2.499
32.90	2.597
33.00	2.694
33.10	2.794
33.20	2.895
33.30	2.995
33.40	3.096
33.50	3.196
33.60	3.300
33.70	3.404
33.80	3.507
33.90	3.611
34.00	3.715
34.10	3.822
34.20	3.929
34.30	4.036
34.40	4.143
34.50	4.250
34.60	4.360
34.70	4.470
34.80	4.581
34.90	4.691
35.00	4.801
35.10	4.915
35.20	5.029
35.30	5.142
35.40	5.256
35.50	5.370
35.60	5.487
35.70	5.604
35.80	5.721
35.90	5.838
36.00	5.955
36.10	6.076
36.20	6.196
36.30	6.317
36.40	6.437
36.50	**6.558**

Summary for Pond 4P: Sand Filter

NOTE:

Influent Clear Well not modeled.

Storage in Sand Filter not modeled, flow modeled as lag.

Inflow	=	1.35 cfs @	24.13 hrs,	Volume=	4.040 af
Outflow	=	1.06 cfs @	29.58 hrs,	Volume=	4.040 af, Atten= 22%, Lag= 326.7 min
Primary	=	1.06 cfs @	29.58 hrs,	Volume=	4.040 af
Secondary	=	0.00 cfs @	0.00 hrs,	Volume=	0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 31.45' @ 29.58 hrs Surf.Area= 0.367 ac Storage= 0.349 af

Plug-Flow detention time= 114.6 min calculated for 4.040 af (100% of inflow)
Center-of-Mass det. time= 114.5 min (2,515.0 - 2,400.5)

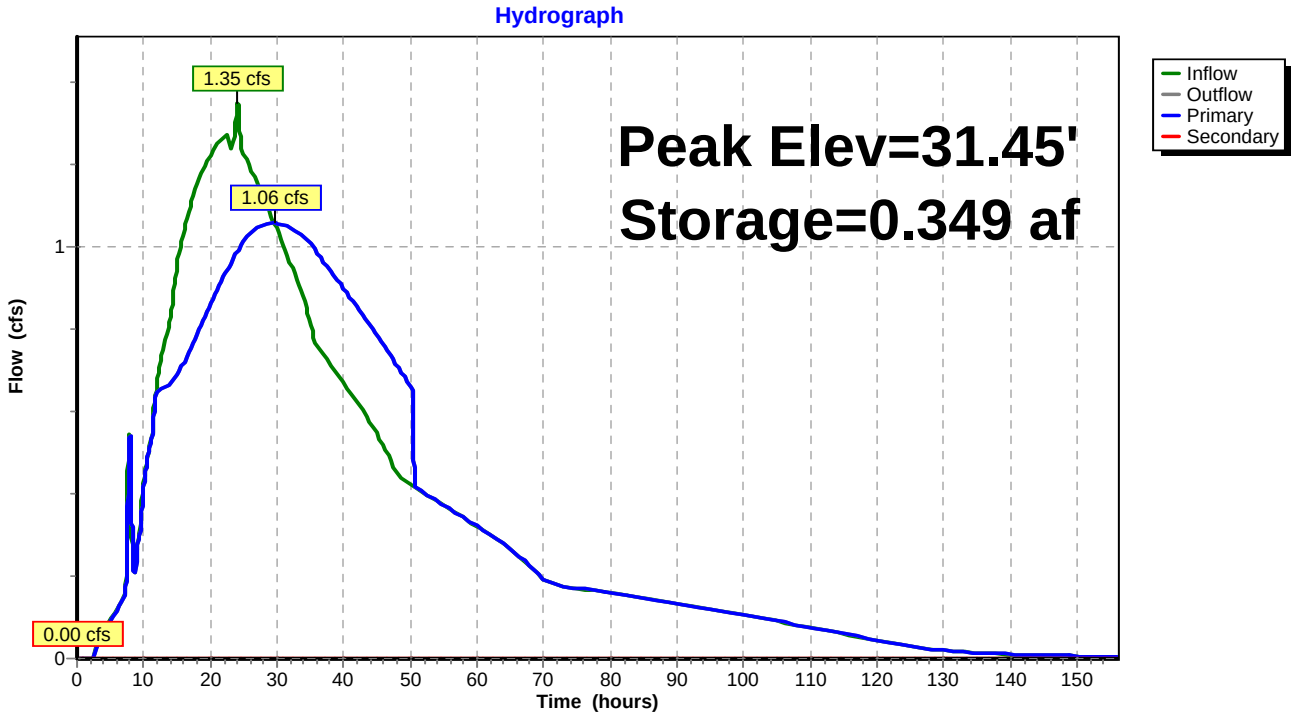
Volume	Invert	Avail.Storage	Storage Description
#1	30.50'	2.204 af	**100.00'W x 160.00'L x 6.00'H Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Secondary	35.25'	**130.0' long x 2.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 Coef. (English) 2.48 2.60 2.60 2.60 2.64 2.65 2.68 2.75 2.74 2.76 2.89 3.05 3.19 3.32
#2	Device 3	30.50'	**1.750 in/hr Exfiltration over Horizontal area** Conductivity to Groundwater Elevation = 29.00' Phase-In= 0.01'
#3	Device 4	29.00'	**0.3" Horiz. Orifice/Grate X 8.00 columns** X 150 rows C= 0.600
#4	Primary	28.76'	**4.0" Round Culvert X 8.00** L= 152.0' Ke= 0.900 Inlet / Outlet Invert= 28.76' / 28.00' S= 0.0050 '/' Cc= 0.500 n= 0.011

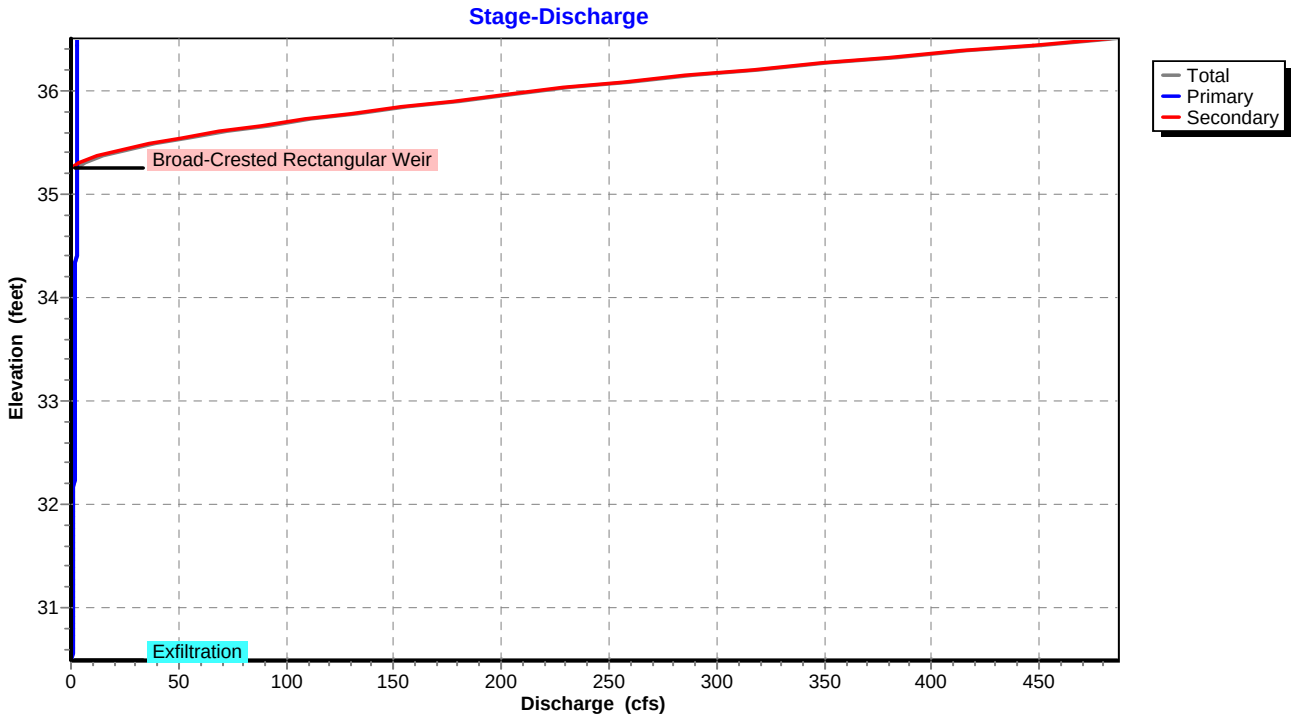
Primary OutFlow Max=1.06 cfs @ 29.58 hrs HW=31.45' TW=0.00' (Dynamic Tailwater)
└─**4=Culvert** (Passes 1.06 cfs of 2.34 cfs potential flow)
  └─**3=Orifice/Grate** (Passes 1.06 cfs of 4.44 cfs potential flow)
    └─**2=Exfiltration** (Controls 1.06 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=30.50' TW=29.00' (Dynamic Tailwater)
└─**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

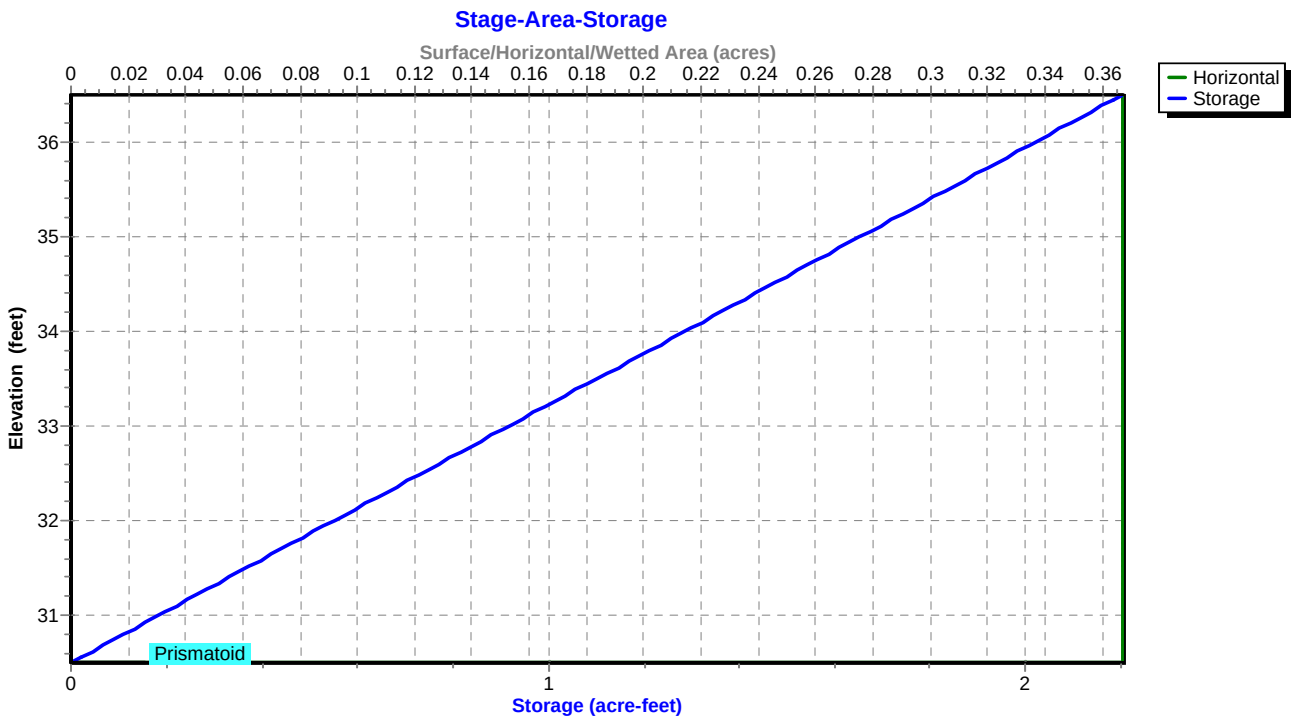
Pond 4P: Sand Filter



Pond 4P: Sand Filter



Pond 4P: Sand Filter



Hydrograph for Pond 4P: Sand Filter

Time (hours)	Inflow (cfs)	Storage (acre-feet)	Elevation (feet)	Outflow (cfs)	Primary (cfs)	Secondary (cfs)
0.00	0.00	0.000	30.50	0.00	0.00	**0.00**
4.00	0.07	0.000	30.50	0.07	0.07	0.00
8.00	0.53	0.003	30.51	0.54	0.54	0.00
12.00	0.67	0.004	30.51	0.65	0.65	0.00
16.00	1.03	0.061	30.67	0.72	0.72	0.00
20.00	1.22	0.179	30.99	0.86	0.86	0.00
24.00	**1.34**	0.288	31.28	0.99	0.99	0.00
28.00	**1.12**	**0.345**	**31.44**	**1.05**	**1.05**	0.00
32.00	0.96	**0.340**	**31.43**	**1.05**	**1.05**	0.00
36.00	0.76	0.289	31.29	0.99	0.99	0.00
40.00	0.67	0.213	31.08	0.90	0.90	0.00
44.00	0.57	0.136	30.87	0.81	0.81	0.00
48.00	0.45	0.054	30.65	0.71	0.71	0.00
52.00	0.40	0.002	30.51	0.40	0.40	0.00
56.00	0.36	0.002	30.51	0.36	0.36	0.00
60.00	0.32	0.002	30.50	0.32	0.32	0.00
64.00	0.28	0.002	30.50	0.28	0.28	0.00
68.00	0.22	0.001	30.50	0.22	0.22	0.00
72.00	0.18	0.001	30.50	0.18	0.18	0.00
76.00	0.17	0.001	30.50	0.17	0.17	0.00
80.00	0.16	0.001	30.50	0.16	0.16	0.00
84.00	0.15	0.001	30.50	0.15	0.15	0.00
88.00	0.14	0.001	30.50	0.14	0.14	0.00
92.00	0.13	0.001	30.50	0.13	0.13	0.00
96.00	0.12	0.001	30.50	0.12	0.12	0.00
100.00	0.11	0.001	30.50	0.11	0.11	0.00
104.00	0.09	0.001	30.50	0.09	0.09	0.00
108.00	0.08	0.000	30.50	0.08	0.08	0.00
112.00	0.07	0.000	30.50	0.07	0.07	0.00
116.00	0.06	0.000	30.50	0.06	0.06	0.00
120.00	0.04	0.000	30.50	0.04	0.04	0.00
124.00	0.03	0.000	30.50	0.03	0.03	0.00
128.00	0.02	0.000	30.50	0.02	0.02	0.00
132.00	0.02	0.000	30.50	0.02	0.02	0.00
136.00	0.01	0.000	30.50	0.01	0.01	0.00
140.00	0.01	0.000	30.50	0.01	0.01	0.00
144.00	0.01	0.000	30.50	0.01	0.01	0.00
148.00	0.01	0.000	30.50	0.01	0.01	0.00
152.00	0.01	0.000	30.50	0.01	0.01	0.00
156.00	0.00	0.000	30.50	0.00	0.00	0.00

Stage-Discharge for Pond 4P: Sand Filter

Elevation (feet)	Discharge (cfs)	Primary (cfs)	Secondary (cfs)
30.50	0.00	0.00	0.00
30.60	0.69	0.69	0.00
30.70	0.73	0.73	0.00
30.80	0.78	0.78	0.00
30.90	0.82	0.82	0.00
31.00	0.86	0.86	0.00
31.10	0.91	0.91	0.00
31.20	0.95	0.95	0.00
31.30	0.99	0.99	0.00
31.40	1.04	1.04	0.00
31.50	1.08	1.08	0.00
31.60	1.12	1.12	0.00
31.70	1.17	1.17	0.00
31.80	1.21	1.21	0.00
31.90	1.25	1.25	0.00
32.00	1.30	1.30	0.00
32.10	1.34	1.34	0.00
32.20	1.38	1.38	0.00
32.30	1.43	1.43	0.00
32.40	1.47	1.47	0.00
32.50	1.51	1.51	0.00
32.60	1.56	1.56	0.00
32.70	1.60	1.60	0.00
32.80	1.64	1.64	0.00
32.90	1.69	1.69	0.00
33.00	1.73	1.73	0.00
33.10	1.77	1.77	0.00
33.20	1.81	1.81	0.00
33.30	1.86	1.86	0.00
33.40	1.90	1.90	0.00
33.50	1.94	1.94	0.00
33.60	1.99	1.99	0.00
33.70	2.03	2.03	0.00
33.80	2.07	2.07	0.00
33.90	2.12	2.12	0.00
34.00	2.16	2.16	0.00
34.10	2.20	2.20	0.00
34.20	2.25	2.25	0.00
34.30	2.29	2.29	0.00
34.40	2.33	2.33	0.00
34.50	2.38	2.38	0.00
34.60	2.42	2.42	0.00
34.70	2.46	2.46	0.00
34.80	2.51	2.51	0.00
34.90	2.55	2.55	0.00
35.00	2.59	2.59	0.00
35.10	2.64	2.64	0.00
35.20	2.68	2.68	0.00
35.30	6.33	2.72	3.60
35.40	21.50	2.77	18.73
35.50	43.60	2.81	40.79
35.60	72.03	2.85	69.18
35.70	104.93	2.90	102.03
35.80	140.81	2.94	137.87
35.90	180.11	2.98	177.13
36.00	222.56	3.02	219.54
36.10	268.96	3.07	265.90
36.20	319.69	3.11	316.58
36.30	372.76	3.15	369.61
36.40	427.65	3.20	424.45
36.50	**486.06**	**3.24**	**482.82**

Stage-Area-Storage for Pond 4P: Sand Filter

Elevation (feet)	Horizontal (acres)	Storage (acre-feet)
30.50	**0.367**	0.000
30.60	0.367	0.037
30.70	0.367	0.073
30.80	0.367	0.110
30.90	0.367	0.147
31.00	0.367	0.184
31.10	0.367	0.220
31.20	0.367	0.257
31.30	0.367	0.294
31.40	0.367	0.331
31.50	0.367	0.367
31.60	0.367	0.404
31.70	0.367	0.441
31.80	0.367	0.478
31.90	0.367	0.514
32.00	0.367	0.551
32.10	0.367	0.588
32.20	0.367	0.624
32.30	0.367	0.661
32.40	0.367	0.698
32.50	0.367	0.735
32.60	0.367	0.771
32.70	0.367	0.808
32.80	0.367	0.845
32.90	0.367	0.882
33.00	0.367	0.918
33.10	0.367	0.955
33.20	0.367	0.992
33.30	0.367	1.028
33.40	0.367	1.065
33.50	0.367	1.102
33.60	0.367	1.139
33.70	0.367	1.175
33.80	0.367	1.212
33.90	0.367	1.249
34.00	0.367	1.286
34.10	0.367	1.322
34.20	0.367	1.359
34.30	0.367	1.396
34.40	0.367	1.433
34.50	0.367	1.469
34.60	0.367	1.506
34.70	0.367	1.543
34.80	0.367	1.579
34.90	0.367	1.616
35.00	0.367	1.653
35.10	0.367	1.690
35.20	0.367	1.726
35.30	0.367	1.763
35.40	0.367	1.800
35.50	0.367	1.837
35.60	0.367	1.873
35.70	0.367	1.910
35.80	0.367	1.947
35.90	0.367	1.983
36.00	0.367	2.020
36.10	0.367	2.057
36.20	0.367	2.094
36.30	0.367	2.130
36.40	0.367	2.167
36.50	0.367	**2.204**

Summary for Pond 6P: Post Clear Well

Inflow	=	1.06 cfs @	33.01 hrs,	Volume=	4.038 af
Outflow	=	1.06 cfs @	33.01 hrs,	Volume=	4.038 af, Atten= 0%, Lag= 0.0 min
Primary	=	1.06 cfs @	33.01 hrs,	Volume=	4.038 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 29.00' @ 30.86 hrs Surf.Area= 0.000 ac Storage= 0.000 af

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 0.0 min (2,718.6 - 2,718.6)

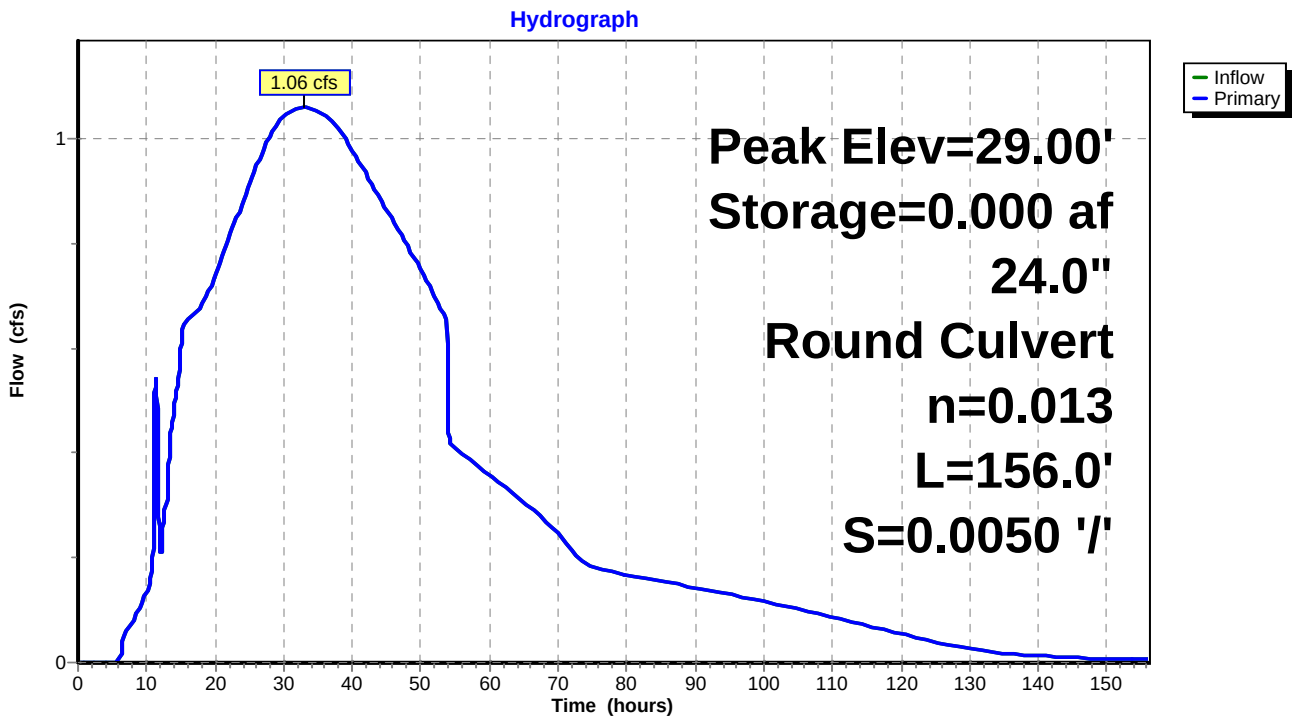
Volume	Invert	Avail.Storage	Storage Description
#1	29.00'	0.549 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
29.00	0.000
29.50	0.014
30.00	0.031
30.50	0.051
31.00	0.074
31.50	0.101
32.00	0.132
32.50	0.166
33.00	0.206
33.50	0.250
34.00	0.298
34.50	0.353
35.00	0.412
35.50	0.478
36.00	0.549

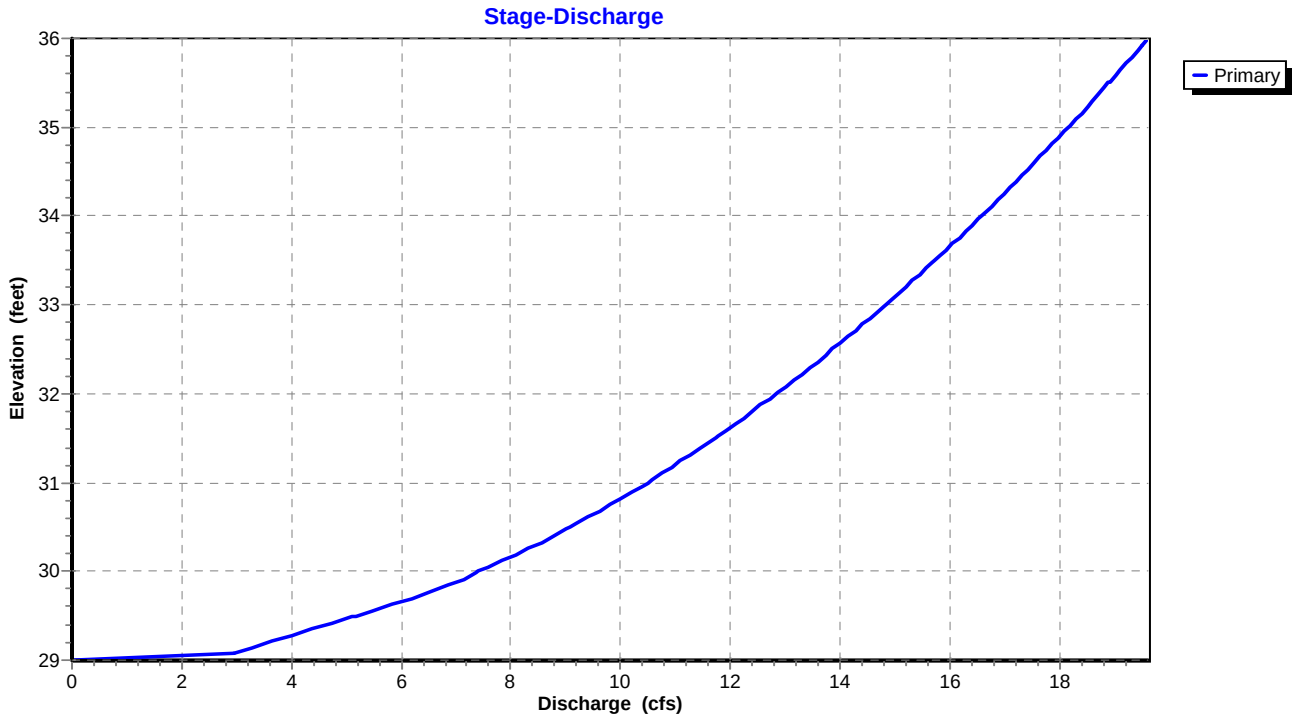
Device	Routing	Invert	Outlet Devices
#1	Primary	28.00'	**24.0" Round Culvert** L= 156.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 28.00' / 27.22' S= 0.0050 '/' Cc= 0.500 n= 0.013

Primary OutFlow Max=2.62 cfs @ 33.01 hrs HW=29.00' TW=27.70' (Dynamic Tailwater)
└─**1=Culvert** (Inlet Controls 2.62 cfs @ 1.67 fps)

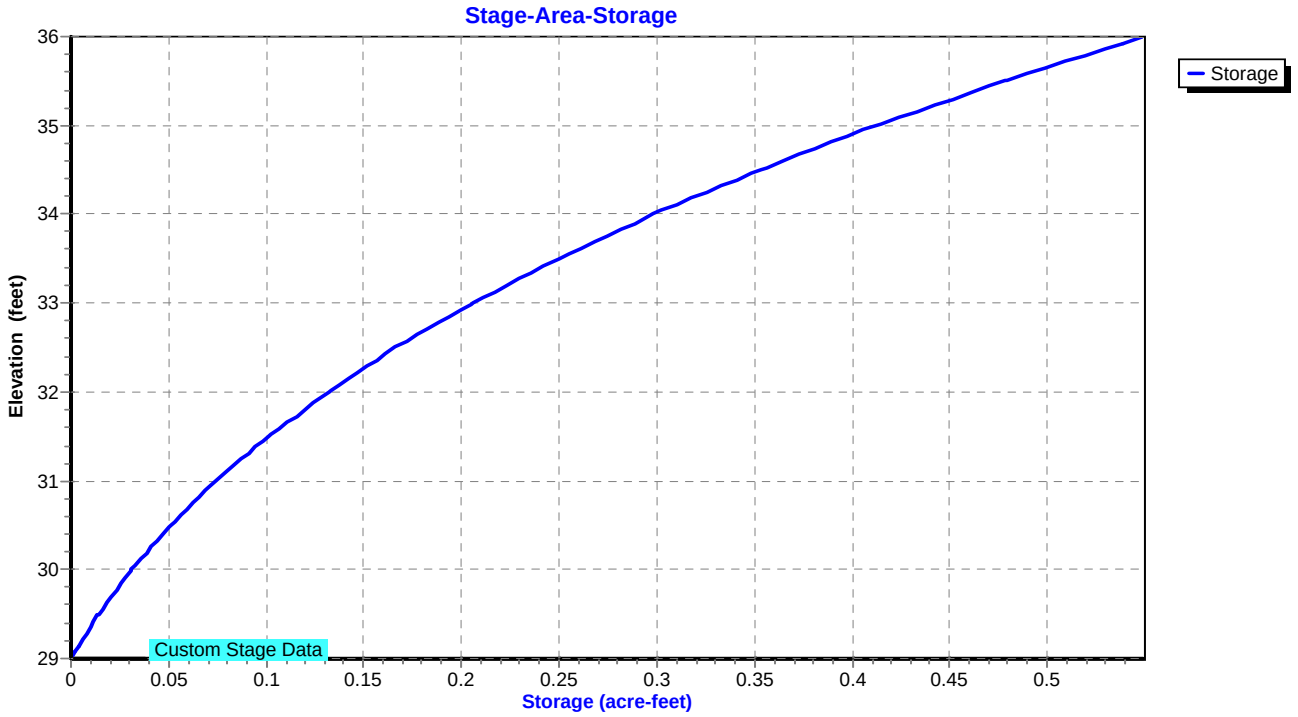
Pond 6P: Post Clear Well



Pond 6P: Post Clear Well



Pond 6P: Post Clear Well



Hydrograph for Pond 6P: Post Clear Well

Time (hours)	Inflow (cfs)	Storage (acre-feet)	Elevation (feet)	Primary (cfs)
0.00	0.00	0.000	29.00	0.00
4.00	0.00	0.000	29.00	0.00
8.00	0.08	0.000	29.00	0.08
12.00	0.21	0.000	29.00	0.21
16.00	0.66	0.000	29.00	0.66
20.00	0.74	0.000	29.00	0.74
24.00	0.88	0.000	29.00	0.88
28.00	1.00	0.000	**29.00**	1.00
32.00	**1.06**	**0.000**	**29.00**	**1.06**
36.00	**1.04**	**0.000**	29.00	**1.04**
40.00	0.98	0.000	29.00	0.98
44.00	0.89	0.000	29.00	0.89
48.00	0.80	0.000	29.00	0.80
52.00	0.70	0.000	29.00	0.70
56.00	0.40	0.000	29.00	0.40
60.00	0.36	0.000	29.00	0.36
64.00	0.32	0.000	29.00	0.32
68.00	0.27	0.000	29.00	0.27
72.00	0.21	0.000	29.00	0.21
76.00	0.18	0.000	29.00	0.18
80.00	0.17	0.000	29.00	0.17
84.00	0.16	0.000	29.00	0.16
88.00	0.15	0.000	29.00	0.15
92.00	0.14	0.000	29.00	0.14
96.00	0.13	0.000	29.00	0.13
100.00	0.12	0.000	29.00	0.12
104.00	0.10	0.000	29.00	0.10
108.00	0.09	0.000	29.00	0.09
112.00	0.08	0.000	29.00	0.08
116.00	0.07	0.000	29.00	0.07
120.00	0.05	0.000	29.00	0.05
124.00	0.04	0.000	29.00	0.04
128.00	0.03	0.000	29.00	0.03
132.00	0.02	0.000	29.00	0.02
136.00	0.02	0.000	29.00	0.02
140.00	0.01	0.000	29.00	0.01
144.00	0.01	0.000	29.00	0.01
148.00	0.01	0.000	29.00	0.01
152.00	0.01	0.000	29.00	0.01
156.00	0.01	0.000	29.00	0.01

Stage-Discharge for Pond 6P: Post Clear Well

Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)
29.00	0.00	31.12	10.80	33.24	15.27	35.36	18.70
29.04	2.81	31.16	10.90	33.28	15.34	35.40	18.76
29.08	3.00	31.20	11.00	33.32	15.41	35.44	18.82
29.12	3.20	31.24	11.10	33.36	15.48	35.48	18.88
29.16	3.40	31.28	11.20	33.40	15.55	35.52	18.93
29.20	3.60	31.32	11.29	33.44	15.62	35.56	18.99
29.24	3.80	31.36	11.39	33.48	15.69	35.60	19.05
29.28	4.01	31.40	11.49	33.52	15.76	35.64	19.11
29.32	4.22	31.44	11.58	33.56	15.83	35.68	19.16
29.36	4.43	31.48	11.68	33.60	15.90	35.72	19.22
29.40	4.64	31.52	11.77	33.64	15.97	35.76	19.28
29.44	4.85	31.56	11.86	33.68	16.04	35.80	19.34
29.48	5.06	31.60	11.96	33.72	16.11	35.84	19.39
29.52	5.27	31.64	12.05	33.76	16.18	35.88	19.45
29.56	5.48	31.68	12.14	33.80	16.25	35.92	19.51
29.60	5.69	31.72	12.23	33.84	16.31	35.96	19.56
29.64	5.89	31.76	12.32	33.88	16.38	36.00	**19.62**
29.68	6.09	31.80	12.41	33.92	16.45		
29.72	6.29	31.84	12.50	33.96	16.51		
29.76	6.48	31.88	12.58	34.00	16.58		
29.80	6.67	31.92	12.67	34.04	16.65		
29.84	6.85	31.96	12.76	34.08	16.71		
29.88	7.01	32.00	12.84	34.12	16.78		
29.92	7.17	32.04	12.93	34.16	16.84		
29.96	7.31	32.08	13.01	34.20	16.91		
30.00	7.42	32.12	13.10	34.24	16.97		
30.04	7.56	32.16	13.18	34.28	17.04		
30.08	7.71	32.20	13.26	34.32	17.10		
30.12	7.85	32.24	13.35	34.36	17.17		
30.16	7.99	32.28	13.43	34.40	17.23		
30.20	8.12	32.32	13.51	34.44	17.29		
30.24	8.26	32.36	13.59	34.48	17.36		
30.28	8.39	32.40	13.67	34.52	17.42		
30.32	8.52	32.44	13.75	34.56	17.48		
30.36	8.65	32.48	13.83	34.60	17.55		
30.40	8.77	32.52	13.91	34.64	17.61		
30.44	8.90	32.56	13.99	34.68	17.67		
30.48	9.02	32.60	14.07	34.72	17.73		
30.52	9.14	32.64	14.15	34.76	17.80		
30.56	9.26	32.68	14.22	34.80	17.86		
30.60	9.38	32.72	14.30	34.84	17.92		
30.64	9.50	32.76	14.38	34.88	17.98		
30.68	9.61	32.80	14.45	34.92	18.04		
30.72	9.72	32.84	14.53	34.96	18.10		
30.76	9.84	32.88	14.61	35.00	18.16		
30.80	9.95	32.92	14.68	35.04	18.22		
30.84	10.06	32.96	14.76	35.08	18.28		
30.88	10.17	33.00	14.83	35.12	18.34		
30.92	10.27	33.04	14.90	35.16	18.40		
30.96	10.38	33.08	14.98	35.20	18.46		
31.00	10.49	33.12	15.05	35.24	18.52		
31.04	10.59	33.16	15.12	35.28	18.58		
31.08	10.69	33.20	15.20	35.32	18.64		

Stage-Area-Storage for Pond 6P: Post Clear Well

Elevation (feet)	Storage (acre-feet)
29.00	0.000
29.10	0.003
29.20	0.006
29.30	0.008
29.40	0.011
29.50	0.014
29.60	0.017
29.70	0.021
29.80	0.024
29.90	0.028
30.00	0.031
30.10	0.035
30.20	0.039
30.30	0.043
30.40	0.047
30.50	0.051
30.60	0.056
30.70	0.060
30.80	0.065
30.90	0.069
31.00	0.074
31.10	0.079
31.20	0.085
31.30	0.090
31.40	0.096
31.50	0.101
31.60	0.107
31.70	0.113
31.80	0.120
31.90	0.126
32.00	0.132
32.10	0.139
32.20	0.146
32.30	0.152
32.40	0.159
32.50	0.166
32.60	0.174
32.70	0.182
32.80	0.190
32.90	0.198
33.00	0.206
33.10	0.215
33.20	0.224
33.30	0.232
33.40	0.241
33.50	0.250
33.60	0.260
33.70	0.269
33.80	0.279
33.90	0.288
34.00	0.298
34.10	0.309
34.20	0.320
34.30	0.331
34.40	0.342
34.50	0.353
34.60	0.365
34.70	0.377
34.80	0.388
34.90	0.400
35.00	0.412
35.10	0.425
35.20	0.438
35.30	0.452
35.40	0.465
35.50	0.478
35.60	0.492
35.70	0.506
35.80	0.521
35.90	0.535
36.00	**0.549**

Summary for Pond 12P: Sediment Forebay

Inflow	=	15.72 cfs @	8.06 hrs,	Volume=	5.555 af
Outflow	=	14.36 cfs @	8.22 hrs,	Volume=	5.169 af, Atten= 9%, Lag= 10.0 min
Primary	=	14.36 cfs @	8.22 hrs,	Volume=	5.169 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 33.77' @ 24.13 hrs Surf.Area= 0.000 ac Storage= 0.940 af

Plug-Flow detention time= 287.4 min calculated for 5.168 af (93% of inflow)
Center-of-Mass det. time= 241.0 min (988.9 - 747.9)

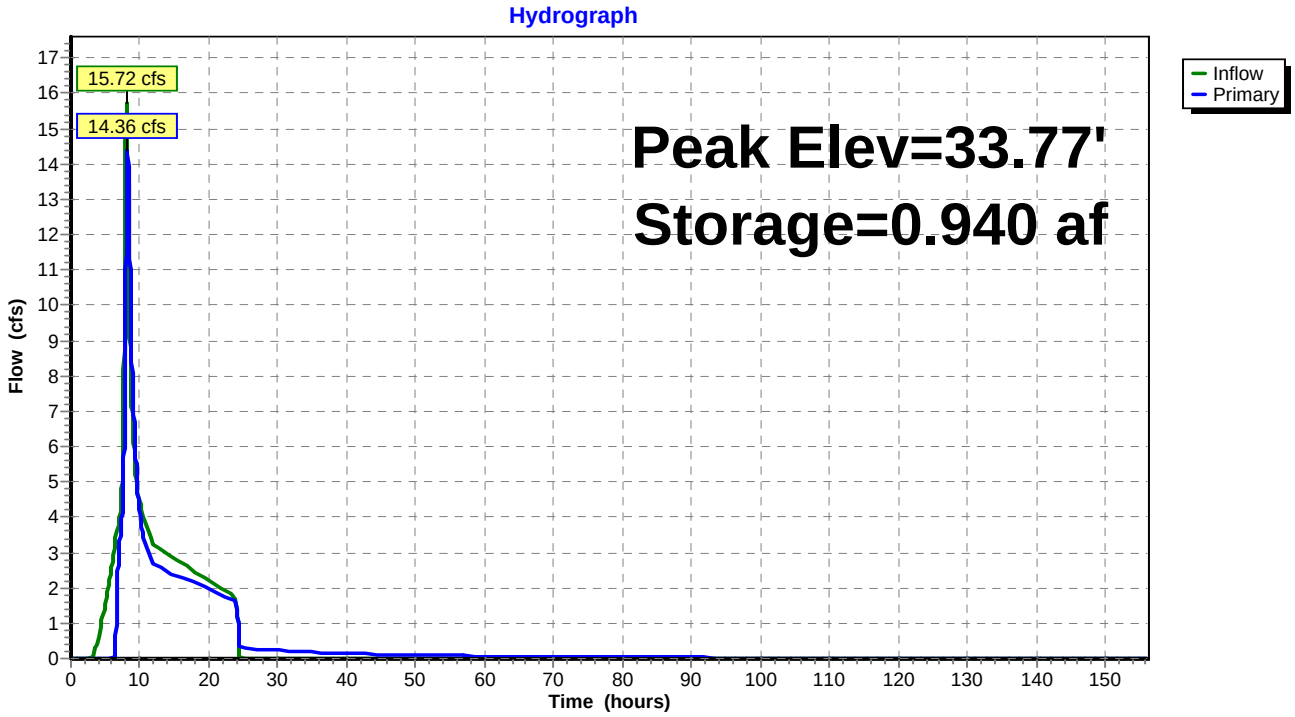
Volume	Invert	Avail.Storage	Storage Description
#1	30.00'	1.902 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
30.00	0.000
30.50	0.102
31.00	0.211
31.50	0.326
31.75	0.386
32.00	0.445
32.50	0.577
33.00	0.713
33.50	0.858
34.00	1.010
34.50	1.171
35.00	1.340
35.50	1.518
36.00	1.705
36.50	1.902

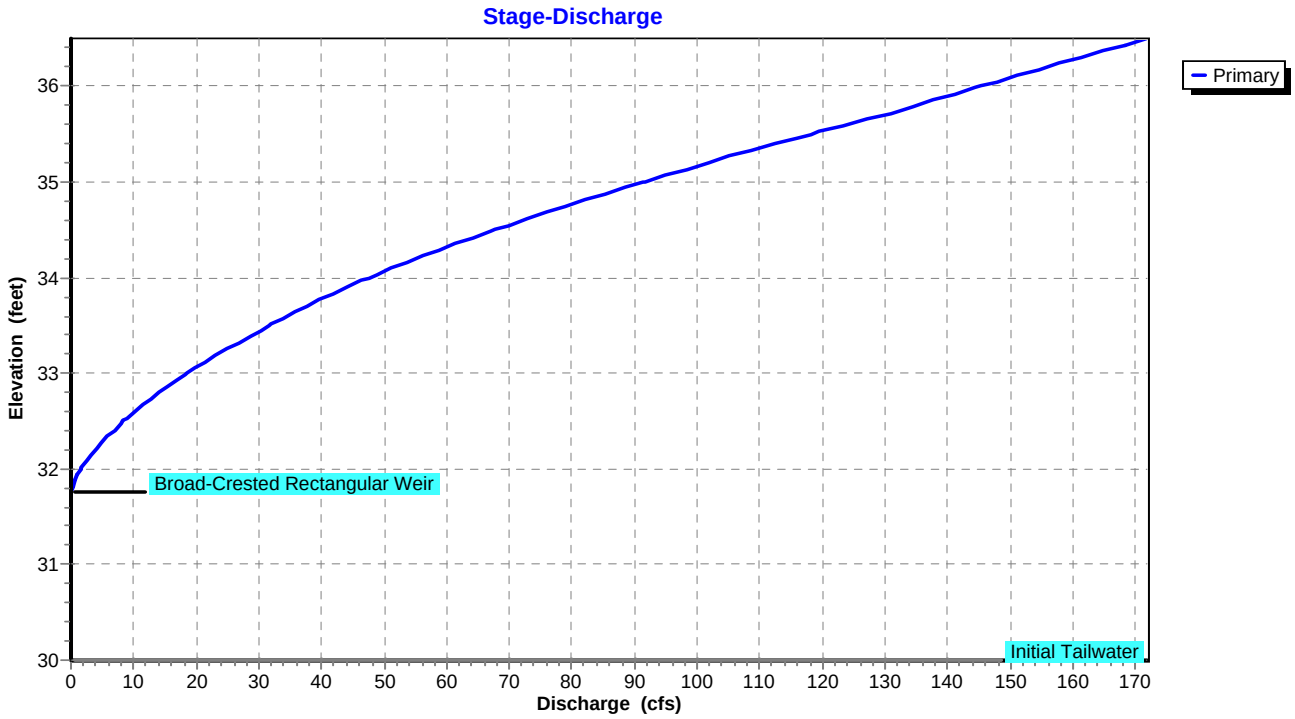
Device	Routing	Invert	Outlet Devices
#1	Primary	31.75'	**5.0' long x 2.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 Coef. (English) 2.48 2.60 2.60 2.60 2.64 2.65 2.68 2.75 2.74 2.76 2.89 3.05 3.19 3.32

Primary OutFlow Max=14.36 cfs @ 8.22 hrs HW=32.81' TW=30.95' (Dynamic Tailwater)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 14.36 cfs @ 2.72 fps)

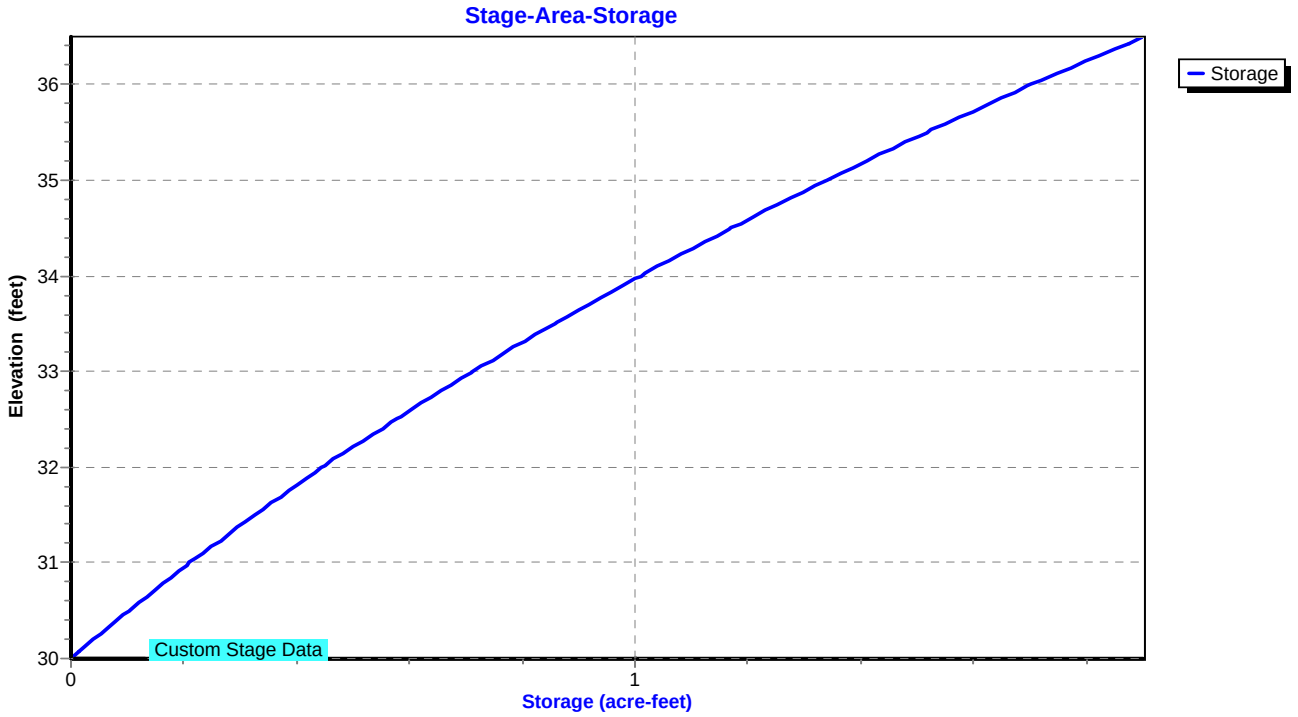
Pond 12P: Sediment Forebay



Pond 12P: Sediment Forebay



Pond 12P: Sediment Forebay



Hydrograph for Pond 12P: Sediment Forebay

Time (hours)	Inflow (cfs)	Storage (acre-feet)	Elevation (feet)	Primary (cfs)
0.00	0.00	0.000	30.00	0.00
4.00	0.46	0.021	30.10	0.00
8.00	**15.32**	0.627	32.68	**11.86**
12.00	**3.20**	0.626	32.68	**2.66**
16.00	2.70	0.782	33.24	2.31
20.00	2.21	0.885	33.59	1.97
24.00	1.70	**0.940**	**33.77**	1.62
28.00	0.00	**0.858**	**33.50**	0.25
32.00	0.00	0.781	33.23	0.22
36.00	0.00	0.717	33.01	0.17
40.00	0.00	0.665	32.82	0.15
44.00	0.00	0.620	32.66	0.13
48.00	0.00	0.583	32.52	0.10
52.00	0.00	0.552	32.41	0.09
56.00	0.00	0.525	32.30	0.08
60.00	0.00	0.500	32.21	0.07
64.00	0.00	0.478	32.13	0.06
68.00	0.00	0.460	32.06	0.05
72.00	0.00	0.446	32.00	0.04
76.00	0.00	0.434	31.95	0.03
80.00	0.00	0.423	31.91	0.03
84.00	0.00	0.413	31.86	0.03
88.00	0.00	0.403	31.82	0.03
92.00	0.00	0.394	31.78	0.02
96.00	0.00	0.388	31.76	0.01
100.00	0.00	0.387	31.75	0.00
104.00	0.00	0.386	31.75	0.00
108.00	0.00	0.386	31.75	0.00
112.00	0.00	0.386	31.75	0.00
116.00	0.00	0.386	31.75	0.00
120.00	0.00	0.386	31.75	0.00
124.00	0.00	0.386	31.75	0.00
128.00	0.00	0.386	31.75	0.00
132.00	0.00	0.386	31.75	0.00
136.00	0.00	0.386	31.75	0.00
140.00	0.00	0.386	31.75	0.00
144.00	0.00	0.386	31.75	0.00
148.00	0.00	0.386	31.75	0.00
152.00	0.00	0.386	31.75	0.00
156.00	0.00	0.386	31.75	0.00

Stage-Discharge for Pond 12P: Sediment Forebay

Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)
30.00	0.00	32.12	2.91	34.24	56.73	36.36	164.31
30.04	0.00	32.16	3.41	34.28	58.34	36.40	166.45
30.08	0.00	32.20	3.92	34.32	60.00	36.44	168.60
30.12	0.00	32.24	4.46	34.36	61.67	36.48	**170.77**
30.16	0.00	32.28	5.02	34.40	63.37		
30.20	0.00	32.32	5.59	34.44	65.09		
30.24	0.00	32.36	6.19	34.48	66.84		
30.28	0.00	32.40	6.81	34.52	68.61		
30.32	0.00	32.44	7.45	34.56	70.40		
30.36	0.00	32.48	8.11	34.60	72.22		
30.40	0.00	32.52	8.78	34.64	74.06		
30.44	0.00	32.56	9.48	34.68	75.92		
30.48	0.00	32.60	10.23	34.72	77.81		
30.52	0.00	32.64	10.99	34.76	79.71		
30.56	0.00	32.68	11.78	34.80	81.60		
30.60	0.00	32.72	12.58	34.84	83.52		
30.64	0.00	32.76	13.40	34.88	85.46		
30.68	0.00	32.80	14.22	34.92	87.41		
30.72	0.00	32.84	15.05	34.96	89.40		
30.76	0.00	32.88	15.89	35.00	91.40		
30.80	0.00	32.92	16.76	35.04	93.43		
30.84	0.00	32.96	17.65	35.08	95.48		
30.88	0.00	33.00	18.57	35.12	97.55		
30.92	0.00	33.04	19.51	35.16	99.64		
30.96	0.00	33.08	20.47	35.20	101.76		
31.00	0.00	33.12	21.45	35.24	103.90		
31.04	0.00	33.16	22.46	35.28	106.04		
31.08	0.00	33.20	23.55	35.32	108.20		
31.12	0.00	33.24	24.66	35.36	110.38		
31.16	0.00	33.28	25.79	35.40	112.58		
31.20	0.00	33.32	26.95	35.44	114.81		
31.24	0.00	33.36	28.08	35.48	117.05		
31.28	0.00	33.40	29.12	35.52	119.32		
31.32	0.00	33.44	30.16	35.56	121.61		
31.36	0.00	33.48	31.21	35.60	123.93		
31.40	0.00	33.52	32.28	35.64	126.26		
31.44	0.00	33.56	33.37	35.68	128.62		
31.48	0.00	33.60	34.54	35.72	131.00		
31.52	0.00	33.64	35.71	35.76	133.30		
31.56	0.00	33.68	36.91	35.80	135.30		
31.60	0.00	33.72	38.12	35.84	137.31		
31.64	0.00	33.76	39.36	35.88	139.33		
31.68	0.00	33.80	40.70	35.92	141.36		
31.72	0.00	33.84	42.05	35.96	143.39		
31.76	0.01	33.88	43.42	36.00	145.44		
31.80	0.14	33.92	44.82	36.04	147.50		
31.84	0.33	33.96	46.24	36.08	149.57		
31.88	0.58	34.00	47.67	36.12	151.65		
31.92	0.87	34.04	49.13	36.16	153.73		
31.96	1.20	34.08	50.61	36.20	155.83		
32.00	1.57	34.12	52.11	36.24	157.93		
32.04	1.98	34.16	53.62	36.28	160.05		
32.08	2.42	34.20	55.16	36.32	162.17		

Stage-Area-Storage for Pond 12P: Sediment Forebay

Elevation (feet)	Storage (acre-feet)
30.00	0.000
30.10	0.020
30.20	0.041
30.30	0.061
30.40	0.082
30.50	0.102
30.60	0.124
30.70	0.146
30.80	0.167
30.90	0.189
31.00	0.211
31.10	0.234
31.20	0.257
31.30	0.280
31.40	0.303
31.50	0.326
31.60	0.350
31.70	0.374
31.80	0.398
31.90	0.421
32.00	0.445
32.10	0.471
32.20	0.498
32.30	0.524
32.40	0.551
32.50	0.577
32.60	0.604
32.70	0.631
32.80	0.659
32.90	0.686
33.00	0.713
33.10	0.742
33.20	0.771
33.30	0.800
33.40	0.829
33.50	0.858
33.60	0.888
33.70	0.919
33.80	0.949
33.90	0.980
34.00	1.010
34.10	1.042
34.20	1.074
34.30	1.107
34.40	1.139
34.50	1.171
34.60	1.205
34.70	1.239
34.80	1.272
34.90	1.306
35.00	1.340
35.10	1.376
35.20	1.411
35.30	1.447
35.40	1.482
35.50	1.518
35.60	1.555
35.70	1.593
35.80	1.630
35.90	1.668
36.00	1.705
36.10	1.744
36.20	1.784
36.30	1.823
36.40	1.863
36.50	**1.902**

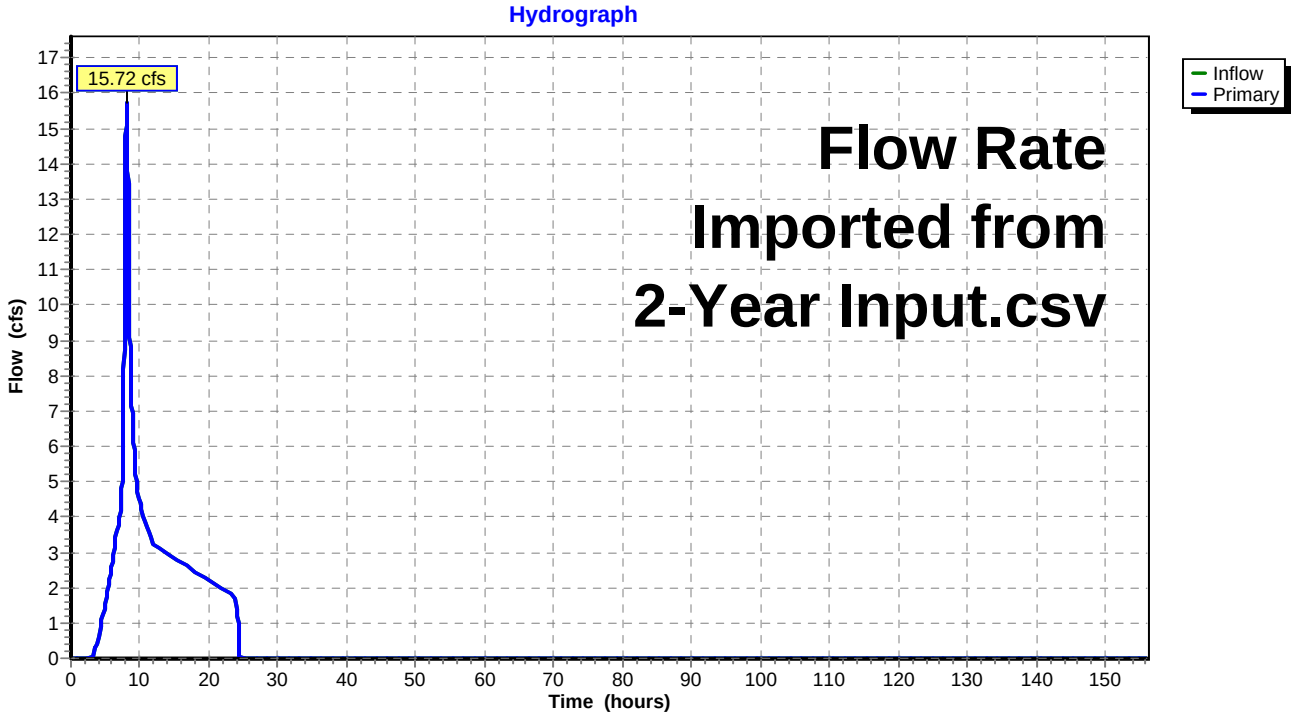
Summary for Link 1L: Input Hydrograhp

Inflow	=	15.72 cfs @	8.06 hrs,	Volume=	5.555 af
Primary	=	15.72 cfs @	8.06 hrs,	Volume=	5.555 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs

Flow Rate Imported from 2-Year Input.csv

Link 1L: Input Hydrograhp



Hydrograph for Link 1L: Input Hydrograhp

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**0.00**	0.00
2.00	0.00	0.00	0.00
4.00	0.46	0.00	0.46
6.00	2.71	0.00	2.71
8.00	**15.32**	0.00	**15.32**
10.00	**4.40**	0.00	**4.40**
12.00	3.20	0.00	3.20
14.00	2.90	0.00	2.90
16.00	2.70	0.00	2.70
18.00	2.46	0.00	2.46
20.00	2.21	0.00	2.21
22.00	1.96	0.00	1.96
24.00	1.70	0.00	1.70
26.00	0.00	0.00	0.00
28.00	0.00	0.00	0.00
30.00	0.00	0.00	0.00
32.00	0.00	0.00	0.00
34.00	0.00	0.00	0.00
36.00	0.00	0.00	0.00
38.00	0.00	0.00	0.00
40.00	0.00	0.00	0.00
42.00	0.00	0.00	0.00
44.00	0.00	0.00	0.00
46.00	0.00	0.00	0.00
48.00	0.00	0.00	0.00
50.00	0.00	0.00	0.00
52.00	0.00	0.00	0.00
54.00	0.00	0.00	0.00
56.00	0.00	0.00	0.00
58.00	0.00	0.00	0.00
60.00	0.00	0.00	0.00
62.00	0.00	0.00	0.00
64.00	0.00	0.00	0.00
66.00	0.00	0.00	0.00
68.00	0.00	0.00	0.00
70.00	0.00	0.00	0.00
72.00	0.00	0.00	0.00
74.00	0.00	0.00	0.00
76.00	0.00	0.00	0.00
78.00	0.00	0.00	0.00
80.00	0.00	0.00	0.00
82.00	0.00	0.00	0.00
84.00	0.00	0.00	0.00
86.00	0.00	0.00	0.00
88.00	0.00	0.00	0.00
90.00	0.00	0.00	0.00
92.00	0.00	0.00	0.00
94.00	0.00	0.00	0.00
96.00	0.00	0.00	0.00
98.00	0.00	0.00	0.00
100.00	0.00	0.00	0.00
102.00	0.00	0.00	0.00
104.00	0.00	0.00	0.00
106.00	0.00	0.00	0.00
108.00	0.00	0.00	0.00
110.00	0.00	0.00	0.00
112.00	0.00	0.00	0.00
114.00	0.00	0.00	0.00
116.00	0.00	0.00	0.00
118.00	0.00	0.00	0.00
120.00	0.00	0.00	0.00
122.00	0.00	0.00	0.00
124.00	0.00	0.00	0.00
126.00	0.00	0.00	0.00
128.00	0.00	0.00	0.00
130.00	0.00	0.00	0.00
132.00	0.00	0.00	0.00
134.00	0.00	0.00	0.00
136.00	0.00	0.00	0.00
138.00	0.00	0.00	0.00
140.00	0.00	0.00	0.00
142.00	0.00	0.00	0.00
144.00	0.00	0.00	0.00
146.00	0.00	0.00	0.00
148.00	0.00	0.00	0.00
150.00	0.00	0.00	0.00
152.00	0.00	0.00	0.00
154.00	0.00	0.00	0.00
156.00	0.00	0.00	0.00

Summary for Link 4L: Lag Thru Filter

Storage in sand filter modeled here as lag time from sand filter outlet to clear well outlet on downstream side of sand filter.

Lagtime estimate at conductivity of 1.75 inches/hour, with a hydraulic gradient of {[(31.00-28)/2]+1.5}*/(1.5)** thru 18 inches of sand.

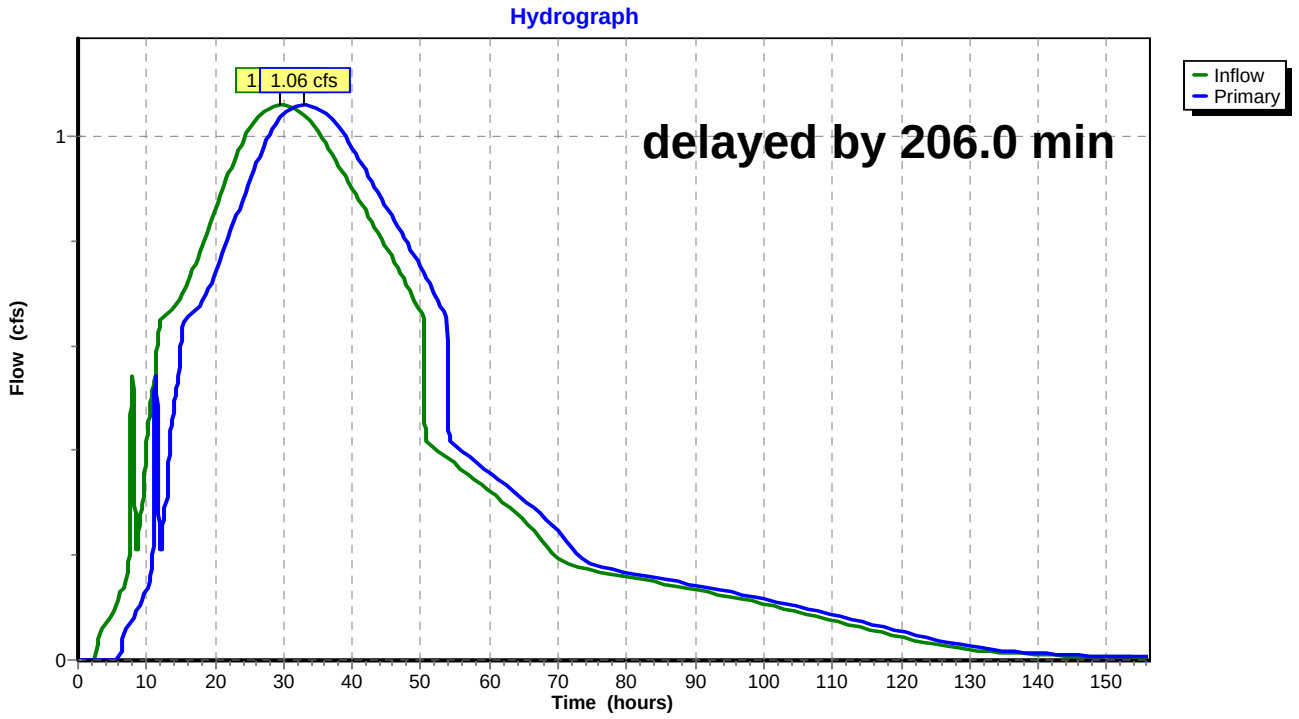
Result is 206 minutes

* "Average" Head on Sand Filter.
** Depth of Sand Filter

Inflow	=	1.06 cfs @	29.58 hrs,	Volume=	4.040 af
Primary	=	1.06 cfs @	33.01 hrs,	Volume=	4.038 af, Atten= 0%, Lag= 206.0 min

Primary outflow = Inflow delayed by 206.0 min, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs

Link 4L: Lag Thru Filter



Hydrograph for Link 4L: Lag Thru Filter

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**0.00**	0.00
2.00	0.00	0.00	0.00
4.00	0.07	0.00	0.00
6.00	0.12	0.00	0.00
8.00	0.54	0.00	0.08
10.00	0.42	0.00	0.14
12.00	0.65	0.00	0.21
14.00	0.67	0.00	0.49
16.00	0.72	0.00	0.66
18.00	0.79	0.00	0.68
20.00	0.86	0.00	0.74
22.00	0.93	0.00	0.81
24.00	0.99	0.00	0.88
26.00	1.03	0.00	0.95
28.00	**1.05**	0.00	1.00
30.00	**1.06**	0.00	1.04
32.00	1.05	0.00	**1.06**
34.00	1.03	0.00	**1.06**
36.00	0.99	0.00	1.04
38.00	0.94	0.00	1.02
40.00	0.90	0.00	0.98
42.00	0.85	0.00	0.93
44.00	0.81	0.00	0.89
46.00	0.76	0.00	0.84
48.00	0.71	0.00	0.80
50.00	0.66	0.00	0.75
52.00	0.40	0.00	0.70
54.00	0.38	0.00	0.46
56.00	0.36	0.00	0.40
58.00	0.34	0.00	0.38
60.00	0.32	0.00	0.36
62.00	0.30	0.00	0.34
64.00	0.28	0.00	0.32
66.00	0.25	0.00	0.29
68.00	0.22	0.00	0.27
70.00	0.19	0.00	0.25
72.00	0.18	0.00	0.21
74.00	0.17	0.00	0.19
76.00	0.17	0.00	0.18
78.00	0.16	0.00	0.17
80.00	0.16	0.00	0.17
82.00	0.15	0.00	0.16
84.00	0.15	0.00	0.16
86.00	0.14	0.00	0.15
88.00	0.14	0.00	0.15
90.00	0.13	0.00	0.14
92.00	0.13	0.00	0.14
94.00	0.12	0.00	0.13
96.00	0.12	0.00	0.13
98.00	0.11	0.00	0.12
100.00	0.11	0.00	0.12
102.00	0.10	0.00	0.11
104.00	0.09	0.00	0.10
106.00	0.09	0.00	0.10
108.00	0.08	0.00	0.09
110.00	0.08	0.00	0.09
112.00	0.07	0.00	0.08
114.00	0.06	0.00	0.07
116.00	0.06	0.00	0.07
118.00	0.05	0.00	0.06
120.00	0.04	0.00	0.05
122.00	0.04	0.00	0.05
124.00	0.03	0.00	0.04
126.00	0.03	0.00	0.04
128.00	0.02	0.00	0.03
130.00	0.02	0.00	0.03
132.00	0.02	0.00	0.02
134.00	0.01	0.00	0.02
136.00	0.01	0.00	0.02
138.00	0.01	0.00	0.01
140.00	0.01	0.00	0.01
142.00	0.01	0.00	0.01
144.00	0.01	0.00	0.01
146.00	0.01	0.00	0.01
148.00	0.01	0.00	0.01
150.00	0.01	0.00	0.01
152.00	0.01	0.00	0.01
154.00	0.01	0.00	0.01
156.00	0.00	0.00	0.01

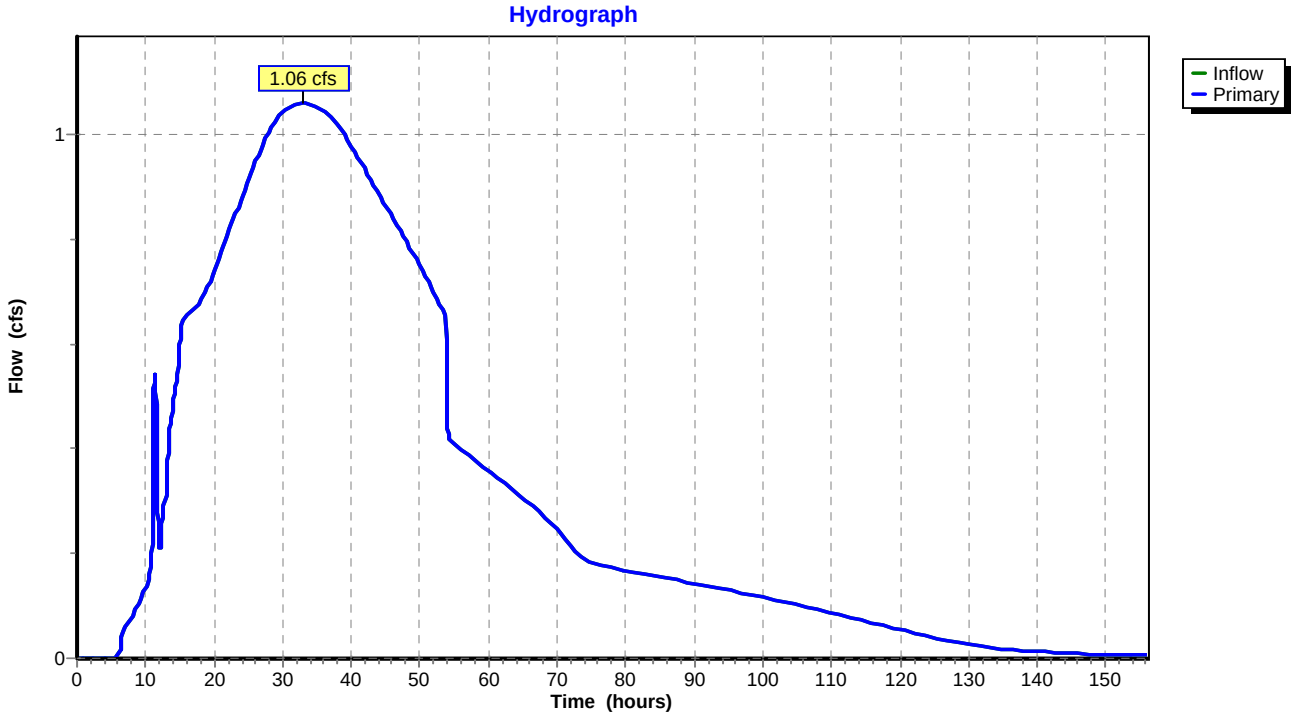
Summary for Link 9L: Discharge Elevation

Inflow	=	1.06 cfs @	33.01 hrs,	Volume=	4.038 af
Primary	=	1.06 cfs @	33.01 hrs,	Volume=	4.038 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs

Fixed water surface Elevation= 27.70'

Link 9L: Discharge Elevation



Hydrograph for Link 9L: Discharge Elevation

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**27.70**	0.00
2.00	0.00	27.70	0.00
4.00	0.00	27.70	0.00
6.00	0.00	27.70	0.00
8.00	0.08	27.70	0.08
10.00	0.14	27.70	0.14
12.00	0.21	27.70	0.21
14.00	0.49	27.70	0.49
16.00	0.66	27.70	0.66
18.00	0.68	27.70	0.68
20.00	0.74	27.70	0.74
22.00	0.81	27.70	0.81
24.00	0.88	27.70	0.88
26.00	0.95	27.70	0.95
28.00	1.00	27.70	1.00
30.00	1.04	27.70	1.04
32.00	**1.06**	27.70	**1.06**
34.00	**1.06**	27.70	**1.06**
36.00	1.04	27.70	1.04
38.00	1.02	27.70	1.02
40.00	0.98	27.70	0.98
42.00	0.93	27.70	0.93
44.00	0.89	27.70	0.89
46.00	0.84	27.70	0.84
48.00	0.80	27.70	0.80
50.00	0.75	27.70	0.75
52.00	0.70	27.70	0.70
54.00	0.46	27.70	0.46
56.00	0.40	27.70	0.40
58.00	0.38	27.70	0.38
60.00	0.36	27.70	0.36
62.00	0.34	27.70	0.34
64.00	0.32	27.70	0.32
66.00	0.29	27.70	0.29
68.00	0.27	27.70	0.27
70.00	0.25	27.70	0.25
72.00	0.21	27.70	0.21
74.00	0.19	27.70	0.19
76.00	0.18	27.70	0.18
78.00	0.17	27.70	0.17
80.00	0.17	27.70	0.17
82.00	0.16	27.70	0.16
84.00	0.16	27.70	0.16
86.00	0.15	27.70	0.15
88.00	0.15	27.70	0.15
90.00	0.14	27.70	0.14
92.00	0.14	27.70	0.14
94.00	0.13	27.70	0.13
96.00	0.13	27.70	0.13
98.00	0.12	27.70	0.12
100.00	0.12	27.70	0.12
102.00	0.11	27.70	0.11
104.00	0.10	27.70	0.10
106.00	0.10	27.70	0.10
108.00	0.09	27.70	0.09
110.00	0.09	27.70	0.09
112.00	0.08	27.70	0.08
114.00	0.07	27.70	0.07
116.00	0.07	27.70	0.07
118.00	0.06	27.70	0.06
120.00	0.05	27.70	0.05
122.00	0.05	27.70	0.05
124.00	0.04	27.70	0.04
126.00	0.04	27.70	0.04
128.00	0.03	27.70	0.03
130.00	0.03	27.70	0.03
132.00	0.02	27.70	0.02
134.00	0.02	27.70	0.02
136.00	0.02	27.70	0.02
138.00	0.01	27.70	0.01
140.00	0.01	27.70	0.01
142.00	0.01	27.70	0.01
144.00	0.01	27.70	0.01
146.00	0.01	27.70	0.01
148.00	0.01	27.70	0.01
150.00	0.01	27.70	0.01
152.00	0.01	27.70	0.01
154.00	0.01	27.70	0.01
156.00	0.01	27.70	0.01

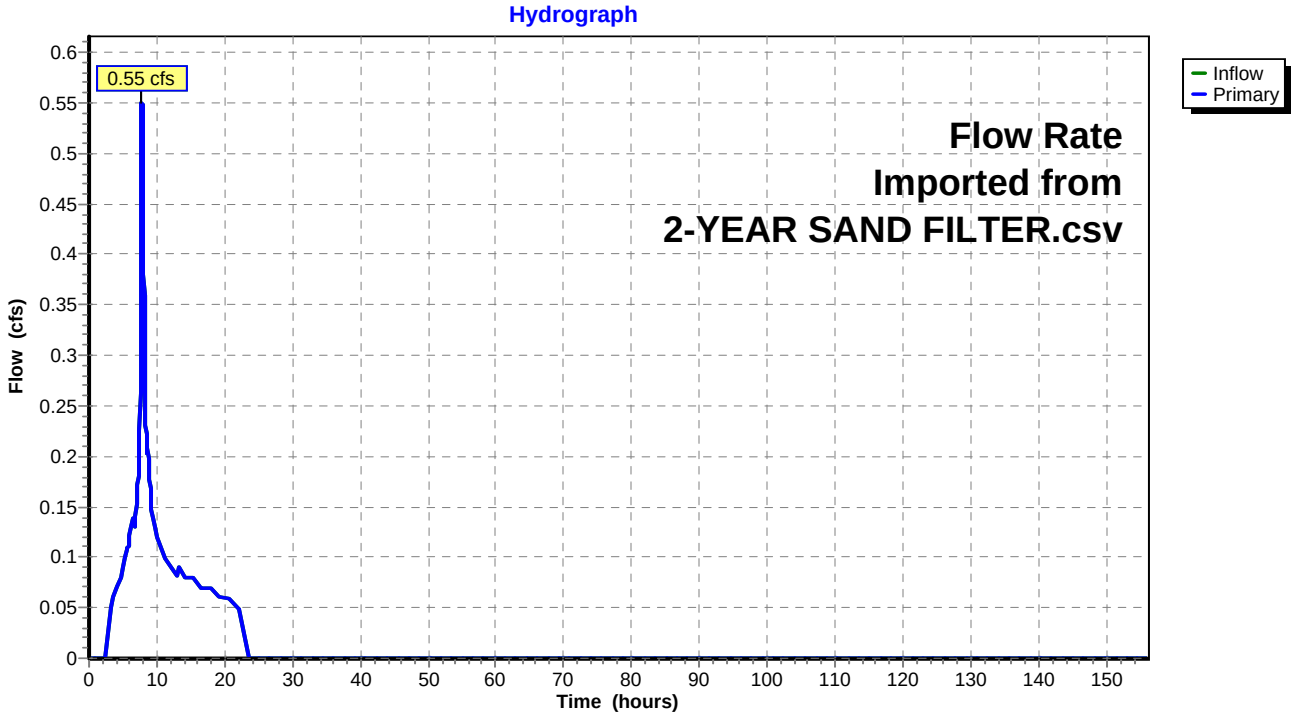
Summary for Link 10L: Sand Filter Input

Inflow	=	0.55 cfs @	7.78 hrs,	Volume=	0.169 af
Primary	=	0.55 cfs @	7.78 hrs,	Volume=	0.169 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs

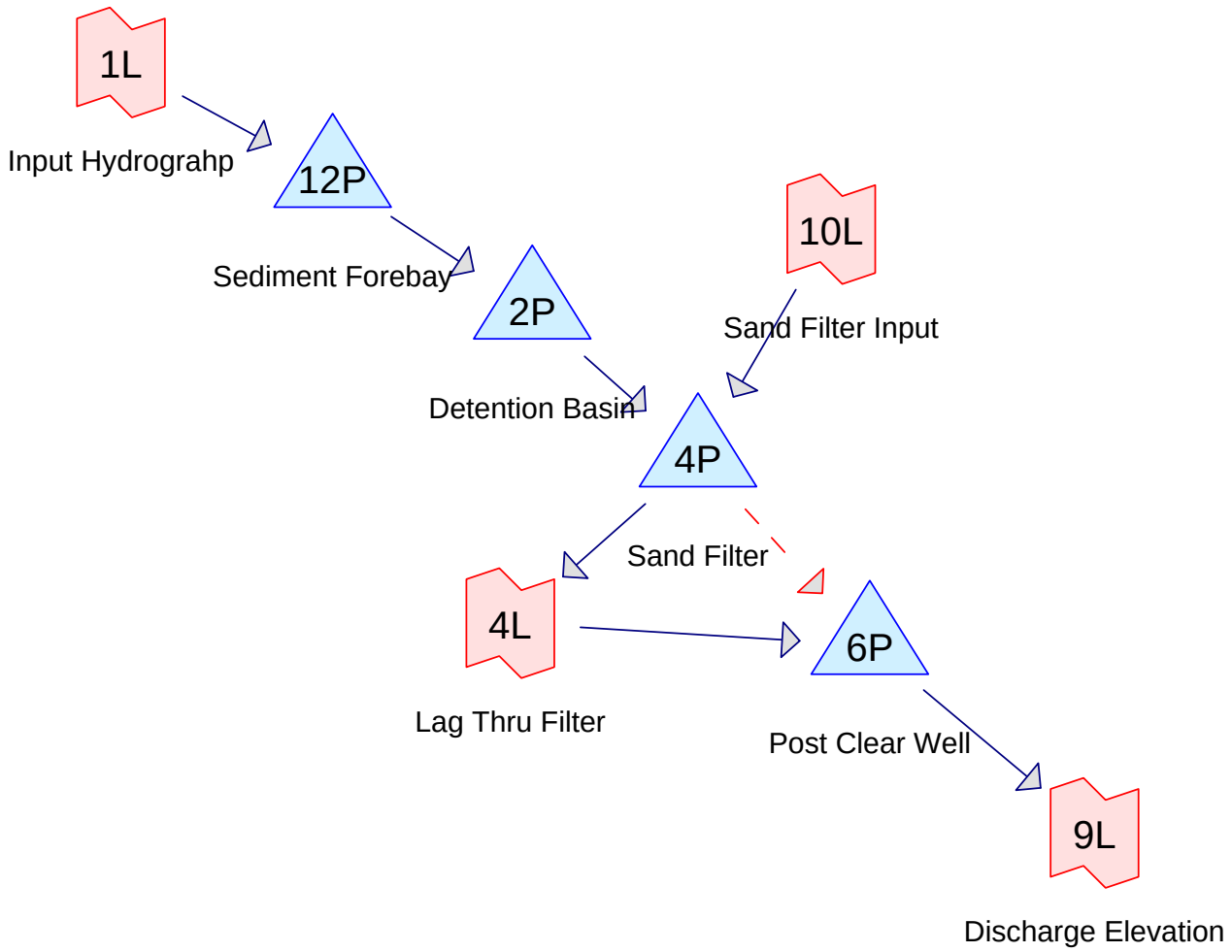
Flow Rate Imported from 2-YEAR SAND FILTER.csv

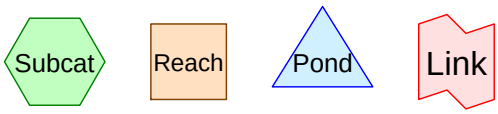
Link 10L: Sand Filter Input



Hydrograph for Link 10L: Sand Filter Input

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**0.00**	0.00
2.00	0.00	0.00	0.00
4.00	0.07	0.00	0.07
6.00	**0.12**	0.00	**0.12**
8.00	**0.53**	0.00	**0.53**
10.00	0.12	0.00	0.12
12.00	0.09	0.00	0.09
14.00	0.08	0.00	0.08
16.00	0.07	0.00	0.07
18.00	0.07	0.00	0.07
20.00	0.06	0.00	0.06
22.00	0.05	0.00	0.05
24.00	0.00	0.00	0.00
26.00	0.00	0.00	0.00
28.00	0.00	0.00	0.00
30.00	0.00	0.00	0.00
32.00	0.00	0.00	0.00
34.00	0.00	0.00	0.00
36.00	0.00	0.00	0.00
38.00	0.00	0.00	0.00
40.00	0.00	0.00	0.00
42.00	0.00	0.00	0.00
44.00	0.00	0.00	0.00
46.00	0.00	0.00	0.00
48.00	0.00	0.00	0.00
50.00	0.00	0.00	0.00
52.00	0.00	0.00	0.00
54.00	0.00	0.00	0.00
56.00	0.00	0.00	0.00
58.00	0.00	0.00	0.00
60.00	0.00	0.00	0.00
62.00	0.00	0.00	0.00
64.00	0.00	0.00	0.00
66.00	0.00	0.00	0.00
68.00	0.00	0.00	0.00
70.00	0.00	0.00	0.00
72.00	0.00	0.00	0.00
74.00	0.00	0.00	0.00
76.00	0.00	0.00	0.00
78.00	0.00	0.00	0.00
80.00	0.00	0.00	0.00
82.00	0.00	0.00	0.00
84.00	0.00	0.00	0.00
86.00	0.00	0.00	0.00
88.00	0.00	0.00	0.00
90.00	0.00	0.00	0.00
92.00	0.00	0.00	0.00
94.00	0.00	0.00	0.00
96.00	0.00	0.00	0.00
98.00	0.00	0.00	0.00
100.00	0.00	0.00	0.00
102.00	0.00	0.00	0.00
104.00	0.00	0.00	0.00
106.00	0.00	0.00	0.00
108.00	0.00	0.00	0.00
110.00	0.00	0.00	0.00
112.00	0.00	0.00	0.00
114.00	0.00	0.00	0.00
116.00	0.00	0.00	0.00
118.00	0.00	0.00	0.00
120.00	0.00	0.00	0.00
122.00	0.00	0.00	0.00
124.00	0.00	0.00	0.00
126.00	0.00	0.00	0.00
128.00	0.00	0.00	0.00
130.00	0.00	0.00	0.00
132.00	0.00	0.00	0.00
134.00	0.00	0.00	0.00
136.00	0.00	0.00	0.00
138.00	0.00	0.00	0.00
140.00	0.00	0.00	0.00
142.00	0.00	0.00	0.00
144.00	0.00	0.00	0.00
146.00	0.00	0.00	0.00
148.00	0.00	0.00	0.00
150.00	0.00	0.00	0.00
152.00	0.00	0.00	0.00
154.00	0.00	0.00	0.00
156.00	0.00	0.00	0.00





Drainage Diagram for 5-Year Model
Prepared by Integral Consulting Inc., Printed 9/28/2011
HydroCAD® 9.10 s/n 06683 © 2010 HydroCAD Software Solutions LLC

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Fill (inches)
1	2P	31.00	29.45	310.0	0.0050	0.013	24.0	0.0	0.0
2	4P	28.76	28.00	152.0	0.0050	0.011	4.0	0.0	0.0
3	6P	28.00	27.22	156.0	0.0050	0.013	24.0	0.0	0.0

Time span=0.00-156.00 hrs, dt=0.02 hrs, 7801 points x 3
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Pond 2P: Detention Basin Peak Elev=33.89' Storage=3.604 af Inflow=18.63 cfs 6.728 af
Outflow=3.12 cfs 5.429 af

Pond 4P: Sand Filter Peak Elev=33.52' Storage=1.108 af Inflow=3.20 cfs 5.647 af
Primary=1.95 cfs 5.646 af Secondary=0.00 cfs 0.000 af Outflow=1.95 cfs 5.646 af

Pond 6P: Post Clear Well Peak Elev=29.00' Storage=0.000 af Inflow=1.95 cfs 5.645 af
24.0" Round Culvert n=0.013 L=156.0' S=0.0050 '/' Outflow=1.95 cfs 5.645 af

Pond 12P: Sediment Forebay Peak Elev=33.89' Storage=0.978 af Inflow=20.21 cfs 7.114 af
Outflow=18.63 cfs 6.728 af

Link 1L: Input Hydrograhp Flow Rate Imported from 5 Year Input.csv Inflow=20.21 cfs 7.114 af
Primary=20.21 cfs 7.114 af

Link 4L: Lag Thru Filter delayed by 206.0 min Inflow=1.95 cfs 5.646 af
Primary=1.95 cfs 5.645 af

Link 9L: Discharge Elevation Inflow=1.95 cfs 5.645 af
Primary=1.95 cfs 5.645 af

Link 10L: Sand Filter Input Flow Rate Imported from 5-YEAR SAND FILTER.csv Inflow=0.68 cfs 0.218 af
Primary=0.68 cfs 0.218 af

Summary for Pond 2P: Detention Basin

Inflow	=	18.63 cfs @	8.20 hrs,	Volume=	6.728 af
Outflow	=	3.12 cfs @	17.23 hrs,	Volume=	5.429 af, Atten= 83%, Lag= 541.9 min
Primary	=	3.12 cfs @	17.23 hrs,	Volume=	5.429 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 33.89' @ 17.49 hrs Surf.Area= 0.000 ac Storage= 3.604 af

Plug-Flow detention time= 1,467.7 min calculated for 5.429 af (81% of inflow)
Center-of-Mass det. time= 1,215.5 min (2,170.2 - 954.7)

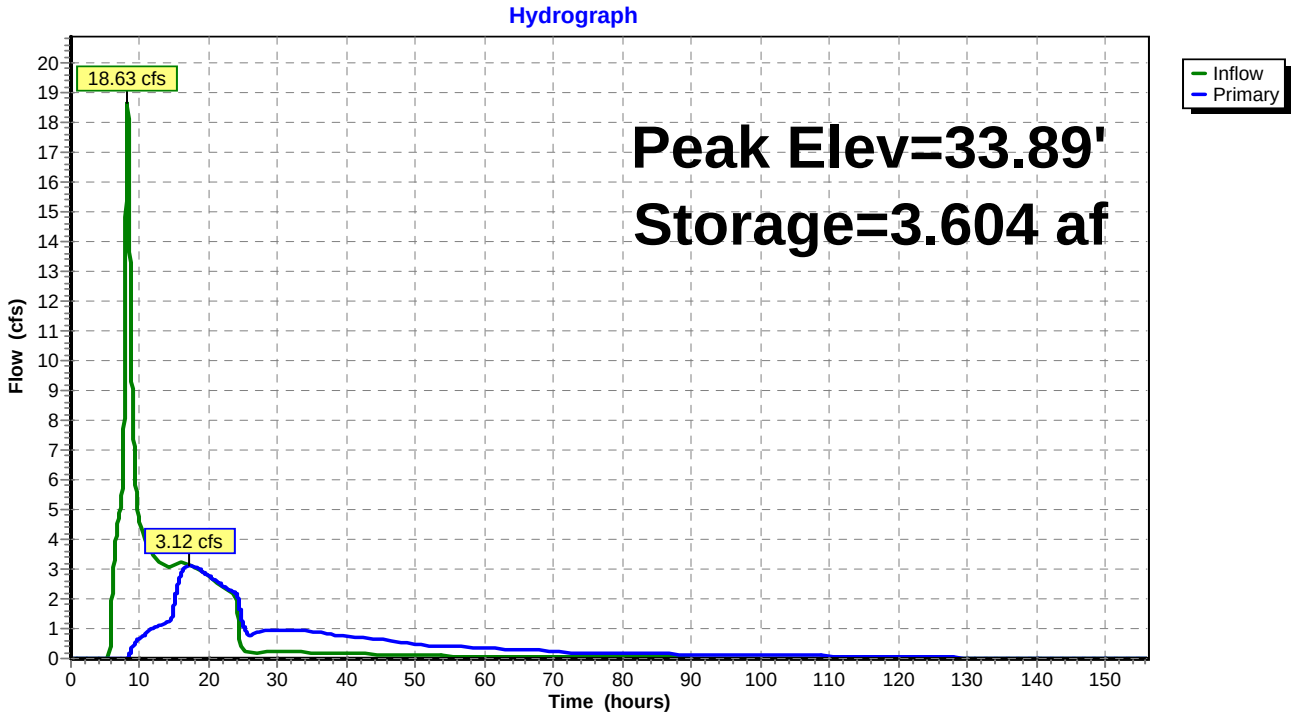
Volume	Invert	Avail.Storage	Storage Description
#1	30.00'	6.558 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
30.00	0.000
30.25	0.204
30.50	0.412
31.00	0.839
31.50	1.280
32.00	1.736
32.50	2.207
33.00	2.694
33.50	3.196
34.00	3.715
34.50	4.250
35.00	4.801
35.50	5.370
36.00	5.955
36.50	6.558

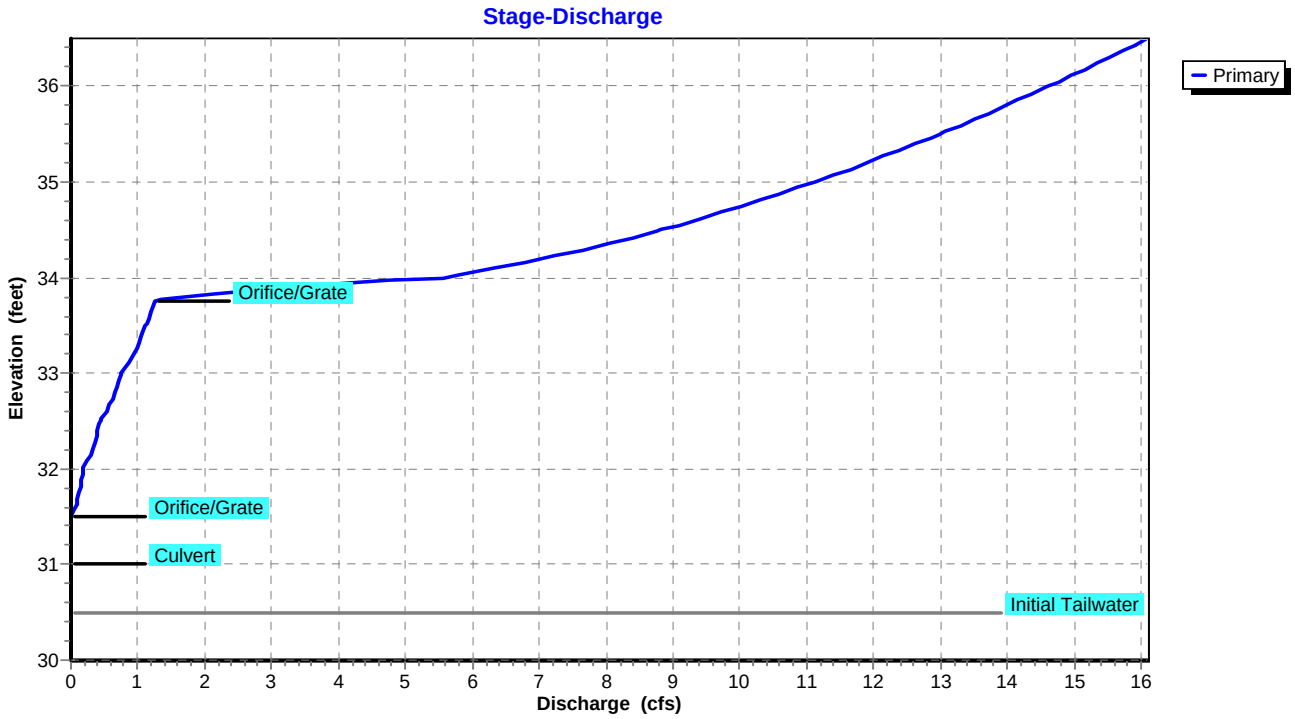
Device	Routing	Invert	Outlet Devices
#1	Device 3	31.50'	**1.0" Vert. Orifice/Grate X 10.00 columns** X 4 rows with 6.0" cc spacing C= 0.600
#2	Device 3	33.75'	**8.0" Horiz. Orifice/Grate X 5.00** C= 0.600 Limited to weir flow at low heads
#3	Primary	31.00'	**24.0" Round Culvert** L= 310.0' CPP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 31.00' / 29.45' S= 0.0050 '/' Cc= 0.500 n= 0.013

Primary OutFlow Max=3.12 cfs @ 17.23 hrs HW=33.89' TW=31.93' (Dynamic Tailwater)
└─**3=Culvert** (Passes 3.12 cfs of 11.56 cfs potential flow)
  ├─**1=Orifice/Grate** (Orifice Controls 1.27 cfs @ 5.83 fps)
  └─**2=Orifice/Grate** (Weir Controls 1.84 cfs @ 1.23 fps)

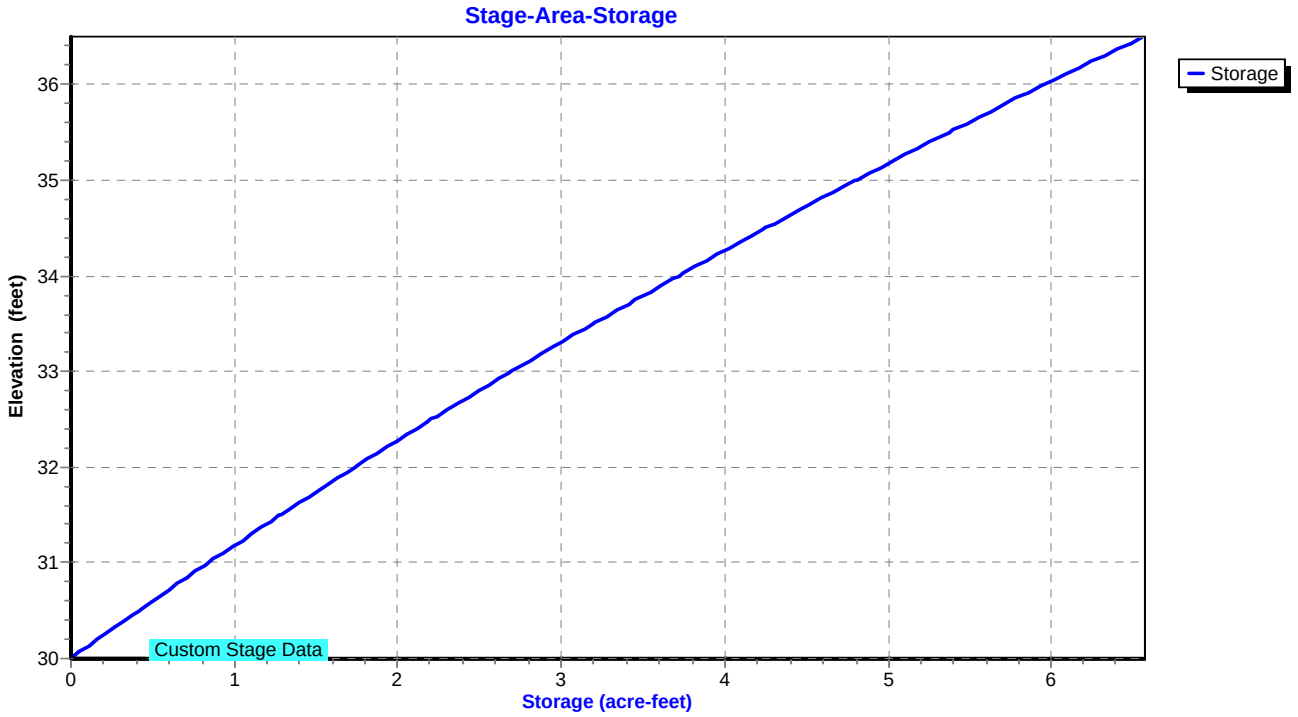
Pond 2P: Detention Basin



Pond 2P: Detention Basin



Pond 2P: Detention Basin



Hydrograph for Pond 2P: Detention Basin

Time (hours)	Inflow (cfs)	Storage (acre-feet)	Elevation (feet)	Primary (cfs)
0.00	0.00	0.000	30.00	0.00
4.00	0.00	0.000	30.00	0.00
8.00	**15.88**	0.979	31.16	0.00
12.00	**3.33**	3.043	33.35	1.03
16.00	3.23	**3.588**	**33.88**	**2.86**
20.00	2.73	**3.598**	**33.89**	**2.77**
24.00	2.11	3.586	33.88	2.16
28.00	0.21	3.349	33.65	0.92
32.00	0.21	3.104	33.41	0.95
36.00	0.20	2.867	33.17	0.88
40.00	0.16	2.663	32.97	0.73
44.00	0.14	2.484	32.78	0.65
48.00	0.12	2.329	32.62	0.55
52.00	0.09	2.203	32.50	0.43
56.00	0.09	2.096	32.38	0.39
60.00	0.08	2.000	32.28	0.35
64.00	0.07	1.914	32.19	0.31
68.00	0.06	1.839	32.11	0.27
72.00	0.05	1.777	32.04	0.21
76.00	0.04	1.729	31.99	0.18
80.00	0.03	1.684	31.94	0.17
84.00	0.03	1.642	31.90	0.16
88.00	0.03	1.602	31.85	0.15
92.00	0.03	1.565	31.81	0.14
96.00	0.02	1.530	31.77	0.13
100.00	0.01	1.495	31.74	0.12
104.00	0.00	1.459	31.70	0.10
108.00	0.00	1.427	31.66	0.09
112.00	0.00	1.400	31.63	0.08
116.00	0.00	1.376	31.60	0.07
120.00	0.00	1.356	31.58	0.05
124.00	0.00	1.340	31.57	0.04
128.00	0.00	1.329	31.55	0.03
132.00	0.00	1.321	31.54	0.02
136.00	0.00	1.315	31.54	0.02
140.00	0.00	1.310	31.53	0.01
144.00	0.00	1.306	31.53	0.01
148.00	0.00	1.303	31.53	0.01
152.00	0.00	1.301	31.52	0.01
156.00	0.00	1.299	31.52	0.01

Stage-Discharge for Pond 2P: Detention Basin

Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)
30.00	0.00	32.12	0.27	34.24	7.33	36.36	15.69
30.04	0.00	32.16	0.30	34.28	7.58	36.40	15.80
30.08	0.00	32.20	0.32	34.32	7.83	36.44	15.92
30.12	0.00	32.24	0.34	34.36	8.06	36.48	**16.03**
30.16	0.00	32.28	0.35	34.40	8.29		
30.20	0.00	32.32	0.37	34.44	8.51		
30.24	0.00	32.36	0.39	34.48	8.72		
30.28	0.00	32.40	0.40	34.52	8.93		
30.32	0.00	32.44	0.41	34.56	9.13		
30.36	0.00	32.48	0.43	34.60	9.33		
30.40	0.00	32.52	0.45	34.64	9.53		
30.44	0.00	32.56	0.49	34.68	9.72		
30.48	0.00	32.60	0.53	34.72	9.90		
30.52	0.00	32.64	0.56	34.76	10.09		
30.56	0.00	32.68	0.59	34.80	10.26		
30.60	0.00	32.72	0.61	34.84	10.44		
30.64	0.00	32.76	0.64	34.88	10.61		
30.68	0.00	32.80	0.66	34.92	10.78		
30.72	0.00	32.84	0.68	34.96	10.95		
30.76	0.00	32.88	0.70	35.00	11.11		
30.80	0.00	32.92	0.72	35.04	11.28		
30.84	0.00	32.96	0.73	35.08	11.44		
30.88	0.00	33.00	0.75	35.12	11.59		
30.92	0.00	33.04	0.79	35.16	11.75		
30.96	0.00	33.08	0.84	35.20	11.90		
31.00	0.00	33.12	0.88	35.24	12.05		
31.04	0.00	33.16	0.91	35.28	12.20		
31.08	0.00	33.20	0.94	35.32	12.35		
31.12	0.00	33.24	0.97	35.36	12.50		
31.16	0.00	33.28	0.99	35.40	12.64		
31.20	0.00	33.32	1.02	35.44	12.78		
31.24	0.00	33.36	1.04	35.48	12.92		
31.28	0.00	33.40	1.06	35.52	13.06		
31.32	0.00	33.44	1.09	35.56	13.20		
31.36	0.00	33.48	1.11	35.60	13.33		
31.40	0.00	33.52	1.13	35.64	13.47		
31.44	0.00	33.56	1.15	35.68	13.60		
31.48	0.00	33.60	1.17	35.72	13.73		
31.52	0.00	33.64	1.19	35.76	13.86		
31.56	0.04	33.68	1.21	35.80	13.99		
31.60	0.06	33.72	1.23	35.84	14.12		
31.64	0.08	33.76	1.28	35.88	14.25		
31.68	0.10	33.80	1.65	35.92	14.37		
31.72	0.11	33.84	2.21	35.96	14.50		
31.76	0.12	33.88	2.91	36.00	14.62		
31.80	0.13	33.92	3.72	36.04	14.75		
31.84	0.14	33.96	4.63	36.08	14.87		
31.88	0.15	34.00	5.56	36.12	14.99		
31.92	0.16	34.04	5.90	36.16	15.11		
31.96	0.17	34.08	6.21	36.20	15.23		
32.00	0.18	34.12	6.51	36.24	15.34		
32.04	0.20	34.16	6.80	36.28	15.46		
32.08	0.24	34.20	7.07	36.32	15.58		

Stage-Area-Storage for Pond 2P: Detention Basin

Elevation (feet)	Storage (acre-feet)
30.00	0.000
30.10	0.082
30.20	0.163
30.30	0.246
30.40	0.329
30.50	0.412
30.60	0.497
30.70	0.583
30.80	0.668
30.90	0.754
31.00	0.839
31.10	0.927
31.20	1.015
31.30	1.104
31.40	1.192
31.50	1.280
31.60	1.371
31.70	1.462
31.80	1.554
31.90	1.645
32.00	1.736
32.10	1.830
32.20	1.924
32.30	2.019
32.40	2.113
32.50	2.207
32.60	2.304
32.70	2.402
32.80	2.499
32.90	2.597
33.00	2.694
33.10	2.794
33.20	2.895
33.30	2.995
33.40	3.096
33.50	3.196
33.60	3.300
33.70	3.404
33.80	3.507
33.90	3.611
34.00	3.715
34.10	3.822
34.20	3.929
34.30	4.036
34.40	4.143
34.50	4.250
34.60	4.360
34.70	4.470
34.80	4.581
34.90	4.691
35.00	4.801
35.10	4.915
35.20	5.029
35.30	5.142
35.40	5.256
35.50	5.370
35.60	5.487
35.70	5.604
35.80	5.721
35.90	5.838
36.00	5.955
36.10	6.076
36.20	6.196
36.30	6.317
36.40	6.437
36.50	**6.558**

Summary for Pond 4P: Sand Filter

NOTE:

Influent Clear Well not modeled.

Storage in Sand Filter not modeled, flow modeled as lag.

Inflow	=	3.20 cfs @	17.03 hrs,	Volume=	5.647 af
Outflow	=	1.95 cfs @	24.31 hrs,	Volume=	5.646 af, Atten= 39%, Lag= 436.9 min
Primary	=	1.95 cfs @	24.31 hrs,	Volume=	5.646 af
Secondary	=	0.00 cfs @	0.00 hrs,	Volume=	0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 33.52' @ 24.31 hrs Surf.Area= 0.367 ac Storage= 1.108 af

Plug-Flow detention time= 227.5 min calculated for 5.646 af (100% of inflow)
Center-of-Mass det. time= 227.5 min (2,340.0 - 2,112.5)

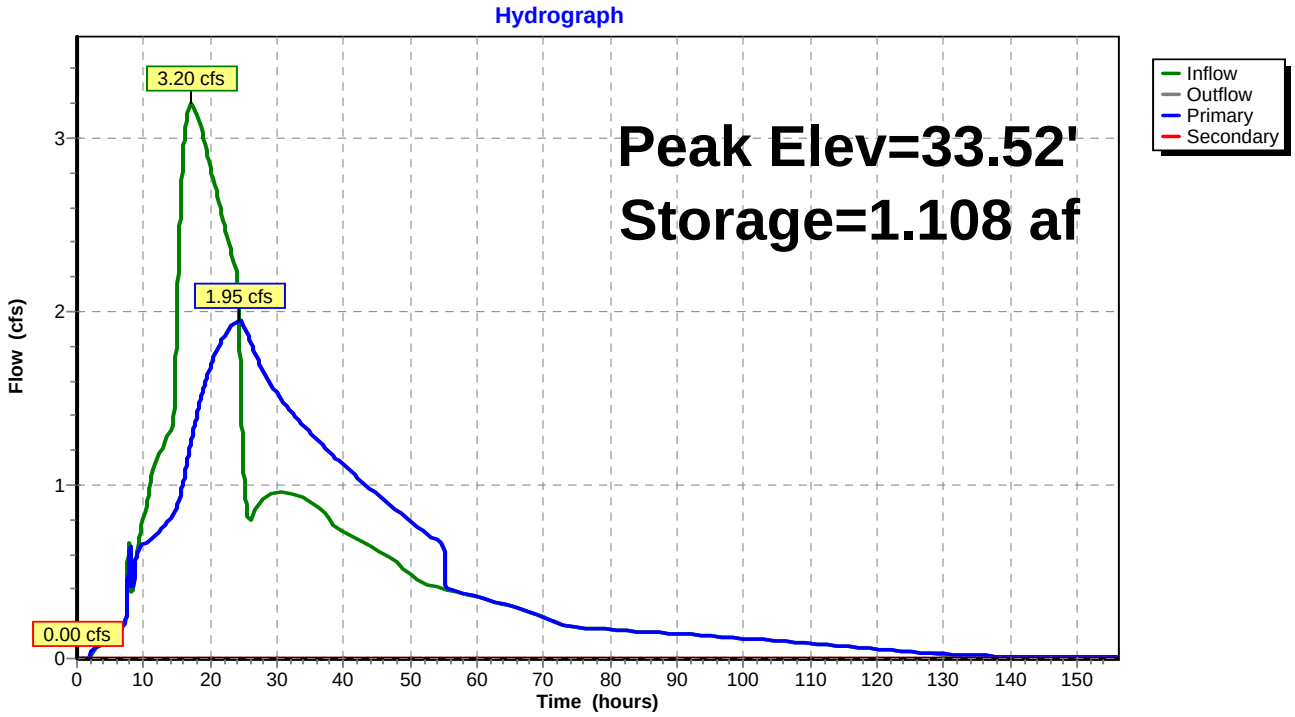
Volume	Invert	Avail.Storage	Storage Description
#1	30.50'	2.204 af	**100.00'W x 160.00'L x 6.00'H Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Secondary	35.25'	**130.0' long x 2.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 Coef. (English) 2.48 2.60 2.60 2.60 2.64 2.65 2.68 2.75 2.74 2.76 2.89 3.05 3.19 3.32
#2	Device 3	30.50'	**1.750 in/hr Exfiltration over Horizontal area** Conductivity to Groundwater Elevation = 29.00' Phase-In= 0.01'
#3	Device 4	29.00'	**0.3" Horiz. Orifice/Grate X 8.00 columns** X 150 rows C= 0.600
#4	Primary	28.76'	**4.0" Round Culvert X 8.00** L= 152.0' Ke= 0.900 Inlet / Outlet Invert= 28.76' / 28.00' S= 0.0050 '/' Cc= 0.500 n= 0.011

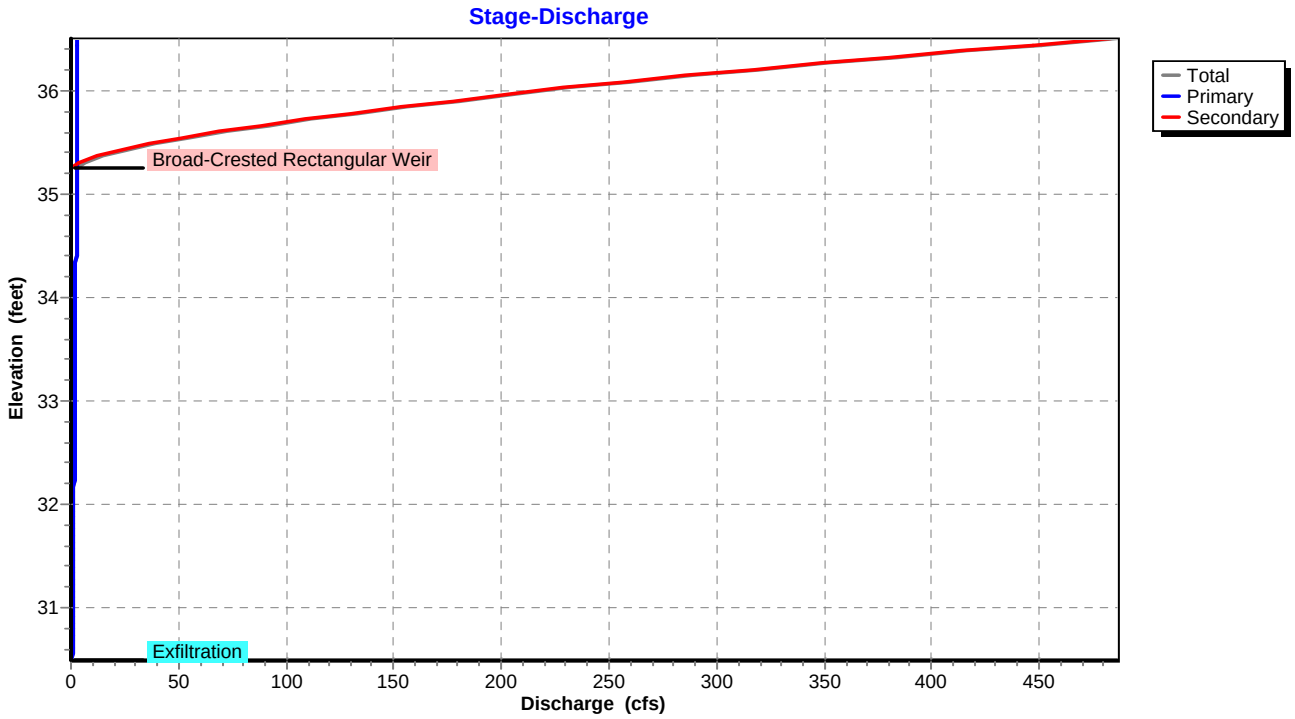
Primary OutFlow Max=1.95 cfs @ 24.31 hrs HW=33.52' TW=0.00' (Dynamic Tailwater)
└─**4=Culvert** (Passes 1.95 cfs of 3.12 cfs potential flow)
  └─**3=Orifice/Grate** (Passes 1.95 cfs of 6.03 cfs potential flow)
    └─**2=Exfiltration** (Controls 1.95 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=30.50' TW=29.00' (Dynamic Tailwater)
└─**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

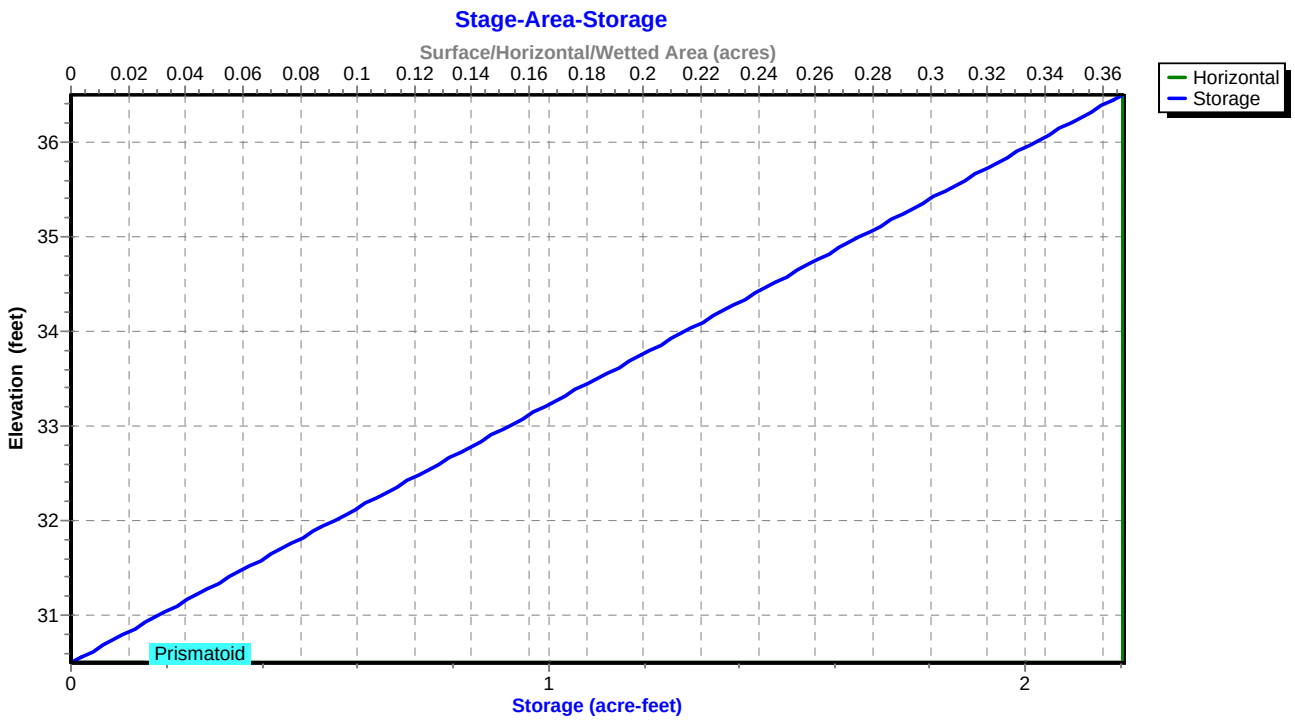
Pond 4P: Sand Filter



Pond 4P: Sand Filter



Pond 4P: Sand Filter



Hydrograph for Pond 4P: Sand Filter

Time (hours)	Inflow (cfs)	Storage (acre-feet)	Elevation (feet)	Outflow (cfs)	Primary (cfs)	Secondary (cfs)
0.00	0.00	0.000	30.50	0.00	0.00	**0.00**
4.00	0.09	0.001	30.50	0.09	0.09	0.00
8.00	0.65	0.004	30.51	0.65	0.65	0.00
12.00	1.14	0.061	30.67	0.72	0.72	0.00
16.00	**2.95**	0.324	31.38	1.03	1.03	0.00
20.00	**2.84**	0.881	32.90	1.68	1.68	0.00
24.00	2.21	**1.105**	**33.51**	**1.95**	**1.95**	0.00
28.00	0.92	**0.855**	**32.83**	**1.65**	**1.65**	0.00
32.00	0.95	0.664	32.31	1.43	1.43	0.00
36.00	0.88	0.525	31.93	1.27	1.27	0.00
40.00	0.73	0.395	31.58	1.11	1.11	0.00
44.00	0.65	0.279	31.26	0.98	0.98	0.00
48.00	0.55	0.175	30.98	0.85	0.85	0.00
52.00	0.43	0.073	30.70	0.73	0.73	0.00
56.00	0.39	0.002	30.51	0.39	0.39	0.00
60.00	0.35	0.002	30.51	0.35	0.35	0.00
64.00	0.31	0.002	30.50	0.31	0.31	0.00
68.00	0.27	0.002	30.50	0.27	0.27	0.00
72.00	0.21	0.001	30.50	0.21	0.21	0.00
76.00	0.18	0.001	30.50	0.18	0.18	0.00
80.00	0.17	0.001	30.50	0.17	0.17	0.00
84.00	0.16	0.001	30.50	0.16	0.16	0.00
88.00	0.15	0.001	30.50	0.15	0.15	0.00
92.00	0.14	0.001	30.50	0.14	0.14	0.00
96.00	0.13	0.001	30.50	0.13	0.13	0.00
100.00	0.12	0.001	30.50	0.12	0.12	0.00
104.00	0.10	0.001	30.50	0.10	0.10	0.00
108.00	0.09	0.001	30.50	0.09	0.09	0.00
112.00	0.08	0.000	30.50	0.08	0.08	0.00
116.00	0.07	0.000	30.50	0.07	0.07	0.00
120.00	0.05	0.000	30.50	0.05	0.05	0.00
124.00	0.04	0.000	30.50	0.04	0.04	0.00
128.00	0.03	0.000	30.50	0.03	0.03	0.00
132.00	0.02	0.000	30.50	0.02	0.02	0.00
136.00	0.02	0.000	30.50	0.02	0.02	0.00
140.00	0.01	0.000	30.50	0.01	0.01	0.00
144.00	0.01	0.000	30.50	0.01	0.01	0.00
148.00	0.01	0.000	30.50	0.01	0.01	0.00
152.00	0.01	0.000	30.50	0.01	0.01	0.00
156.00	0.01	0.000	30.50	0.01	0.01	0.00

Stage-Discharge for Pond 4P: Sand Filter

Elevation (feet)	Discharge (cfs)	Primary (cfs)	Secondary (cfs)
30.50	0.00	0.00	0.00
30.60	0.69	0.69	0.00
30.70	0.73	0.73	0.00
30.80	0.78	0.78	0.00
30.90	0.82	0.82	0.00
31.00	0.86	0.86	0.00
31.10	0.91	0.91	0.00
31.20	0.95	0.95	0.00
31.30	0.99	0.99	0.00
31.40	1.04	1.04	0.00
31.50	1.08	1.08	0.00
31.60	1.12	1.12	0.00
31.70	1.17	1.17	0.00
31.80	1.21	1.21	0.00
31.90	1.25	1.25	0.00
32.00	1.30	1.30	0.00
32.10	1.34	1.34	0.00
32.20	1.38	1.38	0.00
32.30	1.43	1.43	0.00
32.40	1.47	1.47	0.00
32.50	1.51	1.51	0.00
32.60	1.56	1.56	0.00
32.70	1.60	1.60	0.00
32.80	1.64	1.64	0.00
32.90	1.69	1.69	0.00
33.00	1.73	1.73	0.00
33.10	1.77	1.77	0.00
33.20	1.81	1.81	0.00
33.30	1.86	1.86	0.00
33.40	1.90	1.90	0.00
33.50	1.94	1.94	0.00
33.60	1.99	1.99	0.00
33.70	2.03	2.03	0.00
33.80	2.07	2.07	0.00
33.90	2.12	2.12	0.00
34.00	2.16	2.16	0.00
34.10	2.20	2.20	0.00
34.20	2.25	2.25	0.00
34.30	2.29	2.29	0.00
34.40	2.33	2.33	0.00
34.50	2.38	2.38	0.00
34.60	2.42	2.42	0.00
34.70	2.46	2.46	0.00
34.80	2.51	2.51	0.00
34.90	2.55	2.55	0.00
35.00	2.59	2.59	0.00
35.10	2.64	2.64	0.00
35.20	2.68	2.68	0.00
35.30	6.33	2.72	3.60
35.40	21.50	2.77	18.73
35.50	43.60	2.81	40.79
35.60	72.03	2.85	69.18
35.70	104.93	2.90	102.03
35.80	140.81	2.94	137.87
35.90	180.11	2.98	177.13
36.00	222.56	3.02	219.54
36.10	268.96	3.07	265.90
36.20	319.69	3.11	316.58
36.30	372.76	3.15	369.61
36.40	427.65	3.20	424.45
36.50	**486.06**	**3.24**	**482.82**

Stage-Area-Storage for Pond 4P: Sand Filter

Elevation (feet)	Horizontal (acres)	Storage (acre-feet)
30.50	**0.367**	0.000
30.60	0.367	0.037
30.70	0.367	0.073
30.80	0.367	0.110
30.90	0.367	0.147
31.00	0.367	0.184
31.10	0.367	0.220
31.20	0.367	0.257
31.30	0.367	0.294
31.40	0.367	0.331
31.50	0.367	0.367
31.60	0.367	0.404
31.70	0.367	0.441
31.80	0.367	0.478
31.90	0.367	0.514
32.00	0.367	0.551
32.10	0.367	0.588
32.20	0.367	0.624
32.30	0.367	0.661
32.40	0.367	0.698
32.50	0.367	0.735
32.60	0.367	0.771
32.70	0.367	0.808
32.80	0.367	0.845
32.90	0.367	0.882
33.00	0.367	0.918
33.10	0.367	0.955
33.20	0.367	0.992
33.30	0.367	1.028
33.40	0.367	1.065
33.50	0.367	1.102
33.60	0.367	1.139
33.70	0.367	1.175
33.80	0.367	1.212
33.90	0.367	1.249
34.00	0.367	1.286
34.10	0.367	1.322
34.20	0.367	1.359
34.30	0.367	1.396
34.40	0.367	1.433
34.50	0.367	1.469
34.60	0.367	1.506
34.70	0.367	1.543
34.80	0.367	1.579
34.90	0.367	1.616
35.00	0.367	1.653
35.10	0.367	1.690
35.20	0.367	1.726
35.30	0.367	1.763
35.40	0.367	1.800
35.50	0.367	1.837
35.60	0.367	1.873
35.70	0.367	1.910
35.80	0.367	1.947
35.90	0.367	1.983
36.00	0.367	2.020
36.10	0.367	2.057
36.20	0.367	2.094
36.30	0.367	2.130
36.40	0.367	2.167
36.50	0.367	**2.204**

Summary for Pond 6P: Post Clear Well

Inflow	=	1.95 cfs @	27.75 hrs,	Volume=	5.645 af
Outflow	=	1.95 cfs @	27.75 hrs,	Volume=	5.645 af, Atten= 0%, Lag= 0.0 min
Primary	=	1.95 cfs @	27.75 hrs,	Volume=	5.645 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 29.00' @ 27.75 hrs Surf.Area= 0.000 ac Storage= 0.000 af

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 0.0 min (2,544.0 - 2,544.0)

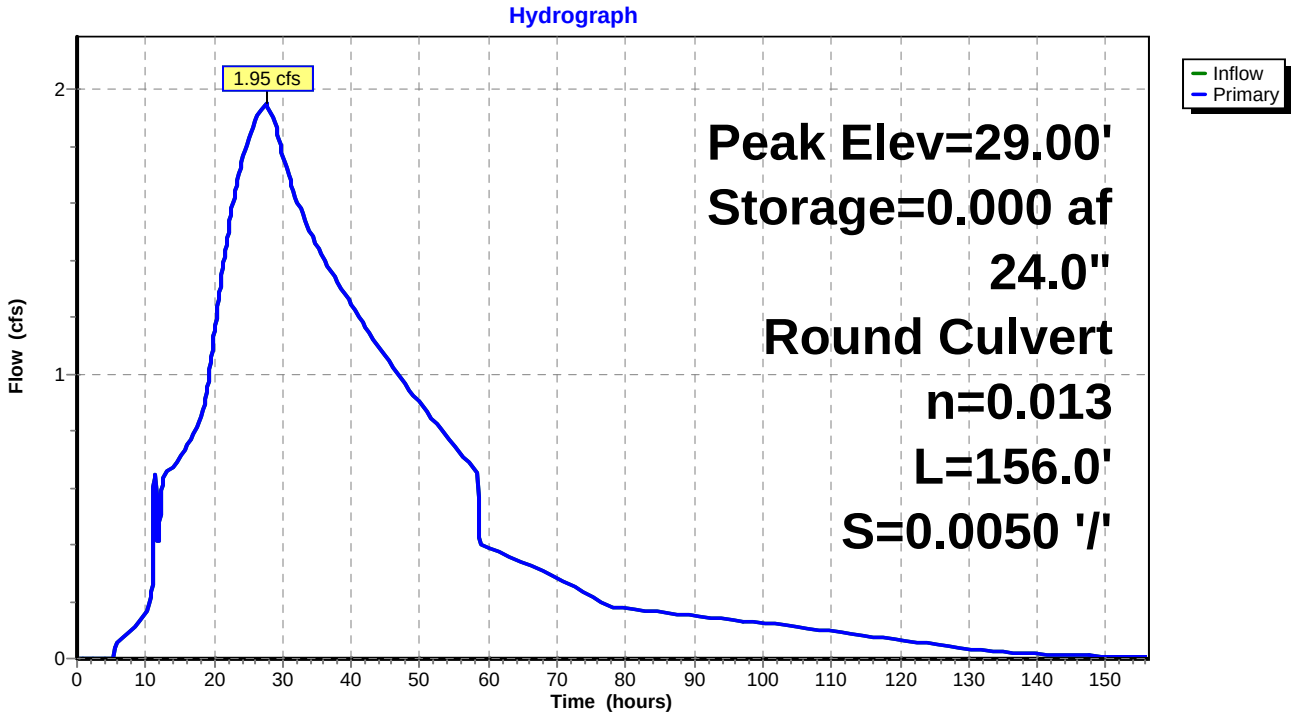
Volume	Invert	Avail.Storage	Storage Description
#1	29.00'	0.549 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
29.00	0.000
29.50	0.014
30.00	0.031
30.50	0.051
31.00	0.074
31.50	0.101
32.00	0.132
32.50	0.166
33.00	0.206
33.50	0.250
34.00	0.298
34.50	0.353
35.00	0.412
35.50	0.478
36.00	0.549

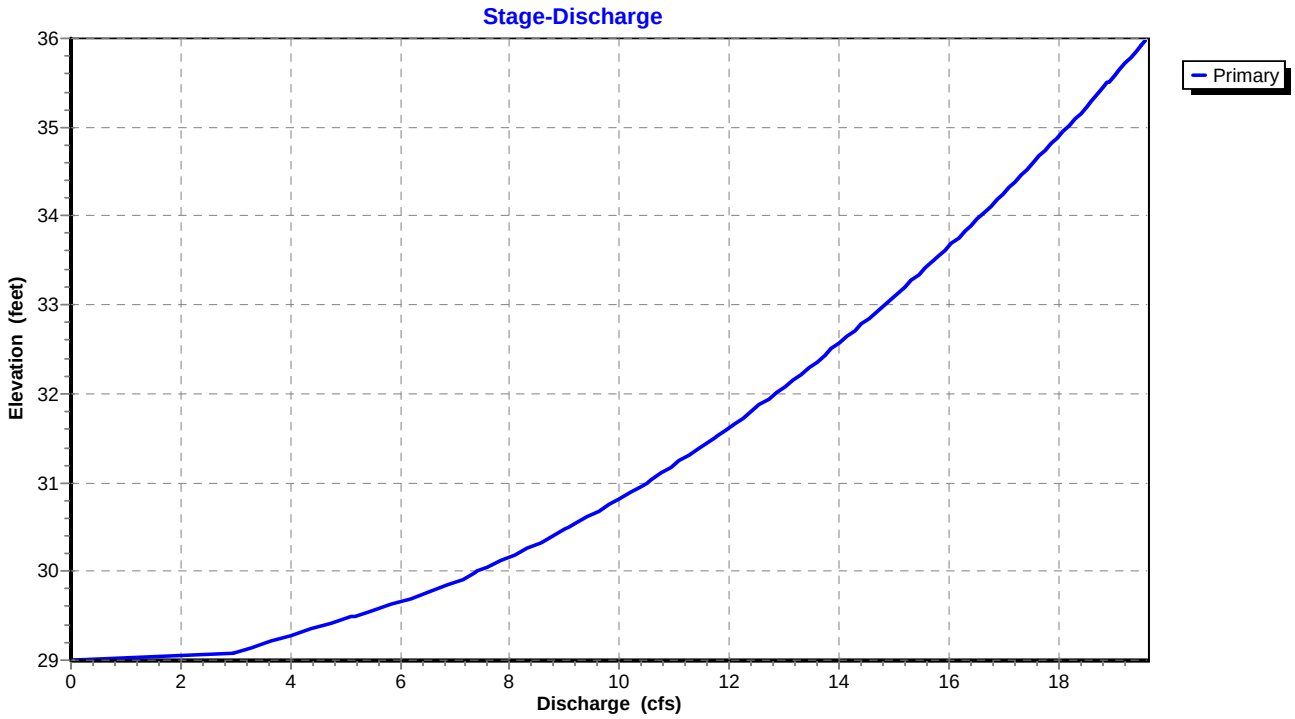
Device	Routing	Invert	Outlet Devices
#1	Primary	28.00'	**24.0" Round Culvert** L= 156.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 28.00' / 27.22' S= 0.0050 '/' Cc= 0.500 n= 0.013

Primary OutFlow Max=2.62 cfs @ 27.75 hrs HW=29.00' TW=27.70' (Dynamic Tailwater)
└─**1=Culvert** (Inlet Controls 2.62 cfs @ 1.67 fps)

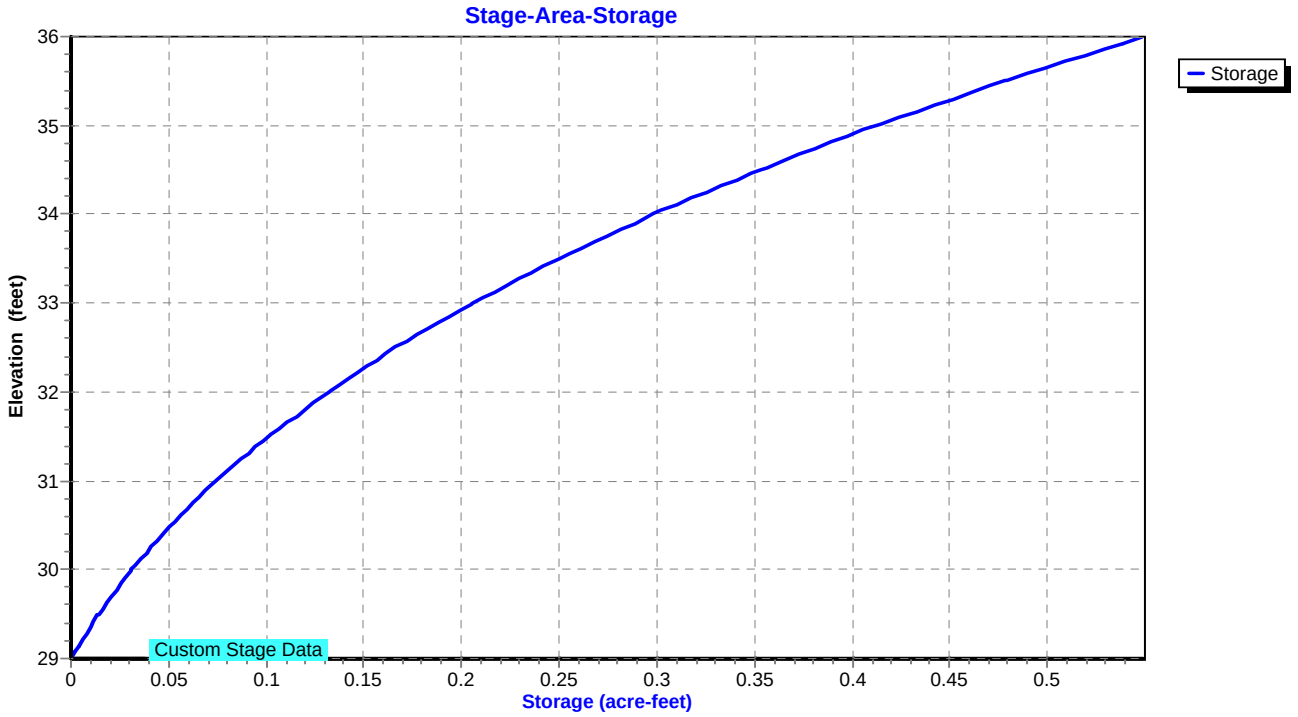
Pond 6P: Post Clear Well



Pond 6P: Post Clear Well



Pond 6P: Post Clear Well



Hydrograph for Pond 6P: Post Clear Well

Time (hours)	Inflow (cfs)	Storage (acre-feet)	Elevation (feet)	Primary (cfs)
0.00	0.00	0.000	29.00	0.00
4.00	0.00	0.000	29.00	0.00
8.00	0.10	0.000	29.00	0.10
12.00	0.42	0.000	29.00	0.42
16.00	0.74	0.000	29.00	0.74
20.00	1.14	0.000	29.00	1.14
24.00	**1.74**	**0.000**	**29.00**	**1.74**
28.00	**1.95**	**0.000**	**29.00**	**1.95**
32.00	1.62	0.000	29.00	1.62
36.00	1.40	0.000	29.00	1.40
40.00	1.24	0.000	29.00	1.24
44.00	1.09	0.000	29.00	1.09
48.00	0.96	0.000	29.00	0.96
52.00	0.84	0.000	29.00	0.84
56.00	0.72	0.000	29.00	0.72
60.00	0.39	0.000	29.00	0.39
64.00	0.35	0.000	29.00	0.35
68.00	0.31	0.000	29.00	0.31
72.00	0.26	0.000	29.00	0.26
76.00	0.20	0.000	29.00	0.20
80.00	0.17	0.000	29.00	0.17
84.00	0.17	0.000	29.00	0.17
88.00	0.16	0.000	29.00	0.16
92.00	0.15	0.000	29.00	0.15
96.00	0.14	0.000	29.00	0.14
100.00	0.13	0.000	29.00	0.13
104.00	0.11	0.000	29.00	0.11
108.00	0.10	0.000	29.00	0.10
112.00	0.09	0.000	29.00	0.09
116.00	0.08	0.000	29.00	0.08
120.00	0.06	0.000	29.00	0.06
124.00	0.05	0.000	29.00	0.05
128.00	0.04	0.000	29.00	0.04
132.00	0.03	0.000	29.00	0.03
136.00	0.02	0.000	29.00	0.02
140.00	0.02	0.000	29.00	0.02
144.00	0.01	0.000	29.00	0.01
148.00	0.01	0.000	29.00	0.01
152.00	0.01	0.000	29.00	0.01
156.00	0.01	0.000	29.00	0.01

Stage-Discharge for Pond 6P: Post Clear Well

Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)
29.00	0.00	31.12	10.80	33.24	15.27	35.36	18.70
29.04	2.81	31.16	10.90	33.28	15.34	35.40	18.76
29.08	3.00	31.20	11.00	33.32	15.41	35.44	18.82
29.12	3.20	31.24	11.10	33.36	15.48	35.48	18.88
29.16	3.40	31.28	11.20	33.40	15.55	35.52	18.93
29.20	3.60	31.32	11.29	33.44	15.62	35.56	18.99
29.24	3.80	31.36	11.39	33.48	15.69	35.60	19.05
29.28	4.01	31.40	11.49	33.52	15.76	35.64	19.11
29.32	4.22	31.44	11.58	33.56	15.83	35.68	19.16
29.36	4.43	31.48	11.68	33.60	15.90	35.72	19.22
29.40	4.64	31.52	11.77	33.64	15.97	35.76	19.28
29.44	4.85	31.56	11.86	33.68	16.04	35.80	19.34
29.48	5.06	31.60	11.96	33.72	16.11	35.84	19.39
29.52	5.27	31.64	12.05	33.76	16.18	35.88	19.45
29.56	5.48	31.68	12.14	33.80	16.25	35.92	19.51
29.60	5.69	31.72	12.23	33.84	16.31	35.96	19.56
29.64	5.89	31.76	12.32	33.88	16.38	36.00	**19.62**
29.68	6.09	31.80	12.41	33.92	16.45		
29.72	6.29	31.84	12.50	33.96	16.51		
29.76	6.48	31.88	12.58	34.00	16.58		
29.80	6.67	31.92	12.67	34.04	16.65		
29.84	6.85	31.96	12.76	34.08	16.71		
29.88	7.01	32.00	12.84	34.12	16.78		
29.92	7.17	32.04	12.93	34.16	16.84		
29.96	7.31	32.08	13.01	34.20	16.91		
30.00	7.42	32.12	13.10	34.24	16.97		
30.04	7.56	32.16	13.18	34.28	17.04		
30.08	7.71	32.20	13.26	34.32	17.10		
30.12	7.85	32.24	13.35	34.36	17.17		
30.16	7.99	32.28	13.43	34.40	17.23		
30.20	8.12	32.32	13.51	34.44	17.29		
30.24	8.26	32.36	13.59	34.48	17.36		
30.28	8.39	32.40	13.67	34.52	17.42		
30.32	8.52	32.44	13.75	34.56	17.48		
30.36	8.65	32.48	13.83	34.60	17.55		
30.40	8.77	32.52	13.91	34.64	17.61		
30.44	8.90	32.56	13.99	34.68	17.67		
30.48	9.02	32.60	14.07	34.72	17.73		
30.52	9.14	32.64	14.15	34.76	17.80		
30.56	9.26	32.68	14.22	34.80	17.86		
30.60	9.38	32.72	14.30	34.84	17.92		
30.64	9.50	32.76	14.38	34.88	17.98		
30.68	9.61	32.80	14.45	34.92	18.04		
30.72	9.72	32.84	14.53	34.96	18.10		
30.76	9.84	32.88	14.61	35.00	18.16		
30.80	9.95	32.92	14.68	35.04	18.22		
30.84	10.06	32.96	14.76	35.08	18.28		
30.88	10.17	33.00	14.83	35.12	18.34		
30.92	10.27	33.04	14.90	35.16	18.40		
30.96	10.38	33.08	14.98	35.20	18.46		
31.00	10.49	33.12	15.05	35.24	18.52		
31.04	10.59	33.16	15.12	35.28	18.58		
31.08	10.69	33.20	15.20	35.32	18.64		

Stage-Area-Storage for Pond 6P: Post Clear Well

Elevation (feet)	Storage (acre-feet)
29.00	0.000
29.10	0.003
29.20	0.006
29.30	0.008
29.40	0.011
29.50	0.014
29.60	0.017
29.70	0.021
29.80	0.024
29.90	0.028
30.00	0.031
30.10	0.035
30.20	0.039
30.30	0.043
30.40	0.047
30.50	0.051
30.60	0.056
30.70	0.060
30.80	0.065
30.90	0.069
31.00	0.074
31.10	0.079
31.20	0.085
31.30	0.090
31.40	0.096
31.50	0.101
31.60	0.107
31.70	0.113
31.80	0.120
31.90	0.126
32.00	0.132
32.10	0.139
32.20	0.146
32.30	0.152
32.40	0.159
32.50	0.166
32.60	0.174
32.70	0.182
32.80	0.190
32.90	0.198
33.00	0.206
33.10	0.215
33.20	0.224
33.30	0.232
33.40	0.241
33.50	0.250
33.60	0.260
33.70	0.269
33.80	0.279
33.90	0.288
34.00	0.298
34.10	0.309
34.20	0.320
34.30	0.331
34.40	0.342
34.50	0.353
34.60	0.365
34.70	0.377
34.80	0.388
34.90	0.400
35.00	0.412
35.10	0.425
35.20	0.438
35.30	0.452
35.40	0.465
35.50	0.478
35.60	0.492
35.70	0.506
35.80	0.521
35.90	0.535
36.00	**0.549**

Summary for Pond 12P: Sediment Forebay

Inflow	=	20.21 cfs @	8.05 hrs,	Volume=	7.114 af
Outflow	=	18.63 cfs @	8.20 hrs,	Volume=	6.728 af, Atten= 8%, Lag= 9.1 min
Primary	=	18.63 cfs @	8.20 hrs,	Volume=	6.728 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 33.89' @ 17.46 hrs Surf.Area= 0.000 ac Storage= 0.978 af

Plug-Flow detention time= 258.5 min calculated for 6.727 af (95% of inflow)
Center-of-Mass det. time= 221.3 min (954.7 - 733.4)

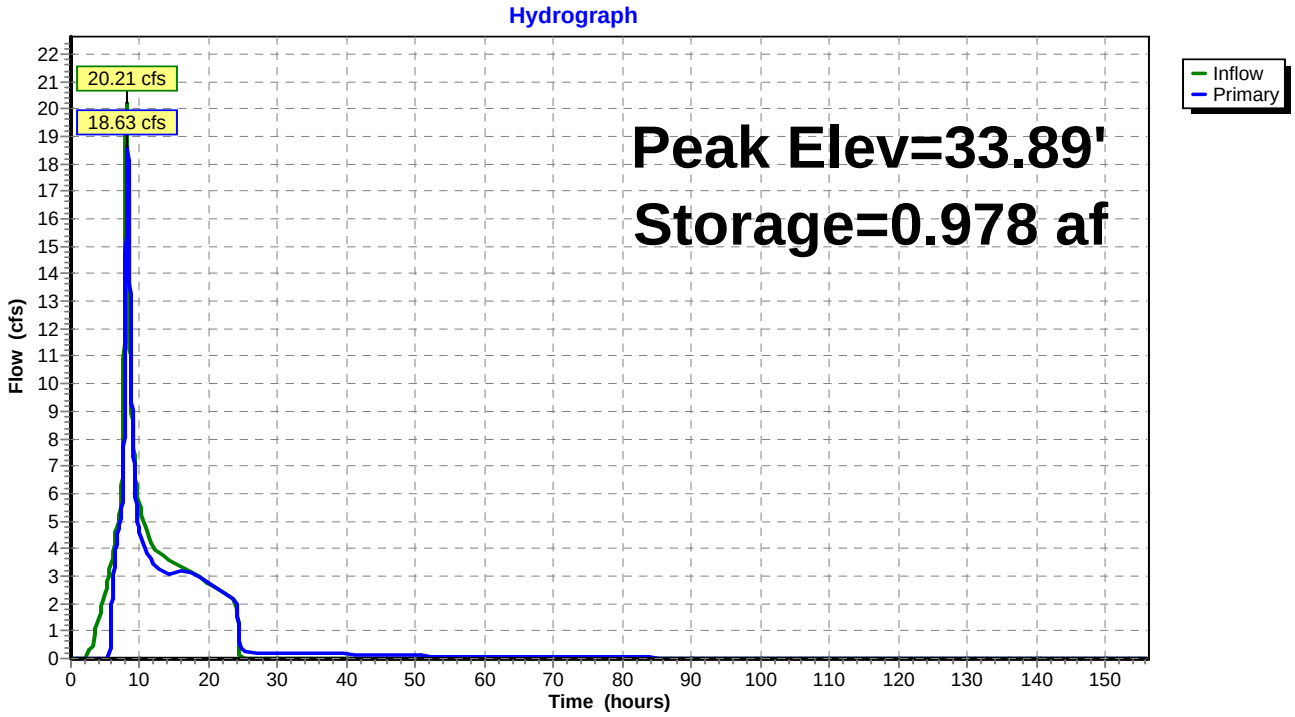
Volume	Invert	Avail.Storage	Storage Description
#1	30.00'	1.902 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
30.00	0.000
30.50	0.102
31.00	0.211
31.50	0.326
31.75	0.386
32.00	0.445
32.50	0.577
33.00	0.713
33.50	0.858
34.00	1.010
34.50	1.171
35.00	1.340
35.50	1.518
36.00	1.705
36.50	1.902

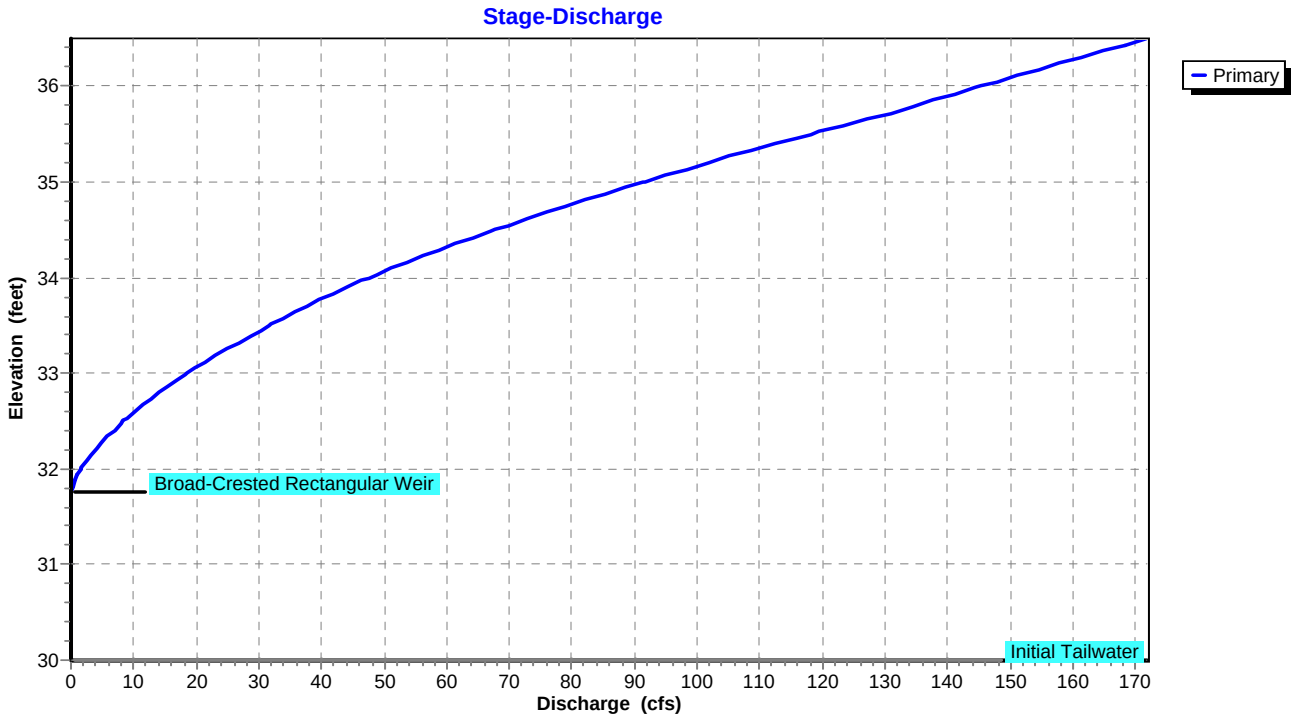
Device	Routing	Invert	Outlet Devices
#1	Primary	31.75'	**5.0' long x 2.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 Coef. (English) 2.48 2.60 2.60 2.60 2.64 2.65 2.68 2.75 2.74 2.76 2.89 3.05 3.19 3.32

Primary OutFlow Max=18.63 cfs @ 8.20 hrs HW=33.00' TW=31.49' (Dynamic Tailwater)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 18.63 cfs @ 2.97 fps)

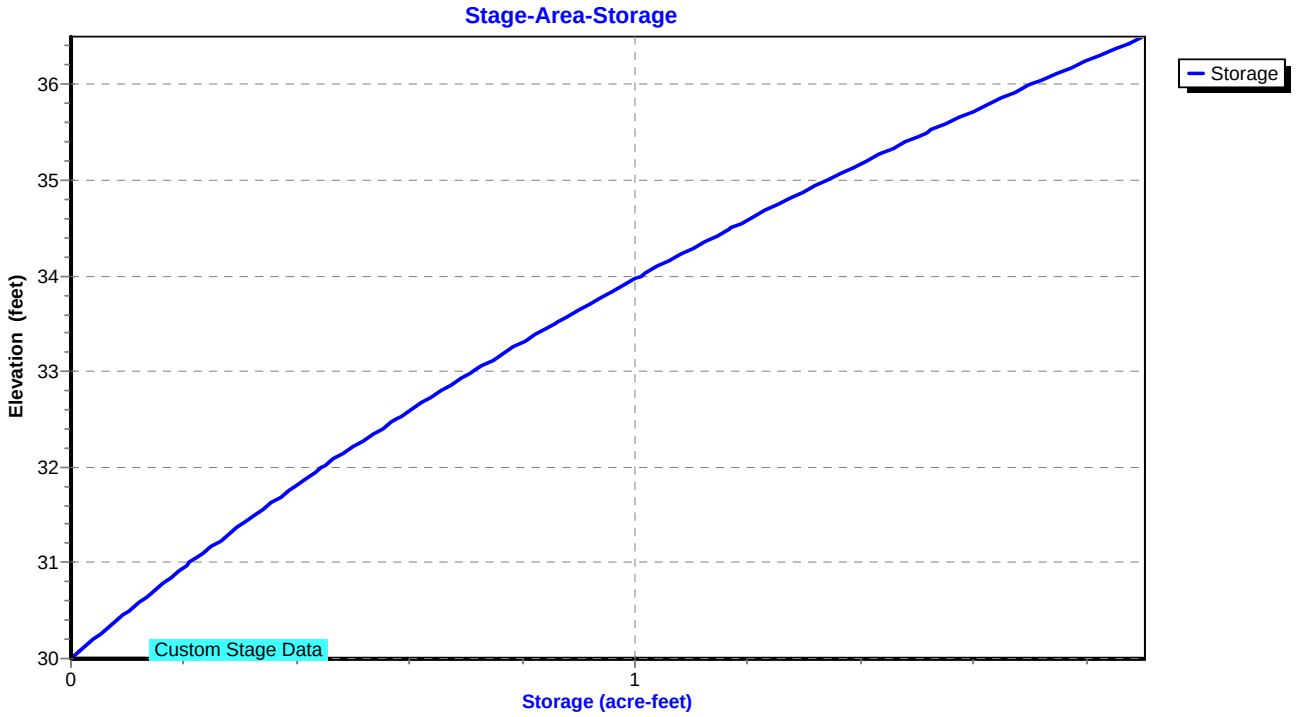
Pond 12P: Sediment Forebay



Pond 12P: Sediment Forebay



Pond 12P: Sediment Forebay



Hydrograph for Pond 12P: Sediment Forebay

Time (hours)	Inflow (cfs)	Storage (acre-feet)	Elevation (feet)	Primary (cfs)
0.00	0.00	0.000	30.00	0.00
4.00	1.43	0.089	30.44	0.00
8.00	**19.83**	0.680	32.88	**15.88**
12.00	**3.98**	0.815	33.35	**3.33**
16.00	3.34	**0.973**	**33.88**	3.23
20.00	2.72	**0.976**	**33.89**	2.73
24.00	2.09	0.972	33.88	2.11
28.00	0.00	0.903	33.65	0.21
32.00	0.00	0.832	33.41	0.21
36.00	0.00	0.763	33.17	0.20
40.00	0.00	0.704	32.97	0.16
44.00	0.00	0.654	32.78	0.14
48.00	0.00	0.611	32.62	0.12
52.00	0.00	0.576	32.50	0.09
56.00	0.00	0.546	32.38	0.09
60.00	0.00	0.519	32.28	0.08
64.00	0.00	0.495	32.19	0.07
68.00	0.00	0.474	32.11	0.06
72.00	0.00	0.457	32.04	0.05
76.00	0.00	0.443	31.99	0.04
80.00	0.00	0.432	31.94	0.03
84.00	0.00	0.421	31.90	0.03
88.00	0.00	0.410	31.85	0.03
92.00	0.00	0.401	31.81	0.03
96.00	0.00	0.392	31.78	0.02
100.00	0.00	0.387	31.76	0.01
104.00	0.00	0.386	31.75	0.00
108.00	0.00	0.386	31.75	0.00
112.00	0.00	0.386	31.75	0.00
116.00	0.00	0.386	31.75	0.00
120.00	0.00	0.386	31.75	0.00
124.00	0.00	0.386	31.75	0.00
128.00	0.00	0.386	31.75	0.00
132.00	0.00	0.386	31.75	0.00
136.00	0.00	0.386	31.75	0.00
140.00	0.00	0.386	31.75	0.00
144.00	0.00	0.386	31.75	0.00
148.00	0.00	0.386	31.75	0.00
152.00	0.00	0.386	31.75	0.00
156.00	0.00	0.386	31.75	0.00

Stage-Discharge for Pond 12P: Sediment Forebay

Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)
30.00	0.00	32.12	2.91	34.24	56.73	36.36	164.31
30.04	0.00	32.16	3.41	34.28	58.34	36.40	166.45
30.08	0.00	32.20	3.92	34.32	60.00	36.44	168.60
30.12	0.00	32.24	4.46	34.36	61.67	36.48	**170.77**
30.16	0.00	32.28	5.02	34.40	63.37		
30.20	0.00	32.32	5.59	34.44	65.09		
30.24	0.00	32.36	6.19	34.48	66.84		
30.28	0.00	32.40	6.81	34.52	68.61		
30.32	0.00	32.44	7.45	34.56	70.40		
30.36	0.00	32.48	8.11	34.60	72.22		
30.40	0.00	32.52	8.78	34.64	74.06		
30.44	0.00	32.56	9.48	34.68	75.92		
30.48	0.00	32.60	10.23	34.72	77.81		
30.52	0.00	32.64	10.99	34.76	79.71		
30.56	0.00	32.68	11.78	34.80	81.60		
30.60	0.00	32.72	12.58	34.84	83.52		
30.64	0.00	32.76	13.40	34.88	85.46		
30.68	0.00	32.80	14.22	34.92	87.41		
30.72	0.00	32.84	15.05	34.96	89.40		
30.76	0.00	32.88	15.89	35.00	91.40		
30.80	0.00	32.92	16.76	35.04	93.43		
30.84	0.00	32.96	17.65	35.08	95.48		
30.88	0.00	33.00	18.57	35.12	97.55		
30.92	0.00	33.04	19.51	35.16	99.64		
30.96	0.00	33.08	20.47	35.20	101.76		
31.00	0.00	33.12	21.45	35.24	103.90		
31.04	0.00	33.16	22.46	35.28	106.04		
31.08	0.00	33.20	23.55	35.32	108.20		
31.12	0.00	33.24	24.66	35.36	110.38		
31.16	0.00	33.28	25.79	35.40	112.58		
31.20	0.00	33.32	26.95	35.44	114.81		
31.24	0.00	33.36	28.08	35.48	117.05		
31.28	0.00	33.40	29.12	35.52	119.32		
31.32	0.00	33.44	30.16	35.56	121.61		
31.36	0.00	33.48	31.21	35.60	123.93		
31.40	0.00	33.52	32.28	35.64	126.26		
31.44	0.00	33.56	33.37	35.68	128.62		
31.48	0.00	33.60	34.54	35.72	131.00		
31.52	0.00	33.64	35.71	35.76	133.30		
31.56	0.00	33.68	36.91	35.80	135.30		
31.60	0.00	33.72	38.12	35.84	137.31		
31.64	0.00	33.76	39.36	35.88	139.33		
31.68	0.00	33.80	40.70	35.92	141.36		
31.72	0.00	33.84	42.05	35.96	143.39		
31.76	0.01	33.88	43.42	36.00	145.44		
31.80	0.14	33.92	44.82	36.04	147.50		
31.84	0.33	33.96	46.24	36.08	149.57		
31.88	0.58	34.00	47.67	36.12	151.65		
31.92	0.87	34.04	49.13	36.16	153.73		
31.96	1.20	34.08	50.61	36.20	155.83		
32.00	1.57	34.12	52.11	36.24	157.93		
32.04	1.98	34.16	53.62	36.28	160.05		
32.08	2.42	34.20	55.16	36.32	162.17		

Stage-Area-Storage for Pond 12P: Sediment Forebay

Elevation (feet)	Storage (acre-feet)
30.00	0.000
30.10	0.020
30.20	0.041
30.30	0.061
30.40	0.082
30.50	0.102
30.60	0.124
30.70	0.146
30.80	0.167
30.90	0.189
31.00	0.211
31.10	0.234
31.20	0.257
31.30	0.280
31.40	0.303
31.50	0.326
31.60	0.350
31.70	0.374
31.80	0.398
31.90	0.421
32.00	0.445
32.10	0.471
32.20	0.498
32.30	0.524
32.40	0.551
32.50	0.577
32.60	0.604
32.70	0.631
32.80	0.659
32.90	0.686
33.00	0.713
33.10	0.742
33.20	0.771
33.30	0.800
33.40	0.829
33.50	0.858
33.60	0.888
33.70	0.919
33.80	0.949
33.90	0.980
34.00	1.010
34.10	1.042
34.20	1.074
34.30	1.107
34.40	1.139
34.50	1.171
34.60	1.205
34.70	1.239
34.80	1.272
34.90	1.306
35.00	1.340
35.10	1.376
35.20	1.411
35.30	1.447
35.40	1.482
35.50	1.518
35.60	1.555
35.70	1.593
35.80	1.630
35.90	1.668
36.00	1.705
36.10	1.744
36.20	1.784
36.30	1.823
36.40	1.863
36.50	**1.902**

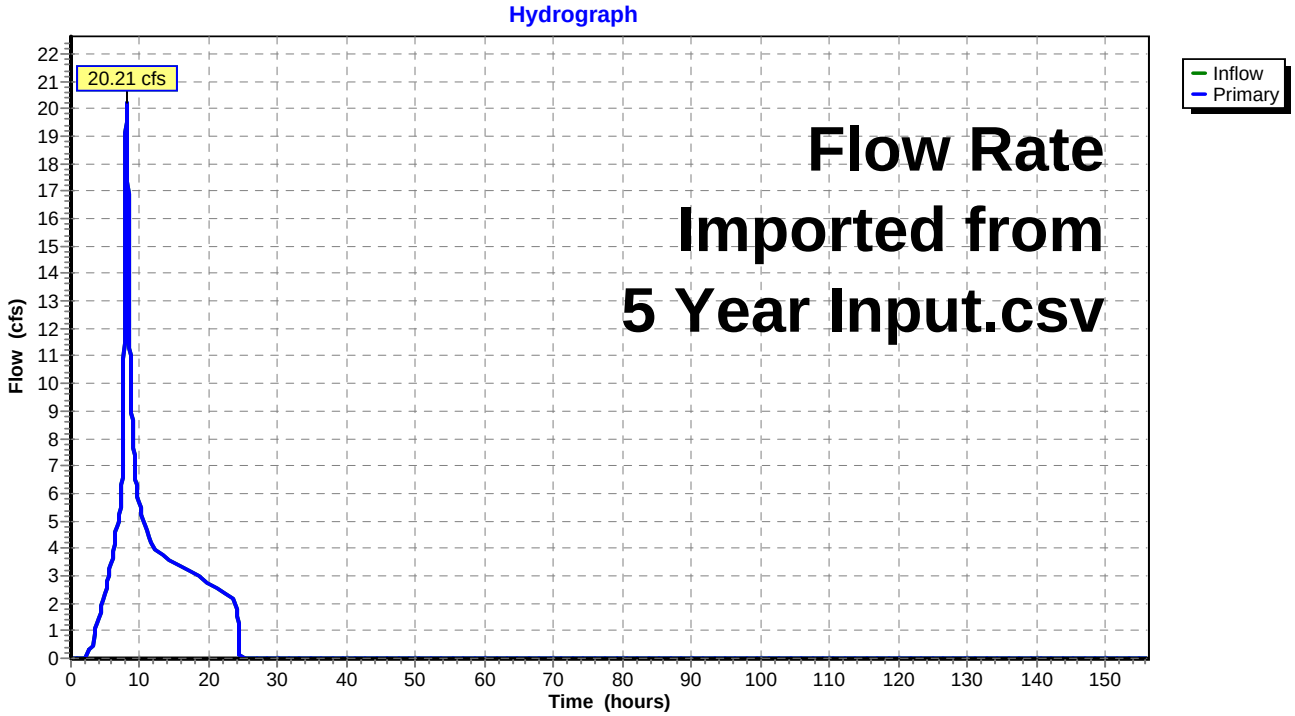
Summary for Link 1L: Input Hydrograhp

Inflow	=	20.21 cfs @	8.05 hrs,	Volume=	7.114 af
Primary	=	20.21 cfs @	8.05 hrs,	Volume=	7.114 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs

Flow Rate Imported from 5 Year Input.csv

Link 1L: Input Hydrograhp



Hydrograph for Link 1L: Input Hydrograhp

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**0.00**	0.00
2.00	0.00	0.00	0.00
4.00	1.43	0.00	1.43
6.00	3.68	0.00	3.68
8.00	**19.83**	0.00	**19.83**
10.00	**5.50**	0.00	**5.50**
12.00	3.98	0.00	3.98
14.00	3.59	0.00	3.59
16.00	3.34	0.00	3.34
18.00	3.03	0.00	3.03
20.00	2.72	0.00	2.72
22.00	2.41	0.00	2.41
24.00	2.09	0.00	2.09
26.00	0.00	0.00	0.00
28.00	0.00	0.00	0.00
30.00	0.00	0.00	0.00
32.00	0.00	0.00	0.00
34.00	0.00	0.00	0.00
36.00	0.00	0.00	0.00
38.00	0.00	0.00	0.00
40.00	0.00	0.00	0.00
42.00	0.00	0.00	0.00
44.00	0.00	0.00	0.00
46.00	0.00	0.00	0.00
48.00	0.00	0.00	0.00
50.00	0.00	0.00	0.00
52.00	0.00	0.00	0.00
54.00	0.00	0.00	0.00
56.00	0.00	0.00	0.00
58.00	0.00	0.00	0.00
60.00	0.00	0.00	0.00
62.00	0.00	0.00	0.00
64.00	0.00	0.00	0.00
66.00	0.00	0.00	0.00
68.00	0.00	0.00	0.00
70.00	0.00	0.00	0.00
72.00	0.00	0.00	0.00
74.00	0.00	0.00	0.00
76.00	0.00	0.00	0.00
78.00	0.00	0.00	0.00
80.00	0.00	0.00	0.00
82.00	0.00	0.00	0.00
84.00	0.00	0.00	0.00
86.00	0.00	0.00	0.00
88.00	0.00	0.00	0.00
90.00	0.00	0.00	0.00
92.00	0.00	0.00	0.00
94.00	0.00	0.00	0.00
96.00	0.00	0.00	0.00
98.00	0.00	0.00	0.00
100.00	0.00	0.00	0.00
102.00	0.00	0.00	0.00
104.00	0.00	0.00	0.00
106.00	0.00	0.00	0.00
108.00	0.00	0.00	0.00
110.00	0.00	0.00	0.00
112.00	0.00	0.00	0.00
114.00	0.00	0.00	0.00
116.00	0.00	0.00	0.00
118.00	0.00	0.00	0.00
120.00	0.00	0.00	0.00
122.00	0.00	0.00	0.00
124.00	0.00	0.00	0.00
126.00	0.00	0.00	0.00
128.00	0.00	0.00	0.00
130.00	0.00	0.00	0.00
132.00	0.00	0.00	0.00
134.00	0.00	0.00	0.00
136.00	0.00	0.00	0.00
138.00	0.00	0.00	0.00
140.00	0.00	0.00	0.00
142.00	0.00	0.00	0.00
144.00	0.00	0.00	0.00
146.00	0.00	0.00	0.00
148.00	0.00	0.00	0.00
150.00	0.00	0.00	0.00
152.00	0.00	0.00	0.00
154.00	0.00	0.00	0.00
156.00	0.00	0.00	0.00

Summary for Link 4L: Lag Thru Filter

Storage in sand filter modeled here as lag time from sand filter outlet to clear well outlet on downstream side of sand filter.

Lagtime estimate at conductivity of 1.75 inches/hour, with a hydraulic gradient of {[(31.00-28)/2]+1.5}*/(1.5)** thru 18 inches of sand.

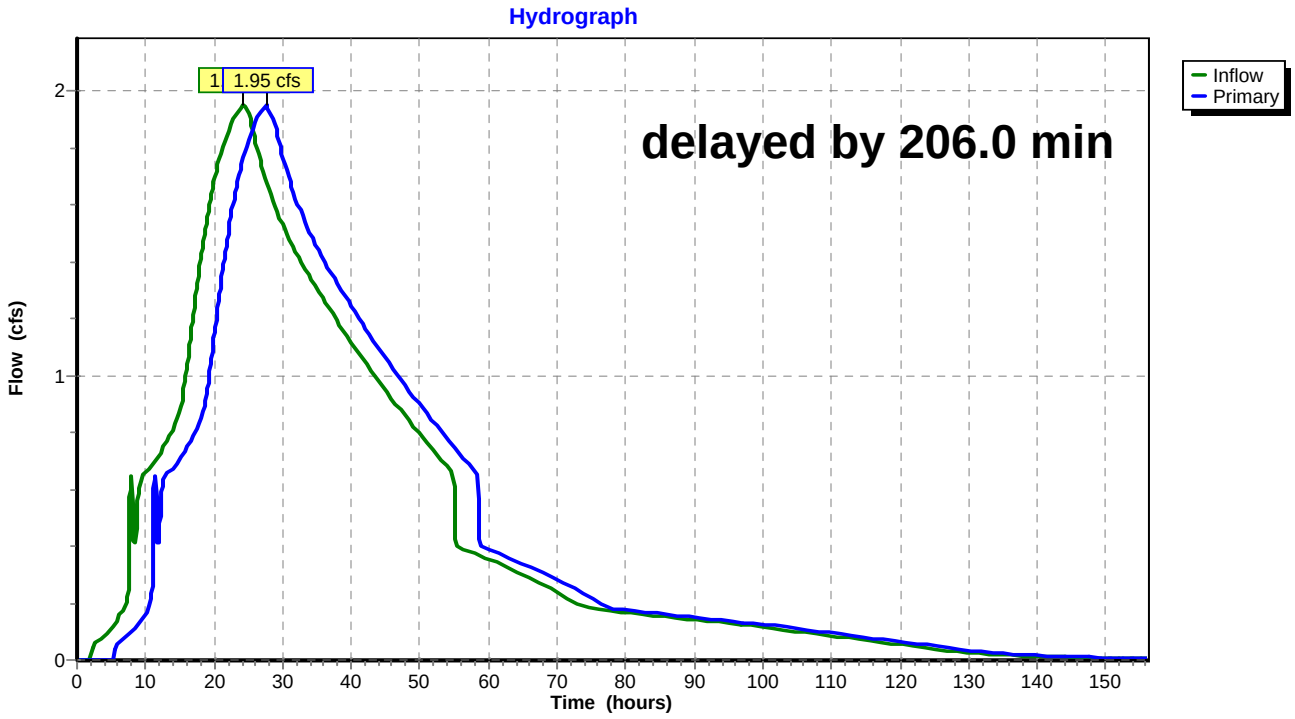
Result is 206 minutes

* "Average" Head on Sand Filter.
** Depth of Sand Filter

Inflow	=	1.95 cfs @	24.31 hrs,	Volume=	5.646 af
Primary	=	1.95 cfs @	27.75 hrs,	Volume=	5.645 af, Atten= 0%, Lag= 206.0 min

Primary outflow = Inflow delayed by 206.0 min, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs

Link 4L: Lag Thru Filter



Hydrograph for Link 4L: Lag Thru Filter

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**0.00**	0.00
2.00	0.00	0.00	0.00
4.00	0.09	0.00	0.00
6.00	0.14	0.00	0.06
8.00	0.65	0.00	0.10
10.00	0.66	0.00	0.17
12.00	0.72	0.00	0.42
14.00	0.81	0.00	0.67
16.00	1.03	0.00	0.74
18.00	1.40	0.00	0.84
20.00	1.68	0.00	1.14
22.00	1.86	0.00	1.50
24.00	**1.95**	0.00	1.74
26.00	**1.82**	0.00	**1.89**
28.00	1.65	0.00	**1.95**
30.00	1.53	0.00	1.77
32.00	1.43	0.00	1.62
34.00	1.34	0.00	1.50
36.00	1.27	0.00	1.40
38.00	1.19	0.00	1.32
40.00	1.11	0.00	1.24
42.00	1.04	0.00	1.17
44.00	0.98	0.00	1.09
46.00	0.91	0.00	1.02
48.00	0.85	0.00	0.96
50.00	0.79	0.00	0.90
52.00	0.73	0.00	0.84
54.00	0.68	0.00	0.78
56.00	0.39	0.00	0.72
58.00	0.37	0.00	0.67
60.00	0.35	0.00	0.39
62.00	0.33	0.00	0.37
64.00	0.31	0.00	0.35
66.00	0.29	0.00	0.33
68.00	0.27	0.00	0.31
70.00	0.24	0.00	0.28
72.00	0.21	0.00	0.26
74.00	0.19	0.00	0.23
76.00	0.18	0.00	0.20
78.00	0.17	0.00	0.18
80.00	0.17	0.00	0.17
82.00	0.16	0.00	0.17
84.00	0.16	0.00	0.17
86.00	0.15	0.00	0.16
88.00	0.15	0.00	0.16
90.00	0.14	0.00	0.15
92.00	0.14	0.00	0.15
94.00	0.13	0.00	0.14
96.00	0.13	0.00	0.14
98.00	0.12	0.00	0.13
100.00	0.12	0.00	0.13
102.00	0.11	0.00	0.12
104.00	0.10	0.00	0.11
106.00	0.10	0.00	0.11
108.00	0.09	0.00	0.10
110.00	0.08	0.00	0.10
112.00	0.08	0.00	0.09
114.00	0.07	0.00	0.08
116.00	0.07	0.00	0.08
118.00	0.06	0.00	0.07
120.00	0.05	0.00	0.06
122.00	0.05	0.00	0.06
124.00	0.04	0.00	0.05
126.00	0.03	0.00	0.05
128.00	0.03	0.00	0.04
130.00	0.03	0.00	0.03
132.00	0.02	0.00	0.03
134.00	0.02	0.00	0.02
136.00	0.02	0.00	0.02
138.00	0.01	0.00	0.02
140.00	0.01	0.00	0.02
142.00	0.01	0.00	0.01
144.00	0.01	0.00	0.01
146.00	0.01	0.00	0.01
148.00	0.01	0.00	0.01
150.00	0.01	0.00	0.01
152.00	0.01	0.00	0.01
154.00	0.01	0.00	0.01
156.00	0.01	0.00	0.01

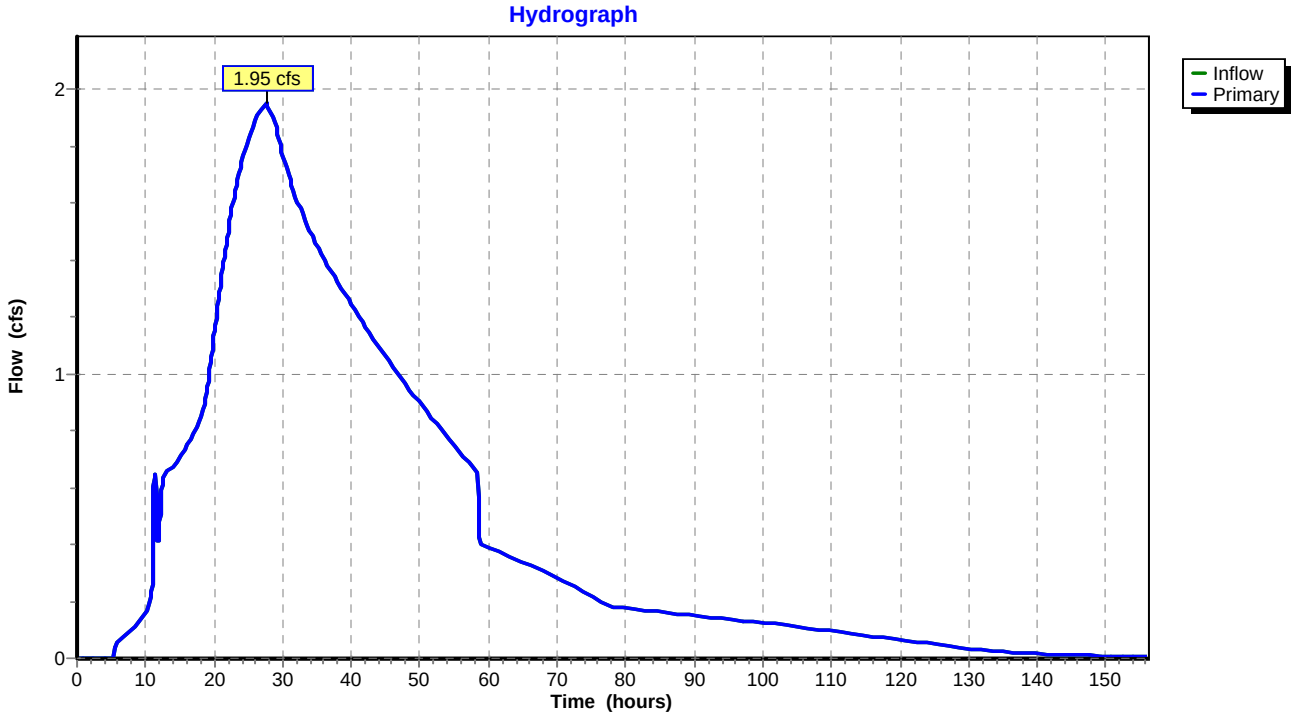
Summary for Link 9L: Discharge Elevation

Inflow	=	1.95 cfs @	27.75 hrs,	Volume=	5.645 af
Primary	=	1.95 cfs @	27.75 hrs,	Volume=	5.645 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs

Fixed water surface Elevation= 27.70'

Link 9L: Discharge Elevation



Hydrograph for Link 9L: Discharge Elevation

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**27.70**	0.00
2.00	0.00	27.70	0.00
4.00	0.00	27.70	0.00
6.00	0.06	27.70	0.06
8.00	0.10	27.70	0.10
10.00	0.17	27.70	0.17
12.00	0.42	27.70	0.42
14.00	0.67	27.70	0.67
16.00	0.74	27.70	0.74
18.00	0.84	27.70	0.84
20.00	1.14	27.70	1.14
22.00	1.50	27.70	1.50
24.00	1.74	27.70	1.74
26.00	**1.89**	27.70	**1.89**
28.00	**1.95**	27.70	**1.95**
30.00	1.77	27.70	1.77
32.00	1.62	27.70	1.62
34.00	1.50	27.70	1.50
36.00	1.40	27.70	1.40
38.00	1.32	27.70	1.32
40.00	1.24	27.70	1.24
42.00	1.17	27.70	1.17
44.00	1.09	27.70	1.09
46.00	1.02	27.70	1.02
48.00	0.96	27.70	0.96
50.00	0.90	27.70	0.90
52.00	0.84	27.70	0.84
54.00	0.78	27.70	0.78
56.00	0.72	27.70	0.72
58.00	0.67	27.70	0.67
60.00	0.39	27.70	0.39
62.00	0.37	27.70	0.37
64.00	0.35	27.70	0.35
66.00	0.33	27.70	0.33
68.00	0.31	27.70	0.31
70.00	0.28	27.70	0.28
72.00	0.26	27.70	0.26
74.00	0.23	27.70	0.23
76.00	0.20	27.70	0.20
78.00	0.18	27.70	0.18
80.00	0.17	27.70	0.17
82.00	0.17	27.70	0.17
84.00	0.17	27.70	0.17
86.00	0.16	27.70	0.16
88.00	0.16	27.70	0.16
90.00	0.15	27.70	0.15
92.00	0.15	27.70	0.15
94.00	0.14	27.70	0.14
96.00	0.14	27.70	0.14
98.00	0.13	27.70	0.13
100.00	0.13	27.70	0.13
102.00	0.12	27.70	0.12
104.00	0.11	27.70	0.11
106.00	0.11	27.70	0.11
108.00	0.10	27.70	0.10
110.00	0.10	27.70	0.10
112.00	0.09	27.70	0.09
114.00	0.08	27.70	0.08
116.00	0.08	27.70	0.08
118.00	0.07	27.70	0.07
120.00	0.06	27.70	0.06
122.00	0.06	27.70	0.06
124.00	0.05	27.70	0.05
126.00	0.05	27.70	0.05
128.00	0.04	27.70	0.04
130.00	0.03	27.70	0.03
132.00	0.03	27.70	0.03
134.00	0.02	27.70	0.02
136.00	0.02	27.70	0.02
138.00	0.02	27.70	0.02
140.00	0.02	27.70	0.02
142.00	0.01	27.70	0.01
144.00	0.01	27.70	0.01
146.00	0.01	27.70	0.01
148.00	0.01	27.70	0.01
150.00	0.01	27.70	0.01
152.00	0.01	27.70	0.01
154.00	0.01	27.70	0.01
156.00	0.01	27.70	0.01

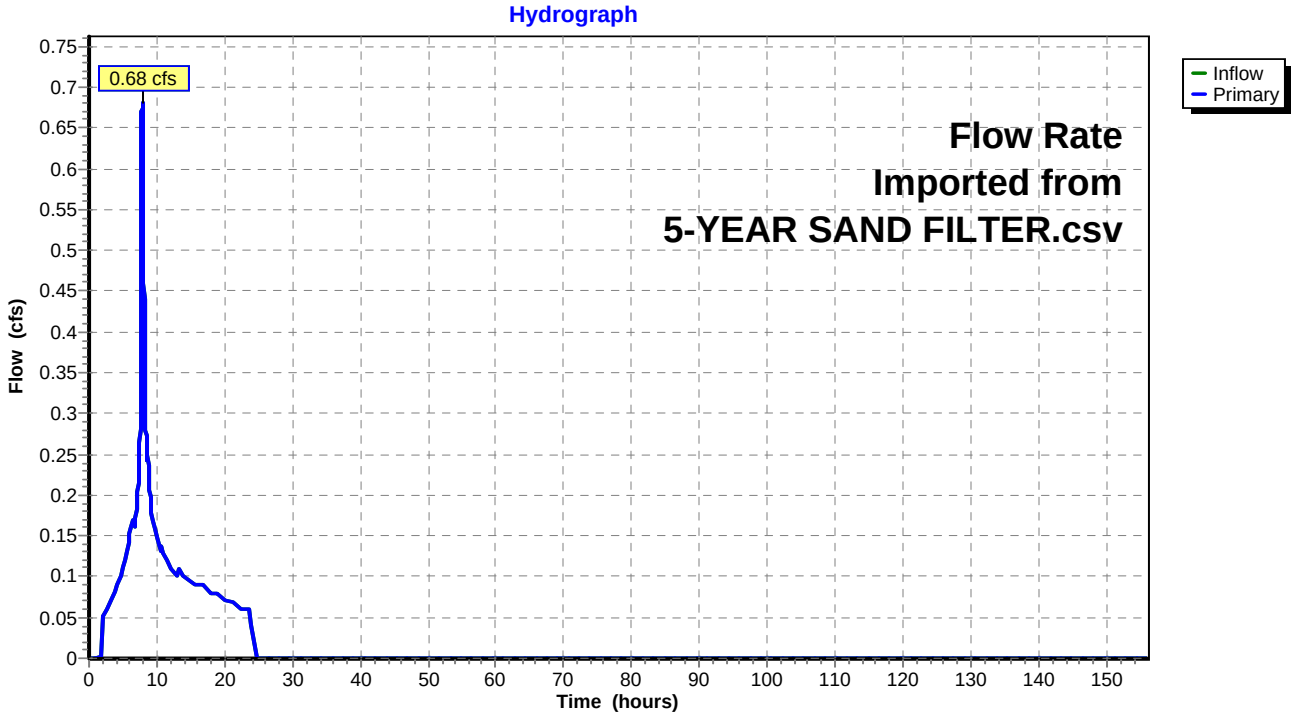
Summary for Link 10L: Sand Filter Input

Inflow	=	0.68 cfs @	7.85 hrs,	Volume=	0.218 af
Primary	=	0.68 cfs @	7.85 hrs,	Volume=	0.218 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs

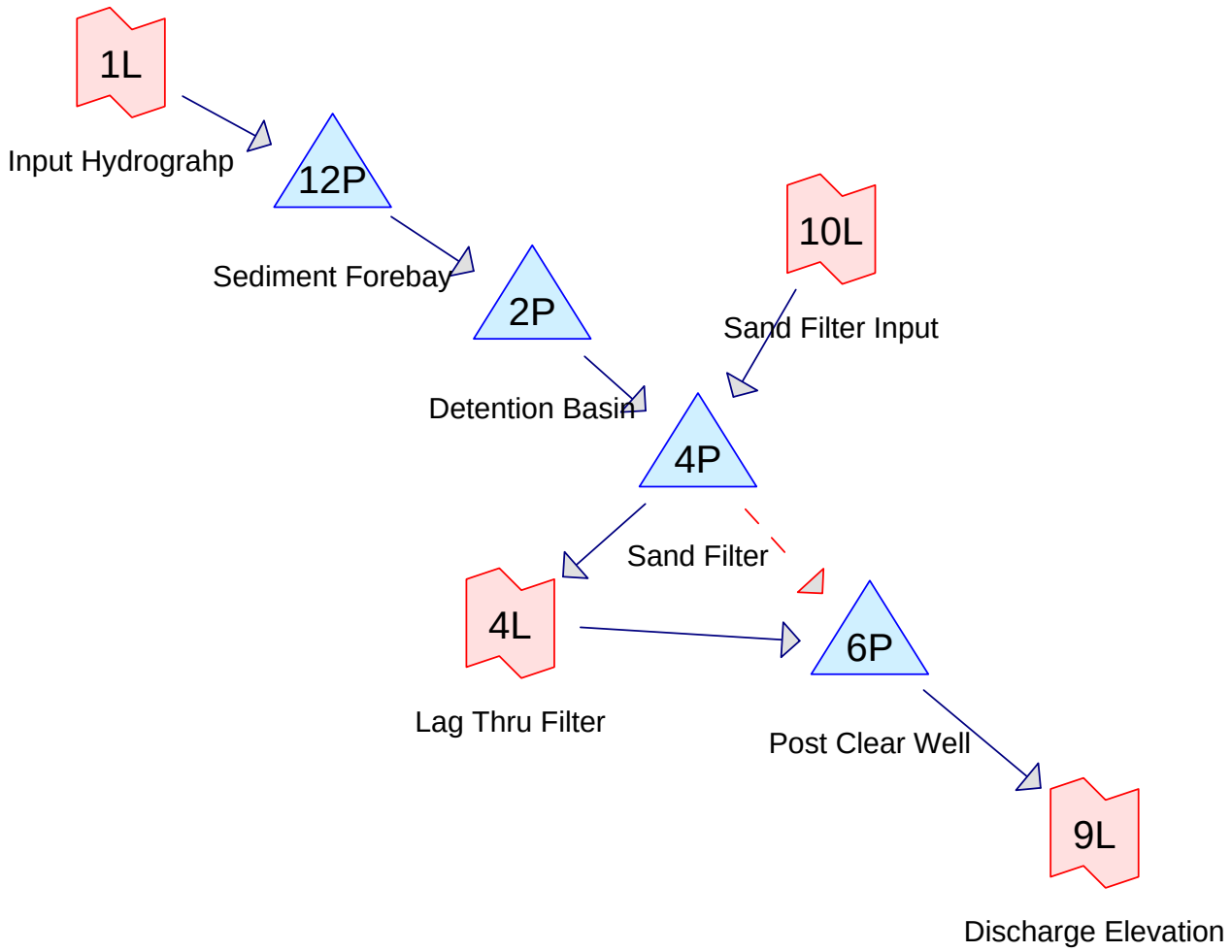
Flow Rate Imported from 5-YEAR SAND FILTER.csv

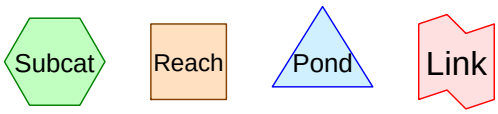
Link 10L: Sand Filter Input



Hydrograph for Link 10L: Sand Filter Input

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**0.00**	0.00
2.00	0.00	0.00	0.00
4.00	0.09	0.00	0.09
6.00	**0.15**	0.00	**0.15**
8.00	**0.65**	0.00	**0.65**
10.00	0.15	0.00	0.15
12.00	0.11	0.00	0.11
14.00	0.10	0.00	0.10
16.00	0.09	0.00	0.09
18.00	0.08	0.00	0.08
20.00	0.07	0.00	0.07
22.00	0.06	0.00	0.06
24.00	0.05	0.00	0.05
26.00	0.00	0.00	0.00
28.00	0.00	0.00	0.00
30.00	0.00	0.00	0.00
32.00	0.00	0.00	0.00
34.00	0.00	0.00	0.00
36.00	0.00	0.00	0.00
38.00	0.00	0.00	0.00
40.00	0.00	0.00	0.00
42.00	0.00	0.00	0.00
44.00	0.00	0.00	0.00
46.00	0.00	0.00	0.00
48.00	0.00	0.00	0.00
50.00	0.00	0.00	0.00
52.00	0.00	0.00	0.00
54.00	0.00	0.00	0.00
56.00	0.00	0.00	0.00
58.00	0.00	0.00	0.00
60.00	0.00	0.00	0.00
62.00	0.00	0.00	0.00
64.00	0.00	0.00	0.00
66.00	0.00	0.00	0.00
68.00	0.00	0.00	0.00
70.00	0.00	0.00	0.00
72.00	0.00	0.00	0.00
74.00	0.00	0.00	0.00
76.00	0.00	0.00	0.00
78.00	0.00	0.00	0.00
80.00	0.00	0.00	0.00
82.00	0.00	0.00	0.00
84.00	0.00	0.00	0.00
86.00	0.00	0.00	0.00
88.00	0.00	0.00	0.00
90.00	0.00	0.00	0.00
92.00	0.00	0.00	0.00
94.00	0.00	0.00	0.00
96.00	0.00	0.00	0.00
98.00	0.00	0.00	0.00
100.00	0.00	0.00	0.00
102.00	0.00	0.00	0.00
104.00	0.00	0.00	0.00
106.00	0.00	0.00	0.00
108.00	0.00	0.00	0.00
110.00	0.00	0.00	0.00
112.00	0.00	0.00	0.00
114.00	0.00	0.00	0.00
116.00	0.00	0.00	0.00
118.00	0.00	0.00	0.00
120.00	0.00	0.00	0.00
122.00	0.00	0.00	0.00
124.00	0.00	0.00	0.00
126.00	0.00	0.00	0.00
128.00	0.00	0.00	0.00
130.00	0.00	0.00	0.00
132.00	0.00	0.00	0.00
134.00	0.00	0.00	0.00
136.00	0.00	0.00	0.00
138.00	0.00	0.00	0.00
140.00	0.00	0.00	0.00
142.00	0.00	0.00	0.00
144.00	0.00	0.00	0.00
146.00	0.00	0.00	0.00
148.00	0.00	0.00	0.00
150.00	0.00	0.00	0.00
152.00	0.00	0.00	0.00
154.00	0.00	0.00	0.00
156.00	0.00	0.00	0.00





Drainage Diagram for 10-Year Model
Prepared by Integral Consulting Inc., Printed 9/28/2011
HydroCAD® 9.10 s/n 06683 © 2010 HydroCAD Software Solutions LLC

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Fill (inches)
1	2P	31.00	29.45	310.0	0.0050	0.013	24.0	0.0	0.0
2	4P	28.76	28.00	152.0	0.0050	0.011	4.0	0.0	0.0
3	6P	28.00	27.22	156.0	0.0050	0.013	24.0	0.0	0.0

Time span=0.00-156.00 hrs, dt=0.02 hrs, 7801 points x 3
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Pond 2P: Detention Basin Peak Elev=34.35' Storage=4.085 af Inflow=22.44 cfs 8.303 af
Outflow=4.43 cfs 7.002 af

Pond 4P: Sand Filter Peak Elev=34.27' Storage=1.386 af Inflow=4.56 cfs 7.261 af
Primary=2.28 cfs 7.261 af Secondary=0.00 cfs 0.000 af Outflow=2.28 cfs 7.261 af

Pond 6P: Post Clear Well Peak Elev=29.00' Storage=0.000 af Inflow=2.28 cfs 7.259 af
24.0" Round Culvert n=0.013 L=156.0' S=0.0050 '/' Outflow=2.28 cfs 7.259 af

Pond 12P: Sediment Forebay Peak Elev=34.35' Storage=1.121 af Inflow=24.72 cfs 8.689 af
Outflow=22.44 cfs 8.303 af

Link 1L: Input Hydrograhp Flow Rate Imported from 10 Year Input.csv Inflow=24.72 cfs 8.689 af
Primary=24.72 cfs 8.689 af

Link 4L: Lag Thru Filter delayed by 206.0 min Inflow=2.28 cfs 7.261 af
Primary=2.28 cfs 7.259 af

Link 9L: Discharge Elevation Inflow=2.28 cfs 7.259 af
Primary=2.28 cfs 7.259 af

Link 10L: Sand Filter Input Flow Rate Imported from 10-YEAR SAND FILTER.csv Inflow=0.80 cfs 0.260 af
Primary=0.80 cfs 0.260 af

Summary for Pond 2P: Detention Basin

Inflow	=	22.44 cfs @	8.16 hrs,	Volume=	8.303 af
Outflow	=	4.43 cfs @	13.42 hrs,	Volume=	7.002 af, Atten= 80%, Lag= 315.8 min
Primary	=	4.43 cfs @	13.42 hrs,	Volume=	7.002 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 34.35' @ 24.07 hrs Surf.Area= 0.000 ac Storage= 4.085 af

Plug-Flow detention time= 1,335.8 min calculated for 7.001 af (84% of inflow)
Center-of-Mass det. time= 1,105.1 min (2,045.7 - 940.7)

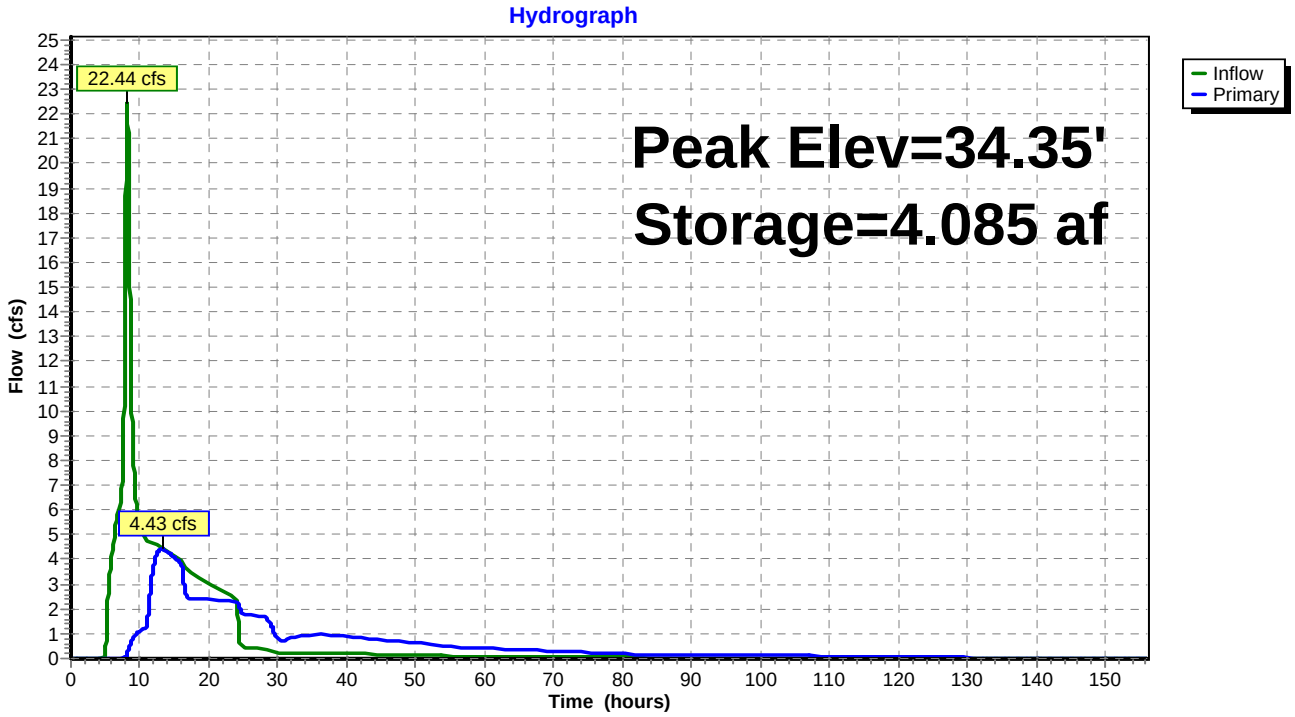
Volume	Invert	Avail.Storage	Storage Description
#1	30.00'	6.558 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
30.00	0.000
30.25	0.204
30.50	0.412
31.00	0.839
31.50	1.280
32.00	1.736
32.50	2.207
33.00	2.694
33.50	3.196
34.00	3.715
34.50	4.250
35.00	4.801
35.50	5.370
36.00	5.955
36.50	6.558

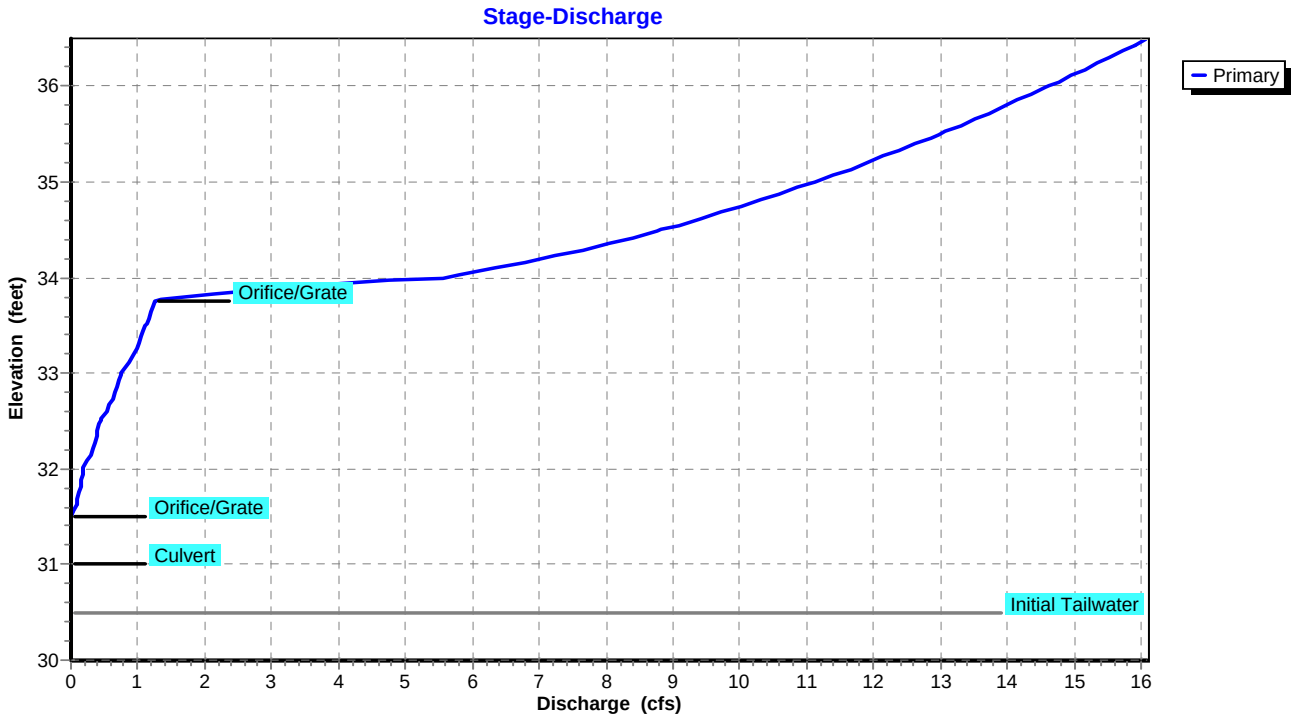
Device	Routing	Invert	Outlet Devices
#1	Device 3	31.50'	**1.0" Vert. Orifice/Grate X 10.00 columns** X 4 rows with 6.0" cc spacing C= 0.600
#2	Device 3	33.75'	**8.0" Horiz. Orifice/Grate X 5.00** C= 0.600 Limited to weir flow at low heads
#3	Primary	31.00'	**24.0" Round Culvert** L= 310.0' CPP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 31.00' / 29.45' S= 0.0050 '/' Cc= 0.500 n= 0.013

Primary OutFlow Max=4.43 cfs @ 13.42 hrs HW=33.96' TW=32.26' (Dynamic Tailwater)
└─**3=Culvert** (Passes 4.43 cfs of 10.94 cfs potential flow)
  ├─**1=Orifice/Grate** (Orifice Controls 1.25 cfs @ 5.72 fps)
  └─**2=Orifice/Grate** (Weir Controls 3.18 cfs @ 1.48 fps)

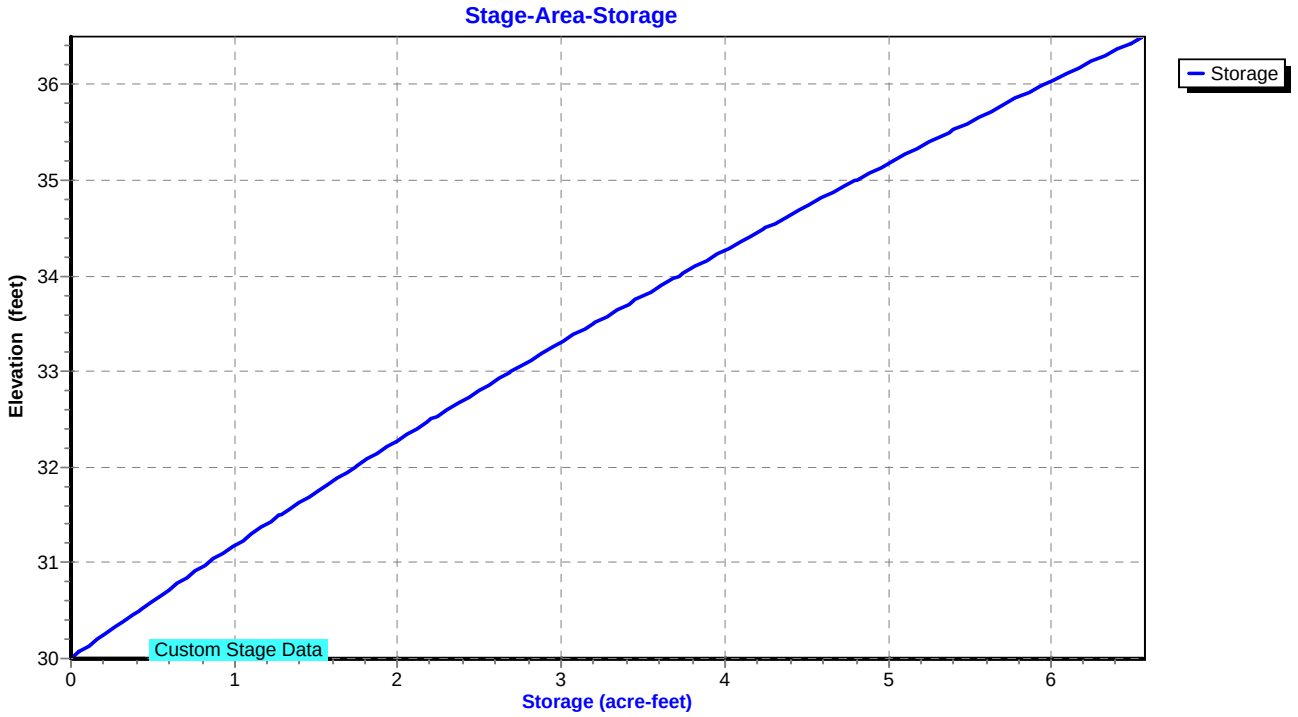
Pond 2P: Detention Basin



Pond 2P: Detention Basin



Pond 2P: Detention Basin



Hydrograph for Pond 2P: Detention Basin

Time (hours)	Inflow (cfs)	Storage (acre-feet)	Elevation (feet)	Primary (cfs)
0.00	0.00	0.000	30.00	0.00
4.00	0.00	0.000	30.00	0.00
8.00	**19.95**	1.438	31.67	0.10
12.00	**4.53**	3.635	33.92	**3.77**
16.00	3.94	3.675	33.96	**3.85**
20.00	3.04	3.949	34.22	2.37
24.00	2.43	**4.084**	**34.35**	2.28
28.00	0.38	**3.666**	**33.95**	1.67
32.00	0.19	3.404	33.70	0.84
36.00	0.21	3.169	33.47	0.96
40.00	0.20	2.928	33.23	0.91
44.00	0.17	2.714	33.02	0.75
48.00	0.15	2.529	32.83	0.67
52.00	0.13	2.367	32.66	0.58
56.00	0.10	2.233	32.53	0.45
60.00	0.09	2.124	32.41	0.40
64.00	0.08	2.024	32.31	0.36
68.00	0.07	1.935	32.21	0.32
72.00	0.06	1.858	32.13	0.28
76.00	0.05	1.792	32.06	0.22
80.00	0.04	1.741	32.01	0.18
84.00	0.03	1.696	31.96	0.17
88.00	0.03	1.653	31.91	0.16
92.00	0.03	1.612	31.86	0.15
96.00	0.03	1.574	31.82	0.14
100.00	0.03	1.539	31.78	0.13
104.00	0.01	1.504	31.75	0.12
108.00	0.00	1.468	31.71	0.11
112.00	0.00	1.436	31.67	0.09
116.00	0.00	1.407	31.64	0.08
120.00	0.00	1.382	31.61	0.07
124.00	0.00	1.361	31.59	0.06
128.00	0.00	1.344	31.57	0.04
132.00	0.00	1.332	31.56	0.03
136.00	0.00	1.323	31.55	0.02
140.00	0.00	1.316	31.54	0.02
144.00	0.00	1.311	31.53	0.01
148.00	0.00	1.307	31.53	0.01
152.00	0.00	1.304	31.53	0.01
156.00	0.00	1.302	31.52	0.01

Stage-Discharge for Pond 2P: Detention Basin

Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)
30.00	0.00	32.12	0.27	34.24	7.33	36.36	15.69
30.04	0.00	32.16	0.30	34.28	7.58	36.40	15.80
30.08	0.00	32.20	0.32	34.32	7.83	36.44	15.92
30.12	0.00	32.24	0.34	34.36	8.06	36.48	**16.03**
30.16	0.00	32.28	0.35	34.40	8.29		
30.20	0.00	32.32	0.37	34.44	8.51		
30.24	0.00	32.36	0.39	34.48	8.72		
30.28	0.00	32.40	0.40	34.52	8.93		
30.32	0.00	32.44	0.41	34.56	9.13		
30.36	0.00	32.48	0.43	34.60	9.33		
30.40	0.00	32.52	0.45	34.64	9.53		
30.44	0.00	32.56	0.49	34.68	9.72		
30.48	0.00	32.60	0.53	34.72	9.90		
30.52	0.00	32.64	0.56	34.76	10.09		
30.56	0.00	32.68	0.59	34.80	10.26		
30.60	0.00	32.72	0.61	34.84	10.44		
30.64	0.00	32.76	0.64	34.88	10.61		
30.68	0.00	32.80	0.66	34.92	10.78		
30.72	0.00	32.84	0.68	34.96	10.95		
30.76	0.00	32.88	0.70	35.00	11.11		
30.80	0.00	32.92	0.72	35.04	11.28		
30.84	0.00	32.96	0.73	35.08	11.44		
30.88	0.00	33.00	0.75	35.12	11.59		
30.92	0.00	33.04	0.79	35.16	11.75		
30.96	0.00	33.08	0.84	35.20	11.90		
31.00	0.00	33.12	0.88	35.24	12.05		
31.04	0.00	33.16	0.91	35.28	12.20		
31.08	0.00	33.20	0.94	35.32	12.35		
31.12	0.00	33.24	0.97	35.36	12.50		
31.16	0.00	33.28	0.99	35.40	12.64		
31.20	0.00	33.32	1.02	35.44	12.78		
31.24	0.00	33.36	1.04	35.48	12.92		
31.28	0.00	33.40	1.06	35.52	13.06		
31.32	0.00	33.44	1.09	35.56	13.20		
31.36	0.00	33.48	1.11	35.60	13.33		
31.40	0.00	33.52	1.13	35.64	13.47		
31.44	0.00	33.56	1.15	35.68	13.60		
31.48	0.00	33.60	1.17	35.72	13.73		
31.52	0.00	33.64	1.19	35.76	13.86		
31.56	0.04	33.68	1.21	35.80	13.99		
31.60	0.06	33.72	1.23	35.84	14.12		
31.64	0.08	33.76	1.28	35.88	14.25		
31.68	0.10	33.80	1.65	35.92	14.37		
31.72	0.11	33.84	2.21	35.96	14.50		
31.76	0.12	33.88	2.91	36.00	14.62		
31.80	0.13	33.92	3.72	36.04	14.75		
31.84	0.14	33.96	4.63	36.08	14.87		
31.88	0.15	34.00	5.56	36.12	14.99		
31.92	0.16	34.04	5.90	36.16	15.11		
31.96	0.17	34.08	6.21	36.20	15.23		
32.00	0.18	34.12	6.51	36.24	15.34		
32.04	0.20	34.16	6.80	36.28	15.46		
32.08	0.24	34.20	7.07	36.32	15.58		

Stage-Area-Storage for Pond 2P: Detention Basin

Elevation (feet)	Storage (acre-feet)
30.00	0.000
30.10	0.082
30.20	0.163
30.30	0.246
30.40	0.329
30.50	0.412
30.60	0.497
30.70	0.583
30.80	0.668
30.90	0.754
31.00	0.839
31.10	0.927
31.20	1.015
31.30	1.104
31.40	1.192
31.50	1.280
31.60	1.371
31.70	1.462
31.80	1.554
31.90	1.645
32.00	1.736
32.10	1.830
32.20	1.924
32.30	2.019
32.40	2.113
32.50	2.207
32.60	2.304
32.70	2.402
32.80	2.499
32.90	2.597
33.00	2.694
33.10	2.794
33.20	2.895
33.30	2.995
33.40	3.096
33.50	3.196
33.60	3.300
33.70	3.404
33.80	3.507
33.90	3.611
34.00	3.715
34.10	3.822
34.20	3.929
34.30	4.036
34.40	4.143
34.50	4.250
34.60	4.360
34.70	4.470
34.80	4.581
34.90	4.691
35.00	4.801
35.10	4.915
35.20	5.029
35.30	5.142
35.40	5.256
35.50	5.370
35.60	5.487
35.70	5.604
35.80	5.721
35.90	5.838
36.00	5.955
36.10	6.076
36.20	6.196
36.30	6.317
36.40	6.437
36.50	**6.558**

Summary for Pond 4P: Sand Filter

NOTE:

Influent Clear Well not modeled.

Storage in Sand Filter not modeled, flow modeled as lag.

Inflow	=	4.56 cfs @	13.13 hrs,	Volume=	7.261 af
Outflow	=	2.28 cfs @	24.04 hrs,	Volume=	7.261 af, Atten= 50%, Lag= 654.6 min
Primary	=	2.28 cfs @	24.04 hrs,	Volume=	7.261 af
Secondary	=	0.00 cfs @	0.00 hrs,	Volume=	0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 34.27' @ 24.04 hrs Surf.Area= 0.367 ac Storage= 1.386 af

Plug-Flow detention time= 288.9 min calculated for 7.260 af (100% of inflow)
Center-of-Mass det. time= 288.8 min (2,285.3 - 1,996.4)

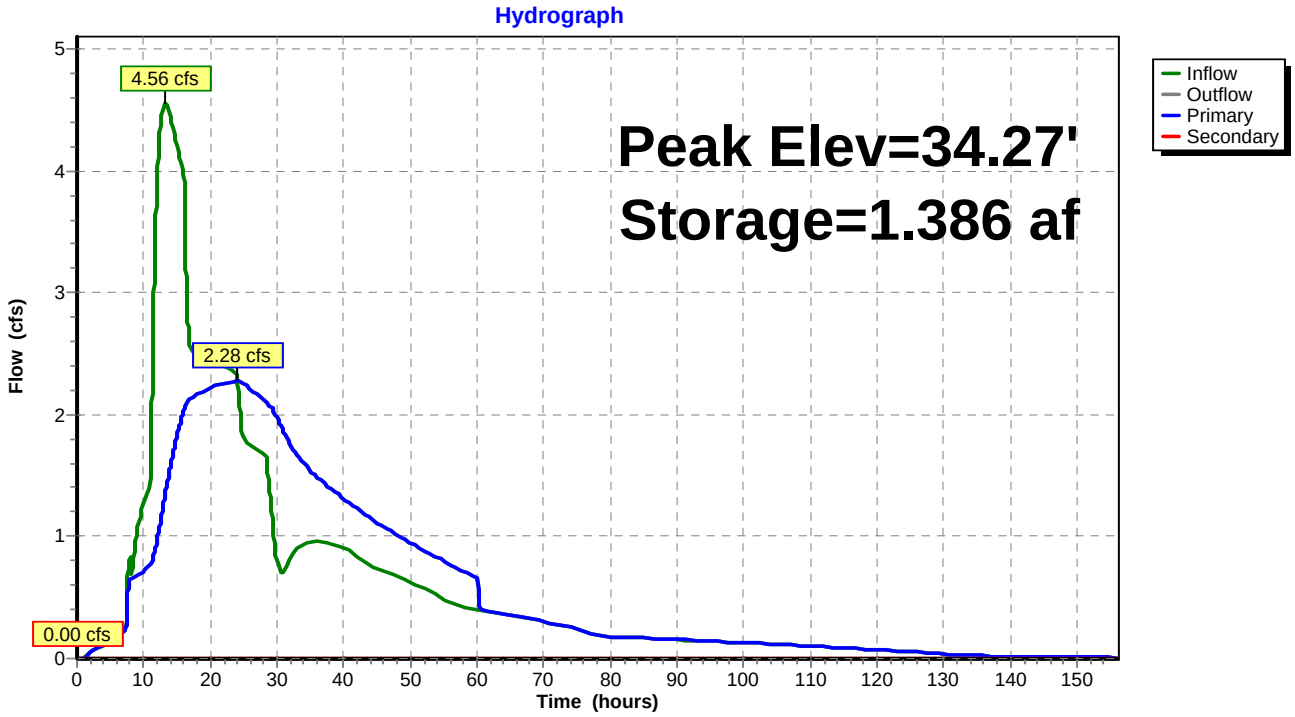
Volume	Invert	Avail.Storage	Storage Description
#1	30.50'	2.204 af	**100.00'W x 160.00'L x 6.00'H Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Secondary	35.25'	**130.0' long x 2.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 Coef. (English) 2.48 2.60 2.60 2.60 2.64 2.65 2.68 2.75 2.74 2.76 2.89 3.05 3.19 3.32
#2	Device 3	30.50'	**1.750 in/hr Exfiltration over Horizontal area** Conductivity to Groundwater Elevation = 29.00' Phase-In= 0.01'
#3	Device 4	29.00'	**0.3" Horiz. Orifice/Grate X 8.00 columns** X 150 rows C= 0.600
#4	Primary	28.76'	**4.0" Round Culvert X 8.00** L= 152.0' Ke= 0.900 Inlet / Outlet Invert= 28.76' / 28.00' S= 0.0050 '/' Cc= 0.500 n= 0.011

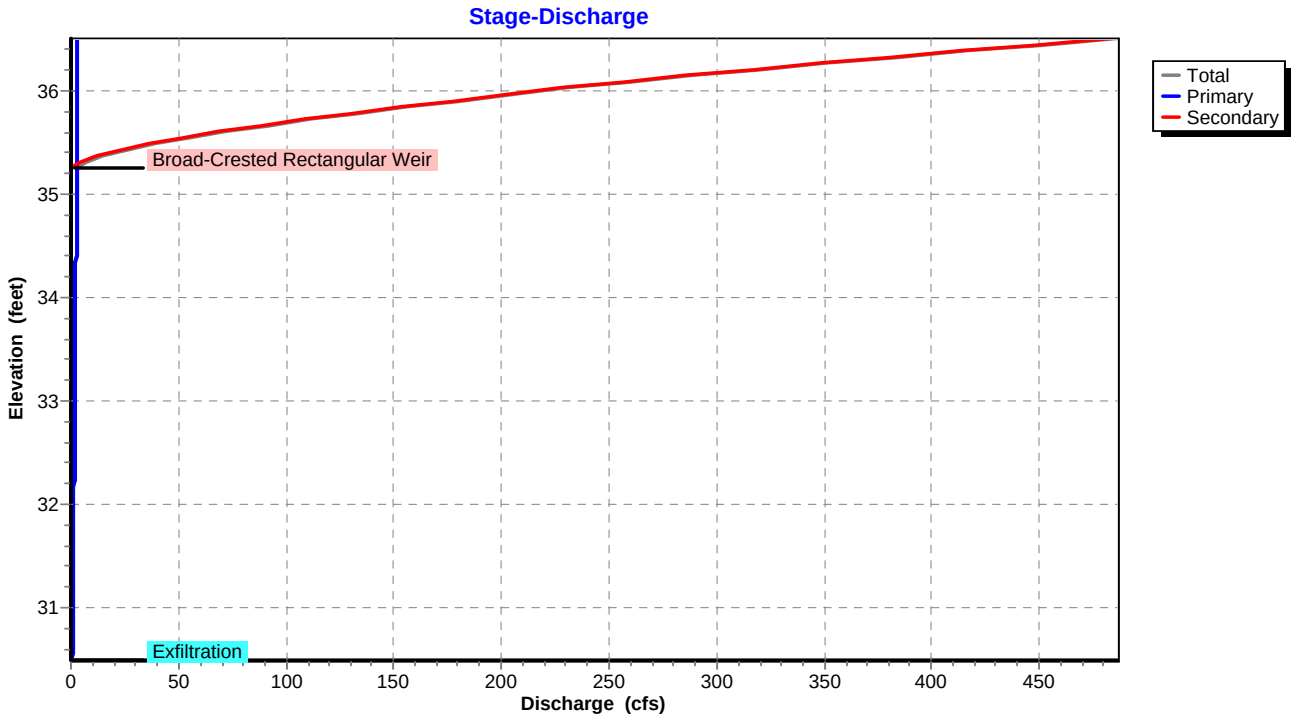
Primary OutFlow Max=2.28 cfs @ 24.04 hrs HW=34.27' TW=0.00' (Dynamic Tailwater)
└─**4=Culvert** (Passes 2.28 cfs of 3.34 cfs potential flow)
  └─**3=Orifice/Grate** (Passes 2.28 cfs of 6.51 cfs potential flow)
    └─**2=Exfiltration** (Controls 2.28 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=30.50' TW=29.00' (Dynamic Tailwater)
└─**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

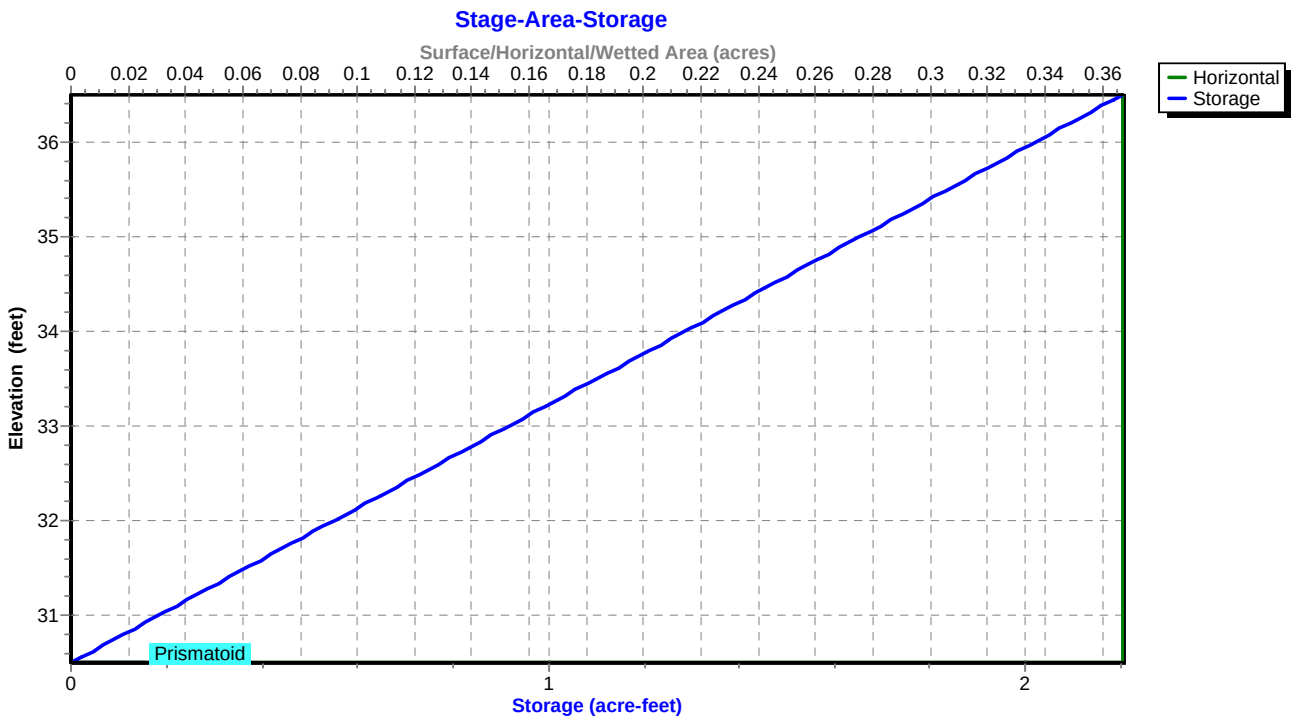
Pond 4P: Sand Filter



Pond 4P: Sand Filter



Pond 4P: Sand Filter



Hydrograph for Pond 4P: Sand Filter

Time (hours)	Inflow (cfs)	Storage (acre-feet)	Elevation (feet)	Outflow (cfs)	Primary (cfs)	Secondary (cfs)
0.00	0.00	0.000	30.50	0.00	0.00	**0.00**
4.00	0.11	0.001	30.50	0.11	0.11	0.00
8.00	0.86	0.007	30.52	0.66	0.66	0.00
12.00	**3.90**	0.271	31.24	0.97	0.97	0.00
16.00	**3.96**	1.183	33.72	2.04	2.04	0.00
20.00	2.45	1.337	34.14	2.22	2.22	0.00
24.00	2.34	**1.385**	**34.27**	**2.28**	**2.28**	0.00
28.00	1.67	**1.254**	**33.91**	**2.12**	**2.12**	0.00
32.00	0.84	0.943	33.07	1.76	1.76	0.00
36.00	0.96	0.715	32.45	1.49	1.49	0.00
40.00	0.91	0.564	32.03	1.31	1.31	0.00
44.00	0.75	0.432	31.68	1.16	1.16	0.00
48.00	0.67	0.310	31.35	1.01	1.01	0.00
52.00	0.58	0.203	31.05	0.89	0.89	0.00
56.00	0.45	0.101	30.78	0.77	0.77	0.00
60.00	0.40	0.007	30.52	0.66	0.66	0.00
64.00	0.36	0.002	30.51	0.37	0.37	0.00
68.00	0.32	0.002	30.50	0.32	0.32	0.00
72.00	0.28	0.002	30.50	0.28	0.28	0.00
76.00	0.22	0.001	30.50	0.22	0.22	0.00
80.00	0.18	0.001	30.50	0.18	0.18	0.00
84.00	0.17	0.001	30.50	0.17	0.17	0.00
88.00	0.16	0.001	30.50	0.16	0.16	0.00
92.00	0.15	0.001	30.50	0.15	0.15	0.00
96.00	0.14	0.001	30.50	0.14	0.14	0.00
100.00	0.13	0.001	30.50	0.13	0.13	0.00
104.00	0.12	0.001	30.50	0.12	0.12	0.00
108.00	0.11	0.001	30.50	0.11	0.11	0.00
112.00	0.09	0.001	30.50	0.09	0.09	0.00
116.00	0.08	0.000	30.50	0.08	0.08	0.00
120.00	0.07	0.000	30.50	0.07	0.07	0.00
124.00	0.06	0.000	30.50	0.06	0.06	0.00
128.00	0.04	0.000	30.50	0.04	0.04	0.00
132.00	0.03	0.000	30.50	0.03	0.03	0.00
136.00	0.02	0.000	30.50	0.02	0.02	0.00
140.00	0.02	0.000	30.50	0.02	0.02	0.00
144.00	0.01	0.000	30.50	0.01	0.01	0.00
148.00	0.01	0.000	30.50	0.01	0.01	0.00
152.00	0.01	0.000	30.50	0.01	0.01	0.00
156.00	0.01	0.000	30.50	0.01	0.01	0.00

Stage-Discharge for Pond 4P: Sand Filter

Elevation (feet)	Discharge (cfs)	Primary (cfs)	Secondary (cfs)
30.50	0.00	0.00	0.00
30.60	0.69	0.69	0.00
30.70	0.73	0.73	0.00
30.80	0.78	0.78	0.00
30.90	0.82	0.82	0.00
31.00	0.86	0.86	0.00
31.10	0.91	0.91	0.00
31.20	0.95	0.95	0.00
31.30	0.99	0.99	0.00
31.40	1.04	1.04	0.00
31.50	1.08	1.08	0.00
31.60	1.12	1.12	0.00
31.70	1.17	1.17	0.00
31.80	1.21	1.21	0.00
31.90	1.25	1.25	0.00
32.00	1.30	1.30	0.00
32.10	1.34	1.34	0.00
32.20	1.38	1.38	0.00
32.30	1.43	1.43	0.00
32.40	1.47	1.47	0.00
32.50	1.51	1.51	0.00
32.60	1.56	1.56	0.00
32.70	1.60	1.60	0.00
32.80	1.64	1.64	0.00
32.90	1.69	1.69	0.00
33.00	1.73	1.73	0.00
33.10	1.77	1.77	0.00
33.20	1.81	1.81	0.00
33.30	1.86	1.86	0.00
33.40	1.90	1.90	0.00
33.50	1.94	1.94	0.00
33.60	1.99	1.99	0.00
33.70	2.03	2.03	0.00
33.80	2.07	2.07	0.00
33.90	2.12	2.12	0.00
34.00	2.16	2.16	0.00
34.10	2.20	2.20	0.00
34.20	2.25	2.25	0.00
34.30	2.29	2.29	0.00
34.40	2.33	2.33	0.00
34.50	2.38	2.38	0.00
34.60	2.42	2.42	0.00
34.70	2.46	2.46	0.00
34.80	2.51	2.51	0.00
34.90	2.55	2.55	0.00
35.00	2.59	2.59	0.00
35.10	2.64	2.64	0.00
35.20	2.68	2.68	0.00
35.30	6.33	2.72	3.60
35.40	21.50	2.77	18.73
35.50	43.60	2.81	40.79
35.60	72.03	2.85	69.18
35.70	104.93	2.90	102.03
35.80	140.81	2.94	137.87
35.90	180.11	2.98	177.13
36.00	222.56	3.02	219.54
36.10	268.96	3.07	265.90
36.20	319.69	3.11	316.58
36.30	372.76	3.15	369.61
36.40	427.65	3.20	424.45
36.50	**486.06**	**3.24**	**482.82**

Stage-Area-Storage for Pond 4P: Sand Filter

Elevation (feet)	Horizontal (acres)	Storage (acre-feet)
30.50	**0.367**	0.000
30.60	0.367	0.037
30.70	0.367	0.073
30.80	0.367	0.110
30.90	0.367	0.147
31.00	0.367	0.184
31.10	0.367	0.220
31.20	0.367	0.257
31.30	0.367	0.294
31.40	0.367	0.331
31.50	0.367	0.367
31.60	0.367	0.404
31.70	0.367	0.441
31.80	0.367	0.478
31.90	0.367	0.514
32.00	0.367	0.551
32.10	0.367	0.588
32.20	0.367	0.624
32.30	0.367	0.661
32.40	0.367	0.698
32.50	0.367	0.735
32.60	0.367	0.771
32.70	0.367	0.808
32.80	0.367	0.845
32.90	0.367	0.882
33.00	0.367	0.918
33.10	0.367	0.955
33.20	0.367	0.992
33.30	0.367	1.028
33.40	0.367	1.065
33.50	0.367	1.102
33.60	0.367	1.139
33.70	0.367	1.175
33.80	0.367	1.212
33.90	0.367	1.249
34.00	0.367	1.286
34.10	0.367	1.322
34.20	0.367	1.359
34.30	0.367	1.396
34.40	0.367	1.433
34.50	0.367	1.469
34.60	0.367	1.506
34.70	0.367	1.543
34.80	0.367	1.579
34.90	0.367	1.616
35.00	0.367	1.653
35.10	0.367	1.690
35.20	0.367	1.726
35.30	0.367	1.763
35.40	0.367	1.800
35.50	0.367	1.837
35.60	0.367	1.873
35.70	0.367	1.910
35.80	0.367	1.947
35.90	0.367	1.983
36.00	0.367	2.020
36.10	0.367	2.057
36.20	0.367	2.094
36.30	0.367	2.130
36.40	0.367	2.167
36.50	0.367	**2.204**

Summary for Pond 6P: Post Clear Well

Inflow	=	2.28 cfs @	27.48 hrs,	Volume=	7.259 af
Outflow	=	2.28 cfs @	27.48 hrs,	Volume=	7.259 af, Atten= 0%, Lag= 0.0 min
Primary	=	2.28 cfs @	27.48 hrs,	Volume=	7.259 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 29.00' @ 27.48 hrs Surf.Area= 0.000 ac Storage= 0.000 af

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 0.0 min (2,489.3 - 2,489.3)

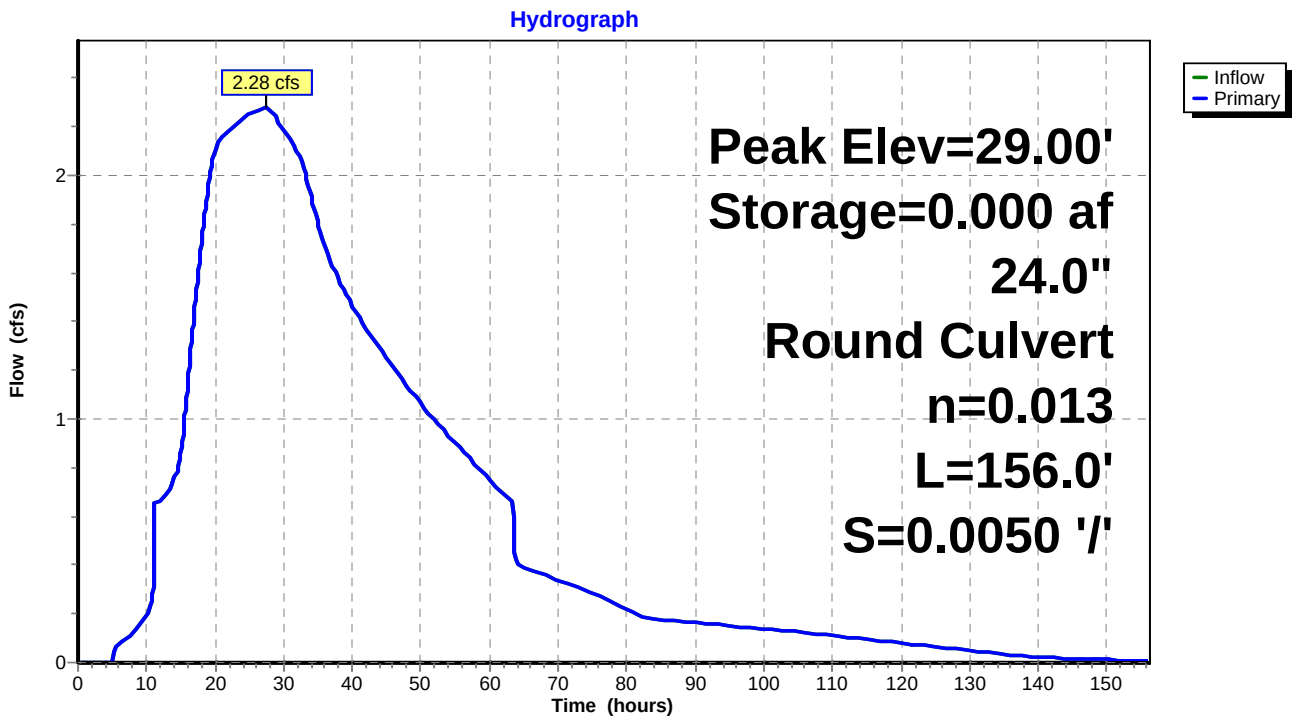
Volume	Invert	Avail.Storage	Storage Description
#1	29.00'	0.549 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
29.00	0.000
29.50	0.014
30.00	0.031
30.50	0.051
31.00	0.074
31.50	0.101
32.00	0.132
32.50	0.166
33.00	0.206
33.50	0.250
34.00	0.298
34.50	0.353
35.00	0.412
35.50	0.478
36.00	0.549

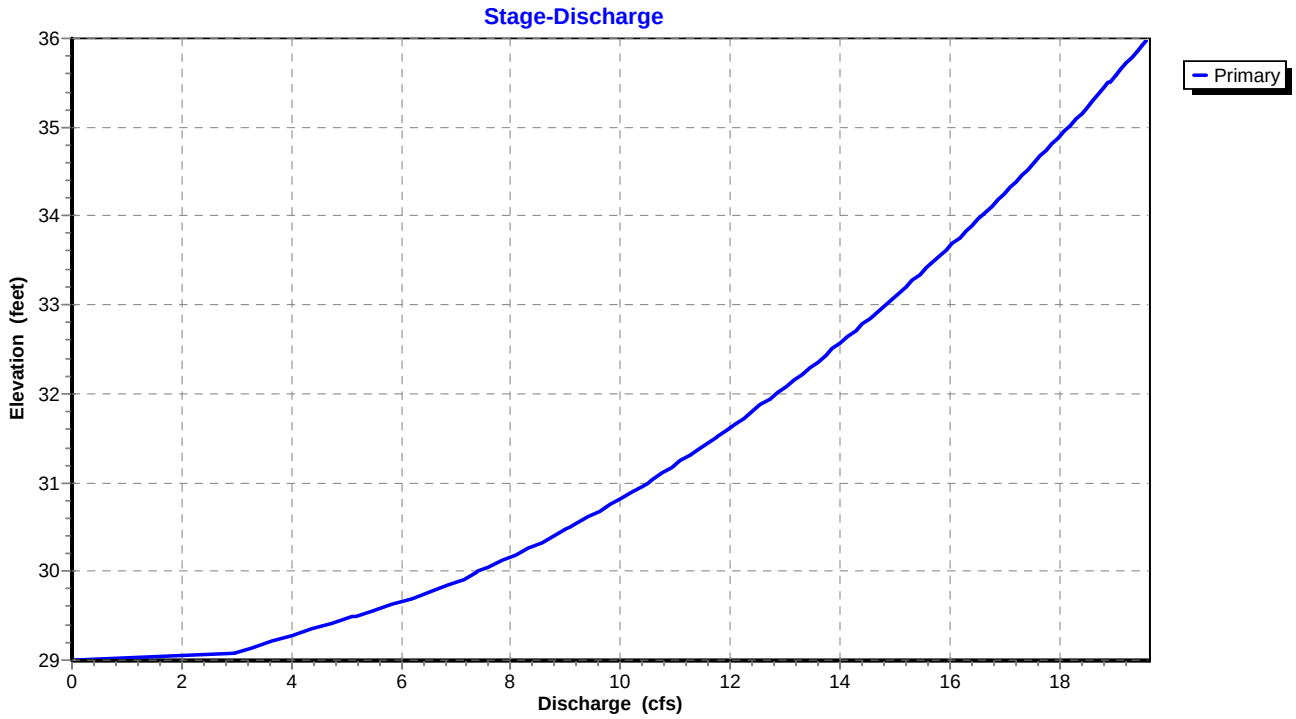
Device	Routing	Invert	Outlet Devices
#1	Primary	28.00'	**24.0" Round Culvert** L= 156.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 28.00' / 27.22' S= 0.0050 '/' Cc= 0.500 n= 0.013

Primary OutFlow Max=2.62 cfs @ 27.48 hrs HW=29.00' TW=27.70' (Dynamic Tailwater)
└─**1=Culvert** (Inlet Controls 2.62 cfs @ 1.67 fps)

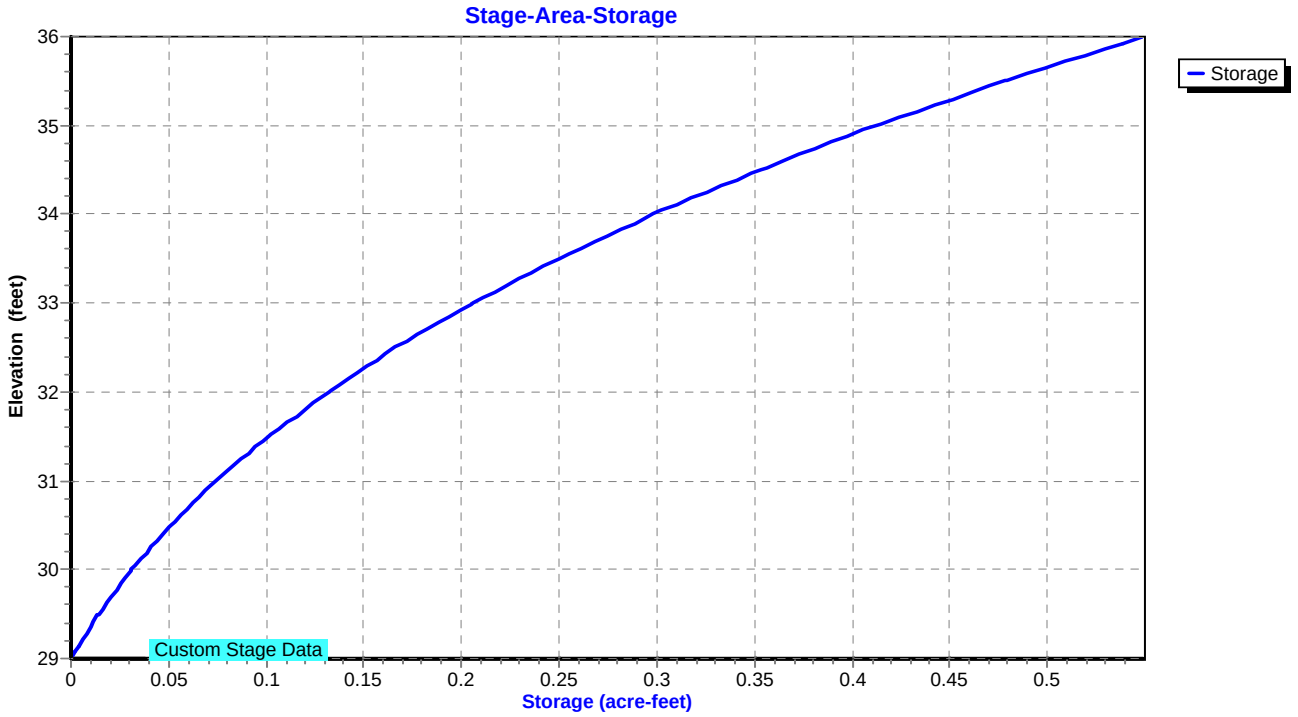
Pond 6P: Post Clear Well



Pond 6P: Post Clear Well



Pond 6P: Post Clear Well



Hydrograph for Pond 6P: Post Clear Well

Time (hours)	Inflow (cfs)	Storage (acre-feet)	Elevation (feet)	Primary (cfs)
0.00	0.00	0.000	29.00	0.00
4.00	0.00	0.000	29.00	0.00
8.00	0.12	0.000	29.00	0.12
12.00	0.66	0.000	29.00	0.66
16.00	1.14	0.000	29.00	1.14
20.00	2.11	0.000	29.00	2.11
24.00	**2.23**	**0.000**	**29.00**	**2.23**
28.00	**2.27**	**0.000**	**29.00**	**2.27**
32.00	2.10	0.000	29.00	2.10
36.00	1.71	0.000	29.00	1.71
40.00	1.46	0.000	29.00	1.46
44.00	1.29	0.000	29.00	1.29
48.00	1.13	0.000	29.00	1.13
52.00	0.99	0.000	29.00	0.99
56.00	0.87	0.000	29.00	0.87
60.00	0.75	0.000	29.00	0.75
64.00	0.40	0.000	29.00	0.40
68.00	0.36	0.000	29.00	0.36
72.00	0.32	0.000	29.00	0.32
76.00	0.27	0.000	29.00	0.27
80.00	0.22	0.000	29.00	0.22
84.00	0.18	0.000	29.00	0.18
88.00	0.17	0.000	29.00	0.17
92.00	0.16	0.000	29.00	0.16
96.00	0.15	0.000	29.00	0.15
100.00	0.14	0.000	29.00	0.14
104.00	0.13	0.000	29.00	0.13
108.00	0.12	0.000	29.00	0.12
112.00	0.10	0.000	29.00	0.10
116.00	0.09	0.000	29.00	0.09
120.00	0.08	0.000	29.00	0.08
124.00	0.07	0.000	29.00	0.07
128.00	0.06	0.000	29.00	0.06
132.00	0.04	0.000	29.00	0.04
136.00	0.03	0.000	29.00	0.03
140.00	0.02	0.000	29.00	0.02
144.00	0.02	0.000	29.00	0.02
148.00	0.01	0.000	29.00	0.01
152.00	0.01	0.000	29.00	0.01
156.00	0.01	0.000	29.00	0.01

Stage-Discharge for Pond 6P: Post Clear Well

Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)
29.00	0.00	31.12	10.80	33.24	15.27	35.36	18.70
29.04	2.81	31.16	10.90	33.28	15.34	35.40	18.76
29.08	3.00	31.20	11.00	33.32	15.41	35.44	18.82
29.12	3.20	31.24	11.10	33.36	15.48	35.48	18.88
29.16	3.40	31.28	11.20	33.40	15.55	35.52	18.93
29.20	3.60	31.32	11.29	33.44	15.62	35.56	18.99
29.24	3.80	31.36	11.39	33.48	15.69	35.60	19.05
29.28	4.01	31.40	11.49	33.52	15.76	35.64	19.11
29.32	4.22	31.44	11.58	33.56	15.83	35.68	19.16
29.36	4.43	31.48	11.68	33.60	15.90	35.72	19.22
29.40	4.64	31.52	11.77	33.64	15.97	35.76	19.28
29.44	4.85	31.56	11.86	33.68	16.04	35.80	19.34
29.48	5.06	31.60	11.96	33.72	16.11	35.84	19.39
29.52	5.27	31.64	12.05	33.76	16.18	35.88	19.45
29.56	5.48	31.68	12.14	33.80	16.25	35.92	19.51
29.60	5.69	31.72	12.23	33.84	16.31	35.96	19.56
29.64	5.89	31.76	12.32	33.88	16.38	36.00	**19.62**
29.68	6.09	31.80	12.41	33.92	16.45		
29.72	6.29	31.84	12.50	33.96	16.51		
29.76	6.48	31.88	12.58	34.00	16.58		
29.80	6.67	31.92	12.67	34.04	16.65		
29.84	6.85	31.96	12.76	34.08	16.71		
29.88	7.01	32.00	12.84	34.12	16.78		
29.92	7.17	32.04	12.93	34.16	16.84		
29.96	7.31	32.08	13.01	34.20	16.91		
30.00	7.42	32.12	13.10	34.24	16.97		
30.04	7.56	32.16	13.18	34.28	17.04		
30.08	7.71	32.20	13.26	34.32	17.10		
30.12	7.85	32.24	13.35	34.36	17.17		
30.16	7.99	32.28	13.43	34.40	17.23		
30.20	8.12	32.32	13.51	34.44	17.29		
30.24	8.26	32.36	13.59	34.48	17.36		
30.28	8.39	32.40	13.67	34.52	17.42		
30.32	8.52	32.44	13.75	34.56	17.48		
30.36	8.65	32.48	13.83	34.60	17.55		
30.40	8.77	32.52	13.91	34.64	17.61		
30.44	8.90	32.56	13.99	34.68	17.67		
30.48	9.02	32.60	14.07	34.72	17.73		
30.52	9.14	32.64	14.15	34.76	17.80		
30.56	9.26	32.68	14.22	34.80	17.86		
30.60	9.38	32.72	14.30	34.84	17.92		
30.64	9.50	32.76	14.38	34.88	17.98		
30.68	9.61	32.80	14.45	34.92	18.04		
30.72	9.72	32.84	14.53	34.96	18.10		
30.76	9.84	32.88	14.61	35.00	18.16		
30.80	9.95	32.92	14.68	35.04	18.22		
30.84	10.06	32.96	14.76	35.08	18.28		
30.88	10.17	33.00	14.83	35.12	18.34		
30.92	10.27	33.04	14.90	35.16	18.40		
30.96	10.38	33.08	14.98	35.20	18.46		
31.00	10.49	33.12	15.05	35.24	18.52		
31.04	10.59	33.16	15.12	35.28	18.58		
31.08	10.69	33.20	15.20	35.32	18.64		

Stage-Area-Storage for Pond 6P: Post Clear Well

Elevation (feet)	Storage (acre-feet)	Elevation (feet)	Storage (acre-feet)
29.00	0.000	34.30	0.331
29.10	0.003	34.40	0.342
29.20	0.006	34.50	0.353
29.30	0.008	34.60	0.365
29.40	0.011	34.70	0.377
29.50	0.014	34.80	0.388
29.60	0.017	34.90	0.400
29.70	0.021	35.00	0.412
29.80	0.024	35.10	0.425
29.90	0.028	35.20	0.438
30.00	0.031	35.30	0.452
30.10	0.035	35.40	0.465
30.20	0.039	35.50	0.478
30.30	0.043	35.60	0.492
30.40	0.047	35.70	0.506
30.50	0.051	35.80	0.521
30.60	0.056	35.90	0.535
30.70	0.060	36.00	**0.549**
30.80	0.065		
30.90	0.069		
31.00	0.074		
31.10	0.079		
31.20	0.085		
31.30	0.090		
31.40	0.096		
31.50	0.101		
31.60	0.107		
31.70	0.113		
31.80	0.120		
31.90	0.126		
32.00	0.132		
32.10	0.139		
32.20	0.146		
32.30	0.152		
32.40	0.159		
32.50	0.166		
32.60	0.174		
32.70	0.182		
32.80	0.190		
32.90	0.198		
33.00	0.206		
33.10	0.215		
33.20	0.224		
33.30	0.232		
33.40	0.241		
33.50	0.250		
33.60	0.260		
33.70	0.269		
33.80	0.279		
33.90	0.288		
34.00	0.298		
34.10	0.309		
34.20	0.320		

Summary for Pond 12P: Sediment Forebay

Inflow	=	24.72 cfs @	8.05 hrs,	Volume=	8.689 af
Outflow	=	22.44 cfs @	8.16 hrs,	Volume=	8.303 af, Atten= 9%, Lag= 6.7 min
Primary	=	22.44 cfs @	8.16 hrs,	Volume=	8.303 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 34.35' @ 24.07 hrs Surf.Area= 0.000 ac Storage= 1.121 af

Plug-Flow detention time= 249.5 min calculated for 8.303 af (96% of inflow)
Center-of-Mass det. time= 217.8 min (940.7 - 722.9)

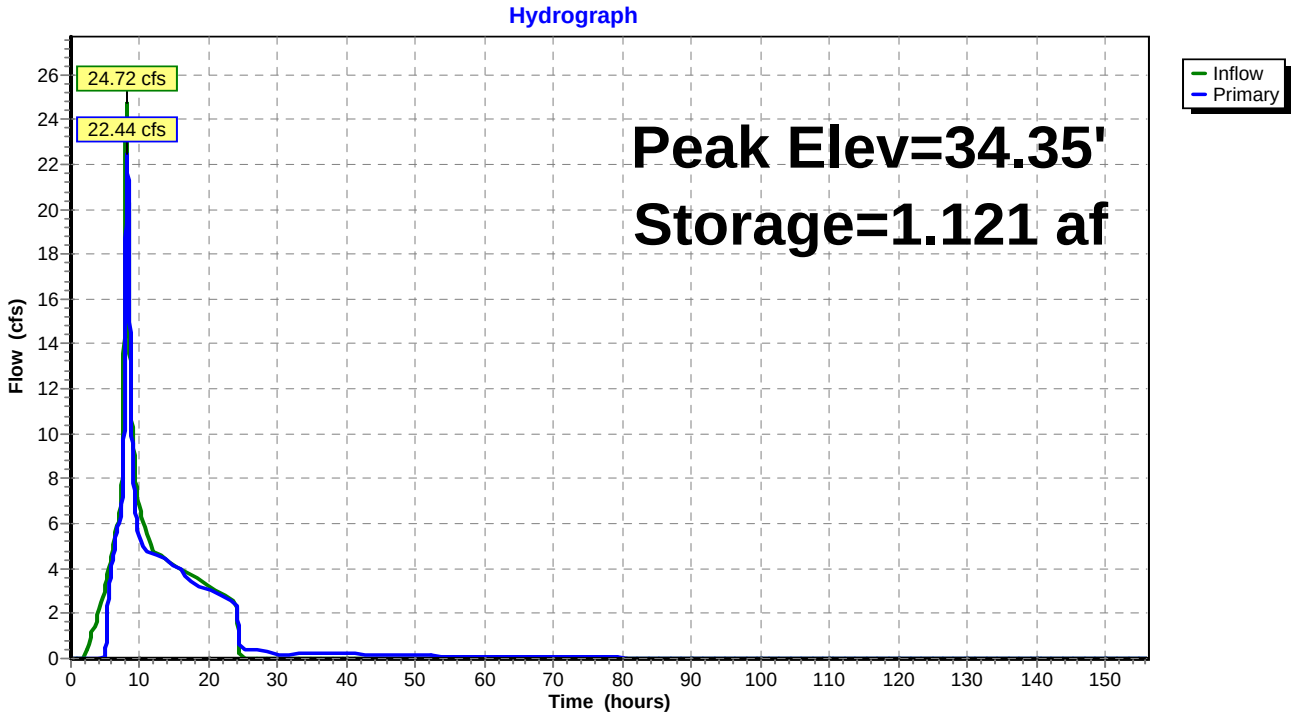
Volume	Invert	Avail.Storage	Storage Description
#1	30.00'	1.902 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
30.00	0.000
30.50	0.102
31.00	0.211
31.50	0.326
31.75	0.386
32.00	0.445
32.50	0.577
33.00	0.713
33.50	0.858
34.00	1.010
34.50	1.171
35.00	1.340
35.50	1.518
36.00	1.705
36.50	1.902

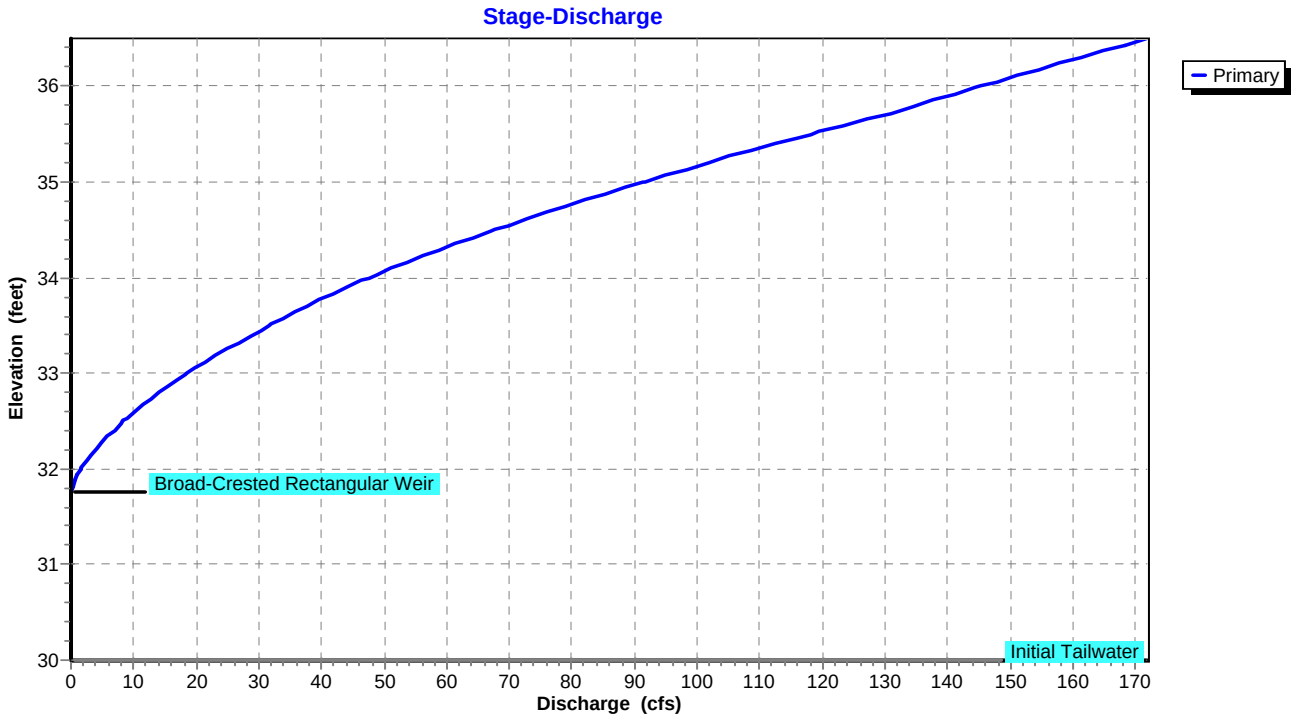
Device	Routing	Invert	Outlet Devices
#1	Primary	31.75'	**5.0' long x 2.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 Coef. (English) 2.48 2.60 2.60 2.60 2.64 2.65 2.68 2.75 2.74 2.76 2.89 3.05 3.19 3.32

Primary OutFlow Max=22.44 cfs @ 8.16 hrs HW=33.18' TW=31.98' (Dynamic Tailwater)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 22.44 cfs @ 3.14 fps)

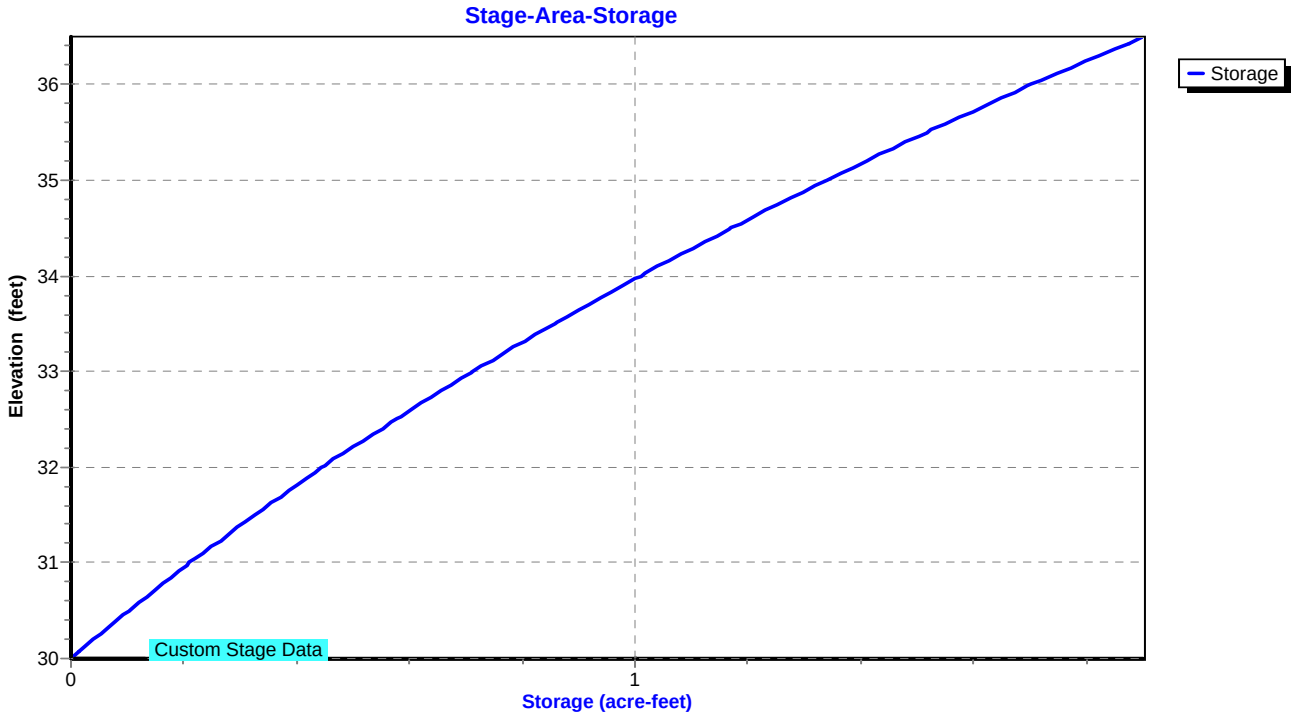
Pond 12P: Sediment Forebay



Pond 12P: Sediment Forebay



Pond 12P: Sediment Forebay



Hydrograph for Pond 12P: Sediment Forebay

Time (hours)	Inflow (cfs)	Storage (acre-feet)	Elevation (feet)	Primary (cfs)
0.00	0.00	0.000	30.00	0.00
4.00	2.18	0.175	30.84	0.00
8.00	**24.32**	0.730	33.06	**19.95**
12.00	**4.75**	0.988	33.93	**4.53**
16.00	3.97	0.999	33.96	3.94
20.00	3.24	1.081	34.22	3.04
24.00	2.48	**1.121**	**34.35**	2.43
28.00	0.00	**0.996**	**33.95**	0.38
32.00	0.00	0.919	33.70	0.19
36.00	0.00	0.850	33.47	0.21
40.00	0.00	0.781	33.23	0.20
44.00	0.00	0.719	33.02	0.17
48.00	0.00	0.667	32.83	0.15
52.00	0.00	0.622	32.66	0.13
56.00	0.00	0.584	32.53	0.10
60.00	0.00	0.554	32.41	0.09
64.00	0.00	0.526	32.31	0.08
68.00	0.00	0.501	32.21	0.07
72.00	0.00	0.479	32.13	0.06
76.00	0.00	0.461	32.06	0.05
80.00	0.00	0.447	32.01	0.04
84.00	0.00	0.435	31.96	0.03
88.00	0.00	0.423	31.91	0.03
92.00	0.00	0.413	31.86	0.03
96.00	0.00	0.403	31.82	0.03
100.00	0.00	0.394	31.79	0.03
104.00	0.00	0.388	31.76	0.01
108.00	0.00	0.387	31.75	0.00
112.00	0.00	0.386	31.75	0.00
116.00	0.00	0.386	31.75	0.00
120.00	0.00	0.386	31.75	0.00
124.00	0.00	0.386	31.75	0.00
128.00	0.00	0.386	31.75	0.00
132.00	0.00	0.386	31.75	0.00
136.00	0.00	0.386	31.75	0.00
140.00	0.00	0.386	31.75	0.00
144.00	0.00	0.386	31.75	0.00
148.00	0.00	0.386	31.75	0.00
152.00	0.00	0.386	31.75	0.00
156.00	0.00	0.386	31.75	0.00

Stage-Discharge for Pond 12P: Sediment Forebay

Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)
30.00	0.00	32.12	2.91	34.24	56.73	36.36	164.31
30.04	0.00	32.16	3.41	34.28	58.34	36.40	166.45
30.08	0.00	32.20	3.92	34.32	60.00	36.44	168.60
30.12	0.00	32.24	4.46	34.36	61.67	36.48	**170.77**
30.16	0.00	32.28	5.02	34.40	63.37		
30.20	0.00	32.32	5.59	34.44	65.09		
30.24	0.00	32.36	6.19	34.48	66.84		
30.28	0.00	32.40	6.81	34.52	68.61		
30.32	0.00	32.44	7.45	34.56	70.40		
30.36	0.00	32.48	8.11	34.60	72.22		
30.40	0.00	32.52	8.78	34.64	74.06		
30.44	0.00	32.56	9.48	34.68	75.92		
30.48	0.00	32.60	10.23	34.72	77.81		
30.52	0.00	32.64	10.99	34.76	79.71		
30.56	0.00	32.68	11.78	34.80	81.60		
30.60	0.00	32.72	12.58	34.84	83.52		
30.64	0.00	32.76	13.40	34.88	85.46		
30.68	0.00	32.80	14.22	34.92	87.41		
30.72	0.00	32.84	15.05	34.96	89.40		
30.76	0.00	32.88	15.89	35.00	91.40		
30.80	0.00	32.92	16.76	35.04	93.43		
30.84	0.00	32.96	17.65	35.08	95.48		
30.88	0.00	33.00	18.57	35.12	97.55		
30.92	0.00	33.04	19.51	35.16	99.64		
30.96	0.00	33.08	20.47	35.20	101.76		
31.00	0.00	33.12	21.45	35.24	103.90		
31.04	0.00	33.16	22.46	35.28	106.04		
31.08	0.00	33.20	23.55	35.32	108.20		
31.12	0.00	33.24	24.66	35.36	110.38		
31.16	0.00	33.28	25.79	35.40	112.58		
31.20	0.00	33.32	26.95	35.44	114.81		
31.24	0.00	33.36	28.08	35.48	117.05		
31.28	0.00	33.40	29.12	35.52	119.32		
31.32	0.00	33.44	30.16	35.56	121.61		
31.36	0.00	33.48	31.21	35.60	123.93		
31.40	0.00	33.52	32.28	35.64	126.26		
31.44	0.00	33.56	33.37	35.68	128.62		
31.48	0.00	33.60	34.54	35.72	131.00		
31.52	0.00	33.64	35.71	35.76	133.30		
31.56	0.00	33.68	36.91	35.80	135.30		
31.60	0.00	33.72	38.12	35.84	137.31		
31.64	0.00	33.76	39.36	35.88	139.33		
31.68	0.00	33.80	40.70	35.92	141.36		
31.72	0.00	33.84	42.05	35.96	143.39		
31.76	0.01	33.88	43.42	36.00	145.44		
31.80	0.14	33.92	44.82	36.04	147.50		
31.84	0.33	33.96	46.24	36.08	149.57		
31.88	0.58	34.00	47.67	36.12	151.65		
31.92	0.87	34.04	49.13	36.16	153.73		
31.96	1.20	34.08	50.61	36.20	155.83		
32.00	1.57	34.12	52.11	36.24	157.93		
32.04	1.98	34.16	53.62	36.28	160.05		
32.08	2.42	34.20	55.16	36.32	162.17		

Stage-Area-Storage for Pond 12P: Sediment Forebay

Elevation (feet)	Storage (acre-feet)
30.00	0.000
30.10	0.020
30.20	0.041
30.30	0.061
30.40	0.082
30.50	0.102
30.60	0.124
30.70	0.146
30.80	0.167
30.90	0.189
31.00	0.211
31.10	0.234
31.20	0.257
31.30	0.280
31.40	0.303
31.50	0.326
31.60	0.350
31.70	0.374
31.80	0.398
31.90	0.421
32.00	0.445
32.10	0.471
32.20	0.498
32.30	0.524
32.40	0.551
32.50	0.577
32.60	0.604
32.70	0.631
32.80	0.659
32.90	0.686
33.00	0.713
33.10	0.742
33.20	0.771
33.30	0.800
33.40	0.829
33.50	0.858
33.60	0.888
33.70	0.919
33.80	0.949
33.90	0.980
34.00	1.010
34.10	1.042
34.20	1.074
34.30	1.107
34.40	1.139
34.50	1.171
34.60	1.205
34.70	1.239
34.80	1.272
34.90	1.306
35.00	1.340
35.10	1.376
35.20	1.411
35.30	1.447
35.40	1.482
35.50	1.518
35.60	1.555
35.70	1.593
35.80	1.630
35.90	1.668
36.00	1.705
36.10	1.744
36.20	1.784
36.30	1.823
36.40	1.863
36.50	**1.902**

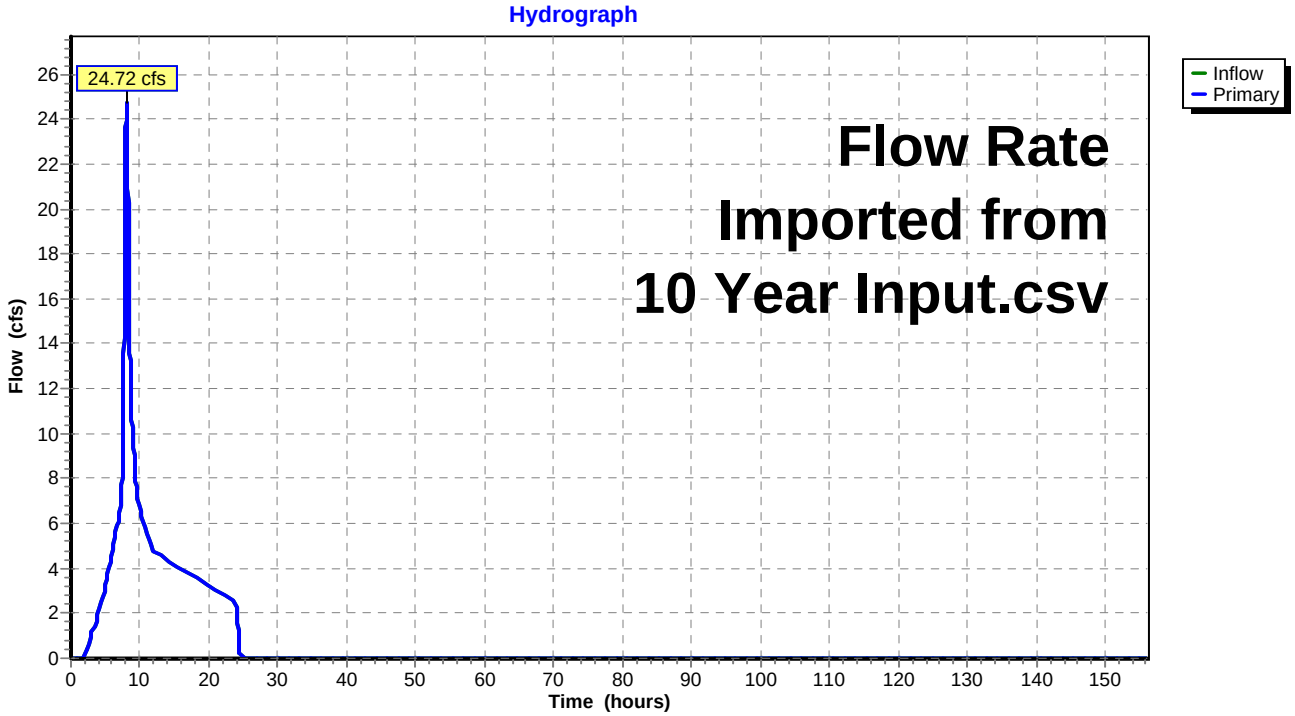
Summary for Link 1L: Input Hydrograhp

Inflow	=	24.72 cfs @	8.05 hrs,	Volume=	8.689 af
Primary	=	24.72 cfs @	8.05 hrs,	Volume=	8.689 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs

Flow Rate Imported from 10 Year Input.csv

Link 1L: Input Hydrograhp



Hydrograph for Link 1L: Input Hydrograhp

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**0.00**	0.00
2.00	0.00	0.00	0.00
4.00	2.18	0.00	2.18
6.00	4.67	0.00	4.67
8.00	**24.32**	0.00	**24.32**
10.00	**6.61**	0.00	**6.61**
12.00	4.75	0.00	4.75
14.00	4.28	0.00	4.28
16.00	3.97	0.00	3.97
18.00	3.61	0.00	3.61
20.00	3.24	0.00	3.24
22.00	2.86	0.00	2.86
24.00	2.48	0.00	2.48
26.00	0.00	0.00	0.00
28.00	0.00	0.00	0.00
30.00	0.00	0.00	0.00
32.00	0.00	0.00	0.00
34.00	0.00	0.00	0.00
36.00	0.00	0.00	0.00
38.00	0.00	0.00	0.00
40.00	0.00	0.00	0.00
42.00	0.00	0.00	0.00
44.00	0.00	0.00	0.00
46.00	0.00	0.00	0.00
48.00	0.00	0.00	0.00
50.00	0.00	0.00	0.00
52.00	0.00	0.00	0.00
54.00	0.00	0.00	0.00
56.00	0.00	0.00	0.00
58.00	0.00	0.00	0.00
60.00	0.00	0.00	0.00
62.00	0.00	0.00	0.00
64.00	0.00	0.00	0.00
66.00	0.00	0.00	0.00
68.00	0.00	0.00	0.00
70.00	0.00	0.00	0.00
72.00	0.00	0.00	0.00
74.00	0.00	0.00	0.00
76.00	0.00	0.00	0.00
78.00	0.00	0.00	0.00
80.00	0.00	0.00	0.00
82.00	0.00	0.00	0.00
84.00	0.00	0.00	0.00
86.00	0.00	0.00	0.00
88.00	0.00	0.00	0.00
90.00	0.00	0.00	0.00
92.00	0.00	0.00	0.00
94.00	0.00	0.00	0.00
96.00	0.00	0.00	0.00
98.00	0.00	0.00	0.00
100.00	0.00	0.00	0.00
102.00	0.00	0.00	0.00
104.00	0.00	0.00	0.00
106.00	0.00	0.00	0.00
108.00	0.00	0.00	0.00
110.00	0.00	0.00	0.00
112.00	0.00	0.00	0.00
114.00	0.00	0.00	0.00
116.00	0.00	0.00	0.00
118.00	0.00	0.00	0.00
120.00	0.00	0.00	0.00
122.00	0.00	0.00	0.00
124.00	0.00	0.00	0.00
126.00	0.00	0.00	0.00
128.00	0.00	0.00	0.00
130.00	0.00	0.00	0.00
132.00	0.00	0.00	0.00
134.00	0.00	0.00	0.00
136.00	0.00	0.00	0.00
138.00	0.00	0.00	0.00
140.00	0.00	0.00	0.00
142.00	0.00	0.00	0.00
144.00	0.00	0.00	0.00
146.00	0.00	0.00	0.00
148.00	0.00	0.00	0.00
150.00	0.00	0.00	0.00
152.00	0.00	0.00	0.00
154.00	0.00	0.00	0.00
156.00	0.00	0.00	0.00

Summary for Link 4L: Lag Thru Filter

Storage in sand filter modeled here as lag time from sand filter outlet to clear well outlet on downstream side of sand filter.

Lagtime estimate at conductivity of 1.75 inches/hour, with a hydraulic gradient of {[(31.00-28)/2]+1.5}*/(1.5)** thru 18 inches of sand.

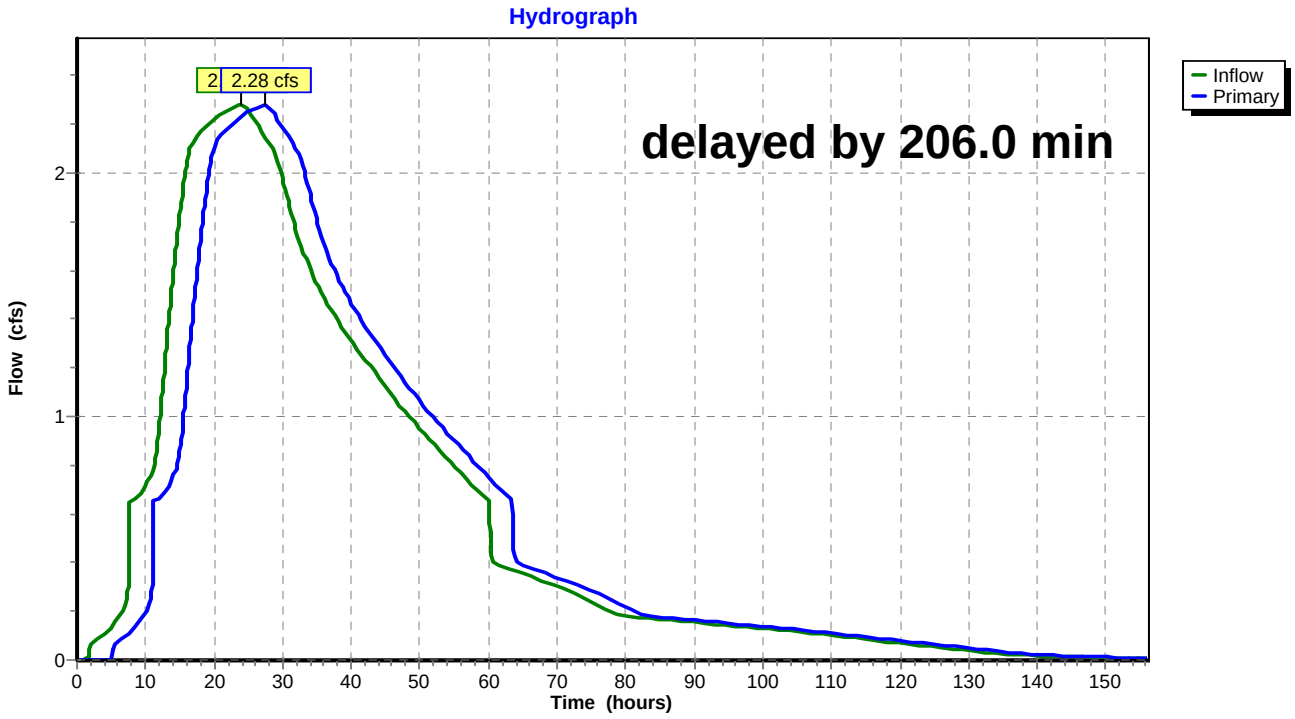
Result is 206 minutes

* "Average" Head on Sand Filter.
** Depth of Sand Filter

Inflow	=	2.28 cfs @	24.04 hrs,	Volume=	7.261 af
Primary	=	2.28 cfs @	27.48 hrs,	Volume=	7.259 af, Atten= 0%, Lag= 206.4 min

Primary outflow = Inflow delayed by 206.0 min, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs

Link 4L: Lag Thru Filter



Hydrograph for Link 4L: Lag Thru Filter

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**0.00**	0.00
2.00	0.06	0.00	0.00
4.00	0.11	0.00	0.00
6.00	0.17	0.00	0.08
8.00	0.66	0.00	0.12
10.00	0.72	0.00	0.20
12.00	0.97	0.00	0.66
14.00	1.58	0.00	0.75
16.00	2.04	0.00	1.14
18.00	2.17	0.00	1.73
20.00	2.22	0.00	2.11
22.00	2.26	0.00	2.18
24.00	**2.28**	0.00	2.23
26.00	**2.21**	0.00	**2.27**
28.00	2.12	0.00	**2.27**
30.00	1.97	0.00	2.19
32.00	1.76	0.00	2.10
34.00	1.60	0.00	1.91
36.00	1.49	0.00	1.71
38.00	1.39	0.00	1.57
40.00	1.31	0.00	1.46
42.00	1.23	0.00	1.37
44.00	1.16	0.00	1.29
46.00	1.08	0.00	1.21
48.00	1.01	0.00	1.13
50.00	0.95	0.00	1.06
52.00	0.89	0.00	0.99
54.00	0.83	0.00	0.93
56.00	0.77	0.00	0.87
58.00	0.71	0.00	0.81
60.00	0.66	0.00	0.75
62.00	0.39	0.00	0.69
64.00	0.37	0.00	0.40
66.00	0.34	0.00	0.38
68.00	0.32	0.00	0.36
70.00	0.30	0.00	0.34
72.00	0.28	0.00	0.32
74.00	0.26	0.00	0.30
76.00	0.22	0.00	0.27
78.00	0.20	0.00	0.25
80.00	0.18	0.00	0.22
82.00	0.17	0.00	0.19
84.00	0.17	0.00	0.18
86.00	0.16	0.00	0.17
88.00	0.16	0.00	0.17
90.00	0.15	0.00	0.16
92.00	0.15	0.00	0.16
94.00	0.14	0.00	0.15
96.00	0.14	0.00	0.15
98.00	0.13	0.00	0.14
100.00	0.13	0.00	0.14
102.00	0.12	0.00	0.13
104.00	0.12	0.00	0.13
106.00	0.11	0.00	0.12
108.00	0.11	0.00	0.12
110.00	0.10	0.00	0.11
112.00	0.09	0.00	0.10
114.00	0.09	0.00	0.10
116.00	0.08	0.00	0.09
118.00	0.08	0.00	0.09
120.00	0.07	0.00	0.08
122.00	0.06	0.00	0.07
124.00	0.06	0.00	0.07
126.00	0.05	0.00	0.06
128.00	0.04	0.00	0.06
130.00	0.04	0.00	0.05
132.00	0.03	0.00	0.04
134.00	0.03	0.00	0.04
136.00	0.02	0.00	0.03
138.00	0.02	0.00	0.03
140.00	0.02	0.00	0.02
142.00	0.02	0.00	0.02
144.00	0.01	0.00	0.02
146.00	0.01	0.00	0.01
148.00	0.01	0.00	0.01
150.00	0.01	0.00	0.01
152.00	0.01	0.00	0.01
154.00	0.01	0.00	0.01
156.00	0.01	0.00	0.01

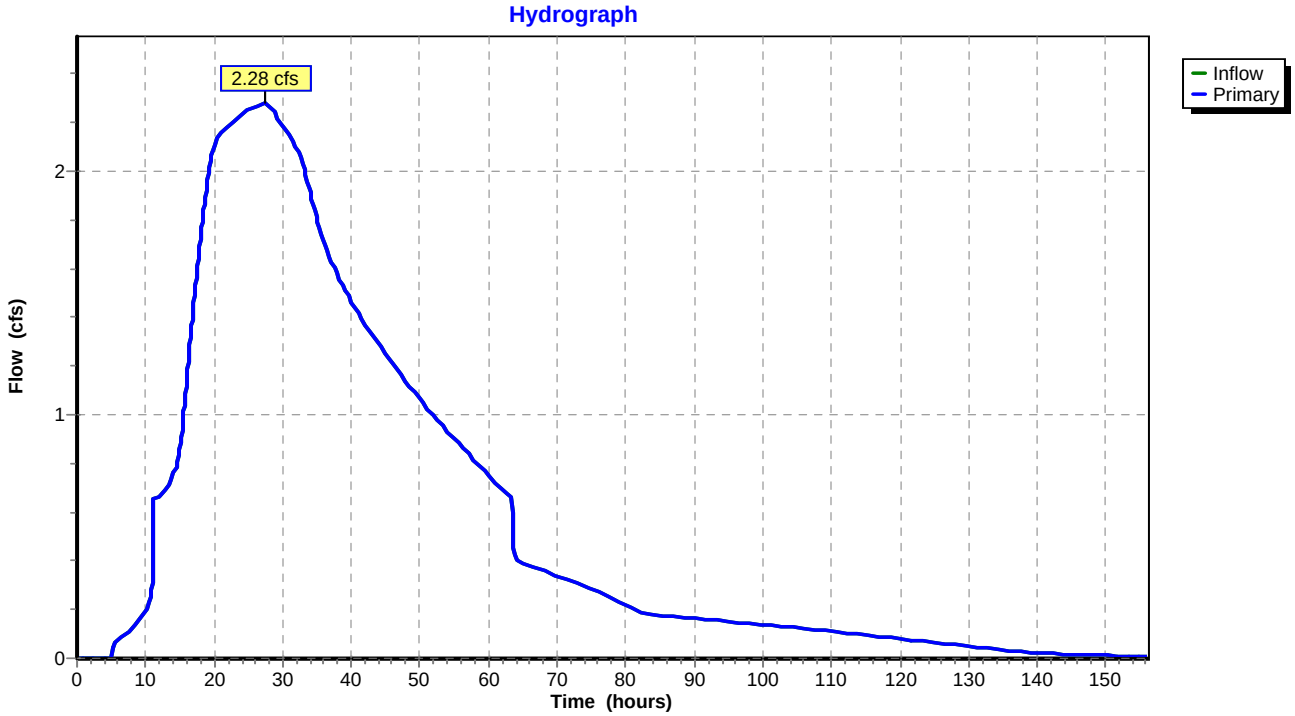
Summary for Link 9L: Discharge Elevation

Inflow	=	2.28 cfs @	27.48 hrs,	Volume=	7.259 af
Primary	=	2.28 cfs @	27.48 hrs,	Volume=	7.259 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs

Fixed water surface Elevation= 27.70'

Link 9L: Discharge Elevation



Hydrograph for Link 9L: Discharge Elevation

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**27.70**	0.00
2.00	0.00	27.70	0.00
4.00	0.00	27.70	0.00
6.00	0.08	27.70	0.08
8.00	0.12	27.70	0.12
10.00	0.20	27.70	0.20
12.00	0.66	27.70	0.66
14.00	0.75	27.70	0.75
16.00	1.14	27.70	1.14
18.00	1.73	27.70	1.73
20.00	2.11	27.70	2.11
22.00	2.18	27.70	2.18
24.00	2.23	27.70	2.23
26.00	**2.26**	27.70	**2.26**
28.00	**2.27**	27.70	**2.27**
30.00	2.19	27.70	2.19
32.00	2.10	27.70	2.10
34.00	1.91	27.70	1.91
36.00	1.71	27.70	1.71
38.00	1.57	27.70	1.57
40.00	1.46	27.70	1.46
42.00	1.37	27.70	1.37
44.00	1.29	27.70	1.29
46.00	1.21	27.70	1.21
48.00	1.13	27.70	1.13
50.00	1.06	27.70	1.06
52.00	0.99	27.70	0.99
54.00	0.93	27.70	0.93
56.00	0.87	27.70	0.87
58.00	0.81	27.70	0.81
60.00	0.75	27.70	0.75
62.00	0.69	27.70	0.69
64.00	0.40	27.70	0.40
66.00	0.38	27.70	0.38
68.00	0.36	27.70	0.36
70.00	0.34	27.70	0.34
72.00	0.32	27.70	0.32
74.00	0.30	27.70	0.30
76.00	0.27	27.70	0.27
78.00	0.25	27.70	0.25
80.00	0.22	27.70	0.22
82.00	0.19	27.70	0.19
84.00	0.18	27.70	0.18
86.00	0.17	27.70	0.17
88.00	0.17	27.70	0.17
90.00	0.16	27.70	0.16
92.00	0.16	27.70	0.16
94.00	0.15	27.70	0.15
96.00	0.15	27.70	0.15
98.00	0.14	27.70	0.14
100.00	0.14	27.70	0.14
102.00	0.13	27.70	0.13
104.00	0.13	27.70	0.13
106.00	0.12	27.70	0.12
108.00	0.12	27.70	0.12
110.00	0.11	27.70	0.11
112.00	0.10	27.70	0.10
114.00	0.10	27.70	0.10
116.00	0.09	27.70	0.09
118.00	0.09	27.70	0.09
120.00	0.08	27.70	0.08
122.00	0.07	27.70	0.07
124.00	0.07	27.70	0.07
126.00	0.06	27.70	0.06
128.00	0.06	27.70	0.06
130.00	0.05	27.70	0.05
132.00	0.04	27.70	0.04
134.00	0.04	27.70	0.04
136.00	0.03	27.70	0.03
138.00	0.03	27.70	0.03
140.00	0.02	27.70	0.02
142.00	0.02	27.70	0.02
144.00	0.02	27.70	0.02
146.00	0.01	27.70	0.01
148.00	0.01	27.70	0.01
150.00	0.01	27.70	0.01
152.00	0.01	27.70	0.01
154.00	0.01	27.70	0.01
156.00	0.01	27.70	0.01

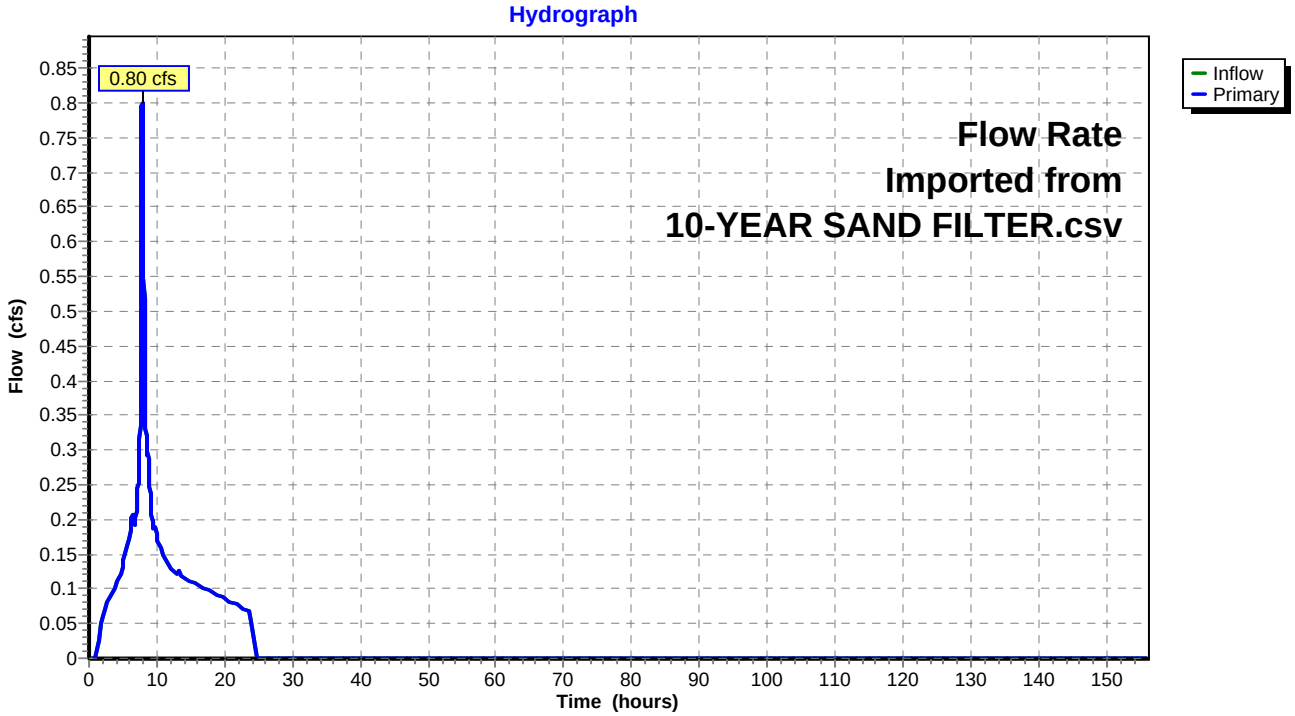
Summary for Link 10L: Sand Filter Input

Inflow	=	0.80 cfs @	7.82 hrs,	Volume=	0.260 af
Primary	=	0.80 cfs @	7.82 hrs,	Volume=	0.260 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs

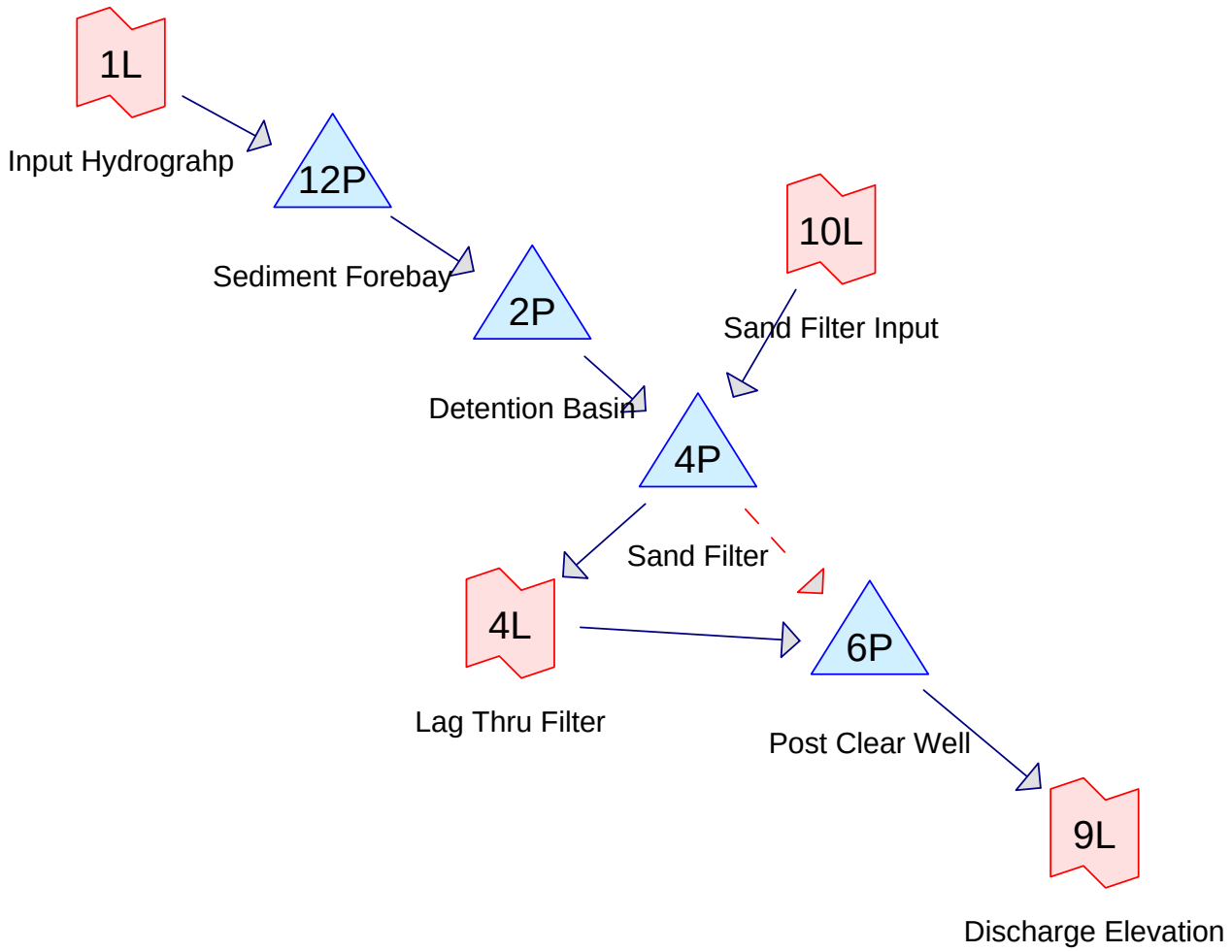
Flow Rate Imported from 10-YEAR SAND FILTER.csv

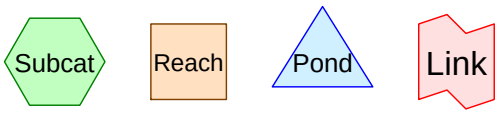
Link 10L: Sand Filter Input



Hydrograph for Link 10L: Sand Filter Input

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**0.00**	0.00
2.00	0.06	0.00	0.06
4.00	0.11	0.00	0.11
6.00	**0.18**	0.00	**0.18**
8.00	**0.76**	0.00	**0.76**
10.00	0.17	0.00	0.17
12.00	0.13	0.00	0.13
14.00	0.11	0.00	0.11
16.00	0.11	0.00	0.11
18.00	0.09	0.00	0.09
20.00	0.08	0.00	0.08
22.00	0.07	0.00	0.07
24.00	0.06	0.00	0.06
26.00	0.00	0.00	0.00
28.00	0.00	0.00	0.00
30.00	0.00	0.00	0.00
32.00	0.00	0.00	0.00
34.00	0.00	0.00	0.00
36.00	0.00	0.00	0.00
38.00	0.00	0.00	0.00
40.00	0.00	0.00	0.00
42.00	0.00	0.00	0.00
44.00	0.00	0.00	0.00
46.00	0.00	0.00	0.00
48.00	0.00	0.00	0.00
50.00	0.00	0.00	0.00
52.00	0.00	0.00	0.00
54.00	0.00	0.00	0.00
56.00	0.00	0.00	0.00
58.00	0.00	0.00	0.00
60.00	0.00	0.00	0.00
62.00	0.00	0.00	0.00
64.00	0.00	0.00	0.00
66.00	0.00	0.00	0.00
68.00	0.00	0.00	0.00
70.00	0.00	0.00	0.00
72.00	0.00	0.00	0.00
74.00	0.00	0.00	0.00
76.00	0.00	0.00	0.00
78.00	0.00	0.00	0.00
80.00	0.00	0.00	0.00
82.00	0.00	0.00	0.00
84.00	0.00	0.00	0.00
86.00	0.00	0.00	0.00
88.00	0.00	0.00	0.00
90.00	0.00	0.00	0.00
92.00	0.00	0.00	0.00
94.00	0.00	0.00	0.00
96.00	0.00	0.00	0.00
98.00	0.00	0.00	0.00
100.00	0.00	0.00	0.00
102.00	0.00	0.00	0.00
104.00	0.00	0.00	0.00
106.00	0.00	0.00	0.00
108.00	0.00	0.00	0.00
110.00	0.00	0.00	0.00
112.00	0.00	0.00	0.00
114.00	0.00	0.00	0.00
116.00	0.00	0.00	0.00
118.00	0.00	0.00	0.00
120.00	0.00	0.00	0.00
122.00	0.00	0.00	0.00
124.00	0.00	0.00	0.00
126.00	0.00	0.00	0.00
128.00	0.00	0.00	0.00
130.00	0.00	0.00	0.00
132.00	0.00	0.00	0.00
134.00	0.00	0.00	0.00
136.00	0.00	0.00	0.00
138.00	0.00	0.00	0.00
140.00	0.00	0.00	0.00
142.00	0.00	0.00	0.00
144.00	0.00	0.00	0.00
146.00	0.00	0.00	0.00
148.00	0.00	0.00	0.00
150.00	0.00	0.00	0.00
152.00	0.00	0.00	0.00
154.00	0.00	0.00	0.00
156.00	0.00	0.00	0.00





Drainage Diagram for 25-Year Model
Prepared by Integral Consulting Inc., Printed 9/28/2011
HydroCAD® 9.10 s/n 06683 © 2010 HydroCAD Software Solutions LLC

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Fill (inches)
1	2P	31.00	29.45	310.0	0.0050	0.013	24.0	0.0	0.0
2	4P	28.76	28.00	152.0	0.0050	0.011	4.0	0.0	0.0
3	6P	28.00	27.22	156.0	0.0050	0.013	24.0	0.0	0.0

Time span=0.00-156.00 hrs, dt=0.02 hrs, 7801 points x 3
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Pond 2P: Detention Basin Peak Elev=34.98' Storage=4.777 af Inflow=25.63 cfs 9.887 af
Outflow=5.96 cfs 8.582 af

Pond 4P: Sand Filter Peak Elev=34.89' Storage=1.611 af Inflow=6.13 cfs 8.884 af
Primary=2.54 cfs 8.883 af Secondary=0.00 cfs 0.000 af Outflow=2.54 cfs 8.883 af

Pond 6P: Post Clear Well Peak Elev=29.00' Storage=0.000 af Inflow=2.54 cfs 8.881 af
24.0" Round Culvert n=0.013 L=156.0' S=0.0050 '/' Outflow=2.54 cfs 8.880 af

Pond 12P: Sediment Forebay Peak Elev=34.98' Storage=1.333 af Inflow=29.25 cfs 10.273 af
Outflow=25.63 cfs 9.887 af

Link 1L: Input Hydrograhp Flow Rate Imported from 25 Year Input.csv Inflow=29.25 cfs 10.273 af
Primary=29.25 cfs 10.273 af

Link 4L: Lag Thru Filter delayed by 206.0 min Inflow=2.54 cfs 8.883 af
Primary=2.54 cfs 8.881 af

Link 9L: Discharge Elevation Inflow=2.54 cfs 8.880 af
Primary=2.54 cfs 8.880 af

Link 10L: Sand Filter Input Flow Rate Imported from 25-YEAR SAND FILTER.csv Inflow=0.92 cfs 0.302 af
Primary=0.92 cfs 0.302 af

Summary for Pond 2P: Detention Basin

Inflow	=	25.63 cfs @	8.14 hrs,	Volume=	9.887 af
Outflow	=	5.96 cfs @	11.21 hrs,	Volume=	8.582 af, Atten= 77%, Lag= 184.1 min
Primary	=	5.96 cfs @	11.21 hrs,	Volume=	8.582 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 34.98' @ 24.08 hrs Surf.Area= 0.000 ac Storage= 4.777 af

Plug-Flow detention time= 1,309.3 min calculated for 8.581 af (87% of inflow)
Center-of-Mass det. time= 1,084.9 min (2,027.6 - 942.7)

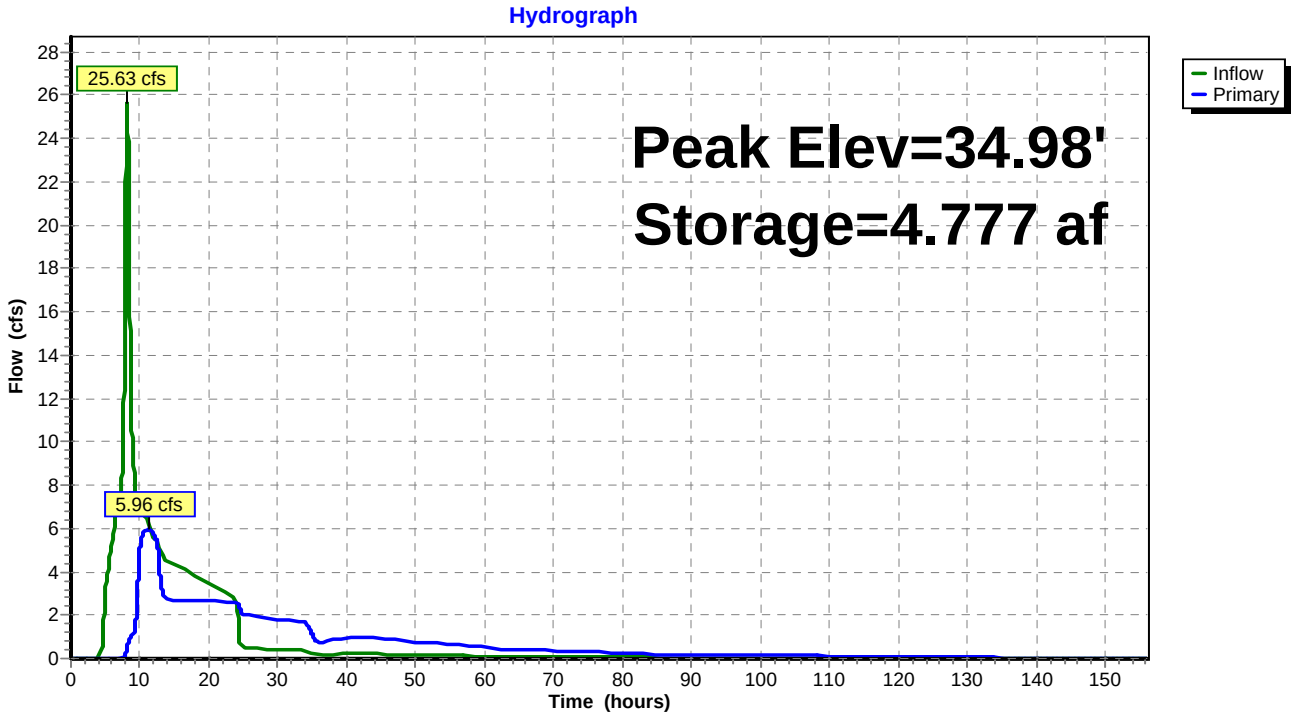
Volume	Invert	Avail.Storage	Storage Description
#1	30.00'	6.558 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
30.00	0.000
30.25	0.204
30.50	0.412
31.00	0.839
31.50	1.280
32.00	1.736
32.50	2.207
33.00	2.694
33.50	3.196
34.00	3.715
34.50	4.250
35.00	4.801
35.50	5.370
36.00	5.955
36.50	6.558

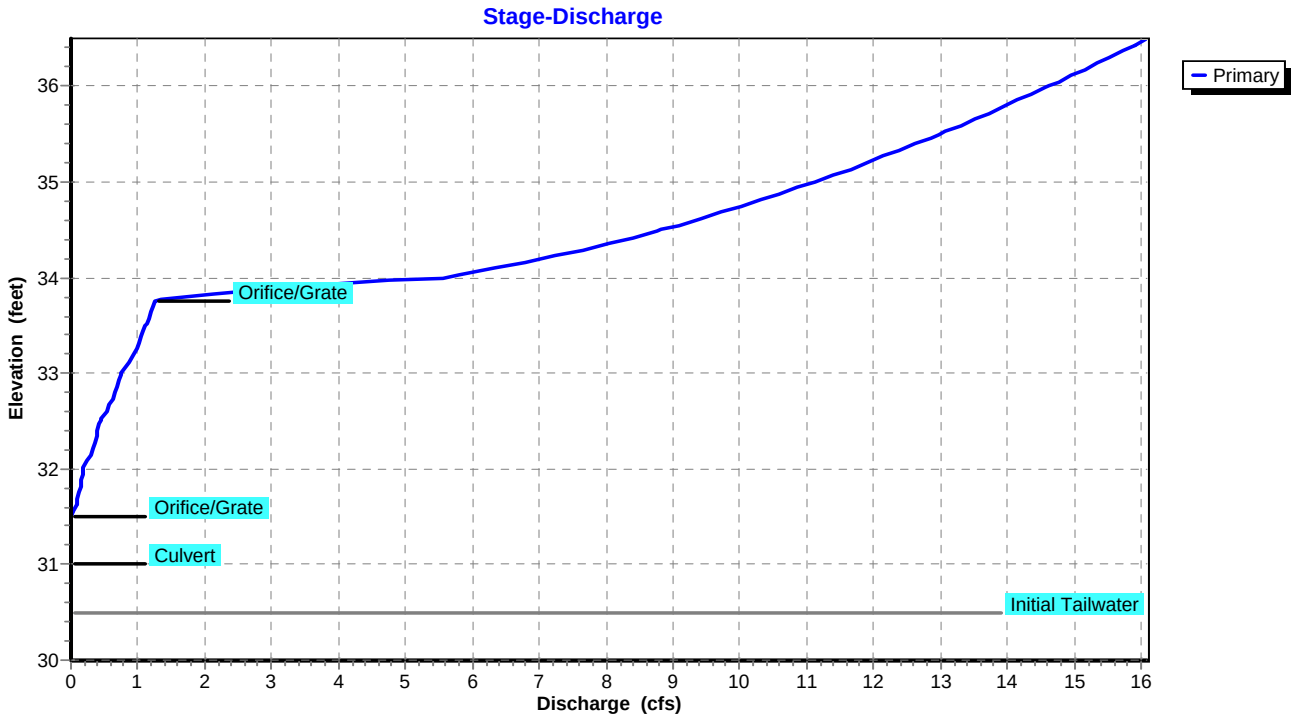
Device	Routing	Invert	Outlet Devices
#1	Device 3	31.50'	**1.0" Vert. Orifice/Grate X 10.00 columns** X 4 rows with 6.0" cc spacing C= 0.600
#2	Device 3	33.75'	**8.0" Horiz. Orifice/Grate X 5.00** C= 0.600 Limited to weir flow at low heads
#3	Primary	31.00'	**24.0" Round Culvert** L= 310.0' CPP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 31.00' / 29.45' S= 0.0050 '/' Cc= 0.500 n= 0.013

Primary OutFlow Max=5.96 cfs @ 11.21 hrs HW=34.06' TW=32.41' (Dynamic Tailwater)
└─**3=Culvert** (Passes 5.96 cfs of 10.80 cfs potential flow)
  ├─**1=Orifice/Grate** (Orifice Controls 1.26 cfs @ 5.79 fps)
  └─**2=Orifice/Grate** (Orifice Controls 4.70 cfs @ 2.69 fps)

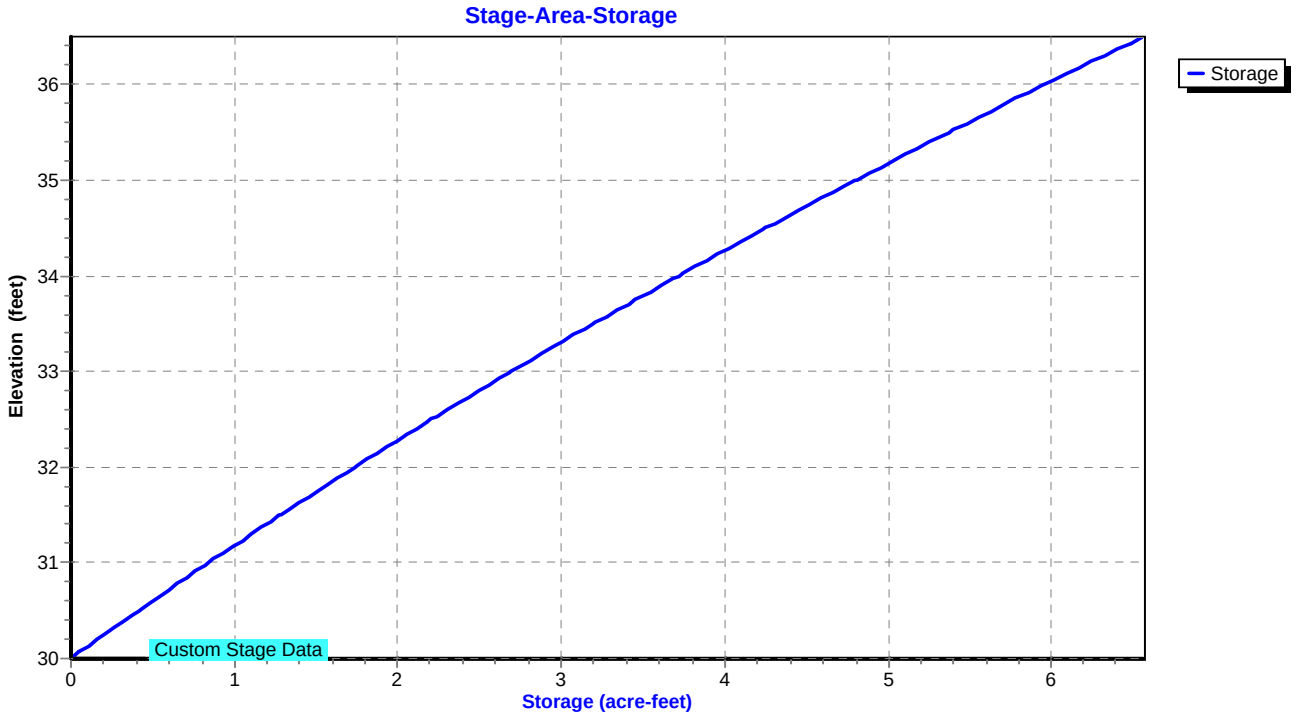
Pond 2P: Detention Basin



Pond 2P: Detention Basin



Pond 2P: Detention Basin



Hydrograph for Pond 2P: Detention Basin

Time (hours)	Inflow (cfs)	Storage (acre-feet)	Elevation (feet)	Primary (cfs)
0.00	0.00	0.000	30.00	0.00
4.00	0.00	0.000	30.00	0.00
8.00	**23.39**	1.899	32.17	**0.30**
12.00	**5.57**	3.786	34.07	**5.71**
16.00	4.17	4.221	34.47	2.70
20.00	3.49	4.600	34.82	2.66
24.00	2.79	**4.776**	**34.98**	2.56
28.00	0.45	**4.307**	**34.55**	1.90
32.00	0.40	3.845	34.12	1.74
36.00	0.16	3.483	33.78	0.72
40.00	0.21	3.269	33.57	0.94
44.00	0.21	3.026	33.33	0.93
48.00	0.19	2.797	33.10	0.83
52.00	0.15	2.603	32.91	0.71
56.00	0.13	2.431	32.73	0.62
60.00	0.11	2.284	32.58	0.51
64.00	0.09	2.167	32.46	0.42
68.00	0.08	2.064	32.35	0.38
72.00	0.07	1.971	32.25	0.34
76.00	0.07	1.888	32.16	0.30
80.00	0.05	1.818	32.09	0.25
84.00	0.04	1.761	32.03	0.19
88.00	0.04	1.714	31.98	0.17
92.00	0.03	1.670	31.93	0.16
96.00	0.03	1.629	31.88	0.15
100.00	0.03	1.590	31.84	0.14
104.00	0.03	1.553	31.80	0.13
108.00	0.02	1.519	31.76	0.12
112.00	0.00	1.483	31.72	0.11
116.00	0.00	1.449	31.68	0.10
120.00	0.00	1.418	31.65	0.09
124.00	0.00	1.391	31.62	0.07
128.00	0.00	1.369	31.60	0.06
132.00	0.00	1.350	31.58	0.05
136.00	0.00	1.336	31.56	0.04
140.00	0.00	1.326	31.55	0.03
144.00	0.00	1.318	31.54	0.02
148.00	0.00	1.313	31.54	0.01
152.00	0.00	1.309	31.53	0.01
156.00	0.00	1.305	31.53	0.01

Stage-Discharge for Pond 2P: Detention Basin

Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)
30.00	0.00	32.12	0.27	34.24	7.33	36.36	15.69
30.04	0.00	32.16	0.30	34.28	7.58	36.40	15.80
30.08	0.00	32.20	0.32	34.32	7.83	36.44	15.92
30.12	0.00	32.24	0.34	34.36	8.06	36.48	**16.03**
30.16	0.00	32.28	0.35	34.40	8.29		
30.20	0.00	32.32	0.37	34.44	8.51		
30.24	0.00	32.36	0.39	34.48	8.72		
30.28	0.00	32.40	0.40	34.52	8.93		
30.32	0.00	32.44	0.41	34.56	9.13		
30.36	0.00	32.48	0.43	34.60	9.33		
30.40	0.00	32.52	0.45	34.64	9.53		
30.44	0.00	32.56	0.49	34.68	9.72		
30.48	0.00	32.60	0.53	34.72	9.90		
30.52	0.00	32.64	0.56	34.76	10.09		
30.56	0.00	32.68	0.59	34.80	10.26		
30.60	0.00	32.72	0.61	34.84	10.44		
30.64	0.00	32.76	0.64	34.88	10.61		
30.68	0.00	32.80	0.66	34.92	10.78		
30.72	0.00	32.84	0.68	34.96	10.95		
30.76	0.00	32.88	0.70	35.00	11.11		
30.80	0.00	32.92	0.72	35.04	11.28		
30.84	0.00	32.96	0.73	35.08	11.44		
30.88	0.00	33.00	0.75	35.12	11.59		
30.92	0.00	33.04	0.79	35.16	11.75		
30.96	0.00	33.08	0.84	35.20	11.90		
31.00	0.00	33.12	0.88	35.24	12.05		
31.04	0.00	33.16	0.91	35.28	12.20		
31.08	0.00	33.20	0.94	35.32	12.35		
31.12	0.00	33.24	0.97	35.36	12.50		
31.16	0.00	33.28	0.99	35.40	12.64		
31.20	0.00	33.32	1.02	35.44	12.78		
31.24	0.00	33.36	1.04	35.48	12.92		
31.28	0.00	33.40	1.06	35.52	13.06		
31.32	0.00	33.44	1.09	35.56	13.20		
31.36	0.00	33.48	1.11	35.60	13.33		
31.40	0.00	33.52	1.13	35.64	13.47		
31.44	0.00	33.56	1.15	35.68	13.60		
31.48	0.00	33.60	1.17	35.72	13.73		
31.52	0.00	33.64	1.19	35.76	13.86		
31.56	0.04	33.68	1.21	35.80	13.99		
31.60	0.06	33.72	1.23	35.84	14.12		
31.64	0.08	33.76	1.28	35.88	14.25		
31.68	0.10	33.80	1.65	35.92	14.37		
31.72	0.11	33.84	2.21	35.96	14.50		
31.76	0.12	33.88	2.91	36.00	14.62		
31.80	0.13	33.92	3.72	36.04	14.75		
31.84	0.14	33.96	4.63	36.08	14.87		
31.88	0.15	34.00	5.56	36.12	14.99		
31.92	0.16	34.04	5.90	36.16	15.11		
31.96	0.17	34.08	6.21	36.20	15.23		
32.00	0.18	34.12	6.51	36.24	15.34		
32.04	0.20	34.16	6.80	36.28	15.46		
32.08	0.24	34.20	7.07	36.32	15.58		

Stage-Area-Storage for Pond 2P: Detention Basin

Elevation (feet)	Storage (acre-feet)
30.00	0.000
30.10	0.082
30.20	0.163
30.30	0.246
30.40	0.329
30.50	0.412
30.60	0.497
30.70	0.583
30.80	0.668
30.90	0.754
31.00	0.839
31.10	0.927
31.20	1.015
31.30	1.104
31.40	1.192
31.50	1.280
31.60	1.371
31.70	1.462
31.80	1.554
31.90	1.645
32.00	1.736
32.10	1.830
32.20	1.924
32.30	2.019
32.40	2.113
32.50	2.207
32.60	2.304
32.70	2.402
32.80	2.499
32.90	2.597
33.00	2.694
33.10	2.794
33.20	2.895
33.30	2.995
33.40	3.096
33.50	3.196
33.60	3.300
33.70	3.404
33.80	3.507
33.90	3.611
34.00	3.715
34.10	3.822
34.20	3.929
34.30	4.036
34.40	4.143
34.50	4.250
34.60	4.360
34.70	4.470
34.80	4.581
34.90	4.691
35.00	4.801
35.10	4.915
35.20	5.029
35.30	5.142
35.40	5.256
35.50	5.370
35.60	5.487
35.70	5.604
35.80	5.721
35.90	5.838
36.00	5.955
36.10	6.076
36.20	6.196
36.30	6.317
36.40	6.437
36.50	**6.558**

Summary for Pond 4P: Sand Filter

NOTE:

Influent Clear Well not modeled.

Storage in Sand Filter not modeled, flow modeled as lag.

Inflow	=	6.13 cfs @	11.21 hrs,	Volume=	8.884 af
Outflow	=	2.54 cfs @	24.16 hrs,	Volume=	8.883 af, Atten= 59%, Lag= 777.0 min
Primary	=	2.54 cfs @	24.16 hrs,	Volume=	8.883 af
Secondary	=	0.00 cfs @	0.00 hrs,	Volume=	0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 34.89' @ 24.16 hrs Surf.Area= 0.367 ac Storage= 1.611 af

Plug-Flow detention time= 327.1 min calculated for 8.882 af (100% of inflow)
Center-of-Mass det. time= 327.1 min (2,308.2 - 1,981.2)

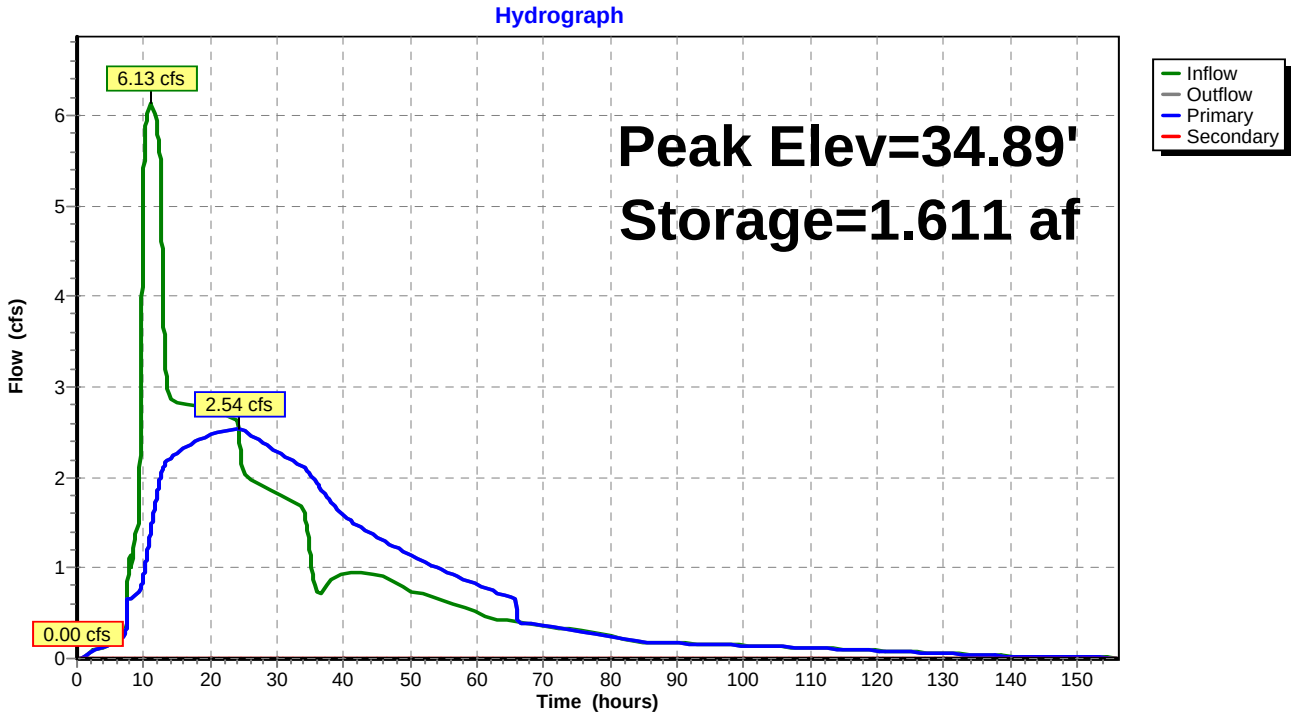
Volume	Invert	Avail.Storage	Storage Description
#1	30.50'	2.204 af	**100.00'W x 160.00'L x 6.00'H Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Secondary	35.25'	**130.0' long x 2.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 Coef. (English) 2.48 2.60 2.60 2.60 2.64 2.65 2.68 2.75 2.74 2.76 2.89 3.05 3.19 3.32
#2	Device 3	30.50'	**1.750 in/hr Exfiltration over Horizontal area** Conductivity to Groundwater Elevation = 29.00' Phase-In= 0.01'
#3	Device 4	29.00'	**0.3" Horiz. Orifice/Grate X 8.00 columns** X 150 rows C= 0.600
#4	Primary	28.76'	**4.0" Round Culvert X 8.00** L= 152.0' Ke= 0.900 Inlet / Outlet Invert= 28.76' / 28.00' S= 0.0050 '/' Cc= 0.500 n= 0.011

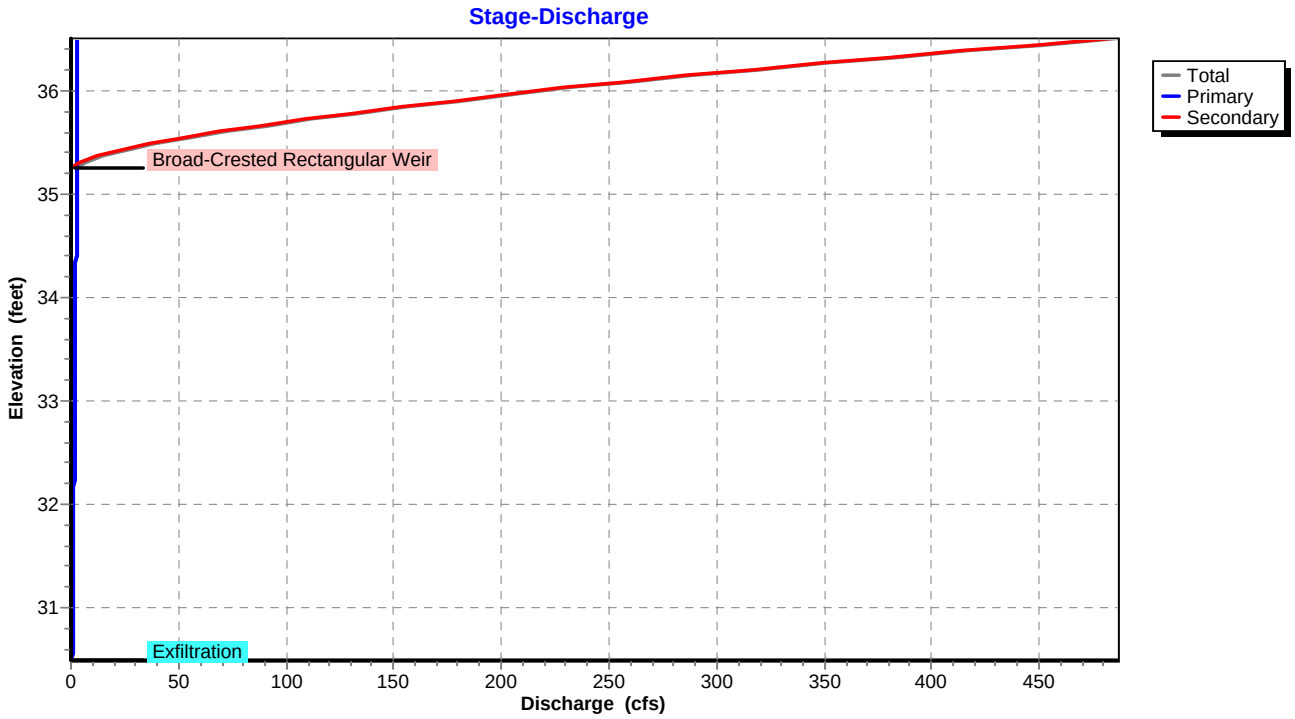
Primary OutFlow Max=2.54 cfs @ 24.16 hrs HW=34.89' TW=0.00' (Dynamic Tailwater)
└─**4=Culvert** (Passes 2.54 cfs of 3.51 cfs potential flow)
  └─**3=Orifice/Grate** (Passes 2.54 cfs of 6.88 cfs potential flow)
    └─**2=Exfiltration** (Controls 2.54 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=30.50' TW=29.00' (Dynamic Tailwater)
└─**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

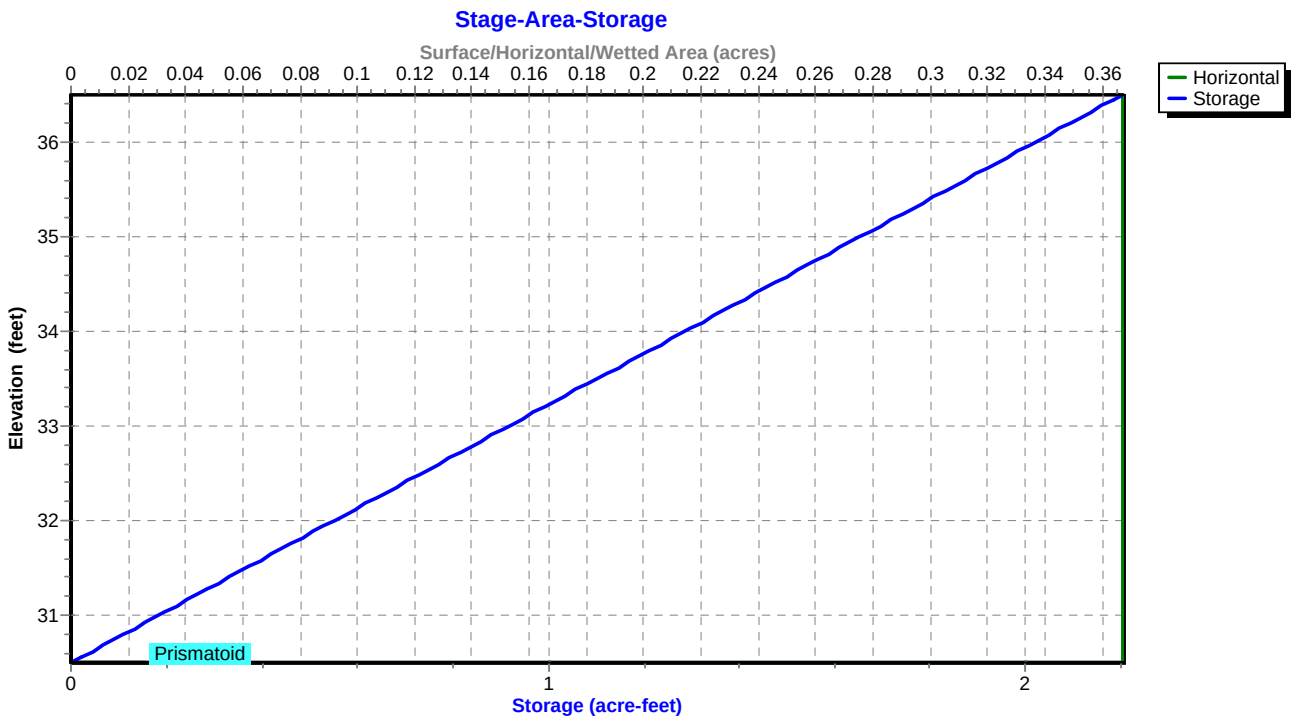
Pond 4P: Sand Filter



Pond 4P: Sand Filter



Pond 4P: Sand Filter



Hydrograph for Pond 4P: Sand Filter

Time (hours)	Inflow (cfs)	Storage (acre-feet)	Elevation (feet)	Outflow (cfs)	Primary (cfs)	Secondary (cfs)
0.00	0.00	0.000	30.50	0.00	0.00	**0.00**
4.00	0.13	0.001	30.50	0.13	0.13	0.00
8.00	**1.18**	0.015	30.54	0.67	0.67	0.00
12.00	**5.86**	0.990	33.19	1.81	1.81	0.00
16.00	2.82	1.421	34.37	2.32	2.32	0.00
20.00	2.76	1.549	34.72	2.47	2.47	0.00
24.00	2.63	**1.610**	**34.88**	**2.54**	**2.54**	0.00
28.00	1.90	**1.469**	**34.50**	**2.38**	**2.38**	0.00
32.00	1.74	1.315	34.08	2.19	2.19	0.00
36.00	0.72	1.093	33.47	1.93	1.93	0.00
40.00	0.94	0.794	32.66	1.58	1.58	0.00
44.00	0.93	0.621	32.19	1.38	1.38	0.00
48.00	0.83	0.487	31.82	1.22	1.22	0.00
52.00	0.71	0.358	31.47	1.07	1.07	0.00
56.00	0.62	0.246	31.17	0.94	0.94	0.00
60.00	0.51	0.144	30.89	0.82	0.82	0.00
64.00	0.42	0.043	30.62	0.70	0.70	0.00
68.00	0.38	0.002	30.51	0.38	0.38	0.00
72.00	0.34	0.002	30.51	0.34	0.34	0.00
76.00	0.30	0.002	30.50	0.30	0.30	0.00
80.00	0.25	0.001	30.50	0.25	0.25	0.00
84.00	0.19	0.001	30.50	0.19	0.19	0.00
88.00	0.17	0.001	30.50	0.17	0.17	0.00
92.00	0.16	0.001	30.50	0.16	0.16	0.00
96.00	0.15	0.001	30.50	0.15	0.15	0.00
100.00	0.14	0.001	30.50	0.14	0.14	0.00
104.00	0.13	0.001	30.50	0.13	0.13	0.00
108.00	0.12	0.001	30.50	0.12	0.12	0.00
112.00	0.11	0.001	30.50	0.11	0.11	0.00
116.00	0.10	0.001	30.50	0.10	0.10	0.00
120.00	0.09	0.000	30.50	0.09	0.09	0.00
124.00	0.07	0.000	30.50	0.07	0.07	0.00
128.00	0.06	0.000	30.50	0.06	0.06	0.00
132.00	0.05	0.000	30.50	0.05	0.05	0.00
136.00	0.04	0.000	30.50	0.04	0.04	0.00
140.00	0.03	0.000	30.50	0.03	0.03	0.00
144.00	0.02	0.000	30.50	0.02	0.02	0.00
148.00	0.01	0.000	30.50	0.01	0.01	0.00
152.00	0.01	0.000	30.50	0.01	0.01	0.00
156.00	0.01	0.000	30.50	0.01	0.01	0.00

Stage-Discharge for Pond 4P: Sand Filter

Elevation (feet)	Discharge (cfs)	Primary (cfs)	Secondary (cfs)
30.50	0.00	0.00	0.00
30.60	0.69	0.69	0.00
30.70	0.73	0.73	0.00
30.80	0.78	0.78	0.00
30.90	0.82	0.82	0.00
31.00	0.86	0.86	0.00
31.10	0.91	0.91	0.00
31.20	0.95	0.95	0.00
31.30	0.99	0.99	0.00
31.40	1.04	1.04	0.00
31.50	1.08	1.08	0.00
31.60	1.12	1.12	0.00
31.70	1.17	1.17	0.00
31.80	1.21	1.21	0.00
31.90	1.25	1.25	0.00
32.00	1.30	1.30	0.00
32.10	1.34	1.34	0.00
32.20	1.38	1.38	0.00
32.30	1.43	1.43	0.00
32.40	1.47	1.47	0.00
32.50	1.51	1.51	0.00
32.60	1.56	1.56	0.00
32.70	1.60	1.60	0.00
32.80	1.64	1.64	0.00
32.90	1.69	1.69	0.00
33.00	1.73	1.73	0.00
33.10	1.77	1.77	0.00
33.20	1.81	1.81	0.00
33.30	1.86	1.86	0.00
33.40	1.90	1.90	0.00
33.50	1.94	1.94	0.00
33.60	1.99	1.99	0.00
33.70	2.03	2.03	0.00
33.80	2.07	2.07	0.00
33.90	2.12	2.12	0.00
34.00	2.16	2.16	0.00
34.10	2.20	2.20	0.00
34.20	2.25	2.25	0.00
34.30	2.29	2.29	0.00
34.40	2.33	2.33	0.00
34.50	2.38	2.38	0.00
34.60	2.42	2.42	0.00
34.70	2.46	2.46	0.00
34.80	2.51	2.51	0.00
34.90	2.55	2.55	0.00
35.00	2.59	2.59	0.00
35.10	2.64	2.64	0.00
35.20	2.68	2.68	0.00
35.30	6.33	2.72	3.60
35.40	21.50	2.77	18.73
35.50	43.60	2.81	40.79
35.60	72.03	2.85	69.18
35.70	104.93	2.90	102.03
35.80	140.81	2.94	137.87
35.90	180.11	2.98	177.13
36.00	222.56	3.02	219.54
36.10	268.96	3.07	265.90
36.20	319.69	3.11	316.58
36.30	372.76	3.15	369.61
36.40	427.65	3.20	424.45
36.50	**486.06**	**3.24**	**482.82**

Stage-Area-Storage for Pond 4P: Sand Filter

Elevation (feet)	Horizontal (acres)	Storage (acre-feet)
30.50	**0.367**	0.000
30.60	0.367	0.037
30.70	0.367	0.073
30.80	0.367	0.110
30.90	0.367	0.147
31.00	0.367	0.184
31.10	0.367	0.220
31.20	0.367	0.257
31.30	0.367	0.294
31.40	0.367	0.331
31.50	0.367	0.367
31.60	0.367	0.404
31.70	0.367	0.441
31.80	0.367	0.478
31.90	0.367	0.514
32.00	0.367	0.551
32.10	0.367	0.588
32.20	0.367	0.624
32.30	0.367	0.661
32.40	0.367	0.698
32.50	0.367	0.735
32.60	0.367	0.771
32.70	0.367	0.808
32.80	0.367	0.845
32.90	0.367	0.882
33.00	0.367	0.918
33.10	0.367	0.955
33.20	0.367	0.992
33.30	0.367	1.028
33.40	0.367	1.065
33.50	0.367	1.102
33.60	0.367	1.139
33.70	0.367	1.175
33.80	0.367	1.212
33.90	0.367	1.249
34.00	0.367	1.286
34.10	0.367	1.322
34.20	0.367	1.359
34.30	0.367	1.396
34.40	0.367	1.433
34.50	0.367	1.469
34.60	0.367	1.506
34.70	0.367	1.543
34.80	0.367	1.579
34.90	0.367	1.616
35.00	0.367	1.653
35.10	0.367	1.690
35.20	0.367	1.726
35.30	0.367	1.763
35.40	0.367	1.800
35.50	0.367	1.837
35.60	0.367	1.873
35.70	0.367	1.910
35.80	0.367	1.947
35.90	0.367	1.983
36.00	0.367	2.020
36.10	0.367	2.057
36.20	0.367	2.094
36.30	0.367	2.130
36.40	0.367	2.167
36.50	0.367	**2.204**

Summary for Pond 6P: Post Clear Well

Inflow	=	2.54 cfs @	27.59 hrs,	Volume=	8.881 af
Outflow	=	2.54 cfs @	27.59 hrs,	Volume=	8.880 af, Atten= 0%, Lag= 0.4 min
Primary	=	2.54 cfs @	27.59 hrs,	Volume=	8.880 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 29.00' @ 27.59 hrs Surf.Area= 0.000 ac Storage= 0.000 af

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 0.1 min (2,512.1 - 2,512.0)

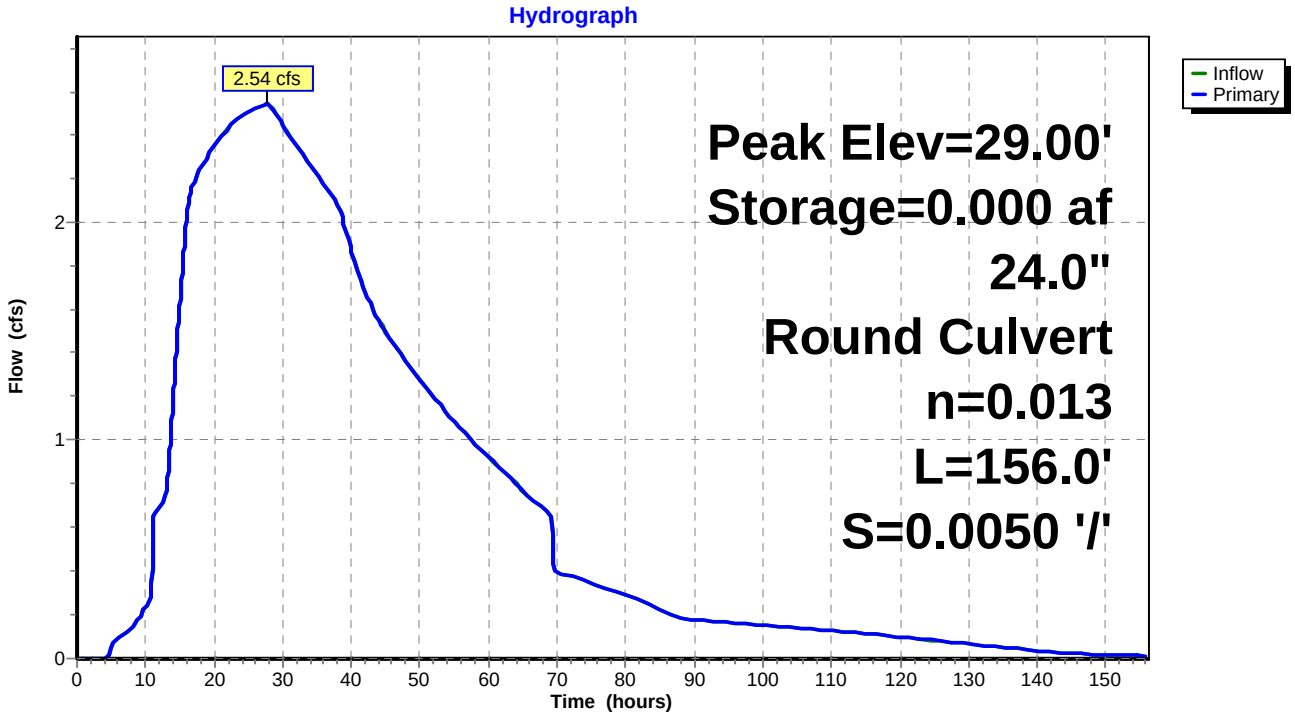
Volume	Invert	Avail.Storage	Storage Description
#1	29.00'	0.549 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
29.00	0.000
29.50	0.014
30.00	0.031
30.50	0.051
31.00	0.074
31.50	0.101
32.00	0.132
32.50	0.166
33.00	0.206
33.50	0.250
34.00	0.298
34.50	0.353
35.00	0.412
35.50	0.478
36.00	0.549

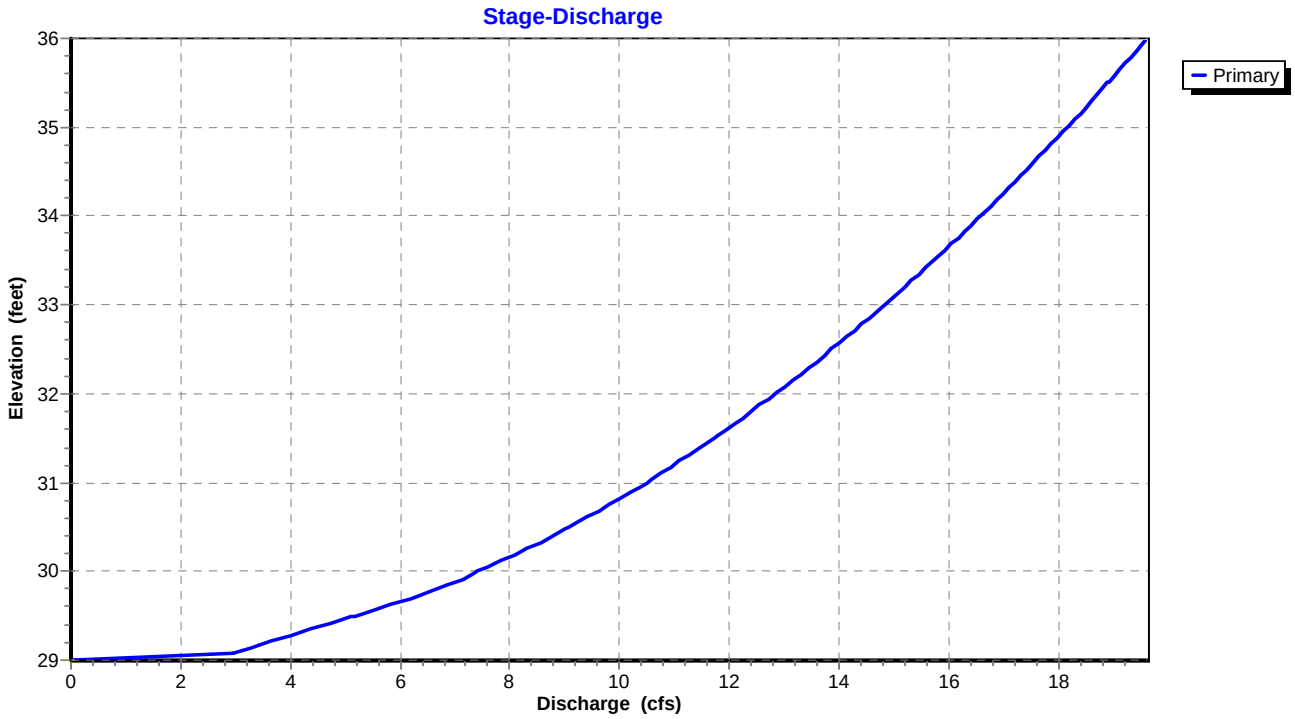
Device	Routing	Invert	Outlet Devices
#1	Primary	28.00'	**24.0" Round Culvert** L= 156.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 28.00' / 27.22' S= 0.0050 '/' Cc= 0.500 n= 0.013

Primary OutFlow Max=2.63 cfs @ 27.59 hrs HW=29.00' TW=27.70' (Dynamic Tailwater)
└─**1=Culvert** (Inlet Controls 2.63 cfs @ 1.67 fps)

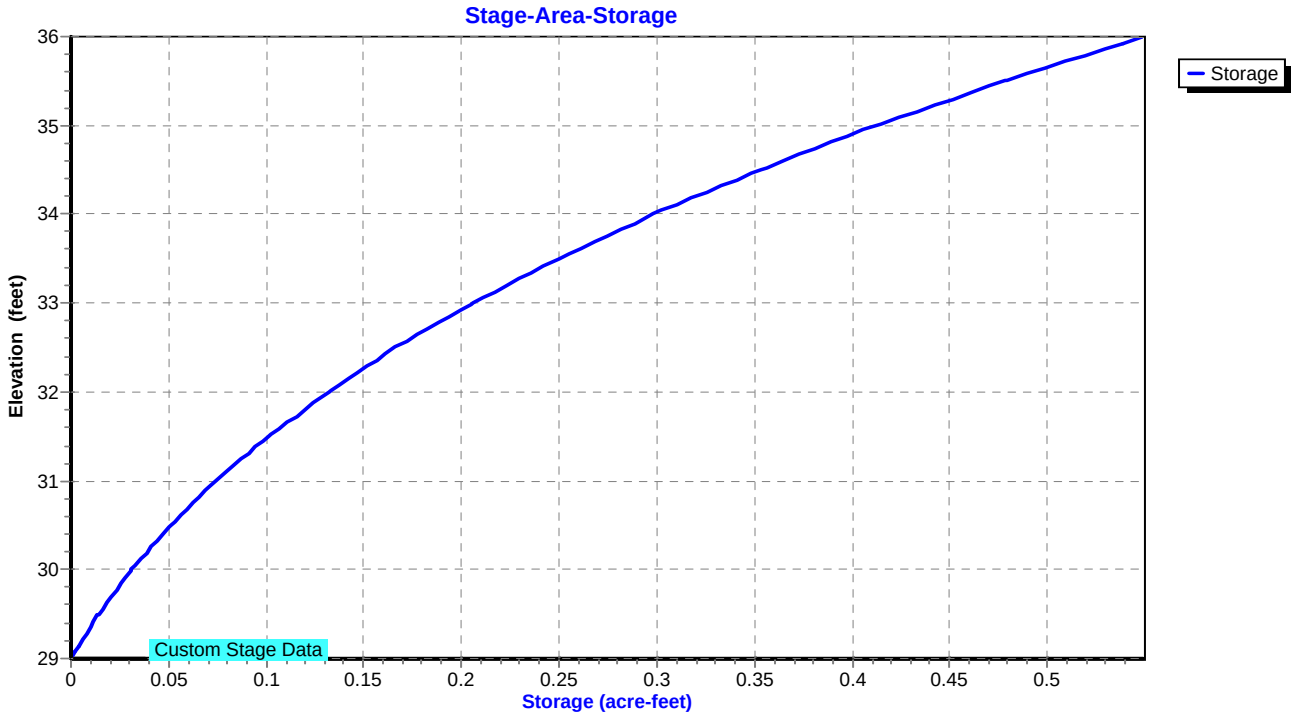
Pond 6P: Post Clear Well



Pond 6P: Post Clear Well



Pond 6P: Post Clear Well



Hydrograph for Pond 6P: Post Clear Well

Time (hours)	Inflow (cfs)	Storage (acre-feet)	Elevation (feet)	Primary (cfs)
0.00	0.00	0.000	29.00	0.00
4.00	0.00	0.000	29.00	0.00
8.00	0.14	0.000	29.00	0.14
12.00	0.69	0.000	29.00	0.69
16.00	2.02	0.000	29.00	2.02
20.00	2.35	0.000	29.00	2.35
24.00	**2.49**	**0.000**	**29.00**	**2.48**
28.00	**2.54**	**0.000**	**29.00**	**2.54**
32.00	2.35	0.000	29.00	2.35
36.00	2.17	0.000	29.00	2.17
40.00	1.87	0.000	29.00	1.87
44.00	1.55	0.000	29.00	1.55
48.00	1.35	0.000	29.00	1.35
52.00	1.20	0.000	29.00	1.20
56.00	1.05	0.000	29.00	1.05
60.00	0.92	0.000	29.00	0.92
64.00	0.80	0.000	29.00	0.80
68.00	0.68	0.000	29.00	0.68
72.00	0.38	0.000	29.00	0.38
76.00	0.33	0.000	29.00	0.33
80.00	0.29	0.000	29.00	0.29
84.00	0.24	0.000	29.00	0.24
88.00	0.19	0.000	29.00	0.19
92.00	0.17	0.000	29.00	0.17
96.00	0.16	0.000	29.00	0.16
100.00	0.15	0.000	29.00	0.15
104.00	0.14	0.000	29.00	0.14
108.00	0.13	0.000	29.00	0.13
112.00	0.12	0.000	29.00	0.12
116.00	0.11	0.000	29.00	0.11
120.00	0.10	0.000	29.00	0.10
124.00	0.09	0.000	29.00	0.09
128.00	0.07	0.000	29.00	0.07
132.00	0.06	0.000	29.00	0.06
136.00	0.05	0.000	29.00	0.05
140.00	0.04	0.000	29.00	0.04
144.00	0.03	0.000	29.00	0.03
148.00	0.02	0.000	29.00	0.02
152.00	0.01	0.000	29.00	0.01
156.00	0.01	0.000	29.00	0.01

Stage-Discharge for Pond 6P: Post Clear Well

Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)
29.00	0.00	31.12	10.80	33.24	15.27	35.36	18.70
29.04	2.81	31.16	10.90	33.28	15.34	35.40	18.76
29.08	3.00	31.20	11.00	33.32	15.41	35.44	18.82
29.12	3.20	31.24	11.10	33.36	15.48	35.48	18.88
29.16	3.40	31.28	11.20	33.40	15.55	35.52	18.93
29.20	3.60	31.32	11.29	33.44	15.62	35.56	18.99
29.24	3.80	31.36	11.39	33.48	15.69	35.60	19.05
29.28	4.01	31.40	11.49	33.52	15.76	35.64	19.11
29.32	4.22	31.44	11.58	33.56	15.83	35.68	19.16
29.36	4.43	31.48	11.68	33.60	15.90	35.72	19.22
29.40	4.64	31.52	11.77	33.64	15.97	35.76	19.28
29.44	4.85	31.56	11.86	33.68	16.04	35.80	19.34
29.48	5.06	31.60	11.96	33.72	16.11	35.84	19.39
29.52	5.27	31.64	12.05	33.76	16.18	35.88	19.45
29.56	5.48	31.68	12.14	33.80	16.25	35.92	19.51
29.60	5.69	31.72	12.23	33.84	16.31	35.96	19.56
29.64	5.89	31.76	12.32	33.88	16.38	36.00	**19.62**
29.68	6.09	31.80	12.41	33.92	16.45		
29.72	6.29	31.84	12.50	33.96	16.51		
29.76	6.48	31.88	12.58	34.00	16.58		
29.80	6.67	31.92	12.67	34.04	16.65		
29.84	6.85	31.96	12.76	34.08	16.71		
29.88	7.01	32.00	12.84	34.12	16.78		
29.92	7.17	32.04	12.93	34.16	16.84		
29.96	7.31	32.08	13.01	34.20	16.91		
30.00	7.42	32.12	13.10	34.24	16.97		
30.04	7.56	32.16	13.18	34.28	17.04		
30.08	7.71	32.20	13.26	34.32	17.10		
30.12	7.85	32.24	13.35	34.36	17.17		
30.16	7.99	32.28	13.43	34.40	17.23		
30.20	8.12	32.32	13.51	34.44	17.29		
30.24	8.26	32.36	13.59	34.48	17.36		
30.28	8.39	32.40	13.67	34.52	17.42		
30.32	8.52	32.44	13.75	34.56	17.48		
30.36	8.65	32.48	13.83	34.60	17.55		
30.40	8.77	32.52	13.91	34.64	17.61		
30.44	8.90	32.56	13.99	34.68	17.67		
30.48	9.02	32.60	14.07	34.72	17.73		
30.52	9.14	32.64	14.15	34.76	17.80		
30.56	9.26	32.68	14.22	34.80	17.86		
30.60	9.38	32.72	14.30	34.84	17.92		
30.64	9.50	32.76	14.38	34.88	17.98		
30.68	9.61	32.80	14.45	34.92	18.04		
30.72	9.72	32.84	14.53	34.96	18.10		
30.76	9.84	32.88	14.61	35.00	18.16		
30.80	9.95	32.92	14.68	35.04	18.22		
30.84	10.06	32.96	14.76	35.08	18.28		
30.88	10.17	33.00	14.83	35.12	18.34		
30.92	10.27	33.04	14.90	35.16	18.40		
30.96	10.38	33.08	14.98	35.20	18.46		
31.00	10.49	33.12	15.05	35.24	18.52		
31.04	10.59	33.16	15.12	35.28	18.58		
31.08	10.69	33.20	15.20	35.32	18.64		

Stage-Area-Storage for Pond 6P: Post Clear Well

Elevation (feet)	Storage (acre-feet)	Elevation (feet)	Storage (acre-feet)
29.00	0.000	34.30	0.331
29.10	0.003	34.40	0.342
29.20	0.006	34.50	0.353
29.30	0.008	34.60	0.365
29.40	0.011	34.70	0.377
29.50	0.014	34.80	0.388
29.60	0.017	34.90	0.400
29.70	0.021	35.00	0.412
29.80	0.024	35.10	0.425
29.90	0.028	35.20	0.438
30.00	0.031	35.30	0.452
30.10	0.035	35.40	0.465
30.20	0.039	35.50	0.478
30.30	0.043	35.60	0.492
30.40	0.047	35.70	0.506
30.50	0.051	35.80	0.521
30.60	0.056	35.90	0.535
30.70	0.060	36.00	**0.549**
30.80	0.065		
30.90	0.069		
31.00	0.074		
31.10	0.079		
31.20	0.085		
31.30	0.090		
31.40	0.096		
31.50	0.101		
31.60	0.107		
31.70	0.113		
31.80	0.120		
31.90	0.126		
32.00	0.132		
32.10	0.139		
32.20	0.146		
32.30	0.152		
32.40	0.159		
32.50	0.166		
32.60	0.174		
32.70	0.182		
32.80	0.190		
32.90	0.198		
33.00	0.206		
33.10	0.215		
33.20	0.224		
33.30	0.232		
33.40	0.241		
33.50	0.250		
33.60	0.260		
33.70	0.269		
33.80	0.279		
33.90	0.288		
34.00	0.298		
34.10	0.309		
34.20	0.320		

Summary for Pond 12P: Sediment Forebay

Inflow	=	29.25 cfs @	8.04 hrs,	Volume=	10.273 af
Outflow	=	25.63 cfs @	8.14 hrs,	Volume=	9.887 af, Atten= 12%, Lag= 5.6 min
Primary	=	25.63 cfs @	8.14 hrs,	Volume=	9.887 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 34.98' @ 24.08 hrs Surf.Area= 0.000 ac Storage= 1.333 af

Plug-Flow detention time= 255.0 min calculated for 9.887 af (96% of inflow)
Center-of-Mass det. time= 227.8 min (942.7 - 714.9)

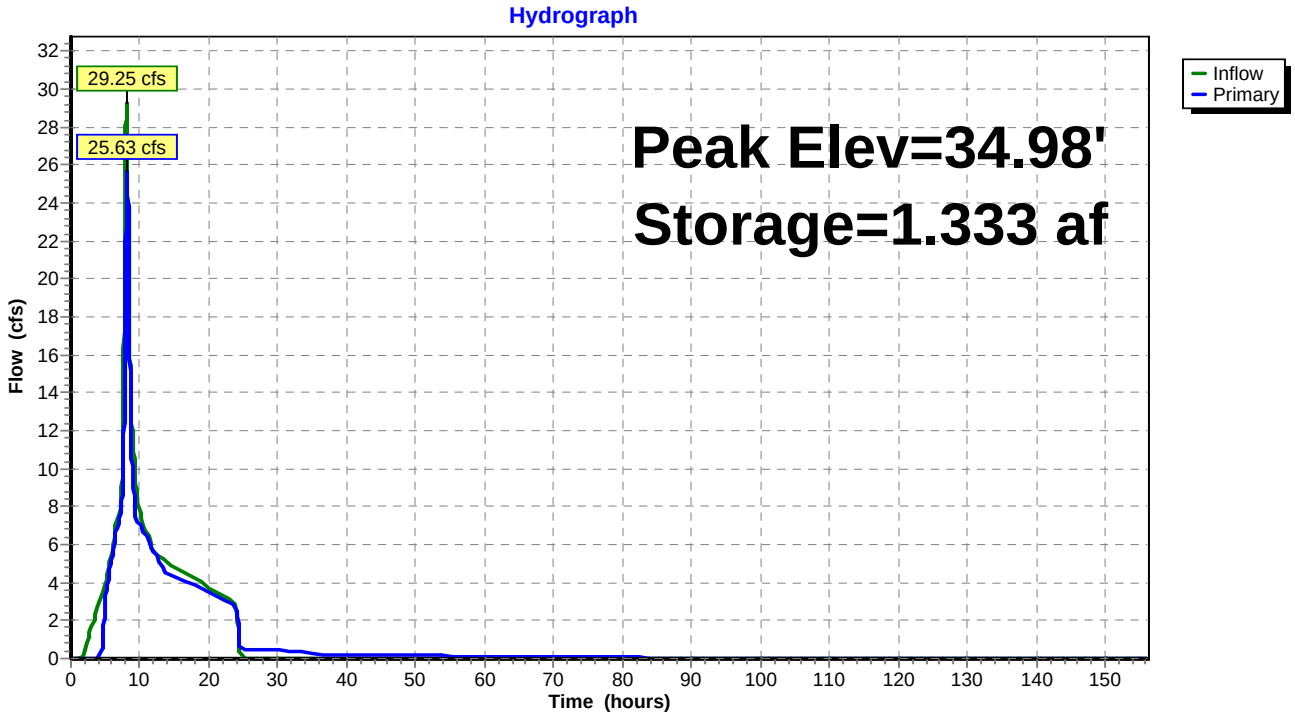
Volume	Invert	Avail.Storage	Storage Description
#1	30.00'	1.902 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
30.00	0.000
30.50	0.102
31.00	0.211
31.50	0.326
31.75	0.386
32.00	0.445
32.50	0.577
33.00	0.713
33.50	0.858
34.00	1.010
34.50	1.171
35.00	1.340
35.50	1.518
36.00	1.705
36.50	1.902

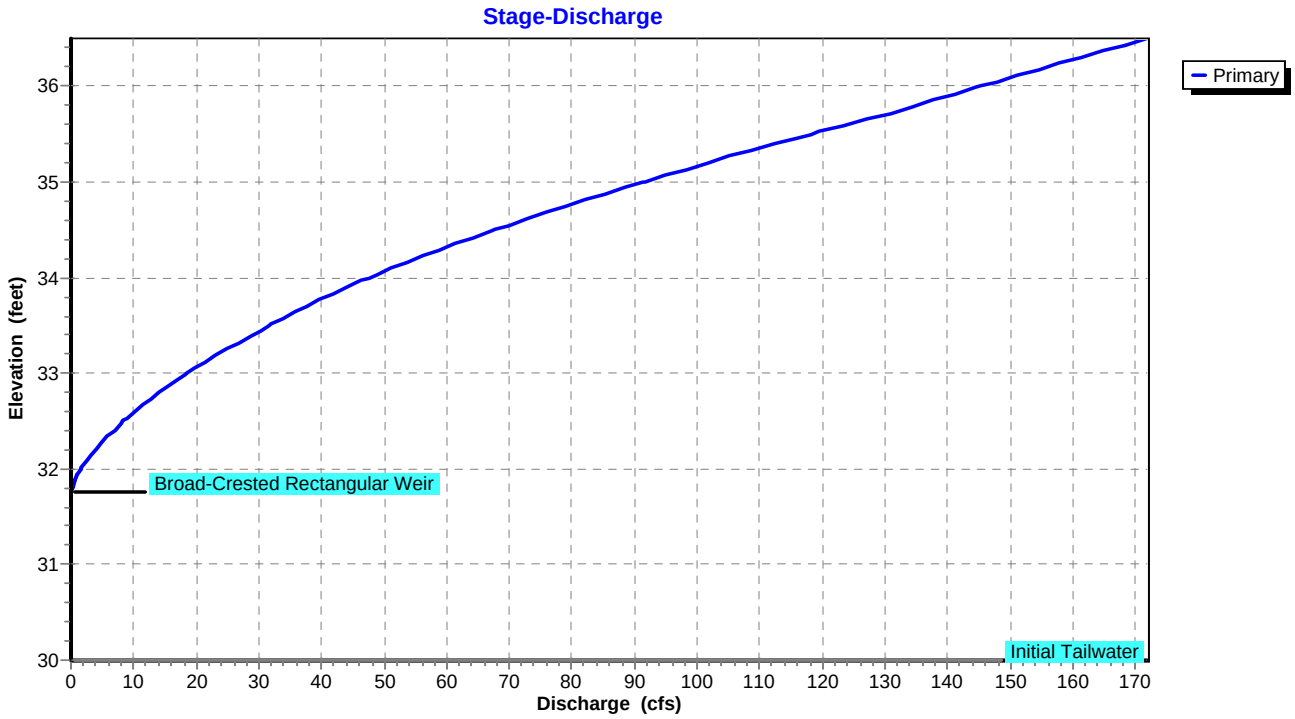
Device	Routing	Invert	Outlet Devices
#1	Primary	31.75'	**5.0' long x 2.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 Coef. (English) 2.48 2.60 2.60 2.60 2.64 2.65 2.68 2.75 2.74 2.76 2.89 3.05 3.19 3.32

Primary OutFlow Max=25.63 cfs @ 8.14 hrs HW=33.40' TW=32.47' (Dynamic Tailwater)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 25.63 cfs @ 3.10 fps)

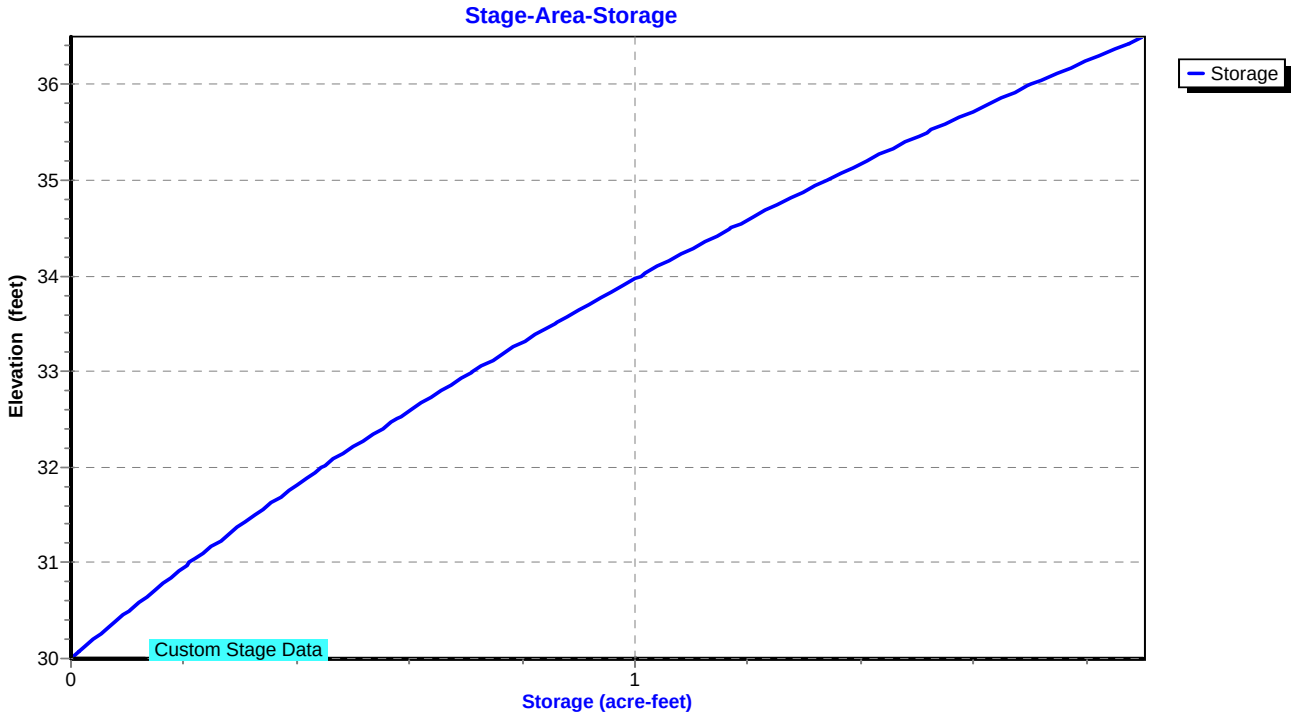
Pond 12P: Sediment Forebay



Pond 12P: Sediment Forebay



Pond 12P: Sediment Forebay



Hydrograph for Pond 12P: Sediment Forebay

Time (hours)	Inflow (cfs)	Storage (acre-feet)	Elevation (feet)	Primary (cfs)
0.00	0.00	0.000	30.00	0.00
4.00	2.79	0.273	31.27	0.00
8.00	**28.85**	0.785	33.25	**23.39**
12.00	**5.53**	1.033	34.07	**5.57**
16.00	4.61	1.163	34.47	4.17
20.00	3.74	1.279	34.82	3.49
24.00	2.86	**1.332**	**34.98**	2.79
28.00	0.00	**1.188**	**34.55**	0.45
32.00	0.00	1.049	34.12	0.40
36.00	0.00	0.942	33.78	0.16
40.00	0.00	0.879	33.57	0.21
44.00	0.00	0.809	33.33	0.21
48.00	0.00	0.743	33.10	0.19
52.00	0.00	0.688	32.91	0.15
56.00	0.00	0.640	32.73	0.13
60.00	0.00	0.599	32.58	0.11
64.00	0.00	0.566	32.46	0.09
68.00	0.00	0.537	32.35	0.08
72.00	0.00	0.511	32.25	0.07
76.00	0.00	0.488	32.16	0.07
80.00	0.00	0.468	32.09	0.05
84.00	0.00	0.452	32.03	0.04
88.00	0.00	0.439	31.98	0.04
92.00	0.00	0.428	31.93	0.03
96.00	0.00	0.417	31.88	0.03
100.00	0.00	0.407	31.84	0.03
104.00	0.00	0.398	31.80	0.03
108.00	0.00	0.390	31.77	0.02
112.00	0.00	0.387	31.75	0.00
116.00	0.00	0.386	31.75	0.00
120.00	0.00	0.386	31.75	0.00
124.00	0.00	0.386	31.75	0.00
128.00	0.00	0.386	31.75	0.00
132.00	0.00	0.386	31.75	0.00
136.00	0.00	0.386	31.75	0.00
140.00	0.00	0.386	31.75	0.00
144.00	0.00	0.386	31.75	0.00
148.00	0.00	0.386	31.75	0.00
152.00	0.00	0.386	31.75	0.00
156.00	0.00	0.386	31.75	0.00

Stage-Discharge for Pond 12P: Sediment Forebay

Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)
30.00	0.00	32.12	2.91	34.24	56.73	36.36	164.31
30.04	0.00	32.16	3.41	34.28	58.34	36.40	166.45
30.08	0.00	32.20	3.92	34.32	60.00	36.44	168.60
30.12	0.00	32.24	4.46	34.36	61.67	36.48	**170.77**
30.16	0.00	32.28	5.02	34.40	63.37		
30.20	0.00	32.32	5.59	34.44	65.09		
30.24	0.00	32.36	6.19	34.48	66.84		
30.28	0.00	32.40	6.81	34.52	68.61		
30.32	0.00	32.44	7.45	34.56	70.40		
30.36	0.00	32.48	8.11	34.60	72.22		
30.40	0.00	32.52	8.78	34.64	74.06		
30.44	0.00	32.56	9.48	34.68	75.92		
30.48	0.00	32.60	10.23	34.72	77.81		
30.52	0.00	32.64	10.99	34.76	79.71		
30.56	0.00	32.68	11.78	34.80	81.60		
30.60	0.00	32.72	12.58	34.84	83.52		
30.64	0.00	32.76	13.40	34.88	85.46		
30.68	0.00	32.80	14.22	34.92	87.41		
30.72	0.00	32.84	15.05	34.96	89.40		
30.76	0.00	32.88	15.89	35.00	91.40		
30.80	0.00	32.92	16.76	35.04	93.43		
30.84	0.00	32.96	17.65	35.08	95.48		
30.88	0.00	33.00	18.57	35.12	97.55		
30.92	0.00	33.04	19.51	35.16	99.64		
30.96	0.00	33.08	20.47	35.20	101.76		
31.00	0.00	33.12	21.45	35.24	103.90		
31.04	0.00	33.16	22.46	35.28	106.04		
31.08	0.00	33.20	23.55	35.32	108.20		
31.12	0.00	33.24	24.66	35.36	110.38		
31.16	0.00	33.28	25.79	35.40	112.58		
31.20	0.00	33.32	26.95	35.44	114.81		
31.24	0.00	33.36	28.08	35.48	117.05		
31.28	0.00	33.40	29.12	35.52	119.32		
31.32	0.00	33.44	30.16	35.56	121.61		
31.36	0.00	33.48	31.21	35.60	123.93		
31.40	0.00	33.52	32.28	35.64	126.26		
31.44	0.00	33.56	33.37	35.68	128.62		
31.48	0.00	33.60	34.54	35.72	131.00		
31.52	0.00	33.64	35.71	35.76	133.30		
31.56	0.00	33.68	36.91	35.80	135.30		
31.60	0.00	33.72	38.12	35.84	137.31		
31.64	0.00	33.76	39.36	35.88	139.33		
31.68	0.00	33.80	40.70	35.92	141.36		
31.72	0.00	33.84	42.05	35.96	143.39		
31.76	0.01	33.88	43.42	36.00	145.44		
31.80	0.14	33.92	44.82	36.04	147.50		
31.84	0.33	33.96	46.24	36.08	149.57		
31.88	0.58	34.00	47.67	36.12	151.65		
31.92	0.87	34.04	49.13	36.16	153.73		
31.96	1.20	34.08	50.61	36.20	155.83		
32.00	1.57	34.12	52.11	36.24	157.93		
32.04	1.98	34.16	53.62	36.28	160.05		
32.08	2.42	34.20	55.16	36.32	162.17		

Stage-Area-Storage for Pond 12P: Sediment Forebay

Elevation (feet)	Storage (acre-feet)
30.00	0.000
30.10	0.020
30.20	0.041
30.30	0.061
30.40	0.082
30.50	0.102
30.60	0.124
30.70	0.146
30.80	0.167
30.90	0.189
31.00	0.211
31.10	0.234
31.20	0.257
31.30	0.280
31.40	0.303
31.50	0.326
31.60	0.350
31.70	0.374
31.80	0.398
31.90	0.421
32.00	0.445
32.10	0.471
32.20	0.498
32.30	0.524
32.40	0.551
32.50	0.577
32.60	0.604
32.70	0.631
32.80	0.659
32.90	0.686
33.00	0.713
33.10	0.742
33.20	0.771
33.30	0.800
33.40	0.829
33.50	0.858
33.60	0.888
33.70	0.919
33.80	0.949
33.90	0.980
34.00	1.010
34.10	1.042
34.20	1.074
34.30	1.107
34.40	1.139
34.50	1.171
34.60	1.205
34.70	1.239
34.80	1.272
34.90	1.306
35.00	1.340
35.10	1.376
35.20	1.411
35.30	1.447
35.40	1.482
35.50	1.518
35.60	1.555
35.70	1.593
35.80	1.630
35.90	1.668
36.00	1.705
36.10	1.744
36.20	1.784
36.30	1.823
36.40	1.863
36.50	**1.902**

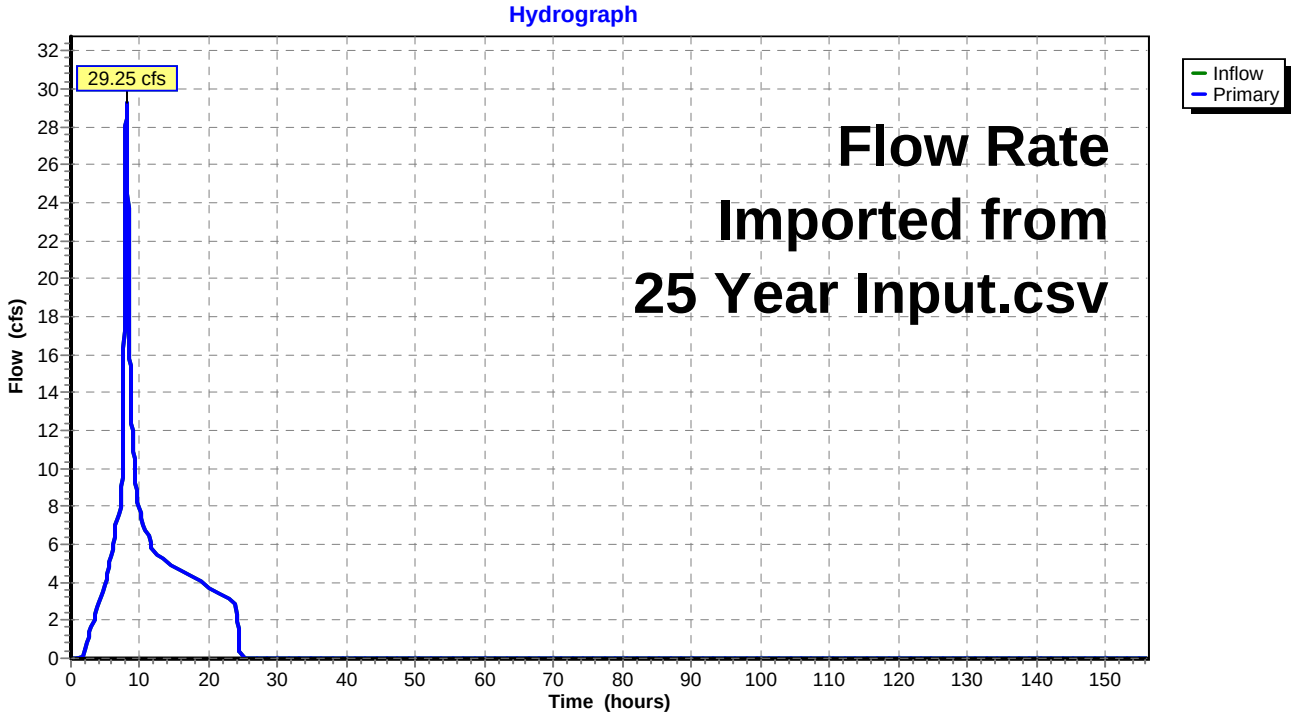
Summary for Link 1L: Input Hydrograhp

Inflow	=	29.25 cfs @	8.04 hrs,	Volume=	10.273 af
Primary	=	29.25 cfs @	8.04 hrs,	Volume=	10.273 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs

Flow Rate Imported from 25 Year Input.csv

Link 1L: Input Hydrograhp



Hydrograph for Link 1L: Input Hydrograhp

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**0.00**	0.00
2.00	0.40	0.00	0.40
4.00	2.79	0.00	2.79
6.00	5.70	0.00	5.70
8.00	**28.85**	0.00	**28.85**
10.00	**7.70**	0.00	**7.70**
12.00	5.53	0.00	5.53
14.00	4.97	0.00	4.97
16.00	4.61	0.00	4.61
18.00	4.18	0.00	4.18
20.00	3.74	0.00	3.74
22.00	3.31	0.00	3.31
24.00	2.86	0.00	2.86
26.00	0.00	0.00	0.00
28.00	0.00	0.00	0.00
30.00	0.00	0.00	0.00
32.00	0.00	0.00	0.00
34.00	0.00	0.00	0.00
36.00	0.00	0.00	0.00
38.00	0.00	0.00	0.00
40.00	0.00	0.00	0.00
42.00	0.00	0.00	0.00
44.00	0.00	0.00	0.00
46.00	0.00	0.00	0.00
48.00	0.00	0.00	0.00
50.00	0.00	0.00	0.00
52.00	0.00	0.00	0.00
54.00	0.00	0.00	0.00
56.00	0.00	0.00	0.00
58.00	0.00	0.00	0.00
60.00	0.00	0.00	0.00
62.00	0.00	0.00	0.00
64.00	0.00	0.00	0.00
66.00	0.00	0.00	0.00
68.00	0.00	0.00	0.00
70.00	0.00	0.00	0.00
72.00	0.00	0.00	0.00
74.00	0.00	0.00	0.00
76.00	0.00	0.00	0.00
78.00	0.00	0.00	0.00
80.00	0.00	0.00	0.00
82.00	0.00	0.00	0.00
84.00	0.00	0.00	0.00
86.00	0.00	0.00	0.00
88.00	0.00	0.00	0.00
90.00	0.00	0.00	0.00
92.00	0.00	0.00	0.00
94.00	0.00	0.00	0.00
96.00	0.00	0.00	0.00
98.00	0.00	0.00	0.00
100.00	0.00	0.00	0.00
102.00	0.00	0.00	0.00
104.00	0.00	0.00	0.00
106.00	0.00	0.00	0.00
108.00	0.00	0.00	0.00
110.00	0.00	0.00	0.00
112.00	0.00	0.00	0.00
114.00	0.00	0.00	0.00
116.00	0.00	0.00	0.00
118.00	0.00	0.00	0.00
120.00	0.00	0.00	0.00
122.00	0.00	0.00	0.00
124.00	0.00	0.00	0.00
126.00	0.00	0.00	0.00
128.00	0.00	0.00	0.00
130.00	0.00	0.00	0.00
132.00	0.00	0.00	0.00
134.00	0.00	0.00	0.00
136.00	0.00	0.00	0.00
138.00	0.00	0.00	0.00
140.00	0.00	0.00	0.00
142.00	0.00	0.00	0.00
144.00	0.00	0.00	0.00
146.00	0.00	0.00	0.00
148.00	0.00	0.00	0.00
150.00	0.00	0.00	0.00
152.00	0.00	0.00	0.00
154.00	0.00	0.00	0.00
156.00	0.00	0.00	0.00

Summary for Link 4L: Lag Thru Filter

Storage in sand filter modeled here as lag time from sand filter outlet to clear well outlet on downstream side of sand filter.

Lagtime estimate at conductivity of 1.75 inches/hour, with a hydraulic gradient of {[(31.00-28)/2]+1.5}*/(1.5)** thru 18 inches of sand.

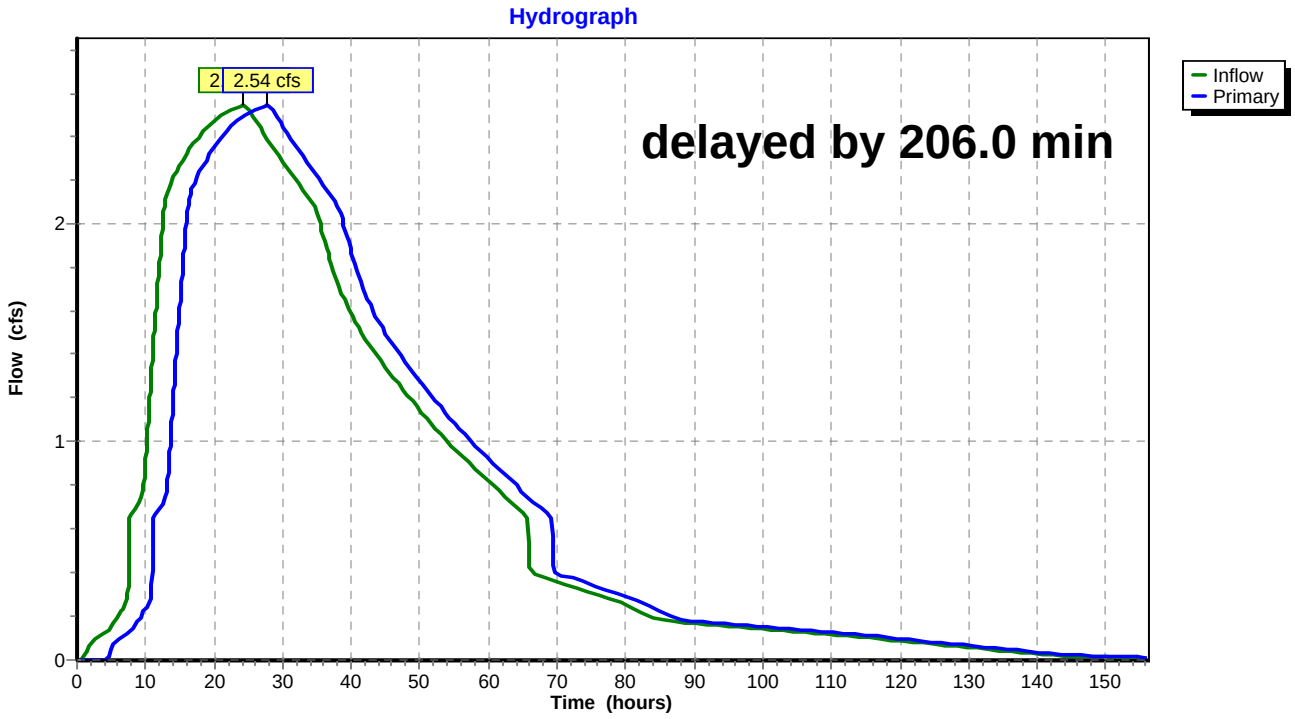
Result is 206 minutes

* "Average" Head on Sand Filter.
** Depth of Sand Filter

Inflow	=	2.54 cfs @	24.16 hrs,	Volume=	8.883 af
Primary	=	2.54 cfs @	27.59 hrs,	Volume=	8.881 af, Atten= 0%, Lag= 206.0 min

Primary outflow = Inflow delayed by 206.0 min, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs

Link 4L: Lag Thru Filter



Hydrograph for Link 4L: Lag Thru Filter

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**0.00**	0.00
2.00	0.08	0.00	0.00
4.00	0.13	0.00	0.00
6.00	0.20	0.00	0.10
8.00	0.67	0.00	0.14
10.00	0.92	0.00	0.24
12.00	1.81	0.00	0.69
14.00	2.21	0.00	1.18
16.00	2.32	0.00	2.02
18.00	2.41	0.00	2.24
20.00	2.47	0.00	2.35
22.00	2.52	0.00	2.43
24.00	**2.54**	0.00	2.49
26.00	**2.47**	0.00	**2.53**
28.00	2.38	0.00	**2.54**
30.00	2.28	0.00	2.44
32.00	2.19	0.00	2.35
34.00	2.11	0.00	2.26
36.00	1.93	0.00	2.17
38.00	1.73	0.00	2.08
40.00	1.58	0.00	1.87
42.00	1.47	0.00	1.68
44.00	1.38	0.00	1.55
46.00	1.30	0.00	1.44
48.00	1.22	0.00	1.35
50.00	1.14	0.00	1.28
52.00	1.07	0.00	1.20
54.00	1.00	0.00	1.12
56.00	0.94	0.00	1.05
58.00	0.88	0.00	0.98
60.00	0.82	0.00	0.92
62.00	0.76	0.00	0.86
64.00	0.70	0.00	0.80
66.00	0.42	0.00	0.74
68.00	0.38	0.00	0.68
70.00	0.36	0.00	0.40
72.00	0.34	0.00	0.38
74.00	0.32	0.00	0.36
76.00	0.30	0.00	0.33
78.00	0.28	0.00	0.31
80.00	0.25	0.00	0.29
82.00	0.22	0.00	0.27
84.00	0.19	0.00	0.24
86.00	0.18	0.00	0.21
88.00	0.17	0.00	0.19
90.00	0.17	0.00	0.18
92.00	0.16	0.00	0.17
94.00	0.16	0.00	0.17
96.00	0.15	0.00	0.16
98.00	0.15	0.00	0.16
100.00	0.14	0.00	0.15
102.00	0.14	0.00	0.15
104.00	0.13	0.00	0.14
106.00	0.13	0.00	0.14
108.00	0.12	0.00	0.13
110.00	0.12	0.00	0.13
112.00	0.11	0.00	0.12
114.00	0.11	0.00	0.12
116.00	0.10	0.00	0.11
118.00	0.09	0.00	0.10
120.00	0.09	0.00	0.10
122.00	0.08	0.00	0.09
124.00	0.07	0.00	0.09
126.00	0.07	0.00	0.08
128.00	0.06	0.00	0.07
130.00	0.06	0.00	0.07
132.00	0.05	0.00	0.06
134.00	0.04	0.00	0.05
136.00	0.04	0.00	0.05
138.00	0.03	0.00	0.04
140.00	0.03	0.00	0.04
142.00	0.02	0.00	0.03
144.00	0.02	0.00	0.03
146.00	0.02	0.00	0.02
148.00	0.01	0.00	0.02
150.00	0.01	0.00	0.02
152.00	0.01	0.00	0.01
154.00	0.01	0.00	0.01
156.00	0.01	0.00	0.01

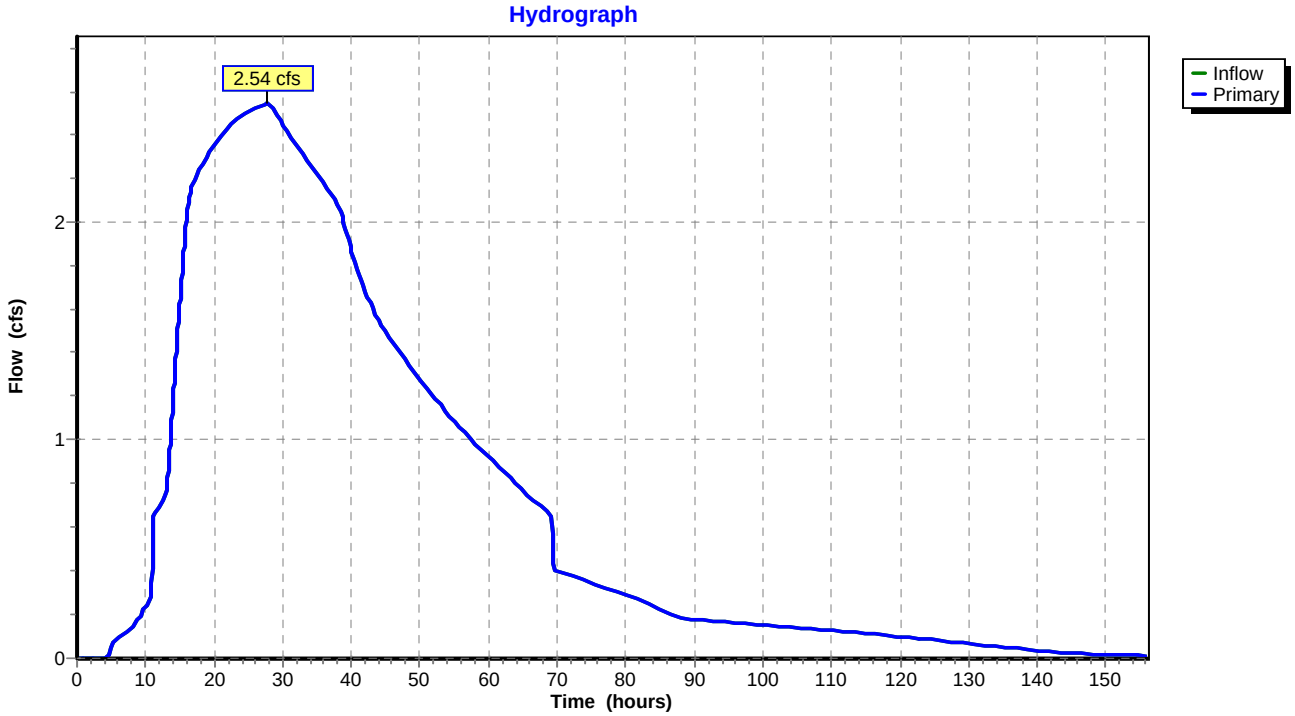
Summary for Link 9L: Discharge Elevation

Inflow	=	2.54 cfs @	27.59 hrs,	Volume=	8.880 af
Primary	=	2.54 cfs @	27.59 hrs,	Volume=	8.880 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs

Fixed water surface Elevation= 27.70'

Link 9L: Discharge Elevation



Hydrograph for Link 9L: Discharge Elevation

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**27.70**	0.00
2.00	0.00	27.70	0.00
4.00	0.00	27.70	0.00
6.00	0.10	27.70	0.10
8.00	0.14	27.70	0.14
10.00	0.24	27.70	0.24
12.00	0.69	27.70	0.69
14.00	1.18	27.70	1.18
16.00	2.02	27.70	2.02
18.00	2.24	27.70	2.24
20.00	2.35	27.70	2.35
22.00	2.43	27.70	2.43
24.00	2.48	27.70	2.48
26.00	**2.52**	27.70	**2.52**
28.00	**2.54**	27.70	**2.54**
30.00	2.44	27.70	2.44
32.00	2.35	27.70	2.35
34.00	2.26	27.70	2.26
36.00	2.17	27.70	2.17
38.00	2.08	27.70	2.08
40.00	1.87	27.70	1.87
42.00	1.68	27.70	1.68
44.00	1.55	27.70	1.55
46.00	1.44	27.70	1.44
48.00	1.35	27.70	1.35
50.00	1.28	27.70	1.28
52.00	1.20	27.70	1.20
54.00	1.12	27.70	1.12
56.00	1.05	27.70	1.05
58.00	0.98	27.70	0.98
60.00	0.92	27.70	0.92
62.00	0.86	27.70	0.86
64.00	0.80	27.70	0.80
66.00	0.74	27.70	0.74
68.00	0.68	27.70	0.68
70.00	0.40	27.70	0.40
72.00	0.38	27.70	0.38
74.00	0.36	27.70	0.36
76.00	0.33	27.70	0.33
78.00	0.31	27.70	0.31
80.00	0.29	27.70	0.29
82.00	0.27	27.70	0.27
84.00	0.24	27.70	0.24
86.00	0.21	27.70	0.21
88.00	0.19	27.70	0.19
90.00	0.18	27.70	0.18
92.00	0.17	27.70	0.17
94.00	0.17	27.70	0.17
96.00	0.16	27.70	0.16
98.00	0.16	27.70	0.16
100.00	0.15	27.70	0.15
102.00	0.15	27.70	0.15
104.00	0.14	27.70	0.14
106.00	0.14	27.70	0.14
108.00	0.13	27.70	0.13
110.00	0.13	27.70	0.13
112.00	0.12	27.70	0.12
114.00	0.12	27.70	0.12
116.00	0.11	27.70	0.11
118.00	0.10	27.70	0.10
120.00	0.10	27.70	0.10
122.00	0.09	27.70	0.09
124.00	0.09	27.70	0.09
126.00	0.08	27.70	0.08
128.00	0.07	27.70	0.07
130.00	0.07	27.70	0.07
132.00	0.06	27.70	0.06
134.00	0.05	27.70	0.05
136.00	0.05	27.70	0.05
138.00	0.04	27.70	0.04
140.00	0.04	27.70	0.04
142.00	0.03	27.70	0.03
144.00	0.03	27.70	0.03
146.00	0.02	27.70	0.02
148.00	0.02	27.70	0.02
150.00	0.02	27.70	0.02
152.00	0.01	27.70	0.01
154.00	0.01	27.70	0.01
156.00	0.01	27.70	0.01

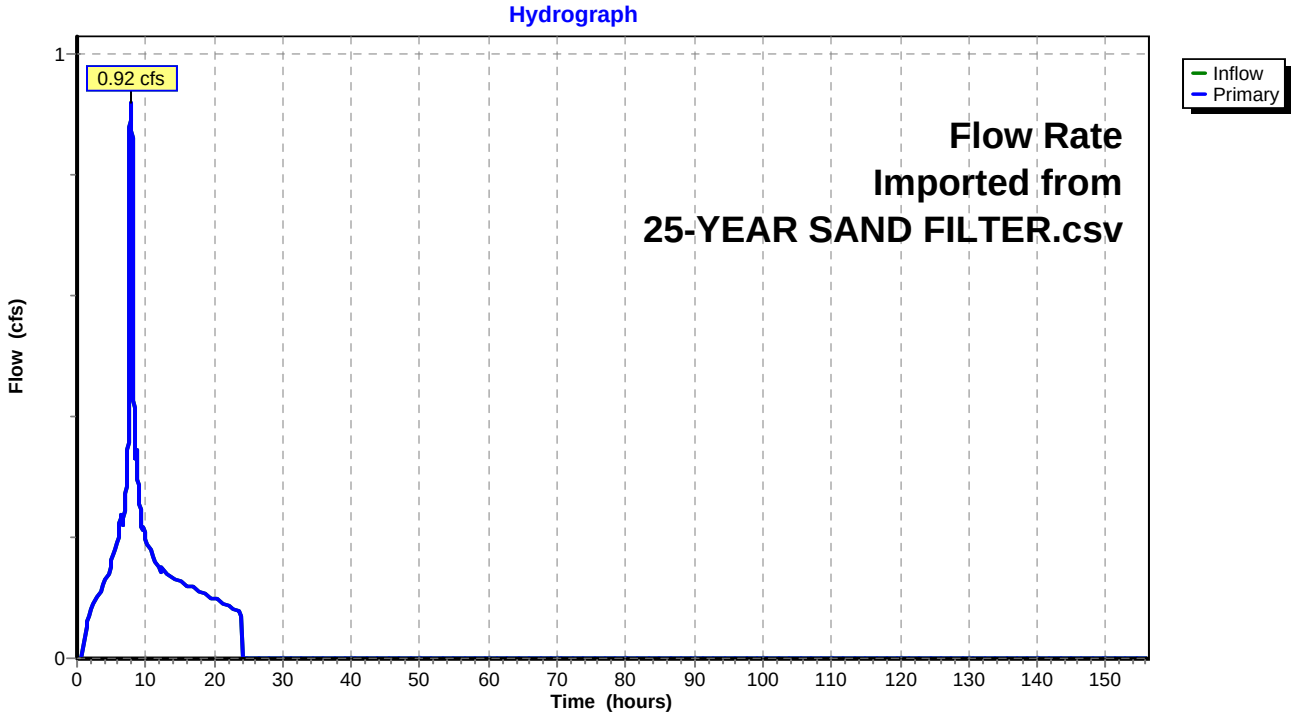
Summary for Link 10L: Sand Filter Input

Inflow	=	0.92 cfs @	7.82 hrs,	Volume=	0.302 af
Primary	=	0.92 cfs @	7.82 hrs,	Volume=	0.302 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs

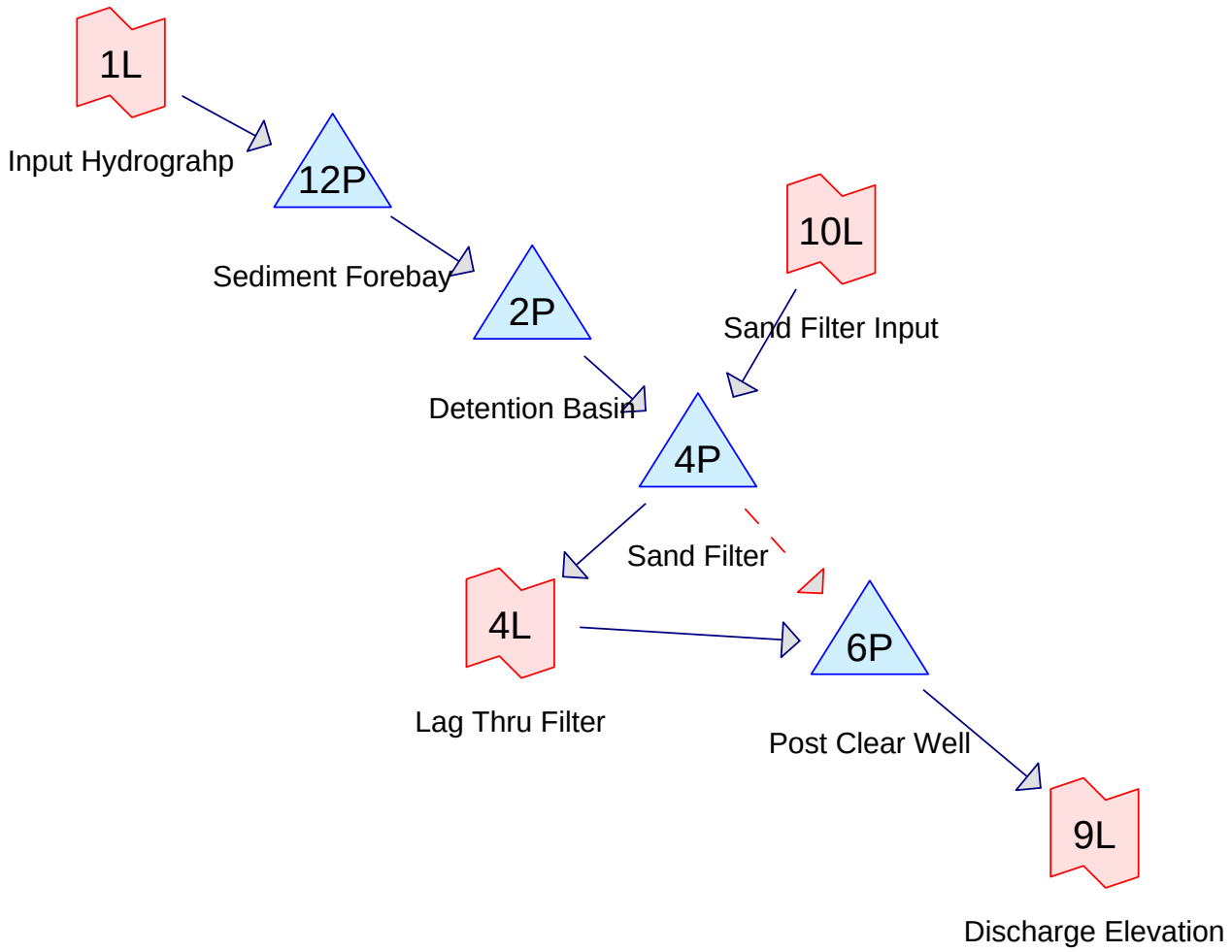
Flow Rate Imported from 25-YEAR SAND FILTER.csv

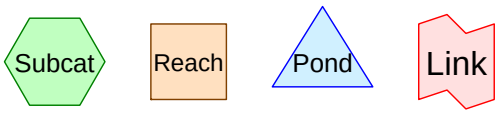
Link 10L: Sand Filter Input



Hydrograph for Link 10L: Sand Filter Input

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**0.00**	0.00
2.00	0.08	0.00	0.08
4.00	0.13	0.00	0.13
6.00	**0.20**	0.00	**0.20**
8.00	**0.87**	0.00	**0.87**
10.00	0.20	0.00	0.20
12.00	0.15	0.00	0.15
14.00	0.13	0.00	0.13
16.00	0.12	0.00	0.12
18.00	0.11	0.00	0.11
20.00	0.10	0.00	0.10
22.00	0.09	0.00	0.09
24.00	0.07	0.00	0.07
26.00	0.00	0.00	0.00
28.00	0.00	0.00	0.00
30.00	0.00	0.00	0.00
32.00	0.00	0.00	0.00
34.00	0.00	0.00	0.00
36.00	0.00	0.00	0.00
38.00	0.00	0.00	0.00
40.00	0.00	0.00	0.00
42.00	0.00	0.00	0.00
44.00	0.00	0.00	0.00
46.00	0.00	0.00	0.00
48.00	0.00	0.00	0.00
50.00	0.00	0.00	0.00
52.00	0.00	0.00	0.00
54.00	0.00	0.00	0.00
56.00	0.00	0.00	0.00
58.00	0.00	0.00	0.00
60.00	0.00	0.00	0.00
62.00	0.00	0.00	0.00
64.00	0.00	0.00	0.00
66.00	0.00	0.00	0.00
68.00	0.00	0.00	0.00
70.00	0.00	0.00	0.00
72.00	0.00	0.00	0.00
74.00	0.00	0.00	0.00
76.00	0.00	0.00	0.00
78.00	0.00	0.00	0.00
80.00	0.00	0.00	0.00
82.00	0.00	0.00	0.00
84.00	0.00	0.00	0.00
86.00	0.00	0.00	0.00
88.00	0.00	0.00	0.00
90.00	0.00	0.00	0.00
92.00	0.00	0.00	0.00
94.00	0.00	0.00	0.00
96.00	0.00	0.00	0.00
98.00	0.00	0.00	0.00
100.00	0.00	0.00	0.00
102.00	0.00	0.00	0.00
104.00	0.00	0.00	0.00
106.00	0.00	0.00	0.00
108.00	0.00	0.00	0.00
110.00	0.00	0.00	0.00
112.00	0.00	0.00	0.00
114.00	0.00	0.00	0.00
116.00	0.00	0.00	0.00
118.00	0.00	0.00	0.00
120.00	0.00	0.00	0.00
122.00	0.00	0.00	0.00
124.00	0.00	0.00	0.00
126.00	0.00	0.00	0.00
128.00	0.00	0.00	0.00
130.00	0.00	0.00	0.00
132.00	0.00	0.00	0.00
134.00	0.00	0.00	0.00
136.00	0.00	0.00	0.00
138.00	0.00	0.00	0.00
140.00	0.00	0.00	0.00
142.00	0.00	0.00	0.00
144.00	0.00	0.00	0.00
146.00	0.00	0.00	0.00
148.00	0.00	0.00	0.00
150.00	0.00	0.00	0.00
152.00	0.00	0.00	0.00
154.00	0.00	0.00	0.00
156.00	0.00	0.00	0.00





Drainage Diagram for 100-Year Model
Prepared by Integral Consulting Inc., Printed 9/28/2011
HydroCAD® 9.10 s/n 06683 © 2010 HydroCAD Software Solutions LLC

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Fill (inches)
1	2P	31.00	29.45	310.0	0.0050	0.013	24.0	0.0	0.0
2	4P	28.76	28.00	152.0	0.0050	0.011	4.0	0.0	0.0
3	6P	28.00	27.22	156.0	0.0050	0.013	24.0	0.0	0.0

Time span=0.00-156.00 hrs, dt=0.02 hrs, 7801 points x 3
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Pond 2P: Detention Basin Peak Elev=35.47' Storage=5.339 af Inflow=28.75 cfs 11.472 af
Outflow=7.34 cfs 10.164 af

Pond 4P: Sand Filter Peak Elev=35.27' Storage=1.753 af Inflow=7.56 cfs 10.507 af
Primary=2.71 cfs 10.077 af Secondary=1.14 cfs 0.430 af Outflow=3.86 cfs 10.507 af

Pond 6P: Post Clear Well Peak Elev=29.25' Storage=0.007 af Inflow=3.83 cfs 10.503 af
24.0" Round Culvert n=0.013 L=156.0' S=0.0050 '/' Outflow=3.83 cfs 10.503 af

Pond 12P: Sediment Forebay Peak Elev=35.47' Storage=1.508 af Inflow=33.77 cfs 11.858 af
Outflow=28.75 cfs 11.472 af

Link 1L: Input Hydrograhp Flow Rate Imported from 100 Year Input.csv Inflow=33.77 cfs 11.858 af
Primary=33.77 cfs 11.858 af

Link 4L: Lag Thru Filter delayed by 206.0 min Inflow=2.71 cfs 10.077 af
Primary=2.71 cfs 10.073 af

Link 9L: Discharge Elevation Inflow=3.83 cfs 10.503 af
Primary=3.83 cfs 10.503 af

Link 10L: Sand Filter Input Flow Rate Imported from 100-YEAR SAND FILTER.csv Inflow=1.04 cfs 0.343 af
Primary=1.04 cfs 0.343 af

Summary for Pond 2P: Detention Basin

Inflow	=	28.75 cfs @	8.13 hrs,	Volume=	11.472 af
Outflow	=	7.34 cfs @	10.19 hrs,	Volume=	10.164 af, Atten= 74%, Lag= 123.8 min
Primary	=	7.34 cfs @	10.19 hrs,	Volume=	10.164 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 35.47' @ 21.99 hrs Surf.Area= 0.000 ac Storage= 5.339 af

Plug-Flow detention time= 1,267.1 min calculated for 10.163 af (89% of inflow)
Center-of-Mass det. time= 1,053.6 min (1,994.2 - 940.6)

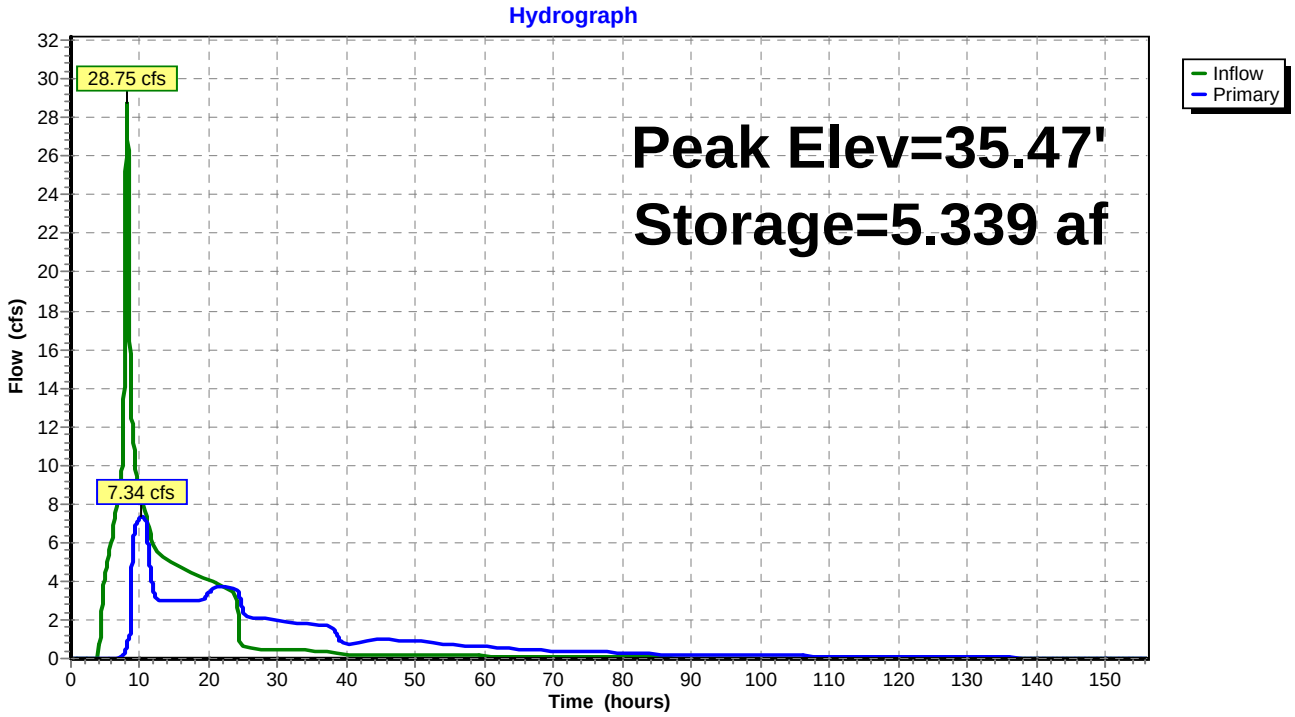
Volume	Invert	Avail.Storage	Storage Description
#1	30.00'	6.558 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
30.00	0.000
30.25	0.204
30.50	0.412
31.00	0.839
31.50	1.280
32.00	1.736
32.50	2.207
33.00	2.694
33.50	3.196
34.00	3.715
34.50	4.250
35.00	4.801
35.50	5.370
36.00	5.955
36.50	6.558

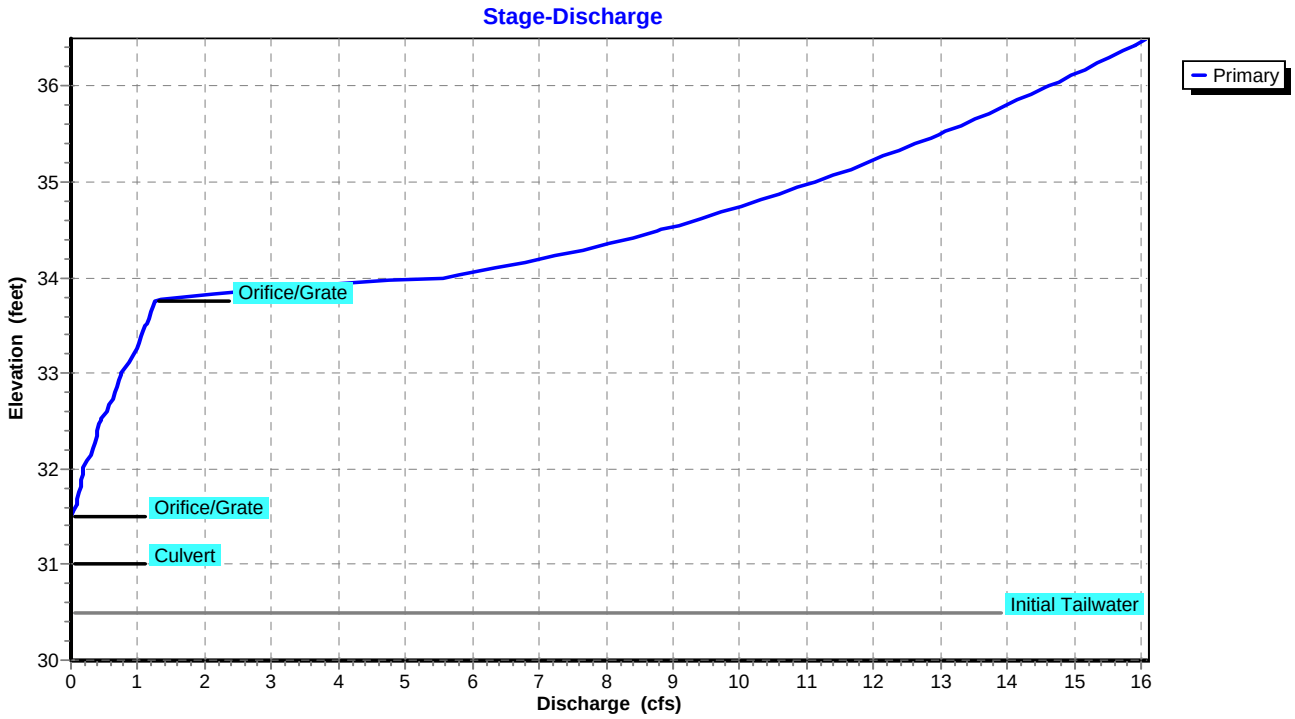
Device	Routing	Invert	Outlet Devices
#1	Device 3	31.50'	**1.0" Vert. Orifice/Grate X 10.00 columns** X 4 rows with 6.0" cc spacing C= 0.600
#2	Device 3	33.75'	**8.0" Horiz. Orifice/Grate X 5.00** C= 0.600 Limited to weir flow at low heads
#3	Primary	31.00'	**24.0" Round Culvert** L= 310.0' CPP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 31.00' / 29.45' S= 0.0050 '/' Cc= 0.500 n= 0.013

Primary OutFlow Max=7.34 cfs @ 10.19 hrs HW=34.27' TW=32.61' (Dynamic Tailwater)
└─**3=Culvert** (Passes 7.34 cfs of 10.82 cfs potential flow)
  ├─**1=Orifice/Grate** (Orifice Controls 1.30 cfs @ 5.98 fps)
  └─**2=Orifice/Grate** (Orifice Controls 6.04 cfs @ 3.46 fps)

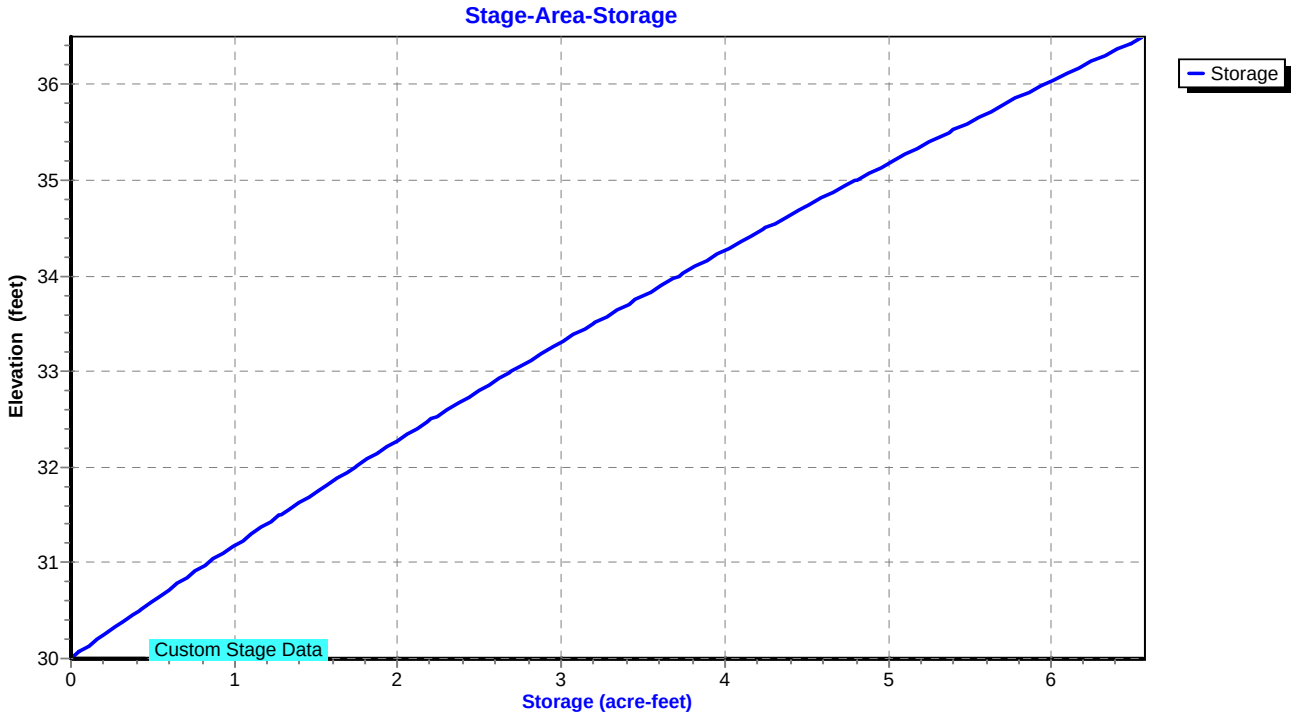
Pond 2P: Detention Basin



Pond 2P: Detention Basin



Pond 2P: Detention Basin



Hydrograph for Pond 2P: Detention Basin

Time (hours)	Inflow (cfs)	Storage (acre-feet)	Elevation (feet)	Primary (cfs)
0.00	0.00	0.000	30.00	0.00
4.00	0.00	0.000	30.00	0.00
8.00	**26.57**	2.342	32.64	**0.56**
12.00	**5.64**	4.171	34.43	**3.44**
16.00	4.70	4.862	35.05	2.98
20.00	4.06	**5.296**	**35.43**	3.43
24.00	3.32	**5.315**	**35.45**	3.58
28.00	0.48	4.771	34.97	2.05
32.00	0.44	4.273	34.52	1.89
36.00	0.40	3.815	34.09	1.73
40.00	0.16	3.470	33.76	0.69
44.00	0.21	3.252	33.55	0.95
48.00	0.21	3.009	33.31	0.93
52.00	0.18	2.782	33.09	0.82
56.00	0.15	2.590	32.89	0.70
60.00	0.13	2.420	32.72	0.61
64.00	0.11	2.275	32.57	0.50
68.00	0.09	2.160	32.45	0.42
72.00	0.08	2.057	32.34	0.38
76.00	0.07	1.965	32.24	0.34
80.00	0.06	1.883	32.16	0.29
84.00	0.05	1.813	32.08	0.25
88.00	0.04	1.758	32.02	0.19
92.00	0.04	1.711	31.97	0.17
96.00	0.03	1.667	31.92	0.16
100.00	0.03	1.626	31.88	0.15
104.00	0.03	1.587	31.84	0.14
108.00	0.03	1.551	31.80	0.13
112.00	0.02	1.516	31.76	0.12
116.00	0.00	1.481	31.72	0.11
120.00	0.00	1.446	31.68	0.10
124.00	0.00	1.416	31.65	0.09
128.00	0.00	1.390	31.62	0.07
132.00	0.00	1.368	31.60	0.06
136.00	0.00	1.349	31.58	0.05
140.00	0.00	1.335	31.56	0.04
144.00	0.00	1.325	31.55	0.03
148.00	0.00	1.318	31.54	0.02
152.00	0.00	1.313	31.54	0.01
156.00	0.00	1.308	31.53	0.01

Stage-Discharge for Pond 2P: Detention Basin

Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)
30.00	0.00	32.12	0.27	34.24	7.33	36.36	15.69
30.04	0.00	32.16	0.30	34.28	7.58	36.40	15.80
30.08	0.00	32.20	0.32	34.32	7.83	36.44	15.92
30.12	0.00	32.24	0.34	34.36	8.06	36.48	**16.03**
30.16	0.00	32.28	0.35	34.40	8.29		
30.20	0.00	32.32	0.37	34.44	8.51		
30.24	0.00	32.36	0.39	34.48	8.72		
30.28	0.00	32.40	0.40	34.52	8.93		
30.32	0.00	32.44	0.41	34.56	9.13		
30.36	0.00	32.48	0.43	34.60	9.33		
30.40	0.00	32.52	0.45	34.64	9.53		
30.44	0.00	32.56	0.49	34.68	9.72		
30.48	0.00	32.60	0.53	34.72	9.90		
30.52	0.00	32.64	0.56	34.76	10.09		
30.56	0.00	32.68	0.59	34.80	10.26		
30.60	0.00	32.72	0.61	34.84	10.44		
30.64	0.00	32.76	0.64	34.88	10.61		
30.68	0.00	32.80	0.66	34.92	10.78		
30.72	0.00	32.84	0.68	34.96	10.95		
30.76	0.00	32.88	0.70	35.00	11.11		
30.80	0.00	32.92	0.72	35.04	11.28		
30.84	0.00	32.96	0.73	35.08	11.44		
30.88	0.00	33.00	0.75	35.12	11.59		
30.92	0.00	33.04	0.79	35.16	11.75		
30.96	0.00	33.08	0.84	35.20	11.90		
31.00	0.00	33.12	0.88	35.24	12.05		
31.04	0.00	33.16	0.91	35.28	12.20		
31.08	0.00	33.20	0.94	35.32	12.35		
31.12	0.00	33.24	0.97	35.36	12.50		
31.16	0.00	33.28	0.99	35.40	12.64		
31.20	0.00	33.32	1.02	35.44	12.78		
31.24	0.00	33.36	1.04	35.48	12.92		
31.28	0.00	33.40	1.06	35.52	13.06		
31.32	0.00	33.44	1.09	35.56	13.20		
31.36	0.00	33.48	1.11	35.60	13.33		
31.40	0.00	33.52	1.13	35.64	13.47		
31.44	0.00	33.56	1.15	35.68	13.60		
31.48	0.00	33.60	1.17	35.72	13.73		
31.52	0.00	33.64	1.19	35.76	13.86		
31.56	0.04	33.68	1.21	35.80	13.99		
31.60	0.06	33.72	1.23	35.84	14.12		
31.64	0.08	33.76	1.28	35.88	14.25		
31.68	0.10	33.80	1.65	35.92	14.37		
31.72	0.11	33.84	2.21	35.96	14.50		
31.76	0.12	33.88	2.91	36.00	14.62		
31.80	0.13	33.92	3.72	36.04	14.75		
31.84	0.14	33.96	4.63	36.08	14.87		
31.88	0.15	34.00	5.56	36.12	14.99		
31.92	0.16	34.04	5.90	36.16	15.11		
31.96	0.17	34.08	6.21	36.20	15.23		
32.00	0.18	34.12	6.51	36.24	15.34		
32.04	0.20	34.16	6.80	36.28	15.46		
32.08	0.24	34.20	7.07	36.32	15.58		

Stage-Area-Storage for Pond 2P: Detention Basin

Elevation (feet)	Storage (acre-feet)
30.00	0.000
30.10	0.082
30.20	0.163
30.30	0.246
30.40	0.329
30.50	0.412
30.60	0.497
30.70	0.583
30.80	0.668
30.90	0.754
31.00	0.839
31.10	0.927
31.20	1.015
31.30	1.104
31.40	1.192
31.50	1.280
31.60	1.371
31.70	1.462
31.80	1.554
31.90	1.645
32.00	1.736
32.10	1.830
32.20	1.924
32.30	2.019
32.40	2.113
32.50	2.207
32.60	2.304
32.70	2.402
32.80	2.499
32.90	2.597
33.00	2.694
33.10	2.794
33.20	2.895
33.30	2.995
33.40	3.096
33.50	3.196
33.60	3.300
33.70	3.404
33.80	3.507
33.90	3.611
34.00	3.715
34.10	3.822
34.20	3.929
34.30	4.036
34.40	4.143
34.50	4.250
34.60	4.360
34.70	4.470
34.80	4.581
34.90	4.691
35.00	4.801
35.10	4.915
35.20	5.029
35.30	5.142
35.40	5.256
35.50	5.370
35.60	5.487
35.70	5.604
35.80	5.721
35.90	5.838
36.00	5.955
36.10	6.076
36.20	6.196
36.30	6.317
36.40	6.437
36.50	**6.558**

Summary for Pond 4P: Sand Filter

NOTE:

Influent Clear Well not modeled.

Storage in Sand Filter not modeled, flow modeled as lag.

Inflow	=	7.56 cfs @	10.16 hrs, Volume=	10.507 af	
Outflow	=	3.86 cfs @	22.04 hrs, Volume=	10.507 af,	Atten= 49%, Lag= 712.9 min
Primary	=	2.71 cfs @	22.04 hrs, Volume=	10.077 af	
Secondary	=	1.14 cfs @	22.04 hrs, Volume=	0.430 af	

Routing by Dyn-Stor-Ind method, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 35.27' @ 22.04 hrs Surf.Area= 0.367 ac Storage= 1.753 af

Plug-Flow detention time= 334.1 min calculated for 10.507 af (100% of inflow)
Center-of-Mass det. time= 334.1 min (2,284.7 - 1,950.6)

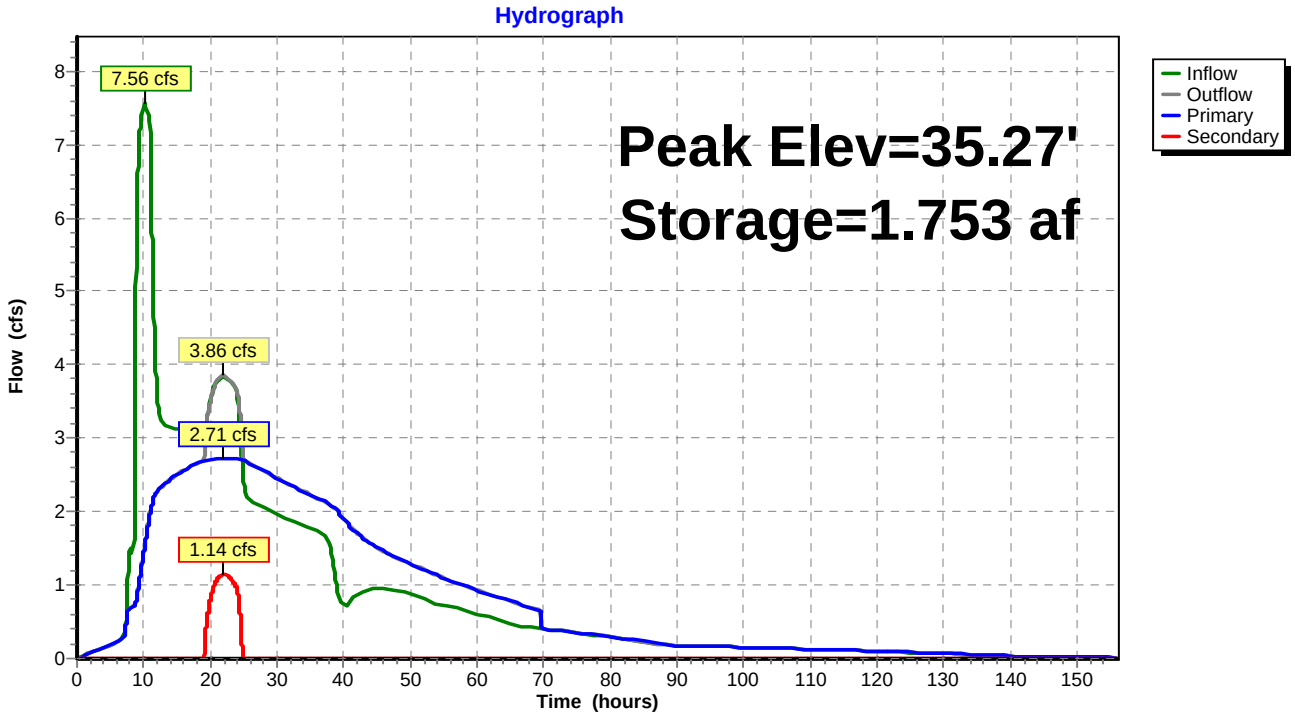
Volume	Invert	Avail.Storage	Storage Description
#1	30.50'	2.204 af	**100.00'W x 160.00'L x 6.00'H Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Secondary	35.25'	**130.0' long x 2.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 Coef. (English) 2.48 2.60 2.60 2.60 2.64 2.65 2.68 2.75 2.74 2.76 2.89 3.05 3.19 3.32
#2	Device 3	30.50'	**1.750 in/hr Exfiltration over Horizontal area** Conductivity to Groundwater Elevation = 29.00' Phase-In= 0.01'
#3	Device 4	29.00'	**0.3" Horiz. Orifice/Grate X 8.00 columns** X 150 rows C= 0.600
#4	Primary	28.76'	**4.0" Round Culvert X 8.00** L= 152.0' Ke= 0.900 Inlet / Outlet Invert= 28.76' / 28.00' S= 0.0050 '/' Cc= 0.500 n= 0.011

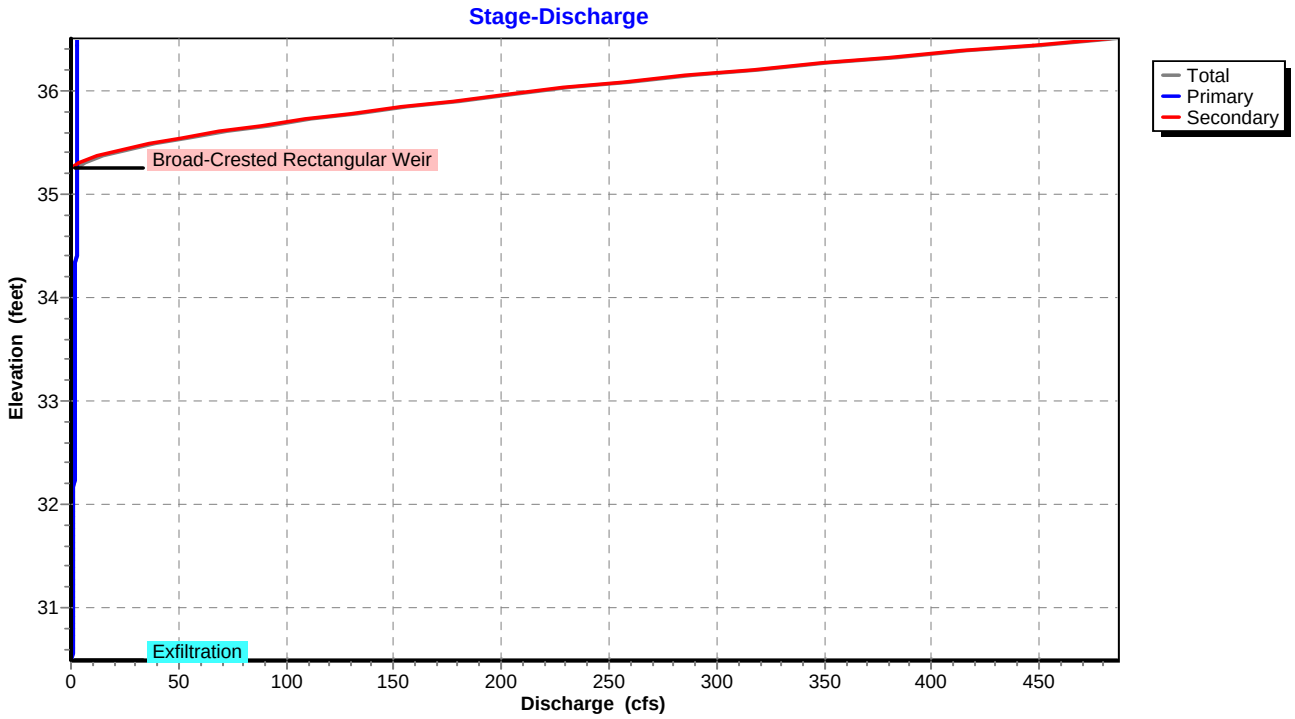
Primary OutFlow Max=2.71 cfs @ 22.04 hrs HW=35.27' TW=0.00' (Dynamic Tailwater)
└─**4=Culvert** (Passes 2.71 cfs of 3.61 cfs potential flow)
  └─**3=Orifice/Grate** (Passes 2.71 cfs of 7.10 cfs potential flow)
    └─**2=Exfiltration** (Controls 2.71 cfs)

Secondary OutFlow Max=1.14 cfs @ 22.04 hrs HW=35.27' TW=29.24' (Dynamic Tailwater)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 1.14 cfs @ 0.38 fps)

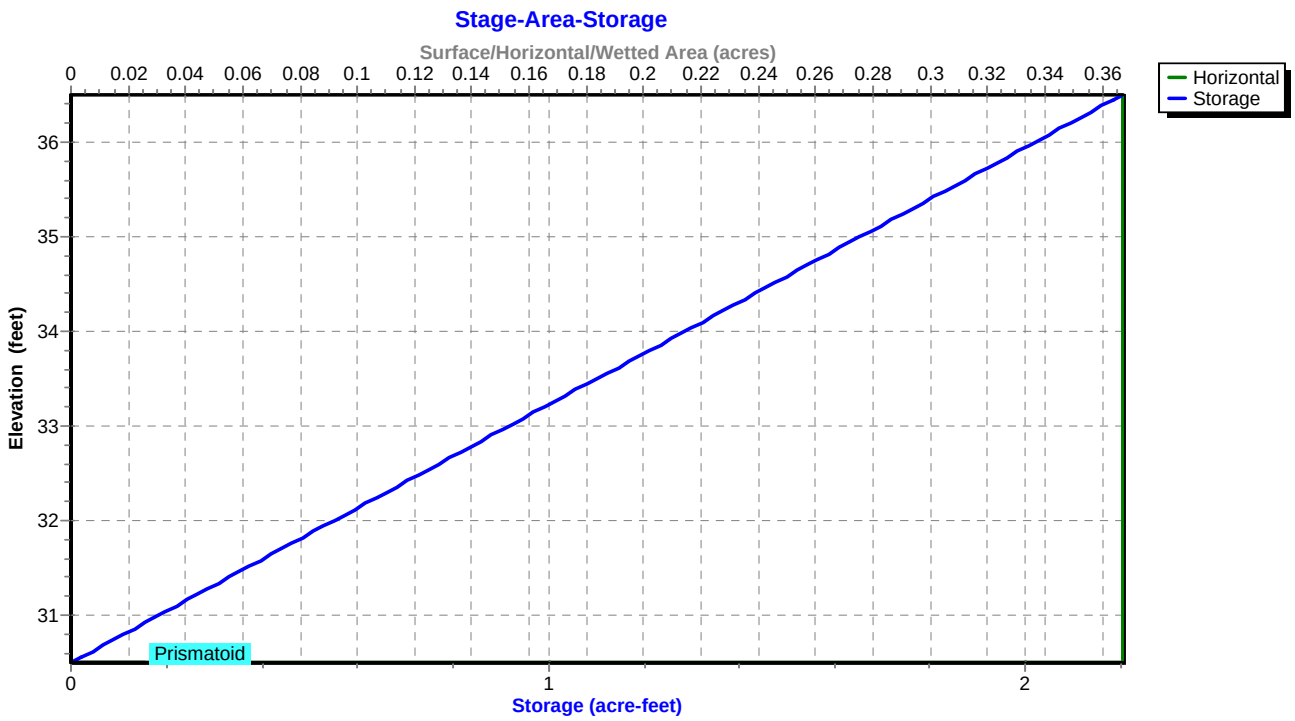
Pond 4P: Sand Filter



Pond 4P: Sand Filter



Pond 4P: Sand Filter



Hydrograph for Pond 4P: Sand Filter

Time (hours)	Inflow (cfs)	Storage (acre-feet)	Elevation (feet)	Outflow (cfs)	Primary (cfs)	Secondary (cfs)
0.00	0.00	0.000	30.50	0.00	0.00	0.00
4.00	0.15	0.001	30.50	0.15	0.15	0.00
8.00	**1.55**	0.027	30.57	0.68	0.68	0.00
12.00	**3.60**	1.381	34.26	2.27	2.27	0.00
16.00	3.12	1.626	34.93	2.56	2.56	0.00
20.00	3.54	**1.751**	**35.27**	**3.51**	**2.71**	**0.80**
24.00	3.66	**1.752**	**35.27**	**3.67**	**2.71**	**0.96**
28.00	2.05	1.621	34.91	2.56	2.56	0.00
32.00	1.89	1.458	34.47	2.36	2.36	0.00
36.00	1.73	1.304	34.05	2.18	2.18	0.00
40.00	0.69	1.065	33.40	1.90	1.90	0.00
44.00	0.95	0.780	32.62	1.57	1.57	0.00
48.00	0.93	0.611	32.16	1.37	1.37	0.00
52.00	0.82	0.478	31.80	1.21	1.21	0.00
56.00	0.70	0.350	31.45	1.06	1.06	0.00
60.00	0.61	0.239	31.15	0.93	0.93	0.00
64.00	0.50	0.137	30.87	0.81	0.81	0.00
68.00	0.42	0.037	30.60	0.69	0.69	0.00
72.00	0.38	0.002	30.51	0.38	0.38	0.00
76.00	0.34	0.002	30.51	0.34	0.34	0.00
80.00	0.29	0.002	30.50	0.30	0.30	0.00
84.00	0.25	0.001	30.50	0.25	0.25	0.00
88.00	0.19	0.001	30.50	0.19	0.19	0.00
92.00	0.17	0.001	30.50	0.17	0.17	0.00
96.00	0.16	0.001	30.50	0.16	0.16	0.00
100.00	0.15	0.001	30.50	0.15	0.15	0.00
104.00	0.14	0.001	30.50	0.14	0.14	0.00
108.00	0.13	0.001	30.50	0.13	0.13	0.00
112.00	0.12	0.001	30.50	0.12	0.12	0.00
116.00	0.11	0.001	30.50	0.11	0.11	0.00
120.00	0.10	0.001	30.50	0.10	0.10	0.00
124.00	0.09	0.000	30.50	0.09	0.09	0.00
128.00	0.07	0.000	30.50	0.07	0.07	0.00
132.00	0.06	0.000	30.50	0.06	0.06	0.00
136.00	0.05	0.000	30.50	0.05	0.05	0.00
140.00	0.04	0.000	30.50	0.04	0.04	0.00
144.00	0.03	0.000	30.50	0.03	0.03	0.00
148.00	0.02	0.000	30.50	0.02	0.02	0.00
152.00	0.01	0.000	30.50	0.01	0.01	0.00
156.00	0.01	0.000	30.50	0.01	0.01	0.00

Stage-Discharge for Pond 4P: Sand Filter

Elevation (feet)	Discharge (cfs)	Primary (cfs)	Secondary (cfs)
30.50	0.00	0.00	0.00
30.60	0.69	0.69	0.00
30.70	0.73	0.73	0.00
30.80	0.78	0.78	0.00
30.90	0.82	0.82	0.00
31.00	0.86	0.86	0.00
31.10	0.91	0.91	0.00
31.20	0.95	0.95	0.00
31.30	0.99	0.99	0.00
31.40	1.04	1.04	0.00
31.50	1.08	1.08	0.00
31.60	1.12	1.12	0.00
31.70	1.17	1.17	0.00
31.80	1.21	1.21	0.00
31.90	1.25	1.25	0.00
32.00	1.30	1.30	0.00
32.10	1.34	1.34	0.00
32.20	1.38	1.38	0.00
32.30	1.43	1.43	0.00
32.40	1.47	1.47	0.00
32.50	1.51	1.51	0.00
32.60	1.56	1.56	0.00
32.70	1.60	1.60	0.00
32.80	1.64	1.64	0.00
32.90	1.69	1.69	0.00
33.00	1.73	1.73	0.00
33.10	1.77	1.77	0.00
33.20	1.81	1.81	0.00
33.30	1.86	1.86	0.00
33.40	1.90	1.90	0.00
33.50	1.94	1.94	0.00
33.60	1.99	1.99	0.00
33.70	2.03	2.03	0.00
33.80	2.07	2.07	0.00
33.90	2.12	2.12	0.00
34.00	2.16	2.16	0.00
34.10	2.20	2.20	0.00
34.20	2.25	2.25	0.00
34.30	2.29	2.29	0.00
34.40	2.33	2.33	0.00
34.50	2.38	2.38	0.00
34.60	2.42	2.42	0.00
34.70	2.46	2.46	0.00
34.80	2.51	2.51	0.00
34.90	2.55	2.55	0.00
35.00	2.59	2.59	0.00
35.10	2.64	2.64	0.00
35.20	2.68	2.68	0.00
35.30	6.33	2.72	3.60
35.40	21.50	2.77	18.73
35.50	43.60	2.81	40.79
35.60	72.03	2.85	69.18
35.70	104.93	2.90	102.03
35.80	140.81	2.94	137.87
35.90	180.11	2.98	177.13
36.00	222.56	3.02	219.54
36.10	268.96	3.07	265.90
36.20	319.69	3.11	316.58
36.30	372.76	3.15	369.61
36.40	427.65	3.20	424.45
36.50	**486.06**	**3.24**	**482.82**

Stage-Area-Storage for Pond 4P: Sand Filter

Elevation (feet)	Horizontal (acres)	Storage (acre-feet)
30.50	**0.367**	0.000
30.60	0.367	0.037
30.70	0.367	0.073
30.80	0.367	0.110
30.90	0.367	0.147
31.00	0.367	0.184
31.10	0.367	0.220
31.20	0.367	0.257
31.30	0.367	0.294
31.40	0.367	0.331
31.50	0.367	0.367
31.60	0.367	0.404
31.70	0.367	0.441
31.80	0.367	0.478
31.90	0.367	0.514
32.00	0.367	0.551
32.10	0.367	0.588
32.20	0.367	0.624
32.30	0.367	0.661
32.40	0.367	0.698
32.50	0.367	0.735
32.60	0.367	0.771
32.70	0.367	0.808
32.80	0.367	0.845
32.90	0.367	0.882
33.00	0.367	0.918
33.10	0.367	0.955
33.20	0.367	0.992
33.30	0.367	1.028
33.40	0.367	1.065
33.50	0.367	1.102
33.60	0.367	1.139
33.70	0.367	1.175
33.80	0.367	1.212
33.90	0.367	1.249
34.00	0.367	1.286
34.10	0.367	1.322
34.20	0.367	1.359
34.30	0.367	1.396
34.40	0.367	1.433
34.50	0.367	1.469
34.60	0.367	1.506
34.70	0.367	1.543
34.80	0.367	1.579
34.90	0.367	1.616
35.00	0.367	1.653
35.10	0.367	1.690
35.20	0.367	1.726
35.30	0.367	1.763
35.40	0.367	1.800
35.50	0.367	1.837
35.60	0.367	1.873
35.70	0.367	1.910
35.80	0.367	1.947
35.90	0.367	1.983
36.00	0.367	2.020
36.10	0.367	2.057
36.20	0.367	2.094
36.30	0.367	2.130
36.40	0.367	2.167
36.50	0.367	**2.204**

Summary for Pond 6P: Post Clear Well

Inflow	=	3.83 cfs @	22.20 hrs,	Volume=	10.503 af
Outflow	=	3.83 cfs @	22.23 hrs,	Volume=	10.503 af, Atten= 0%, Lag= 1.7 min
Primary	=	3.83 cfs @	22.23 hrs,	Volume=	10.503 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 29.25' @ 22.23 hrs Surf.Area= 0.000 ac Storage= 0.007 af

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 0.3 min (2,480.2 - 2,479.9)

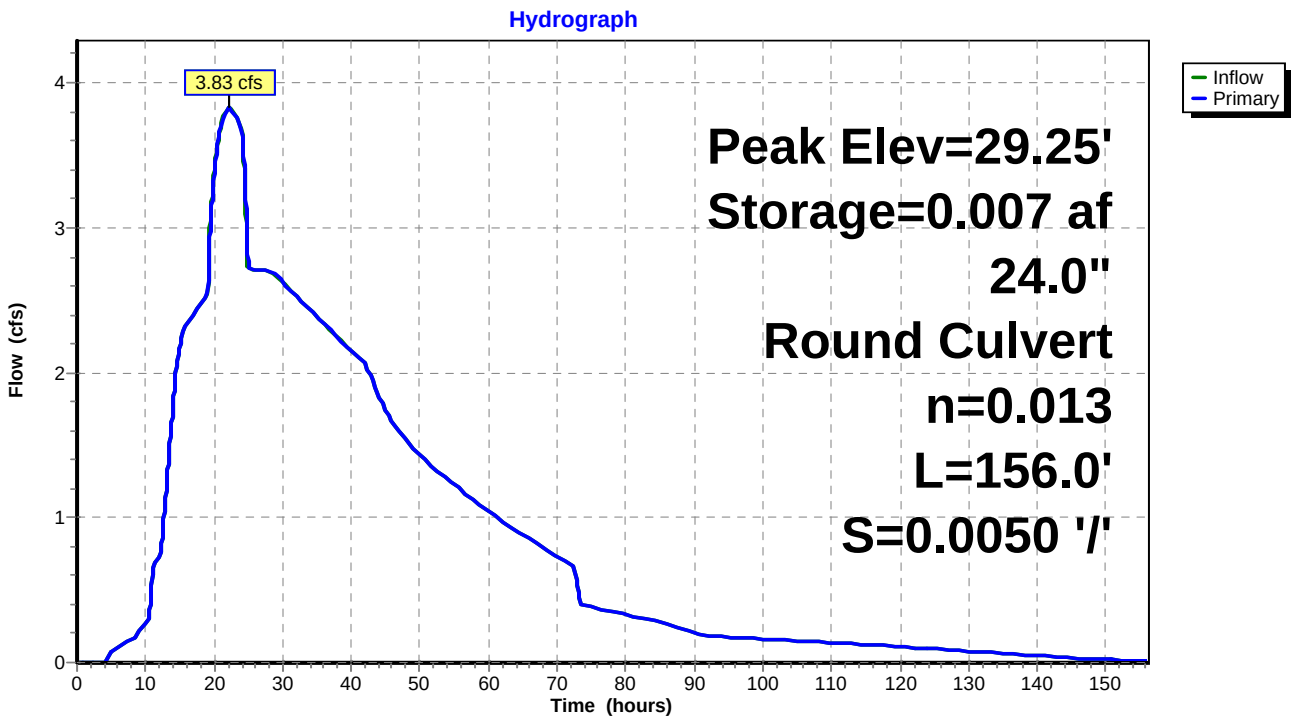
Volume	Invert	Avail.Storage	Storage Description
#1	29.00'	0.549 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
29.00	0.000
29.50	0.014
30.00	0.031
30.50	0.051
31.00	0.074
31.50	0.101
32.00	0.132
32.50	0.166
33.00	0.206
33.50	0.250
34.00	0.298
34.50	0.353
35.00	0.412
35.50	0.478
36.00	0.549

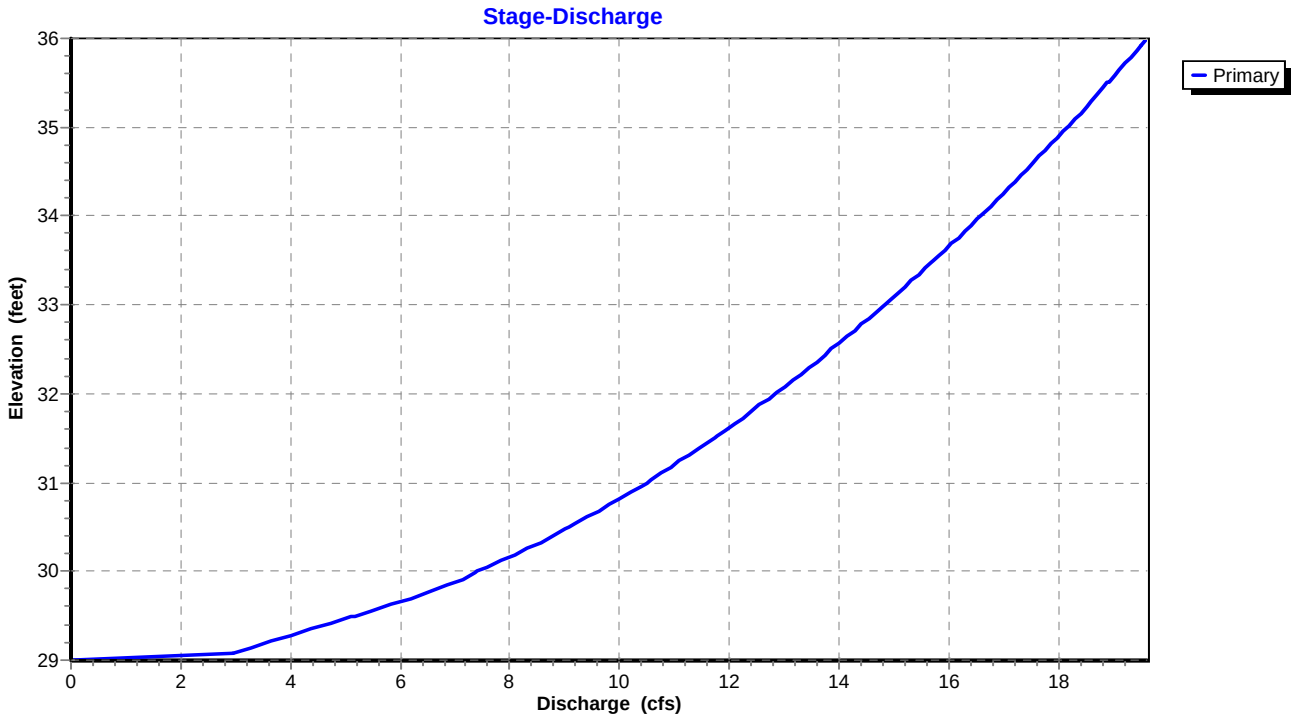
Device	Routing	Invert	Outlet Devices
#1	Primary	28.00'	**24.0" Round Culvert** L= 156.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 28.00' / 27.22' S= 0.0050 '/' Cc= 0.500 n= 0.013

Primary OutFlow Max=3.83 cfs @ 22.23 hrs HW=29.25' TW=27.70' (Dynamic Tailwater)
└─**1=Culvert** (Inlet Controls 3.83 cfs @ 1.86 fps)

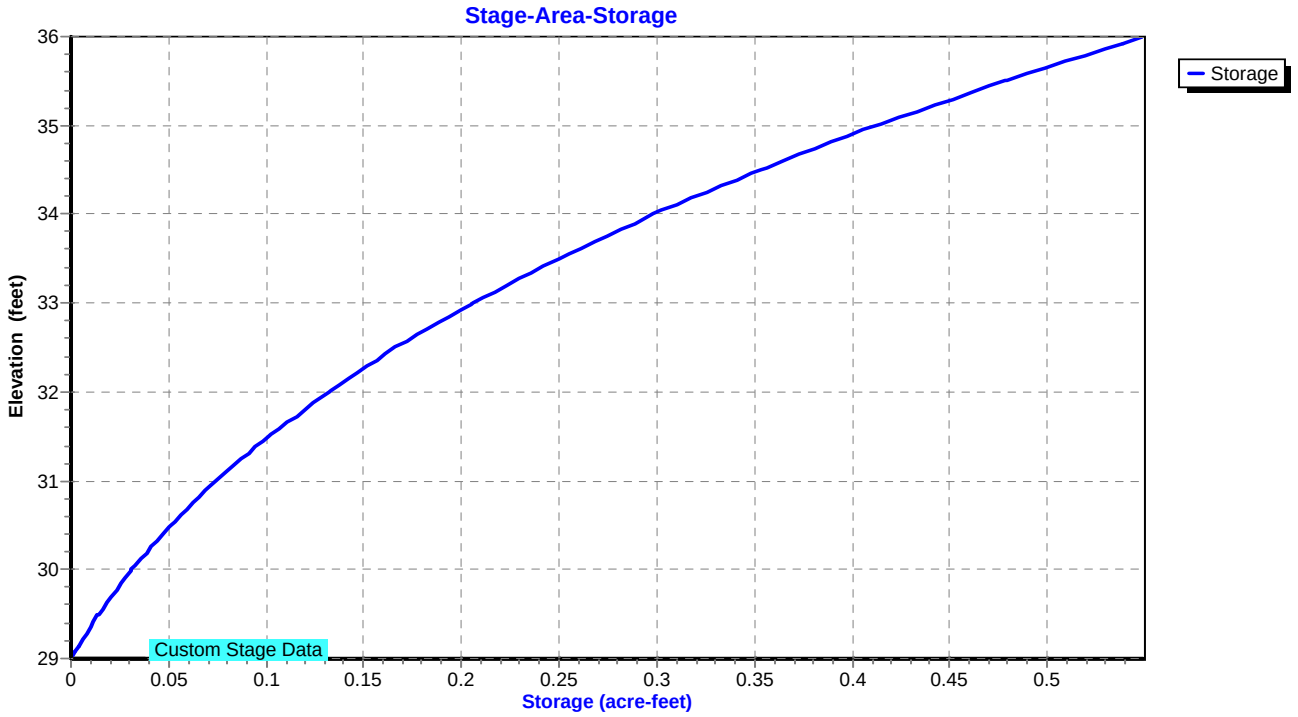
Pond 6P: Post Clear Well



Pond 6P: Post Clear Well



Pond 6P: Post Clear Well



Hydrograph for Pond 6P: Post Clear Well

Time (hours)	Inflow (cfs)	Storage (acre-feet)	Elevation (feet)	Primary (cfs)
0.00	0.00	0.000	29.00	0.00
4.00	0.00	0.000	29.00	0.00
8.00	0.16	0.000	29.00	0.16
12.00	0.72	0.000	29.00	0.72
16.00	2.33	0.000	29.00	2.33
20.00	**3.39**	**0.004**	**29.15**	**3.36**
24.00	**3.67**	**0.006**	**29.22**	**3.68**
28.00	2.71	0.001	29.02	2.71
32.00	2.53	0.000	29.00	2.53
36.00	2.34	0.000	29.00	2.34
40.00	2.16	0.000	29.00	2.16
44.00	1.84	0.000	29.00	1.84
48.00	1.53	0.000	29.00	1.53
52.00	1.34	0.000	29.00	1.34
56.00	1.19	0.000	29.00	1.19
60.00	1.04	0.000	29.00	1.04
64.00	0.91	0.000	29.00	0.91
68.00	0.79	0.000	29.00	0.79
72.00	0.68	0.000	29.00	0.68
76.00	0.37	0.000	29.00	0.37
80.00	0.33	0.000	29.00	0.33
84.00	0.29	0.000	29.00	0.29
88.00	0.24	0.000	29.00	0.24
92.00	0.18	0.000	29.00	0.18
96.00	0.17	0.000	29.00	0.17
100.00	0.16	0.000	29.00	0.16
104.00	0.15	0.000	29.00	0.15
108.00	0.14	0.000	29.00	0.14
112.00	0.13	0.000	29.00	0.13
116.00	0.12	0.000	29.00	0.12
120.00	0.11	0.000	29.00	0.11
124.00	0.10	0.000	29.00	0.10
128.00	0.08	0.000	29.00	0.08
132.00	0.07	0.000	29.00	0.07
136.00	0.06	0.000	29.00	0.06
140.00	0.05	0.000	29.00	0.05
144.00	0.03	0.000	29.00	0.03
148.00	0.02	0.000	29.00	0.02
152.00	0.02	0.000	29.00	0.02
156.00	0.01	0.000	29.00	0.01

Stage-Discharge for Pond 6P: Post Clear Well

Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)
29.00	0.00	31.12	10.80	33.24	15.27	35.36	18.70
29.04	2.81	31.16	10.90	33.28	15.34	35.40	18.76
29.08	3.00	31.20	11.00	33.32	15.41	35.44	18.82
29.12	3.20	31.24	11.10	33.36	15.48	35.48	18.88
29.16	3.40	31.28	11.20	33.40	15.55	35.52	18.93
29.20	3.60	31.32	11.29	33.44	15.62	35.56	18.99
29.24	3.80	31.36	11.39	33.48	15.69	35.60	19.05
29.28	4.01	31.40	11.49	33.52	15.76	35.64	19.11
29.32	4.22	31.44	11.58	33.56	15.83	35.68	19.16
29.36	4.43	31.48	11.68	33.60	15.90	35.72	19.22
29.40	4.64	31.52	11.77	33.64	15.97	35.76	19.28
29.44	4.85	31.56	11.86	33.68	16.04	35.80	19.34
29.48	5.06	31.60	11.96	33.72	16.11	35.84	19.39
29.52	5.27	31.64	12.05	33.76	16.18	35.88	19.45
29.56	5.48	31.68	12.14	33.80	16.25	35.92	19.51
29.60	5.69	31.72	12.23	33.84	16.31	35.96	19.56
29.64	5.89	31.76	12.32	33.88	16.38	36.00	**19.62**
29.68	6.09	31.80	12.41	33.92	16.45		
29.72	6.29	31.84	12.50	33.96	16.51		
29.76	6.48	31.88	12.58	34.00	16.58		
29.80	6.67	31.92	12.67	34.04	16.65		
29.84	6.85	31.96	12.76	34.08	16.71		
29.88	7.01	32.00	12.84	34.12	16.78		
29.92	7.17	32.04	12.93	34.16	16.84		
29.96	7.31	32.08	13.01	34.20	16.91		
30.00	7.42	32.12	13.10	34.24	16.97		
30.04	7.56	32.16	13.18	34.28	17.04		
30.08	7.71	32.20	13.26	34.32	17.10		
30.12	7.85	32.24	13.35	34.36	17.17		
30.16	7.99	32.28	13.43	34.40	17.23		
30.20	8.12	32.32	13.51	34.44	17.29		
30.24	8.26	32.36	13.59	34.48	17.36		
30.28	8.39	32.40	13.67	34.52	17.42		
30.32	8.52	32.44	13.75	34.56	17.48		
30.36	8.65	32.48	13.83	34.60	17.55		
30.40	8.77	32.52	13.91	34.64	17.61		
30.44	8.90	32.56	13.99	34.68	17.67		
30.48	9.02	32.60	14.07	34.72	17.73		
30.52	9.14	32.64	14.15	34.76	17.80		
30.56	9.26	32.68	14.22	34.80	17.86		
30.60	9.38	32.72	14.30	34.84	17.92		
30.64	9.50	32.76	14.38	34.88	17.98		
30.68	9.61	32.80	14.45	34.92	18.04		
30.72	9.72	32.84	14.53	34.96	18.10		
30.76	9.84	32.88	14.61	35.00	18.16		
30.80	9.95	32.92	14.68	35.04	18.22		
30.84	10.06	32.96	14.76	35.08	18.28		
30.88	10.17	33.00	14.83	35.12	18.34		
30.92	10.27	33.04	14.90	35.16	18.40		
30.96	10.38	33.08	14.98	35.20	18.46		
31.00	10.49	33.12	15.05	35.24	18.52		
31.04	10.59	33.16	15.12	35.28	18.58		
31.08	10.69	33.20	15.20	35.32	18.64		

Stage-Area-Storage for Pond 6P: Post Clear Well

Elevation (feet)	Storage (acre-feet)	Elevation (feet)	Storage (acre-feet)
29.00	0.000	34.30	0.331
29.10	0.003	34.40	0.342
29.20	0.006	34.50	0.353
29.30	0.008	34.60	0.365
29.40	0.011	34.70	0.377
29.50	0.014	34.80	0.388
29.60	0.017	34.90	0.400
29.70	0.021	35.00	0.412
29.80	0.024	35.10	0.425
29.90	0.028	35.20	0.438
30.00	0.031	35.30	0.452
30.10	0.035	35.40	0.465
30.20	0.039	35.50	0.478
30.30	0.043	35.60	0.492
30.40	0.047	35.70	0.506
30.50	0.051	35.80	0.521
30.60	0.056	35.90	0.535
30.70	0.060	36.00	**0.549**
30.80	0.065		
30.90	0.069		
31.00	0.074		
31.10	0.079		
31.20	0.085		
31.30	0.090		
31.40	0.096		
31.50	0.101		
31.60	0.107		
31.70	0.113		
31.80	0.120		
31.90	0.126		
32.00	0.132		
32.10	0.139		
32.20	0.146		
32.30	0.152		
32.40	0.159		
32.50	0.166		
32.60	0.174		
32.70	0.182		
32.80	0.190		
32.90	0.198		
33.00	0.206		
33.10	0.215		
33.20	0.224		
33.30	0.232		
33.40	0.241		
33.50	0.250		
33.60	0.260		
33.70	0.269		
33.80	0.279		
33.90	0.288		
34.00	0.298		
34.10	0.309		
34.20	0.320		

Summary for Pond 12P: Sediment Forebay

Inflow	=	33.77 cfs @	8.04 hrs,	Volume=	11.858 af
Outflow	=	28.75 cfs @	8.13 hrs,	Volume=	11.472 af, Atten= 15%, Lag= 5.5 min
Primary	=	28.75 cfs @	8.13 hrs,	Volume=	11.472 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 35.47' @ 21.99 hrs Surf.Area= 0.000 ac Storage= 1.508 af

Plug-Flow detention time= 254.7 min calculated for 11.471 af (97% of inflow)
Center-of-Mass det. time= 231.7 min (940.6 - 708.9)

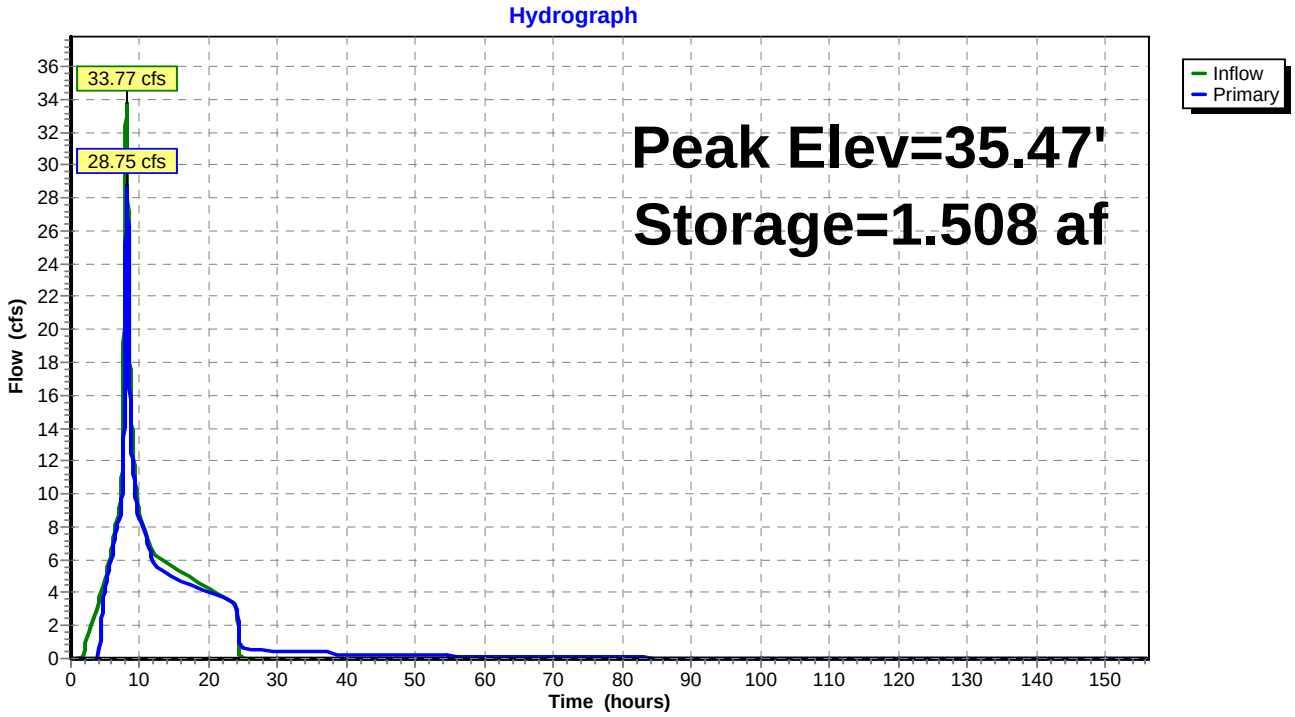
Volume	Invert	Avail.Storage	Storage Description
#1	30.00'	1.902 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
30.00	0.000
30.50	0.102
31.00	0.211
31.50	0.326
31.75	0.386
32.00	0.445
32.50	0.577
33.00	0.713
33.50	0.858
34.00	1.010
34.50	1.171
35.00	1.340
35.50	1.518
36.00	1.705
36.50	1.902

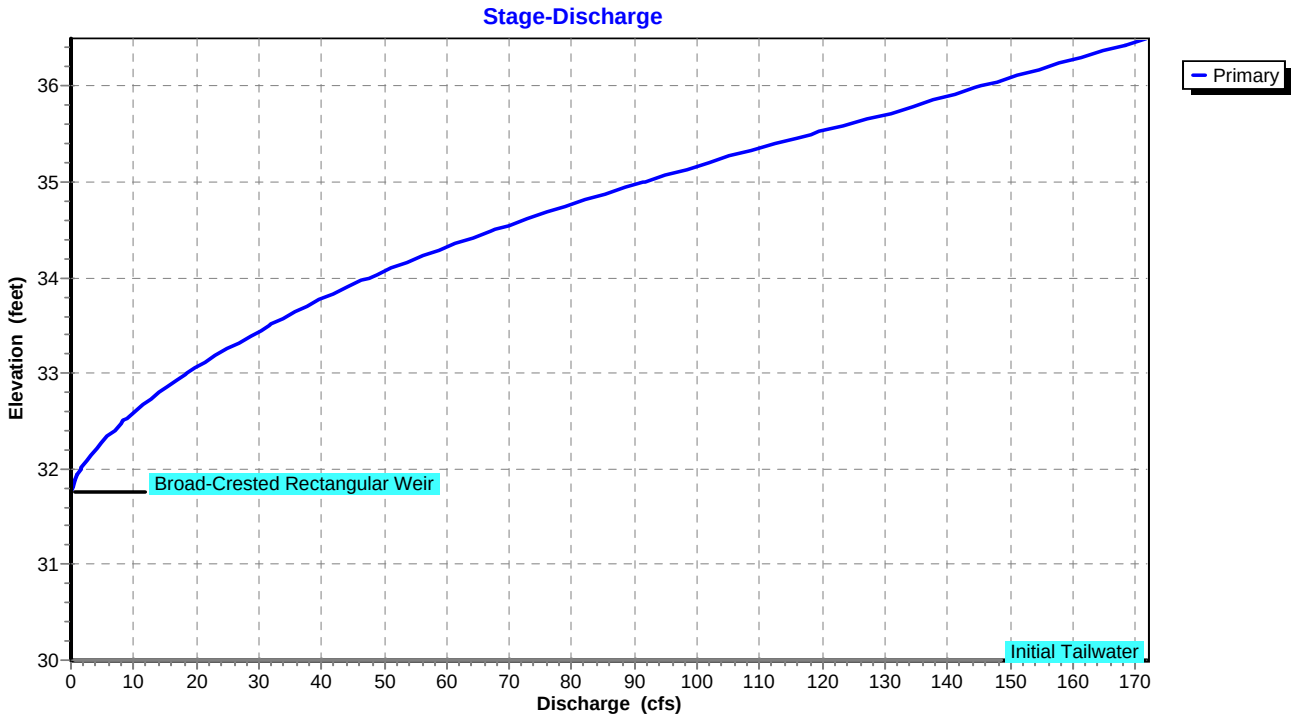
Device	Routing	Invert	Outlet Devices
#1	Primary	31.75'	**5.0' long x 2.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 Coef. (English) 2.48 2.60 2.60 2.60 2.64 2.65 2.68 2.75 2.74 2.76 2.89 3.05 3.19 3.32

Primary OutFlow Max=28.74 cfs @ 8.13 hrs HW=33.69' TW=32.94' (Dynamic Tailwater)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 28.74 cfs @ 2.97 fps)

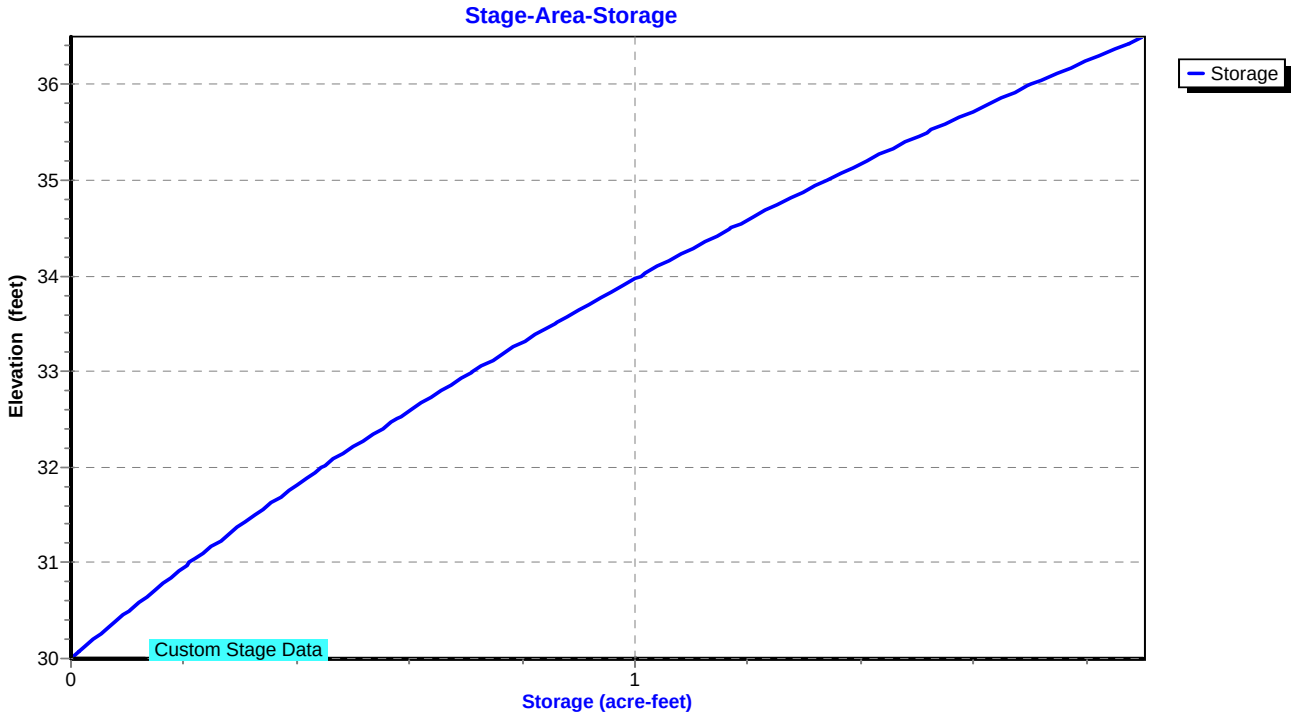
Pond 12P: Sediment Forebay



Pond 12P: Sediment Forebay



Pond 12P: Sediment Forebay



Hydrograph for Pond 12P: Sediment Forebay

Time (hours)	Inflow (cfs)	Storage (acre-feet)	Elevation (feet)	Primary (cfs)
0.00	0.00	0.000	30.00	0.00
4.00	3.48	0.369	31.68	0.00
8.00	**33.33**	0.857	33.49	**26.57**
12.00	**6.30**	1.148	34.43	**5.64**
16.00	5.24	1.359	35.05	4.70
20.00	4.25	**1.495**	**35.44**	4.06
24.00	3.24	**1.501**	**35.45**	3.32
28.00	0.00	1.331	34.97	0.48
32.00	0.00	1.178	34.52	0.44
36.00	0.00	1.040	34.09	0.40
40.00	0.00	0.938	33.76	0.16
44.00	0.00	0.875	33.55	0.21
48.00	0.00	0.804	33.31	0.21
52.00	0.00	0.739	33.09	0.18
56.00	0.00	0.684	32.89	0.15
60.00	0.00	0.637	32.72	0.13
64.00	0.00	0.596	32.57	0.11
68.00	0.00	0.564	32.45	0.09
72.00	0.00	0.535	32.34	0.08
76.00	0.00	0.509	32.24	0.07
80.00	0.00	0.486	32.16	0.06
84.00	0.00	0.467	32.08	0.05
88.00	0.00	0.451	32.02	0.04
92.00	0.00	0.439	31.97	0.04
96.00	0.00	0.427	31.92	0.03
100.00	0.00	0.416	31.88	0.03
104.00	0.00	0.406	31.84	0.03
108.00	0.00	0.397	31.80	0.03
112.00	0.00	0.390	31.76	0.02
116.00	0.00	0.387	31.75	0.00
120.00	0.00	0.386	31.75	0.00
124.00	0.00	0.386	31.75	0.00
128.00	0.00	0.386	31.75	0.00
132.00	0.00	0.386	31.75	0.00
136.00	0.00	0.386	31.75	0.00
140.00	0.00	0.386	31.75	0.00
144.00	0.00	0.386	31.75	0.00
148.00	0.00	0.386	31.75	0.00
152.00	0.00	0.386	31.75	0.00
156.00	0.00	0.386	31.75	0.00

Stage-Discharge for Pond 12P: Sediment Forebay

Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)
30.00	0.00	32.12	2.91	34.24	56.73	36.36	164.31
30.04	0.00	32.16	3.41	34.28	58.34	36.40	166.45
30.08	0.00	32.20	3.92	34.32	60.00	36.44	168.60
30.12	0.00	32.24	4.46	34.36	61.67	36.48	**170.77**
30.16	0.00	32.28	5.02	34.40	63.37		
30.20	0.00	32.32	5.59	34.44	65.09		
30.24	0.00	32.36	6.19	34.48	66.84		
30.28	0.00	32.40	6.81	34.52	68.61		
30.32	0.00	32.44	7.45	34.56	70.40		
30.36	0.00	32.48	8.11	34.60	72.22		
30.40	0.00	32.52	8.78	34.64	74.06		
30.44	0.00	32.56	9.48	34.68	75.92		
30.48	0.00	32.60	10.23	34.72	77.81		
30.52	0.00	32.64	10.99	34.76	79.71		
30.56	0.00	32.68	11.78	34.80	81.60		
30.60	0.00	32.72	12.58	34.84	83.52		
30.64	0.00	32.76	13.40	34.88	85.46		
30.68	0.00	32.80	14.22	34.92	87.41		
30.72	0.00	32.84	15.05	34.96	89.40		
30.76	0.00	32.88	15.89	35.00	91.40		
30.80	0.00	32.92	16.76	35.04	93.43		
30.84	0.00	32.96	17.65	35.08	95.48		
30.88	0.00	33.00	18.57	35.12	97.55		
30.92	0.00	33.04	19.51	35.16	99.64		
30.96	0.00	33.08	20.47	35.20	101.76		
31.00	0.00	33.12	21.45	35.24	103.90		
31.04	0.00	33.16	22.46	35.28	106.04		
31.08	0.00	33.20	23.55	35.32	108.20		
31.12	0.00	33.24	24.66	35.36	110.38		
31.16	0.00	33.28	25.79	35.40	112.58		
31.20	0.00	33.32	26.95	35.44	114.81		
31.24	0.00	33.36	28.08	35.48	117.05		
31.28	0.00	33.40	29.12	35.52	119.32		
31.32	0.00	33.44	30.16	35.56	121.61		
31.36	0.00	33.48	31.21	35.60	123.93		
31.40	0.00	33.52	32.28	35.64	126.26		
31.44	0.00	33.56	33.37	35.68	128.62		
31.48	0.00	33.60	34.54	35.72	131.00		
31.52	0.00	33.64	35.71	35.76	133.30		
31.56	0.00	33.68	36.91	35.80	135.30		
31.60	0.00	33.72	38.12	35.84	137.31		
31.64	0.00	33.76	39.36	35.88	139.33		
31.68	0.00	33.80	40.70	35.92	141.36		
31.72	0.00	33.84	42.05	35.96	143.39		
31.76	0.01	33.88	43.42	36.00	145.44		
31.80	0.14	33.92	44.82	36.04	147.50		
31.84	0.33	33.96	46.24	36.08	149.57		
31.88	0.58	34.00	47.67	36.12	151.65		
31.92	0.87	34.04	49.13	36.16	153.73		
31.96	1.20	34.08	50.61	36.20	155.83		
32.00	1.57	34.12	52.11	36.24	157.93		
32.04	1.98	34.16	53.62	36.28	160.05		
32.08	2.42	34.20	55.16	36.32	162.17		

Stage-Area-Storage for Pond 12P: Sediment Forebay

Elevation (feet)	Storage (acre-feet)
30.00	0.000
30.10	0.020
30.20	0.041
30.30	0.061
30.40	0.082
30.50	0.102
30.60	0.124
30.70	0.146
30.80	0.167
30.90	0.189
31.00	0.211
31.10	0.234
31.20	0.257
31.30	0.280
31.40	0.303
31.50	0.326
31.60	0.350
31.70	0.374
31.80	0.398
31.90	0.421
32.00	0.445
32.10	0.471
32.20	0.498
32.30	0.524
32.40	0.551
32.50	0.577
32.60	0.604
32.70	0.631
32.80	0.659
32.90	0.686
33.00	0.713
33.10	0.742
33.20	0.771
33.30	0.800
33.40	0.829
33.50	0.858
33.60	0.888
33.70	0.919
33.80	0.949
33.90	0.980
34.00	1.010
34.10	1.042
34.20	1.074
34.30	1.107
34.40	1.139
34.50	1.171
34.60	1.205
34.70	1.239
34.80	1.272
34.90	1.306
35.00	1.340
35.10	1.376
35.20	1.411
35.30	1.447
35.40	1.482
35.50	1.518
35.60	1.555
35.70	1.593
35.80	1.630
35.90	1.668
36.00	1.705
36.10	1.744
36.20	1.784
36.30	1.823
36.40	1.863
36.50	**1.902**

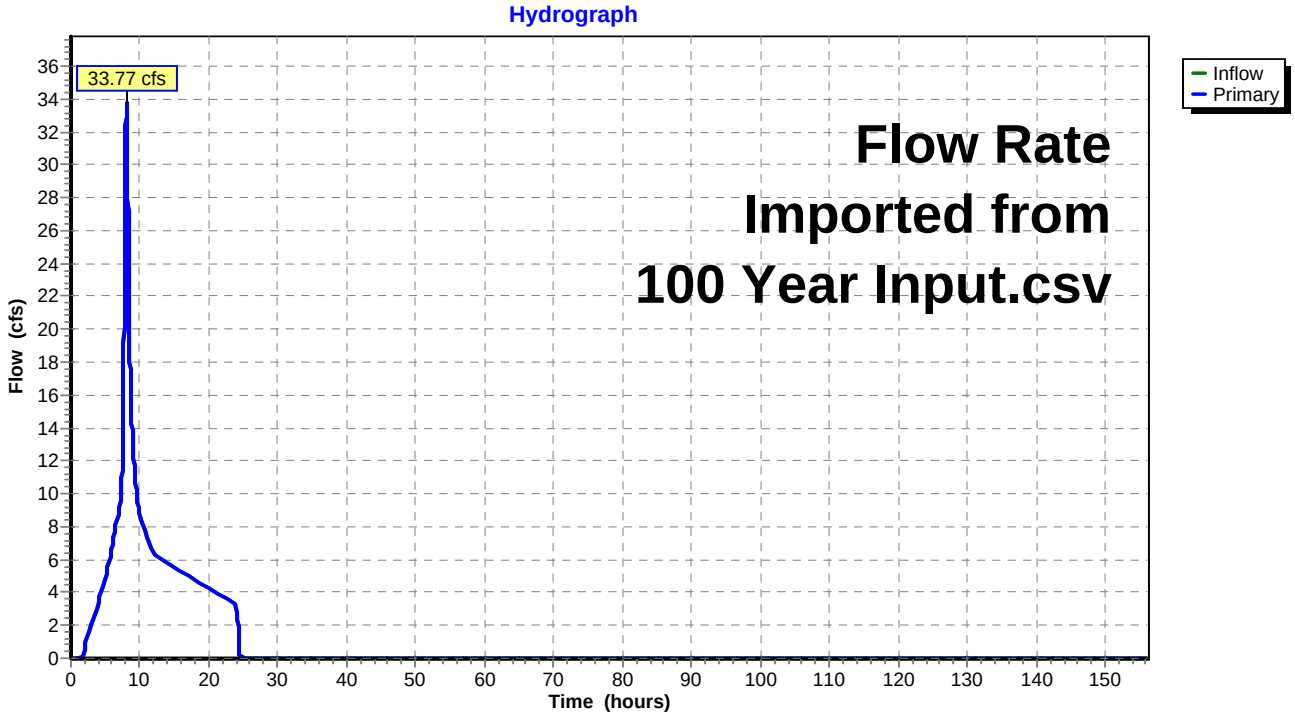
Summary for Link 1L: Input Hydrograhp

Inflow	=	33.77 cfs @	8.04 hrs,	Volume=	11.858 af
Primary	=	33.77 cfs @	8.04 hrs,	Volume=	11.858 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs

Flow Rate Imported from 100 Year Input.csv

Link 1L: Input Hydrograhp



Hydrograph for Link 1L: Input Hydrograhp

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**0.00**	0.00
2.00	0.49	0.00	0.49
4.00	3.48	0.00	3.48
6.00	6.74	0.00	6.74
8.00	**33.33**	0.00	**33.33**
10.00	**8.80**	0.00	**8.80**
12.00	6.30	0.00	6.30
14.00	5.66	0.00	5.66
16.00	5.24	0.00	5.24
18.00	4.75	0.00	4.75
20.00	4.25	0.00	4.25
22.00	3.75	0.00	3.75
24.00	3.24	0.00	3.24
26.00	0.00	0.00	0.00
28.00	0.00	0.00	0.00
30.00	0.00	0.00	0.00
32.00	0.00	0.00	0.00
34.00	0.00	0.00	0.00
36.00	0.00	0.00	0.00
38.00	0.00	0.00	0.00
40.00	0.00	0.00	0.00
42.00	0.00	0.00	0.00
44.00	0.00	0.00	0.00
46.00	0.00	0.00	0.00
48.00	0.00	0.00	0.00
50.00	0.00	0.00	0.00
52.00	0.00	0.00	0.00
54.00	0.00	0.00	0.00
56.00	0.00	0.00	0.00
58.00	0.00	0.00	0.00
60.00	0.00	0.00	0.00
62.00	0.00	0.00	0.00
64.00	0.00	0.00	0.00
66.00	0.00	0.00	0.00
68.00	0.00	0.00	0.00
70.00	0.00	0.00	0.00
72.00	0.00	0.00	0.00
74.00	0.00	0.00	0.00
76.00	0.00	0.00	0.00
78.00	0.00	0.00	0.00
80.00	0.00	0.00	0.00
82.00	0.00	0.00	0.00
84.00	0.00	0.00	0.00
86.00	0.00	0.00	0.00
88.00	0.00	0.00	0.00
90.00	0.00	0.00	0.00
92.00	0.00	0.00	0.00
94.00	0.00	0.00	0.00
96.00	0.00	0.00	0.00
98.00	0.00	0.00	0.00
100.00	0.00	0.00	0.00
102.00	0.00	0.00	0.00
104.00	0.00	0.00	0.00
106.00	0.00	0.00	0.00
108.00	0.00	0.00	0.00
110.00	0.00	0.00	0.00
112.00	0.00	0.00	0.00
114.00	0.00	0.00	0.00
116.00	0.00	0.00	0.00
118.00	0.00	0.00	0.00
120.00	0.00	0.00	0.00
122.00	0.00	0.00	0.00
124.00	0.00	0.00	0.00
126.00	0.00	0.00	0.00
128.00	0.00	0.00	0.00
130.00	0.00	0.00	0.00
132.00	0.00	0.00	0.00
134.00	0.00	0.00	0.00
136.00	0.00	0.00	0.00
138.00	0.00	0.00	0.00
140.00	0.00	0.00	0.00
142.00	0.00	0.00	0.00
144.00	0.00	0.00	0.00
146.00	0.00	0.00	0.00
148.00	0.00	0.00	0.00
150.00	0.00	0.00	0.00
152.00	0.00	0.00	0.00
154.00	0.00	0.00	0.00
156.00	0.00	0.00	0.00

Summary for Link 4L: Lag Thru Filter

Storage in sand filter modeled here as lag time from sand filter outlet to clear well outlet on downstream side of sand filter.

Lagtime estimate at conductivity of 1.75 inches/hour, with a hydraulic gradient of {[(31.00-28)/2]+1.5}*/(1.5)** thru 18 inches of sand.

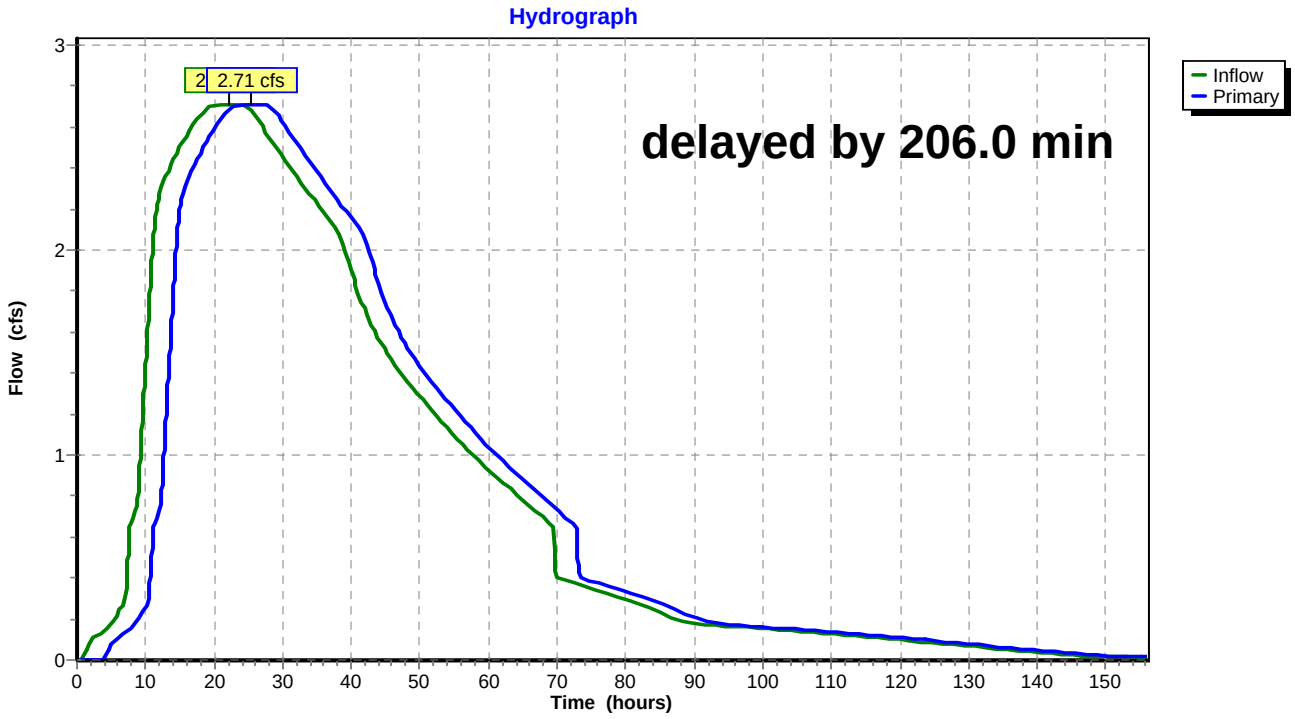
Result is 206 minutes

* "Average" Head on Sand Filter.
** Depth of Sand Filter

Inflow	=	2.71 cfs @	22.04 hrs,	Volume=	10.077 af
Primary	=	2.71 cfs @	25.48 hrs,	Volume=	10.073 af, Atten= 0%, Lag= 206.0 min

Primary outflow = Inflow delayed by 206.0 min, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs

Link 4L: Lag Thru Filter



Hydrograph for Link 4L: Lag Thru Filter

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**0.00**	0.00
2.00	0.09	0.00	0.00
4.00	0.15	0.00	0.00
6.00	0.23	0.00	0.11
8.00	0.68	0.00	0.16
10.00	1.44	0.00	0.27
12.00	2.27	0.00	0.72
14.00	2.44	0.00	1.77
16.00	2.56	0.00	2.33
18.00	2.66	0.00	2.48
20.00	2.71	0.00	2.59
22.00	**2.71**	0.00	2.68
24.00	**2.71**	0.00	**2.71**
26.00	2.65	0.00	**2.71**
28.00	2.56	0.00	2.71
30.00	2.46	0.00	2.63
32.00	2.36	0.00	2.53
34.00	2.27	0.00	2.43
36.00	2.18	0.00	2.34
38.00	2.09	0.00	2.25
40.00	1.90	0.00	2.16
42.00	1.70	0.00	2.06
44.00	1.57	0.00	1.84
46.00	1.46	0.00	1.66
48.00	1.37	0.00	1.53
50.00	1.29	0.00	1.43
52.00	1.21	0.00	1.34
54.00	1.13	0.00	1.26
56.00	1.06	0.00	1.19
58.00	0.99	0.00	1.11
60.00	0.93	0.00	1.04
62.00	0.87	0.00	0.97
64.00	0.81	0.00	0.91
66.00	0.75	0.00	0.85
68.00	0.69	0.00	0.79
70.00	0.40	0.00	0.73
72.00	0.38	0.00	0.68
74.00	0.36	0.00	0.39
76.00	0.34	0.00	0.37
78.00	0.32	0.00	0.35
80.00	0.30	0.00	0.33
82.00	0.27	0.00	0.31
84.00	0.25	0.00	0.29
86.00	0.21	0.00	0.27
88.00	0.19	0.00	0.24
90.00	0.18	0.00	0.21
92.00	0.17	0.00	0.18
94.00	0.17	0.00	0.18
96.00	0.16	0.00	0.17
98.00	0.16	0.00	0.17
100.00	0.15	0.00	0.16
102.00	0.15	0.00	0.16
104.00	0.14	0.00	0.15
106.00	0.14	0.00	0.15
108.00	0.13	0.00	0.14
110.00	0.13	0.00	0.14
112.00	0.12	0.00	0.13
114.00	0.12	0.00	0.13
116.00	0.11	0.00	0.12
118.00	0.10	0.00	0.12
120.00	0.10	0.00	0.11
122.00	0.09	0.00	0.10
124.00	0.09	0.00	0.10
126.00	0.08	0.00	0.09
128.00	0.07	0.00	0.08
130.00	0.07	0.00	0.08
132.00	0.06	0.00	0.07
134.00	0.06	0.00	0.07
136.00	0.05	0.00	0.06
138.00	0.04	0.00	0.05
140.00	0.04	0.00	0.05
142.00	0.03	0.00	0.04
144.00	0.03	0.00	0.03
146.00	0.02	0.00	0.03
148.00	0.02	0.00	0.02
150.00	0.02	0.00	0.02
152.00	0.01	0.00	0.02
154.00	0.01	0.00	0.02
156.00	0.01	0.00	0.01

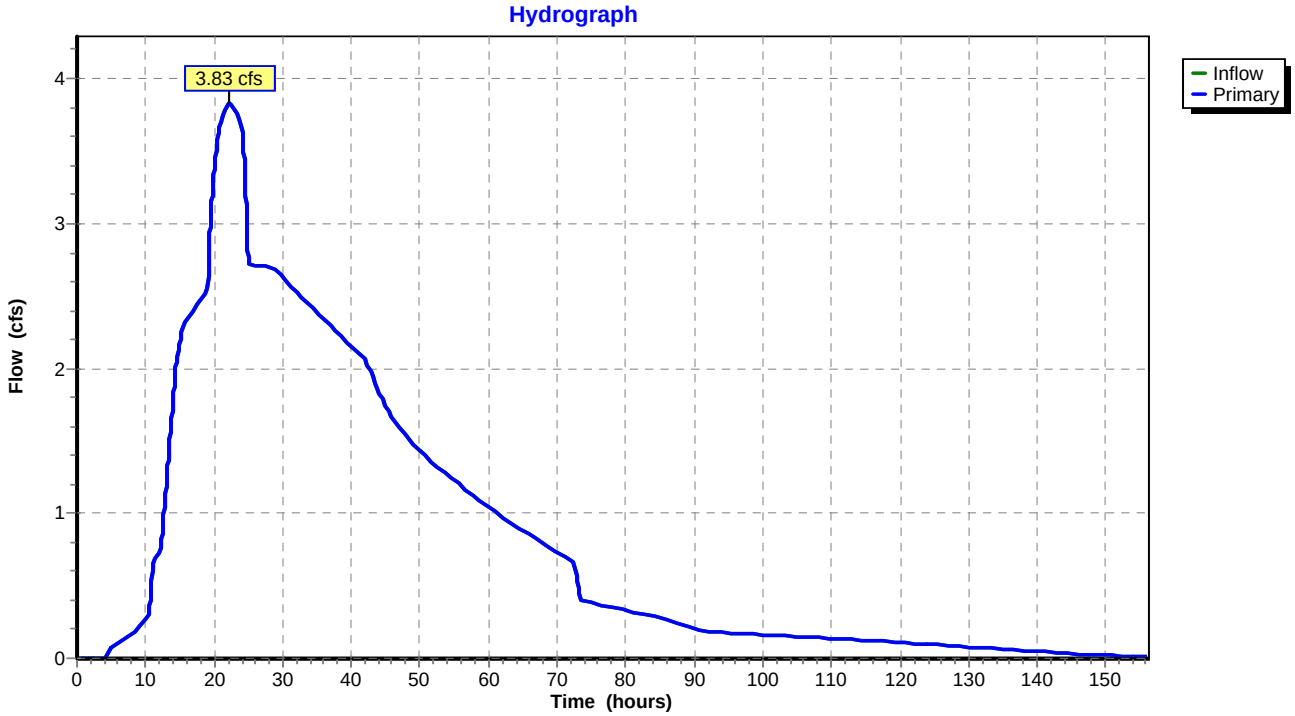
Summary for Link 9L: Discharge Elevation

Inflow	=	3.83 cfs @	22.23 hrs,	Volume=	10.503 af
Primary	=	3.83 cfs @	22.23 hrs,	Volume=	10.503 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs

Fixed water surface Elevation= 27.70'

Link 9L: Discharge Elevation



Hydrograph for Link 9L: Discharge Elevation

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**27.70**	0.00
2.00	0.00	27.70	0.00
4.00	0.00	27.70	0.00
6.00	0.11	27.70	0.11
8.00	0.16	27.70	0.16
10.00	0.27	27.70	0.27
12.00	0.72	27.70	0.72
14.00	1.77	27.70	1.77
16.00	2.33	27.70	2.33
18.00	2.48	27.70	2.48
20.00	3.36	27.70	3.36
22.00	**3.82**	27.70	**3.82**
24.00	**3.68**	27.70	**3.68**
26.00	2.71	27.70	2.71
28.00	2.71	27.70	2.71
30.00	2.63	27.70	2.63
32.00	2.53	27.70	2.53
34.00	2.43	27.70	2.43
36.00	2.34	27.70	2.34
38.00	2.25	27.70	2.25
40.00	2.16	27.70	2.16
42.00	2.06	27.70	2.06
44.00	1.84	27.70	1.84
46.00	1.66	27.70	1.66
48.00	1.53	27.70	1.53
50.00	1.43	27.70	1.43
52.00	1.34	27.70	1.34
54.00	1.26	27.70	1.26
56.00	1.19	27.70	1.19
58.00	1.11	27.70	1.11
60.00	1.04	27.70	1.04
62.00	0.97	27.70	0.97
64.00	0.91	27.70	0.91
66.00	0.85	27.70	0.85
68.00	0.79	27.70	0.79
70.00	0.73	27.70	0.73
72.00	0.68	27.70	0.68
74.00	0.39	27.70	0.39
76.00	0.37	27.70	0.37
78.00	0.35	27.70	0.35
80.00	0.33	27.70	0.33
82.00	0.31	27.70	0.31
84.00	0.29	27.70	0.29
86.00	0.27	27.70	0.27
88.00	0.24	27.70	0.24
90.00	0.21	27.70	0.21
92.00	0.18	27.70	0.18
94.00	0.18	27.70	0.18
96.00	0.17	27.70	0.17
98.00	0.17	27.70	0.17
100.00	0.16	27.70	0.16
102.00	0.16	27.70	0.16
104.00	0.15	27.70	0.15
106.00	0.15	27.70	0.15
108.00	0.14	27.70	0.14
110.00	0.14	27.70	0.14
112.00	0.13	27.70	0.13
114.00	0.13	27.70	0.13
116.00	0.12	27.70	0.12
118.00	0.12	27.70	0.12
120.00	0.11	27.70	0.11
122.00	0.10	27.70	0.10
124.00	0.10	27.70	0.10
126.00	0.09	27.70	0.09
128.00	0.08	27.70	0.08
130.00	0.08	27.70	0.08
132.00	0.07	27.70	0.07
134.00	0.07	27.70	0.07
136.00	0.06	27.70	0.06
138.00	0.05	27.70	0.05
140.00	0.05	27.70	0.05
142.00	0.04	27.70	0.04
144.00	0.03	27.70	0.03
146.00	0.03	27.70	0.03
148.00	0.02	27.70	0.02
150.00	0.02	27.70	0.02
152.00	0.02	27.70	0.02
154.00	0.02	27.70	0.02
156.00	0.01	27.70	0.01

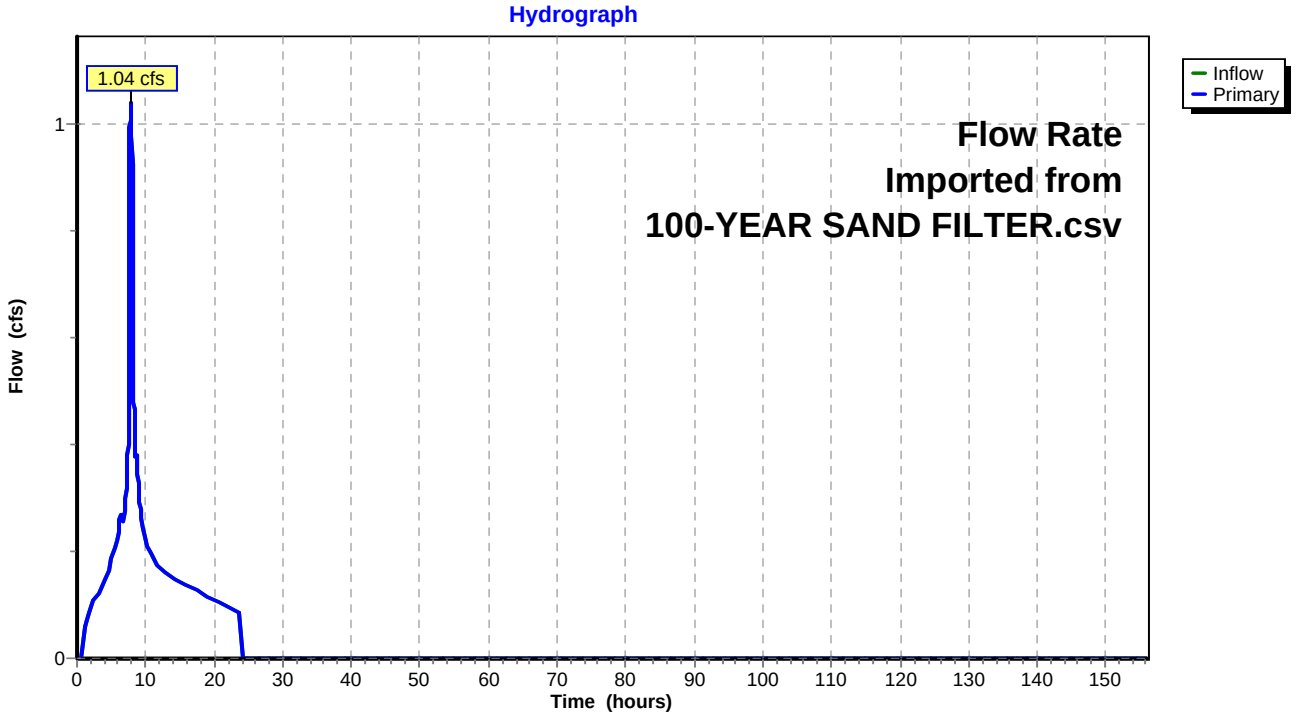
Summary for Link 10L: Sand Filter Input

Inflow	=	1.04 cfs @	7.80 hrs,	Volume=	0.343 af
Primary	=	1.04 cfs @	7.80 hrs,	Volume=	0.343 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-156.00 hrs, dt= 0.02 hrs

Flow Rate Imported from 100-YEAR SAND FILTER.csv

Link 10L: Sand Filter Input



Hydrograph for Link 10L: Sand Filter Input

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**0.00**	0.00
2.00	0.09	0.00	0.09
4.00	0.15	0.00	0.15
6.00	**0.23**	0.00	**0.23**
8.00	**0.99**	0.00	**0.99**
10.00	0.23	0.00	0.23
12.00	0.16	0.00	0.16
14.00	0.15	0.00	0.15
16.00	0.14	0.00	0.14
18.00	0.12	0.00	0.12
20.00	0.11	0.00	0.11
22.00	0.10	0.00	0.10
24.00	0.08	0.00	0.08
26.00	0.00	0.00	0.00
28.00	0.00	0.00	0.00
30.00	0.00	0.00	0.00
32.00	0.00	0.00	0.00
34.00	0.00	0.00	0.00
36.00	0.00	0.00	0.00
38.00	0.00	0.00	0.00
40.00	0.00	0.00	0.00
42.00	0.00	0.00	0.00
44.00	0.00	0.00	0.00
46.00	0.00	0.00	0.00
48.00	0.00	0.00	0.00
50.00	0.00	0.00	0.00
52.00	0.00	0.00	0.00
54.00	0.00	0.00	0.00
56.00	0.00	0.00	0.00
58.00	0.00	0.00	0.00
60.00	0.00	0.00	0.00
62.00	0.00	0.00	0.00
64.00	0.00	0.00	0.00
66.00	0.00	0.00	0.00
68.00	0.00	0.00	0.00
70.00	0.00	0.00	0.00
72.00	0.00	0.00	0.00
74.00	0.00	0.00	0.00
76.00	0.00	0.00	0.00
78.00	0.00	0.00	0.00
80.00	0.00	0.00	0.00
82.00	0.00	0.00	0.00
84.00	0.00	0.00	0.00
86.00	0.00	0.00	0.00
88.00	0.00	0.00	0.00
90.00	0.00	0.00	0.00
92.00	0.00	0.00	0.00
94.00	0.00	0.00	0.00
96.00	0.00	0.00	0.00
98.00	0.00	0.00	0.00
100.00	0.00	0.00	0.00
102.00	0.00	0.00	0.00
104.00	0.00	0.00	0.00
106.00	0.00	0.00	0.00
108.00	0.00	0.00	0.00
110.00	0.00	0.00	0.00
112.00	0.00	0.00	0.00
114.00	0.00	0.00	0.00
116.00	0.00	0.00	0.00
118.00	0.00	0.00	0.00
120.00	0.00	0.00	0.00
122.00	0.00	0.00	0.00
124.00	0.00	0.00	0.00
126.00	0.00	0.00	0.00
128.00	0.00	0.00	0.00
130.00	0.00	0.00	0.00
132.00	0.00	0.00	0.00
134.00	0.00	0.00	0.00
136.00	0.00	0.00	0.00
138.00	0.00	0.00	0.00
140.00	0.00	0.00	0.00
142.00	0.00	0.00	0.00
144.00	0.00	0.00	0.00
146.00	0.00	0.00	0.00
148.00	0.00	0.00	0.00
150.00	0.00	0.00	0.00
152.00	0.00	0.00	0.00
154.00	0.00	0.00	0.00
156.00	0.00	0.00	0.00

APPENDIX K

STANDARD STEP BACKWATER ANALYSIS

STANDARD STEP BACKWATER ANALYSIS
FOR
STORMWATER SOURCE CONTROL MEASURES

Former Arkema Inc. Facility
Portland, Oregon

Prepared for
Legacy Site Services LLC
468 Thomas Jones Way
Exton, PA 19341-2528

Prepared by

integral consulting inc.
319 SW Washington St
Suite 1150
Portland, OR 97204

September 30, 2011

CONTENTS

LIST OF FIGURES ..... **iii**

LIST OF TABLES ..... **iv**

1 INTRODUCTION **1-1**

2 BACKWATER CALCULATIONS **2-1**

3 RESULTS **3-1**

4 REFERENCES **4-1**

LIST OF FIGURES

Figure 1. Overview of Cross Section Locations for Standard Step Method
Figure 2. West Channel (W-2)
Figure 3. West Channel (W-3)
Figure 4. West Channel (W-4)
Figure 5. West Channel (W-5)
Figure 6. West Channel (W-6)
Figure 7. West Channel (W-7)
Figure 8. West Channel (W-8)
Figure 9. East Channel (E-1)
Figure 10. East Channel (E-2)
Figure 11. East Channel (E-3)
Figure 12. East Channel (E-4)
Figure 13. East Channel (E-5)
Figure 14. East Channel (E-6)
Figure 15. East Channel (E-7)
Figures 16a to 16h. Results of Step Backwater Calculations; West Channel, 25-Year Storm
Figures 17a to 17i. Results of Step Backwater Calculations; East Channel, 25-Year Storm
Figures 18a to 18h. Results of Step Backwater Calculations; West Channel, 10-Year Storm
Figures 19a to 19i. Results of Step Backwater Calculations; East Channel, 10-Year Storm
Figures 20a to 20h. Results of Step Backwater Calculations; West Channel, 5-Year Storm
Figures 21a to 21i. Results of Step Backwater Calculations; East Channel, 5-Year Storm
Figures 22a to 22h. Results of Step Backwater Calculations; West Channel, 2-Year Storm
Figures 23a to 23i. Results of Step Backwater Calculations; East Channel, 2-Year Storm
Figures 24a to 24h. Results of Step Backwater Calculations; West Channel, 1-Inch Storm
Figures 25a to 25i. Results of Step Backwater Calculations; East Channel, 1-Inch Storm

LIST OF TABLES

Table 1a. Detention Basin Elevations and Discharge Rate by Reach
Table 1b. Detention Basin Elevations and Discharge Rate by Cross Section
Table 2a. Calculated Model Parameters for 25-Year Storm, East Channel
Table 2b. Calculated Model Parameters for 25-Year Storm, West Channel
Table 3a. Calculated Model Parameters for 10-Year Storm, East Channel
Table 3b. Calculated Model Parameters for 10-Year Storm, West Channel
Table 4a. Calculated Model Parameters for 5-Year Storm, East Channel
Table 4b. Calculated Model Parameters for 5-Year Storm, West Channel
Table 5a. Calculated Model Parameters for 2-Year Storm, East Channel
Table 5b. Calculated Model Parameters for 2-Year Storm, West Channel
Table 6a. Calculated Model Parameters for 1-Inch Storm, East Channel
Table 6b. Calculated Model Parameters for 1-Inch Storm, West Channel

1 INTRODUCTION

A stormwater conveyance system is to be constructed at the former Arkema facility as part of the stormwater source control measures. Surface runoff resulting from precipitation will be collected by this system and transported to the detention basin. A hydraulic analysis was performed to estimate the depth and velocity of flow in the conveyance channels. The Standard Step Backwater Method (TxDOT 2009) was selected to perform this analysis. This method uses an energy balance equation to "step" a water surface elevation along a flow path. This "stepping" proceeds in an upstream direction, which is appropriate for the assumption of subcritical flow. These calculations are described in detail in Section 2.

The Standard Step Backwater Method calculations require the preparation (or identification) of a number of supporting items:

- **Cross Sections:** The standard step backwater method requires a minimum of four cross section locations (TxDOT 2009). For this analysis, eight cross sections were prepared: a cross section at the terminals and approximate mid-point of each reach (as defined by the TR-55 hydrology model [Appendix I of the Final Design Report]). Figure 1 presents the locations of each cross section and Figures 2 through 15 present the cross sections for each location. For the west channel, cross sections were prepared at seven locations: W-2 through W-8 (Figures 4 through 8). For the east channel, cross sections were prepared at an additional seven locations: E-1 through E-7 (Figures 9 through 10). For the purposes of modeling, cross section W-8 was treated as the initial step in the east channel; in addition W-8 was considered to be identical to the cross section at the discharge to the detention basin. Idealized channel geometries used to calculate channel cross-sectional area, wetted perimeters, and hydraulic radii are presented with the calculations (Figures 16 through 23).[1]
- **Manning Roughness Coefficients:** Roughness characteristics were determined by channel design (Section 6.4.1 of the Final Design Report) or assumed to be 0.10 for overbank areas.
- **Discharge Volumes:** Volumetric flow rates at each cross section were estimated from the results of the TR-55 modeling (Appendix I). The TR-55 modeling estimated flow rates for each of the five subbasins comprising the overall area. Subbasins 1, 2 and 3 feed into the east channel; subbasins 4 and 5 feed into the west channel. The TR-55 modeling was performed using design storms with recurrence intervals of 2, 5, 10, and

[1] If the depth from the bottom of the channel to the top of the channel side slope was different than the depth from the bottom of the channel to the average surface elevation of the overbank, the greater depth (i.e., highest elevation) was assumed. This would conservatively estimate friction slope (dominant head loss) due to a smaller K conveyance and thus conservatively estimate the water surface profile. Actual channel overtopping was determined by comparing the depth of water to the depth from the bottom of the channel to the top of the actual side slopes.

25 years that represents 1 inch of precipitation over 24 hours. Tables 1a and b present the results of the TR-55 modeling for each cross section. All cross-sections within a reach were assumed to have equal flow (no discounting of volumes was assumed for upstream locations within a reach).

- **Initial Elevation Control:** The first cross section location (W-8) is located at the outlet of the conveyance system to the detention basin. Because of this, the water surface elevation at this cross section may be controlled by either 1) the elevation of water in the detention basin, or 2) the water surface elevation calculated from flow rates using Manning's equation (assuming uniform flow). HydroCAD modeling (Appendix J of the Final Design Report) was used to estimate the surface water elevations expected to occur in the detention basin. This modeling was performed for design storms with 2-, 5-, 10-, and 25-year recurrence intervals and the 1-inch, 24-hour storm. To determine initial elevation control, the results of the HydroCAD modeling were compared to water surface elevations calculated from the hydraulic channel analysis. The highest elevation was selected as the controlling elevation for the first cross section.

2 BACKWATER CALCULATIONS

The standard step method uses the energy balance equation which allows the water surface elevation at an upstream section to be found from a known water surface elevation at the downstream section:

$$z_2 + d_2 + \alpha_2 V_2^2/2g = z_1 + d_1 + \alpha_1 V_1^2/2g + h_f + \text{other losses}$$

Where:

z = elevation of streambed (ft)

d = depth of flow (ft)

α = kinematic energy coefficient

v = average velocity (ft/second)

h_f = friction loss from upstream to downstream (ft)

g = acceleration due to gravity = 32 ft/second^2

Procedures for completing the standard step procedure.

1. A discharge for each cross section was determined by assuming the reach outlet discharge for each cross section determined from TR-55. Figure 1 indicates the reach used for each cross section and flow rate. A starting water surface elevation (tailwater elevation) was computed by comparing the HydroCAD modeled elevation of the detention basin at its peak and the depth of water at the final section using Manning's Equation (see below), and using whichever is greater.

$$V = (z/n)R^{2/3}S^{1/2}$$

Where:

v = velocity in ft/second

n = Manning's roughness coefficient

R = hydraulic radius (ft) = A/WP

A = cross section area of flow (ft^2)

WP = wetted perimeter (ft)

S = slope of the energy gradeline (ft/ft); assumed uniform, steady flow; therefore, S = channel slope = 0.001 ft/ft.

2. Determine the following for the first cross section (Section E-DB[2] or W-DB depending on the channel):

    a. Z_1 = channel bottom (from associated cross section drawing; e.g. Figure 2).

    b. Y_1 = tailwater elevation minus elevation of the streambed.

    c. Area (A_i), Wetted Perimeter (WP_i) and Hydraulic Radius (R_i) for each subsection (main channel, left overbank and right overbank), and a total Area ($A_t = SA_i$) for the first section.

    d. Conveyance (K_i) for each subsection (main channel, left overbank and right overbank), and a total Conveyance ($K_t = SK_i$) for the first section.

    $$K_i = 0.5A_iR_i^{2/3}/n_i$$

    e. Friction Slope (S_f) for the first section:

    $$S_f = (Q/K_t)^2$$

    f. Kinetic energy coefficient[3] (α) :

    $$\alpha = \{S[K_i(K_i/A_i^2)]\}/ [K_t(K_t/A_t^2)]$$

    g. Velocity of the first section ($Q = V/A_t$)

    h. Velocity head = $\alpha V^2/2g$

3. Complete each calculations for subsequent cross sections:

    a. Assume a water surface elevation.

    b. Area (A_i), Wetted Perimeter (WP_i) and Hydraulic Radius (R_i) for each subsection (main channel, left overbank and right overbank), and a total Area ($A_t = SA_i$) for the section.

---

[2] Cross section W-8 was used for the cross sections as the water enters the detention basin (E-DB or W-DB) as well as the final cross section for both the west (W-8) and east (E-8) channels.

[3] The velocity head based on the average velocity does not give a true measure of the kinetic energy of flow because the velocity distribution varies from the main channel to the overflow banks. The kinetic energy coefficient is taken to have a value of 1.0 in the prismatic channel.

c. Conveyance (K_i) for each subsection (main channel, left overbank and right overbank), and a total Conveyance ($K_t = \Sigma K_i$) for the section. Also calculate an average conveyance between this and the preceding section (K_{ave}).

d. Friction Slope (S_f) for this section and average friction slope between this and the preceding section (S_{ave}).

e. Length between this section and preceding section (L).

f. Friction headloss (h_f) between this section and the preceding section:

$$h_f = S_{ave}L$$

g. Velocity and velocity head for this section.

h. Change in velocity head from this section to the preceding section.

i. Any head losses due to expansion or contraction(H_o)[4]:

$H_o = K\Delta V^2/2b$, where:

K = 0.3 for a gentle expansion; 0.5 for a sudden expansion; 0.1 for a gentle contraction, and 0.3 for a sudden contraction.

j. Change in water surface from preceding section. This equals the preceding section water surface plus the headloss due to friction plus the change in velocity head plus any changes due to expansion or contraction.

k. Computed the water surface at this section. Change assumed water surface until assumed water surface is equal to the computed water surface.

This sequence was completed until all the sections were addressed. A compilation of calculated parameters for each design storm are presented in Tables 2a–b through 6a–b.

[4] Only contraction or expansion due to the channel over-topping its banks were considered, and these expansions or contractions were considered gradual.

3 RESULTS

The detailed results of the step backwater calculations are presented in Figures 16a–h through 25a–i. These figures present the results for each cross section for each design storm. The results for the 25-year recurrence interval storm are presented in Figures 16a–h and 17a–i, for the 10-year recurrence interval storm in Figures 18a–h and 19a–i, for the 5-year recurrence interval storm in Figures 20a–h and 21a–i, for the 2-year recurrence interval storm in Figures 22a–h and 23a–I, and for the 1-inch, 24-hour storm in Figures 24a–h and 25a–i.

For the east channel, none of the flow conditions are expected to result in water surface elevations greater than the elevations of the conveyance channel. As such, the channel is able to convey the entire volume related to storm flows up to the 25-year storm.

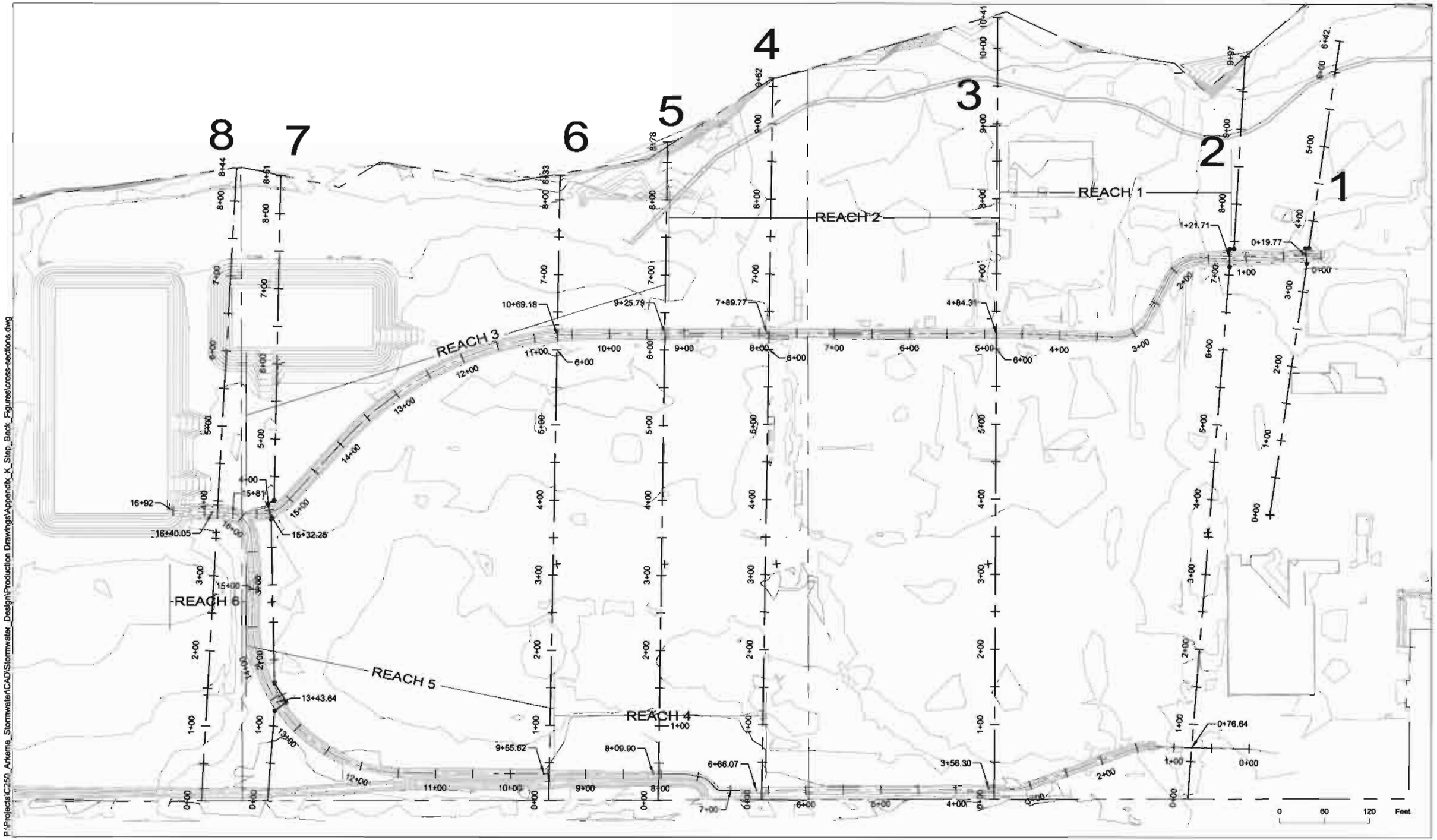
For the west channel, the backwater analysis indicated that storm overbank flow is expected at discharge levels expected for all of the modeled storm events, except the modeled 1-inch, 24-hour storm which is fully contained by both channels. However, this overtopping for the storms is limited to a small "low point" located near former BPA substation. For the 2-year recurrence interval storm, overtopping is predicted at cross sections W-5 and W-4. For the 5-year recurrence interval storm, overtopping is predicted at cross sections W-6, W-5, and W-4. For the 10- and 25-year recurrence interval storms, overtopping is predicted at cross sections W-6 through W-3.

4 REFERENCES

HydroCAD 9.10 (Build 21). Copyright ® 2010 HydroCAD Software Solutions LLC. www.hydrocad.net.

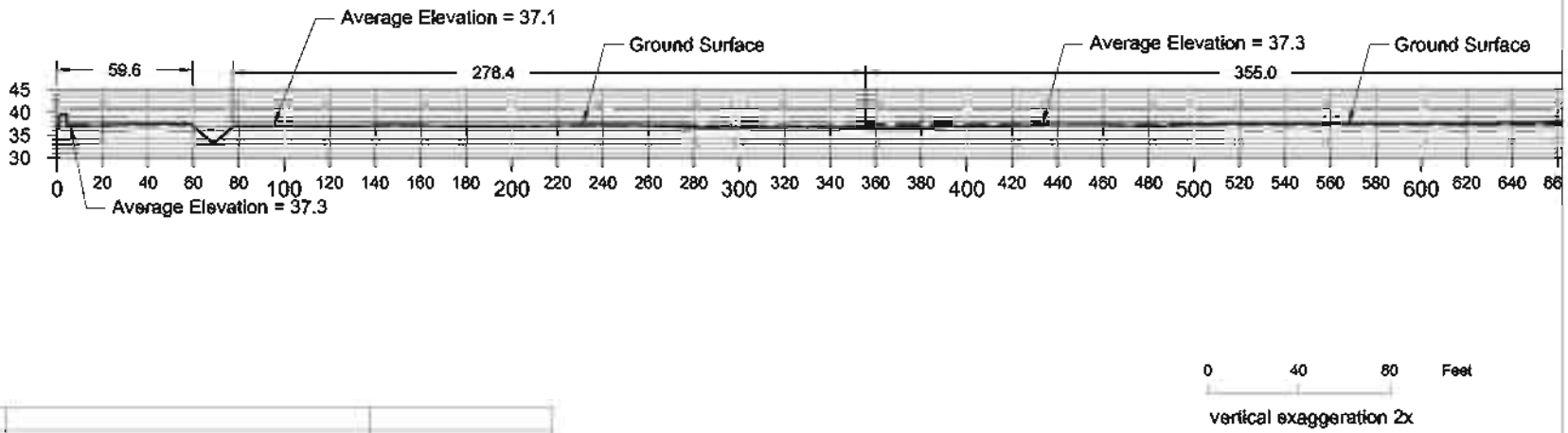
TxDOT. 2009. Hydraulic Design Manual. Available at: http://onlinemanuals.txdot.gov/txdotmanuals/hyd/hyd.pdf. Texas Department of Transportation, Austin, TX. March 2009.

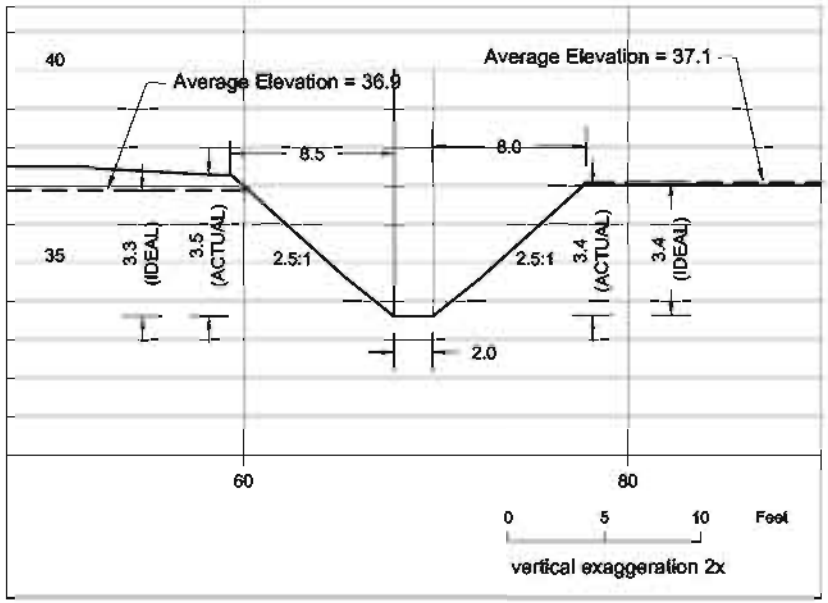
FIGURES



integral

Figure 1
Overview of Cross Section Locations for Standard Step Method
Standard Step Backwater Analysis
Stormwater Source Control Measures

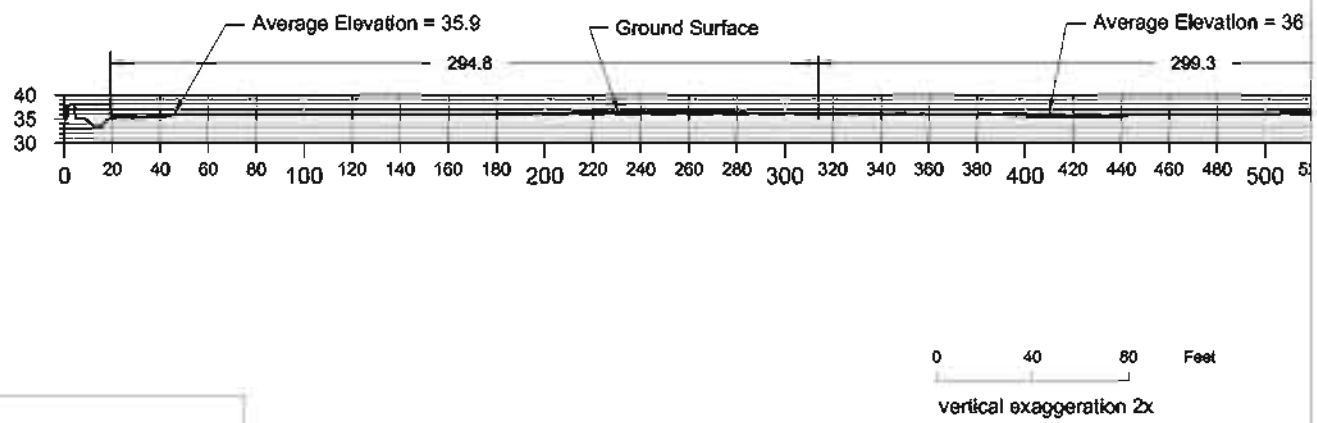


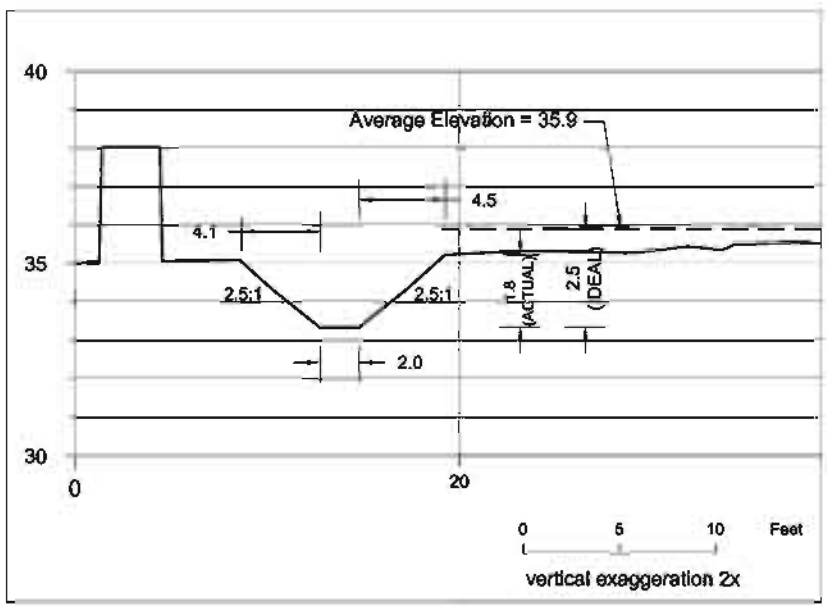


P:\Projects\C250_Arkema_Stormwater\CAD\Stormwater_Design\Production Drawings\Appendix_K_Step_Back_Figures\cross-sections.dwg

integral

Figure 2
West Channel (W-2)
Standard Step Backwater Analysis
Stormwater Source Control Measures

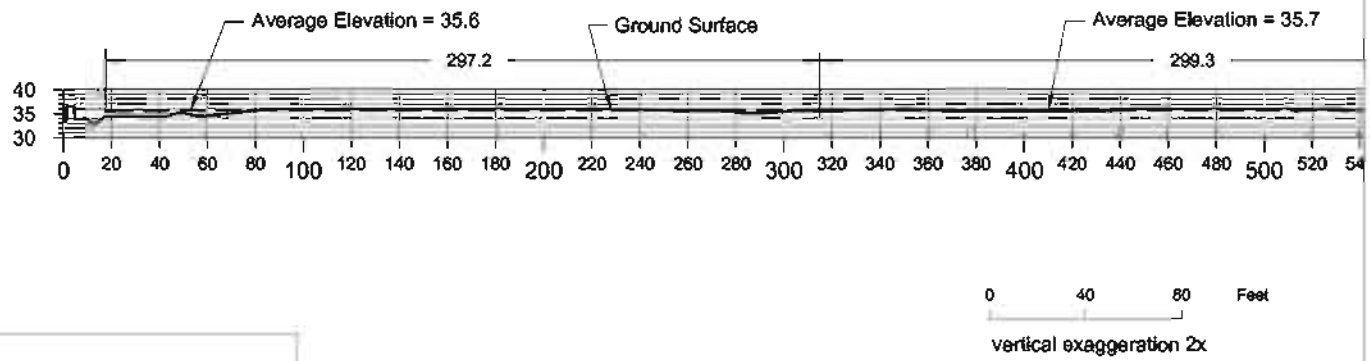


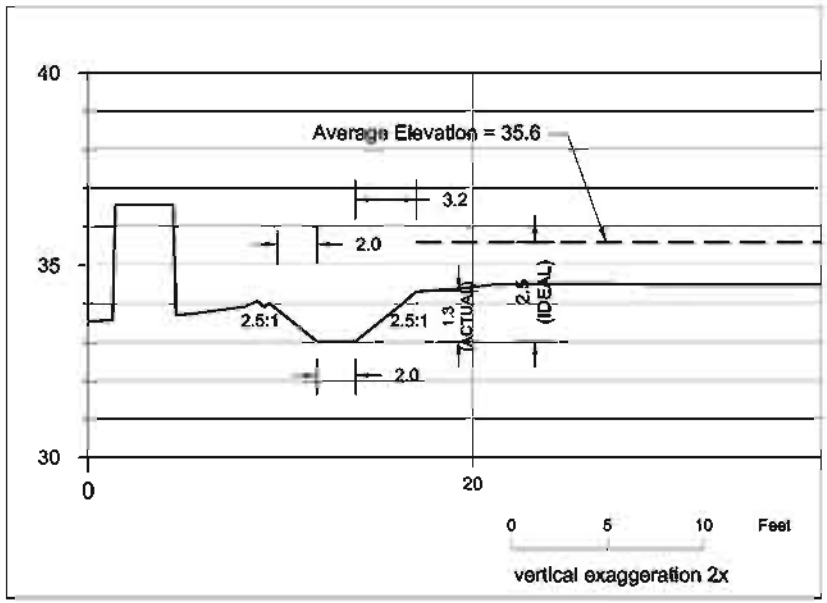


P:\Projects\C250_Arkema_Stormwater\CAD\Stormwater_Design\Production Drawings\Appendix_K_Step_Back_Figures\cross-sections.dwg

integral

Figure 3
West Channel (W-3)
Standard Step Backwater Analysis
Stormwater Source Control Measures

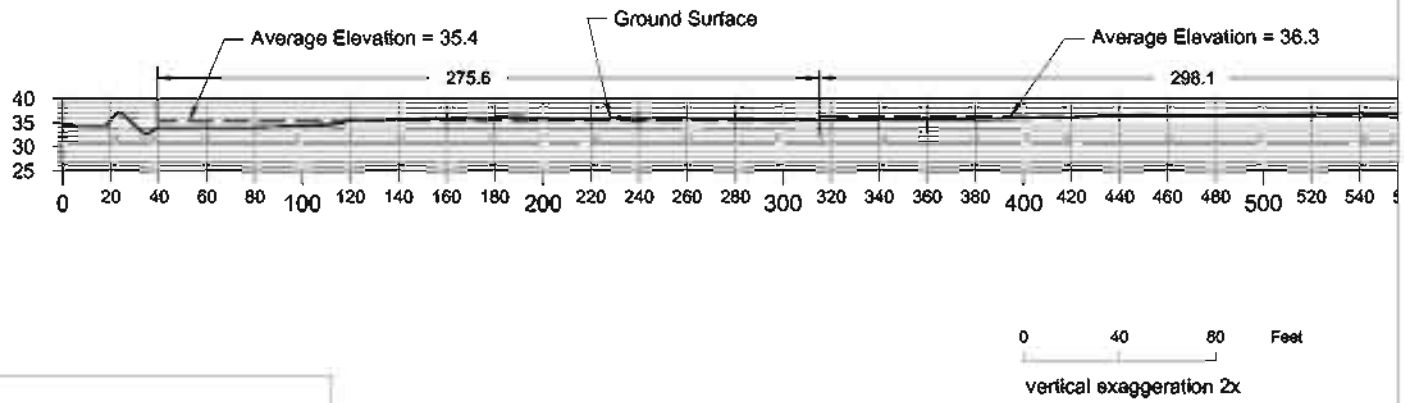


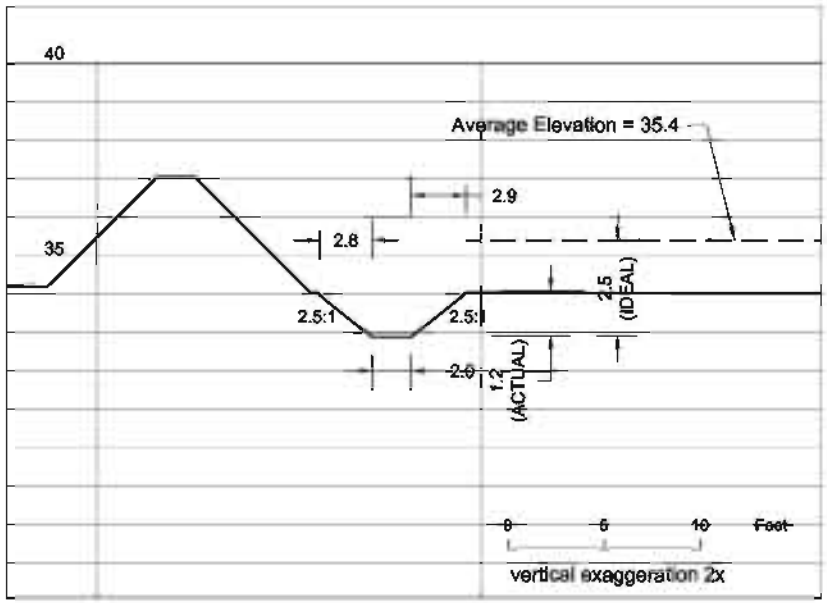


P:\Projects\C250_Arkema_Stormwater\CAD\Stormwater_Design\Production Drawings\Appendix_K_Step_Back_Figures\cross-sections.dwg

integral

Figure 4
West Channel (W-4)
Standard Step Backwater Analysis
Stormwater Source Control Measures

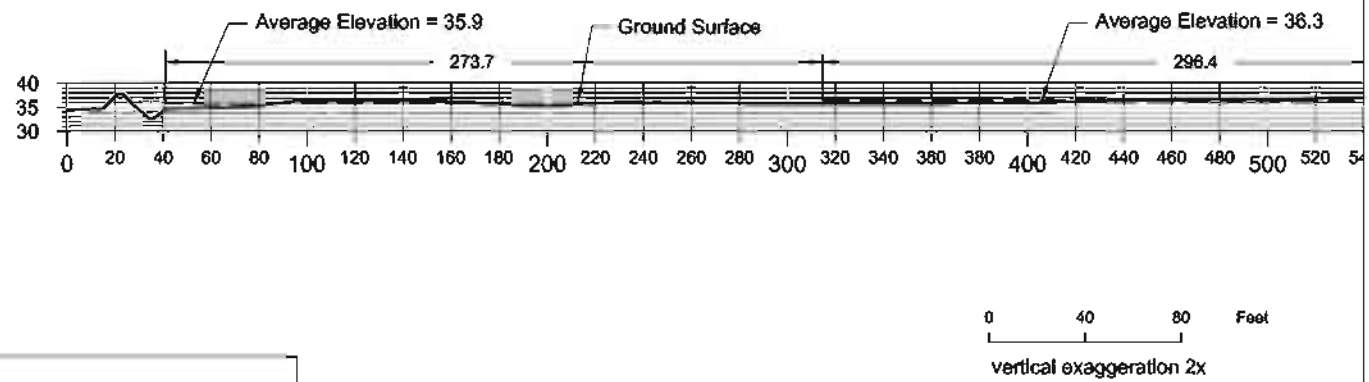


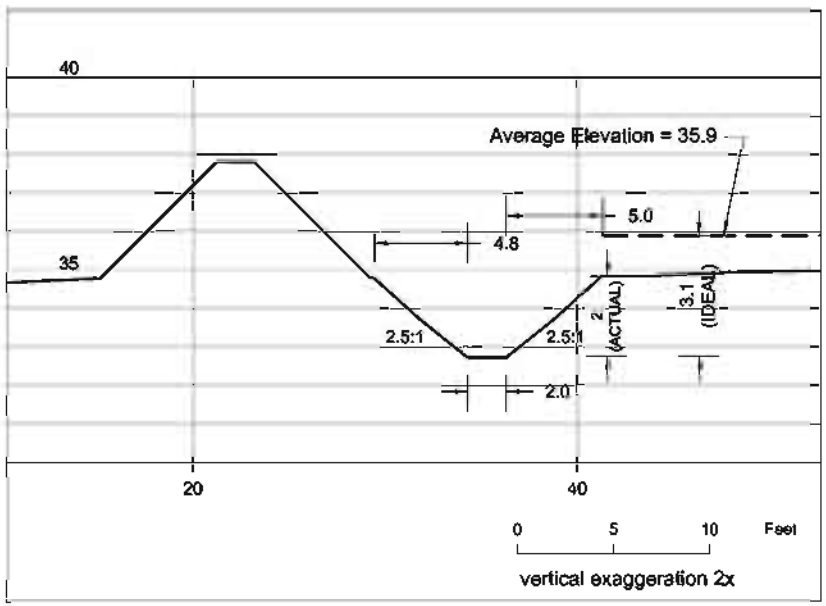


P:\Projects\C250 Arkema Stormwater\CAD\Stormwater Design\Production Drawings\Appendix K Step Back Figures\cross-sections.dwg

integral

Figure 5
West Channel (W-5)
Standard Step Backwater Analysis
Stormwater Source Control Measures

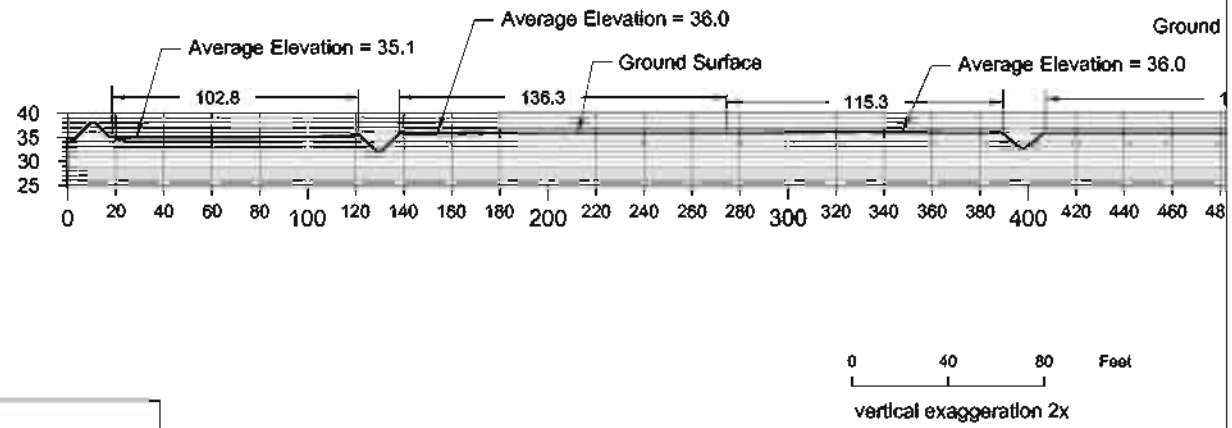


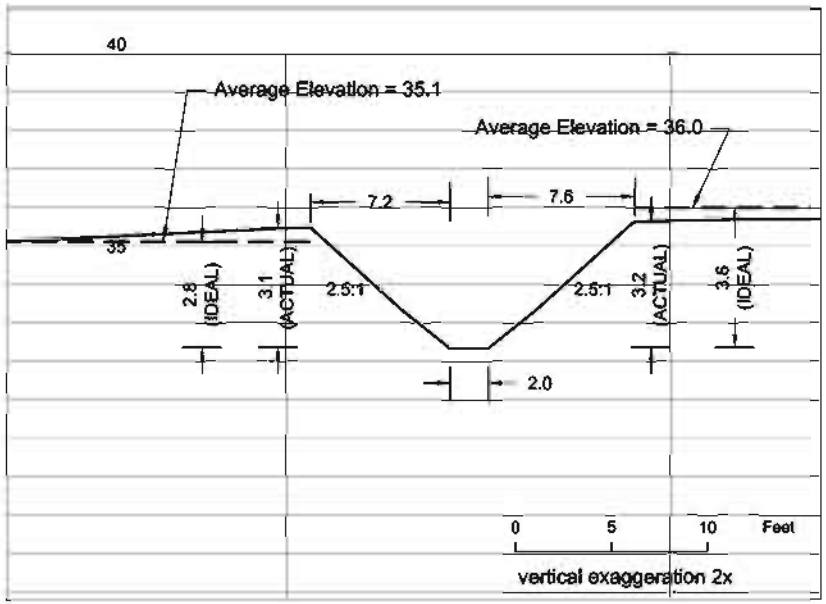


P:\Projects\C250_Arkema_Stormwater\CAD\Stormwater_Design\Production Drawings\Appendix_K_Step_Back_Figures\cross-sections.dwg

integral

Figure 6
West Channel (W-6)
Standard Step Backwater Analysis
Stormwater Source Control Measures

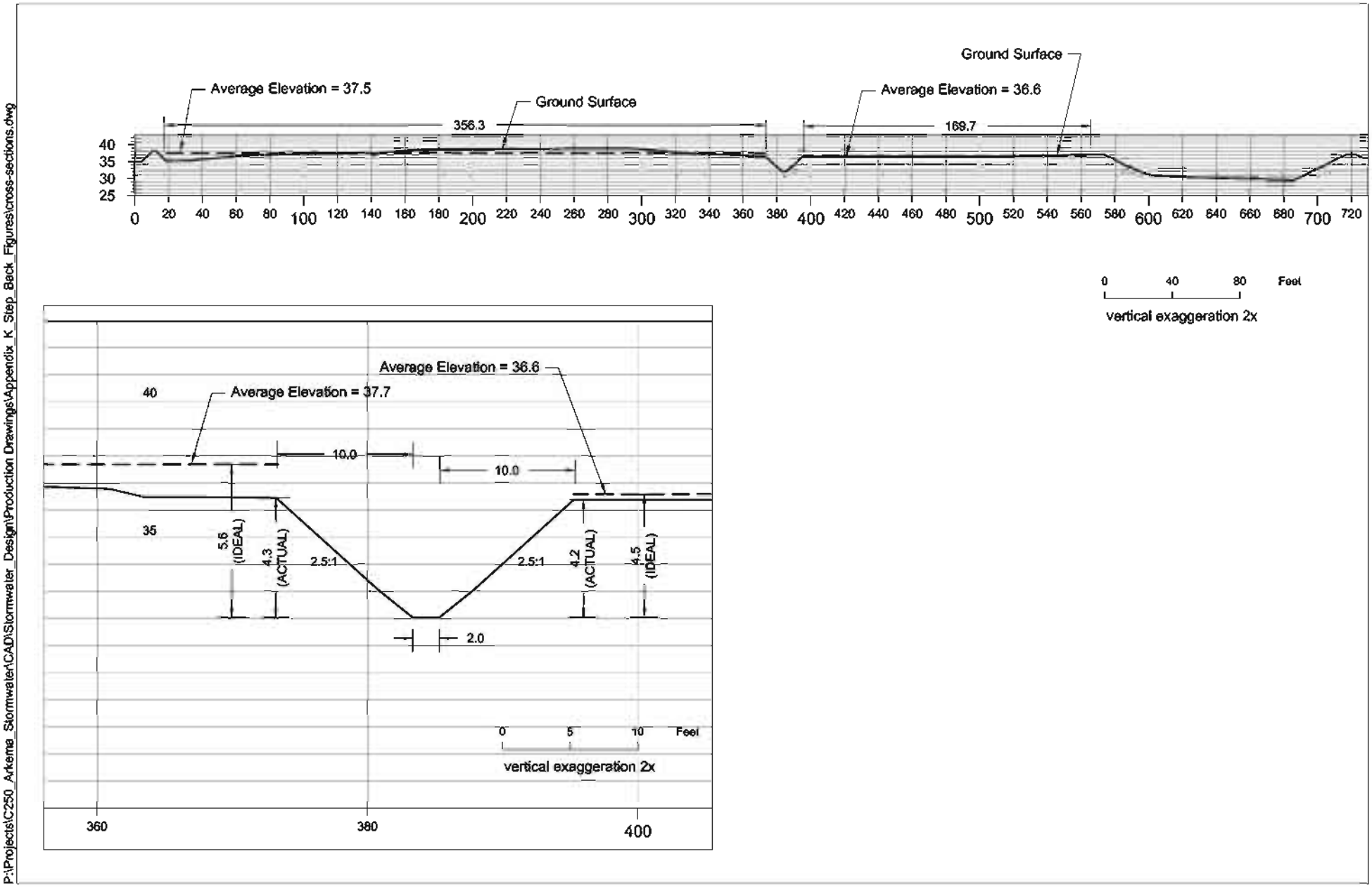




P:\Projects\C250_Arkema_Stormwater\CAD\Stormwater_Design\Production Drawings\Appendix_K_Step_Back_Figures\cross-sections.dwg

integral

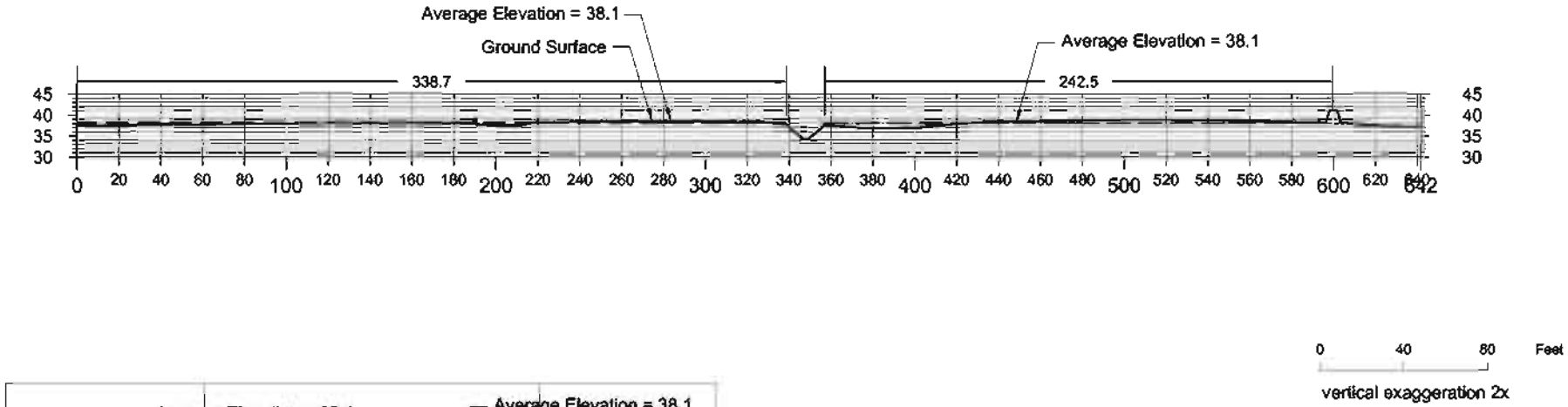
Figure 7
West Channel (W-7)
Standard Step Backwater Analysis
Stormwater Source Control Measures

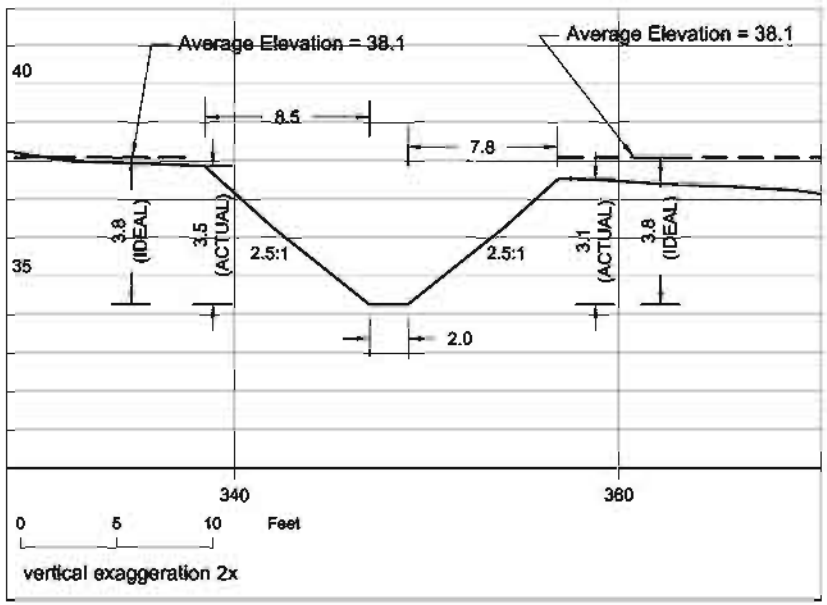


P:\Projects\C250_Arkema_Stormwater\CAD\Stormwater_Design\Production Drawings\Appendix_K_Step_Back_Figures\cross-sections.dwg

integral

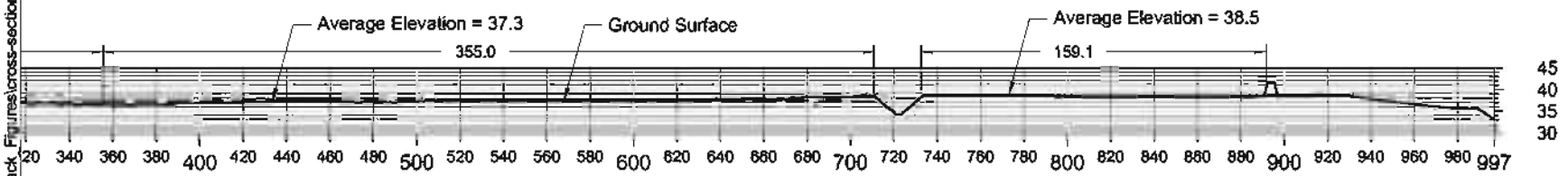
Figure 8
West Channel (W-8)
Standard Step Backwater Analysis
Stormwater Source Control Measures

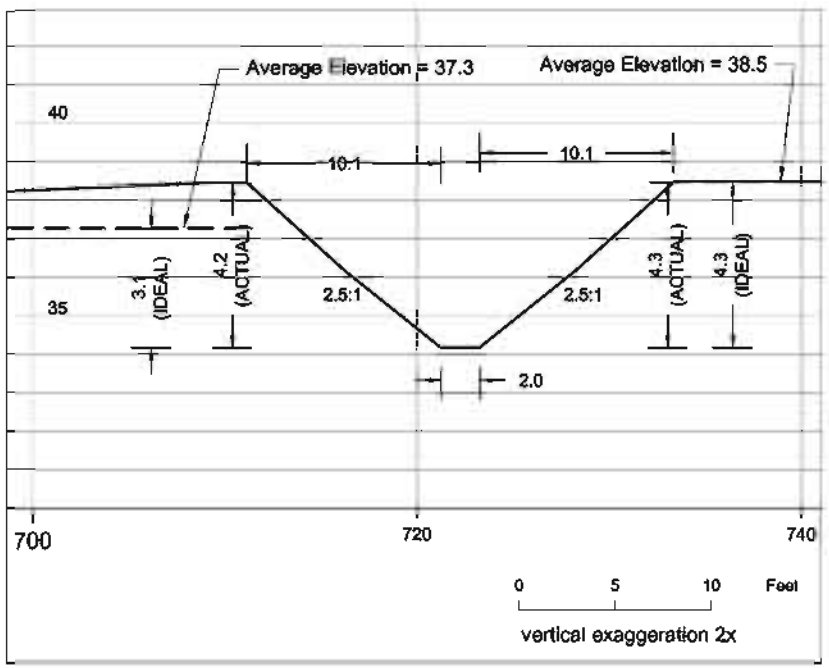




P:\Projects\C250 Arkema Stormwater\CAD\Stormwater Design\Production Drawings\Appendix K Step Back Figures\cross-sections.dwg

Figure 9
East Channel (E-1)
Standard Step Backwater Analysis
Stormwater Source Control Measures





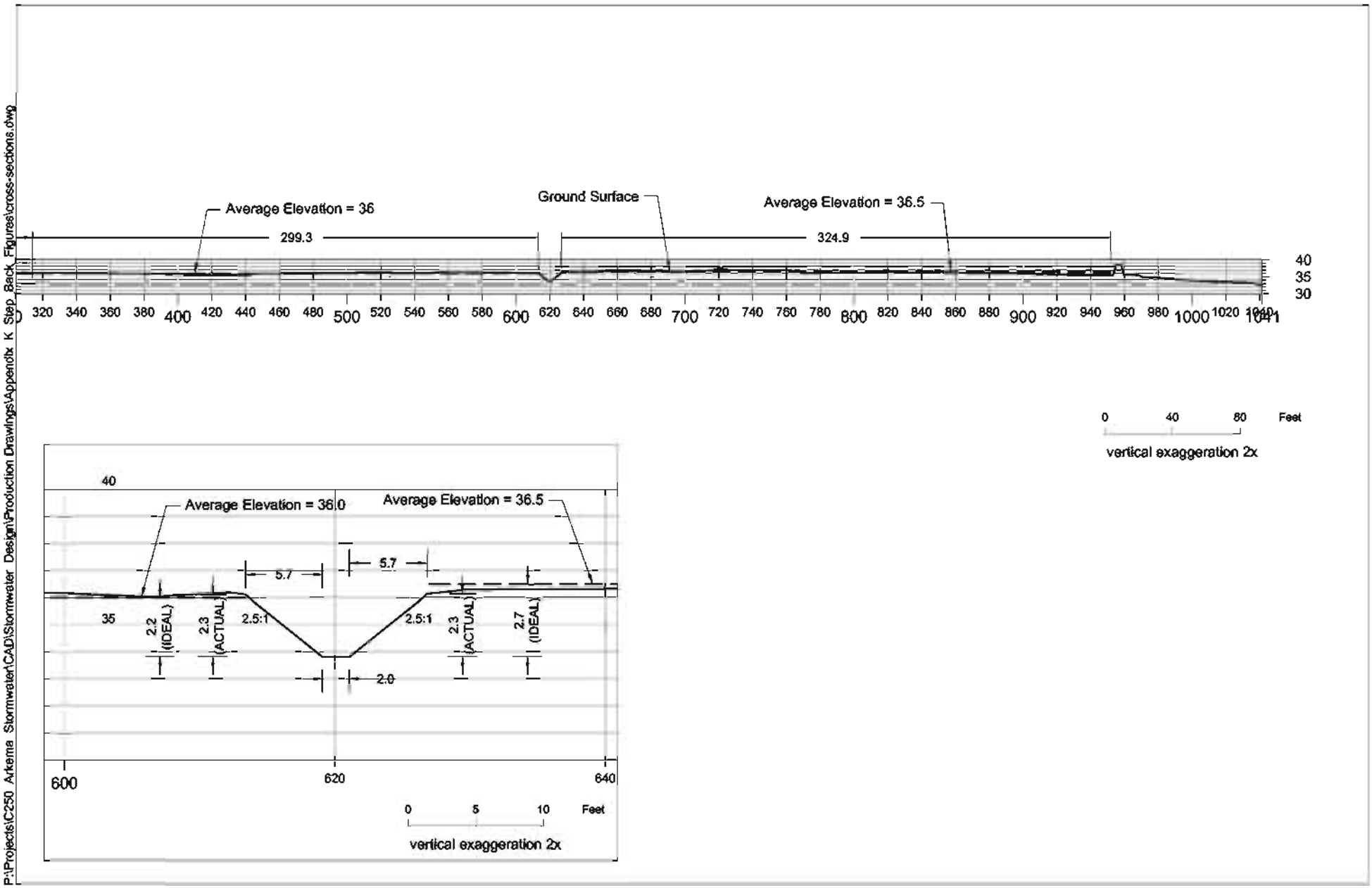
0 40 80 Feet

vertical exaggeration 2x

P:\Projects\C250_Arkema_Stormwater\CAD\Stormwater_Design\Production Drawings\Appendix_K_Step_Back_Figures\cross-sections.dwg

integral

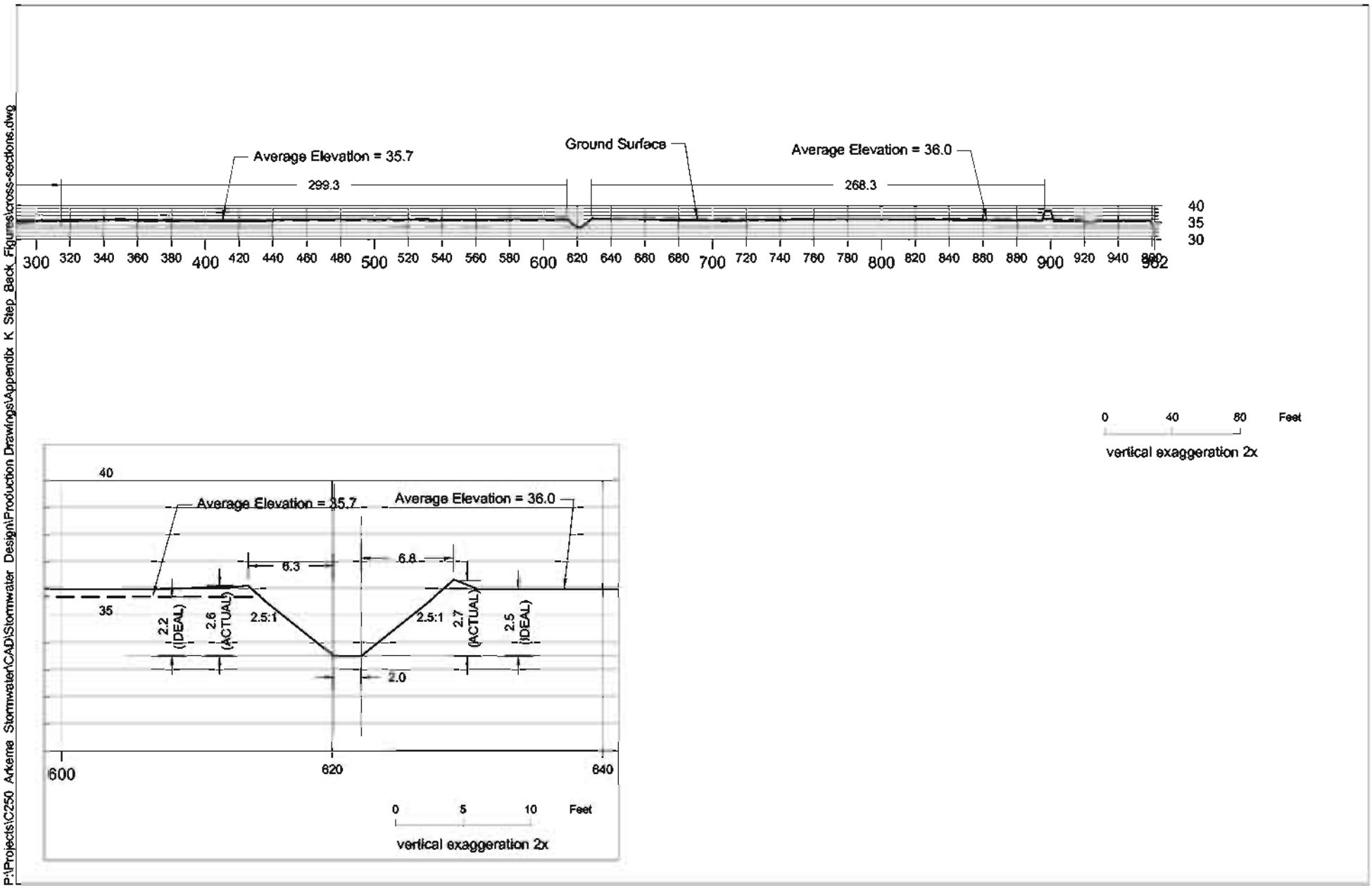
Figure 10
East Channel (E-2)
Standard Step Backwater Analysis
Stormwater Source Control Measures



P:\Projects\C250 Arkema Stormwater\CAD\Stormwater Design\Production Drawings\Appendix K Step Back Figures\cross-sections.dwg

integral

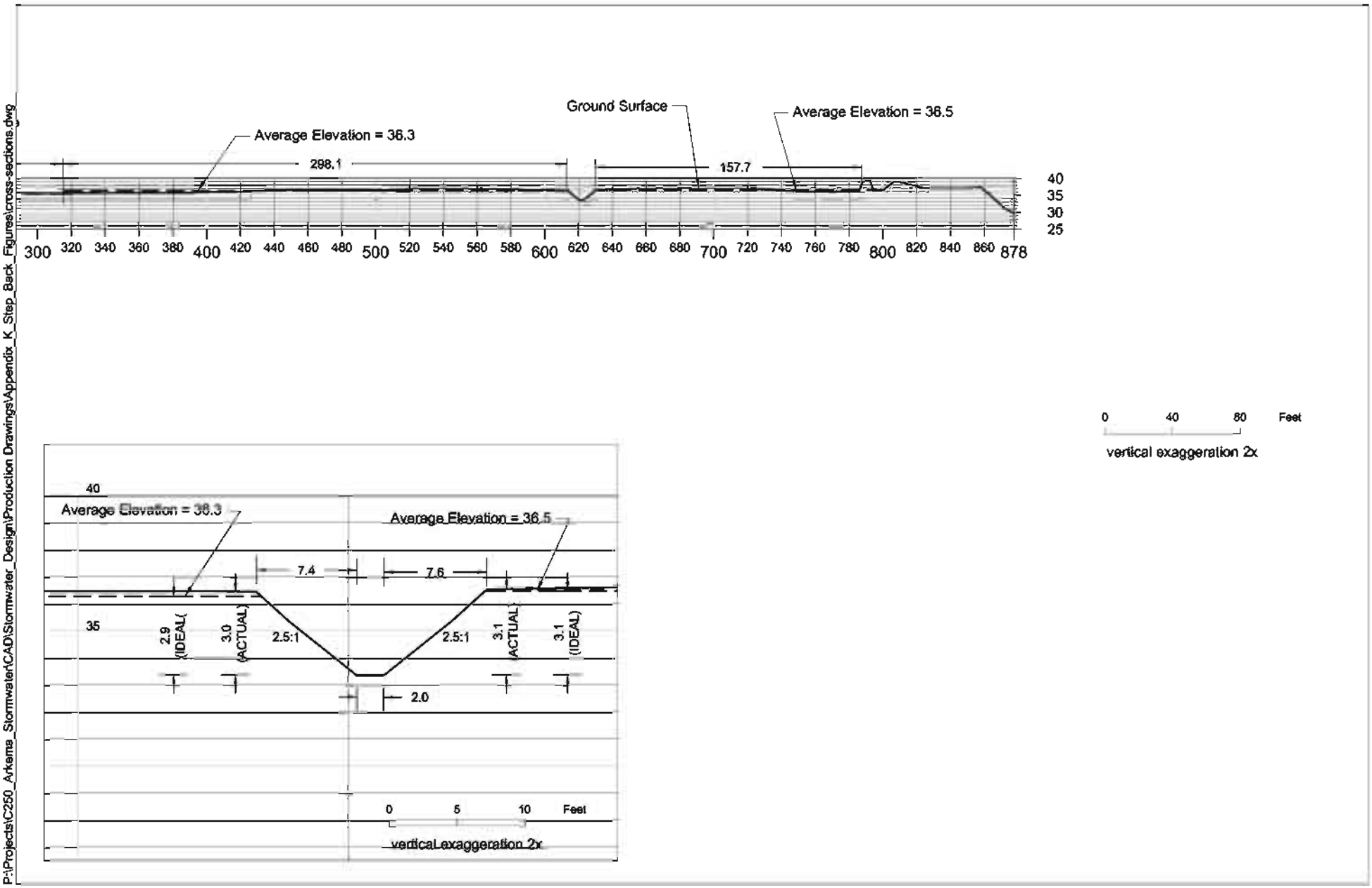
Figure 11
East Channel (E-3)
Standard Step Backwater Analysis
Stormwater Source Control Measures



P:\Projects\C250 Arkema Stormwater\CAD\Stormwater Design\Production Drawings\Appendix K Step Back Figures\cross-sections.dwg

integral

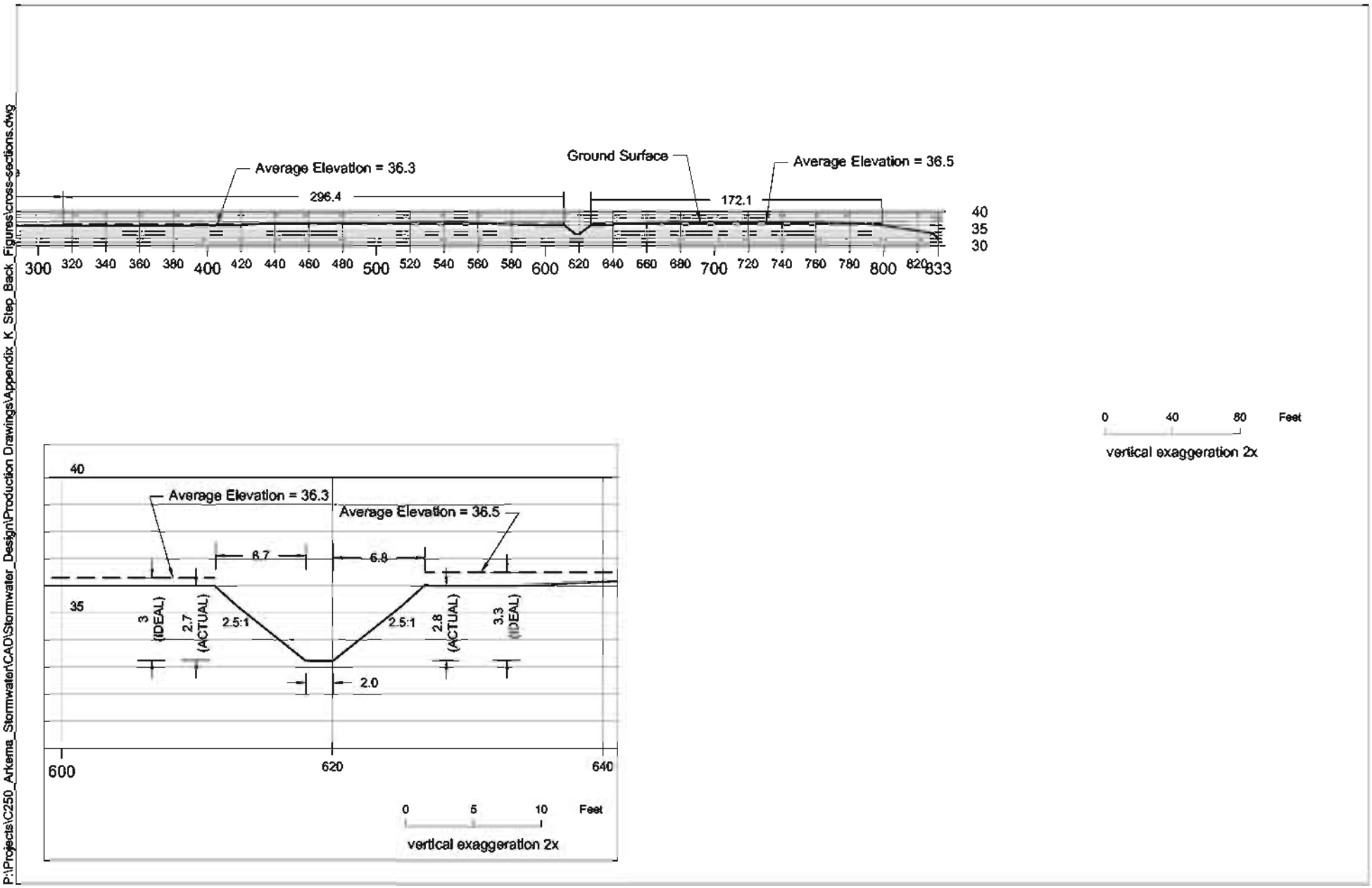
Figure 12
East Channel (E-4)
Standard Step Backwater Analysis
Stormwater Source Control Measures



P:\Projects\C250_Arkema_Stormwater\CAD\Stormwater_Design\Production Drawings\Appendix_K_Step_Back_Figures\cross-sections.dwg

integral

Figure 13
East Channel (E-5)
Standard Step Backwater Analysis
Stormwater Source Control Measures



P:\Projects\C250_Arkema_Stormwater\CAD\Stormwater_Design\Production Drawings\Appendix_K_Step_Back_Figures\cross-sections.dwg

integral

Figure 14
East Channel (E-6)
Standard Step Backwater Analysis
Stormwater Source Control Measures

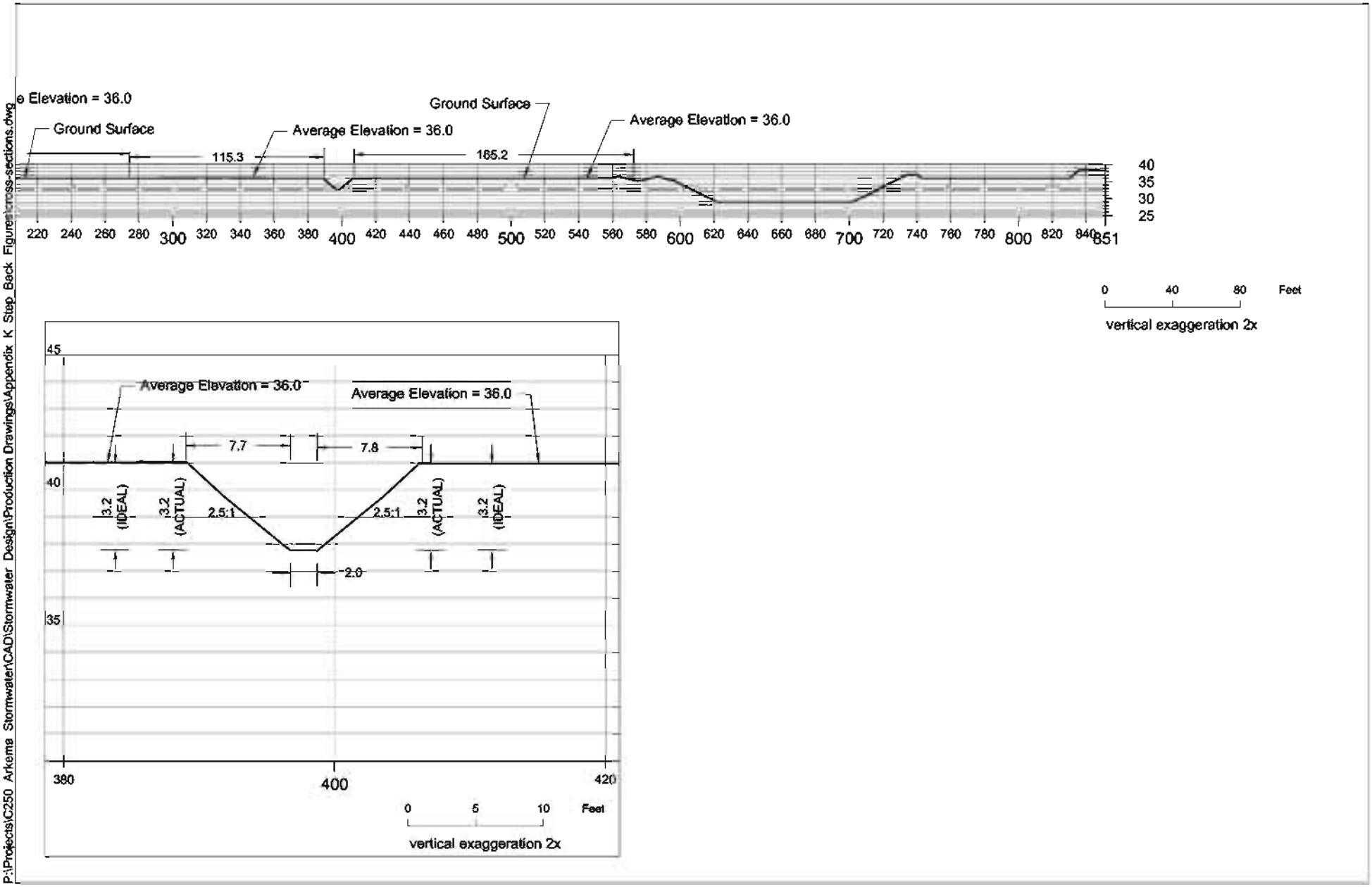


Figure 15
East Channel (E-7)
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

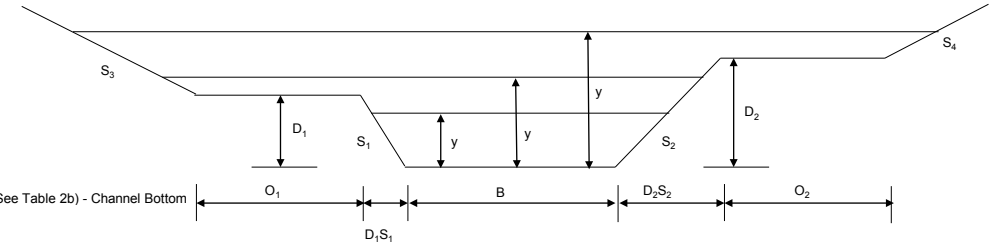
Section: **W-DB** use section W-8 for calculations

Design Storm: **25-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 8
This spreadsheet also calculates the discharge flow (based on Manning's Equation) and compares it to the controlling depth (detention basin, from HydroCAD) to determine which is greater.

Depth, DB	34.98	ft	from HydroCAD Model
Depth, Manning's	35.09	ft	
Controlling Depth	35.09	ft	(max from above)
Freeboard (ft)	2.6	ft	
Did the channel over top?	NO		
Q =	23.00	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.1	ft	(Fig. 8)



Channel Geometry Inputs

y =	2.99	ft	Depth based on computed WS (See Table 2b) - Channel Bottom
B =	2	ft	(Fig. 8)
Actual D1 =	4.2	ft	(Fig. 8)
Actual D2 =	4.3	ft	(Fig. 8)
Idealized D1 =	4.5	ft	(Fig. 8)
Idealized D2 =	5.6	ft	(Fig. 8)
D_1 =	4.5	ft	
D_2 =	5.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 8)
S_2 =	2.5	(ft H / ft V)	(Fig. 8)
O_1 =	169.7	ft	(Fig. 8)
O_2 =	356.3	ft	(Fig. 8)
S_3 =	0	(ft H / ft V)	(Fig. 8)
S_4 =	2	(ft H / ft V)	(Fig. 8)
n1 =	0.078	channel	Channel Design Calcs.
n2 =	0.100	left	(Fig. 8)
n3 =	0.100	right	(Fig. 8)

			Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	T (channel top width at water surface)
A	**For y < D_1**		28.33	18.10	1.565	16.95
		A1	28.33	18.10	1.565	
		A2	0.00	0.00	0.000	
		A3	0.00	0.00	0.000	
B	**For $D_1 \leq y < D_2$**		out of range	out of range	out of range	out of range
		A1	out of range	out of range	out of range	
		A2	out of range	out of range	out of range	
		A3	0	0.00	0.000	
C	**For y (= y_d) ≥ D_2**		out of range	out of range	out of range	out of range
		A1	out of range	out of range	out of range	
		A2	out of range	out of range	out of range	
		A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Discharge Based on Manning's Equation

			Area			Wetted Perimeter				Hydraulic Radius							
Stage	Depth (y)	A,B, C	A1	A2	A3	AT	**WP1**	WP2	WP3	RH1	RH2	RH3	Q1	Q2	Q3	Qt	V
35.09	**2.99**	**A**	**28.330**	**0.000**	**0.000**	**28.330**	**18.102**	**0.000**	**0.000**	**1.565**	**0.000**	**0.000**	**23.007**	**0.000**	**0.000**	**23.007**	**0.812**
34.405	2.305	A	17.893	0.000	0.000	17.893	14.413	0.000	0.000	1.241	0.000	0.000	12.451	0.000	0.000	12.451	0.696
33.9	1.8	A	11.700	0.000	0.000	11.700	11.693	0.000	0.000	1.001	0.000	0.000	7.051	0.000	0.000	7.051	0.603
34	1.9	A	12.825	0.000	0.000	12.825	12.232	0.000	0.000	1.048	0.000	0.000	7.974	0.000	0.000	7.974	0.622
34.1	2	A	14.000	0.000	0.000	14.000	12.770	0.000	0.000	1.096	0.000	0.000	8.967	0.000	0.000	8.967	0.641
34.2	2.1	A	15.225	0.000	0.000	15.225	13.309	0.000	0.000	1.144	0.000	0.000	10.033	0.000	0.000	10.033	0.659
34.3	2.2	A	16.500	0.000	0.000	16.500	13.847	0.000	0.000	1.192	0.000	0.000	11.173	0.000	0.000	11.173	0.677
34.4	2.3	A	17.825	0.000	0.000	17.825	14.386	0.000	0.000	1.239	0.000	0.000	12.388	0.000	0.000	12.388	0.695
34.5	2.4	A	19.200	0.000	0.000	19.200	14.924	0.000	0.000	1.286	0.000	0.000	13.682	0.000	0.000	13.682	0.713
34.6	2.5	A	20.625	0.000	0.000	20.625	15.463	0.000	0.000	1.334	0.000	0.000	15.056	0.000	0.000	15.056	0.730
34.7	2.6	A	22.100	0.000	0.000	22.100	16.001	0.000	0.000	1.381	0.000	0.000	16.512	0.000	0.000	16.512	0.747
34.8	2.7	A	23.625	0.000	0.000	23.625	16.540	0.000	0.000	1.428	0.000	0.000	18.052	0.000	0.000	18.052	0.764
34.9	2.8	A	25.200	0.000	0.000	25.200	17.078	0.000	0.000	1.476	0.000	0.000	19.677	0.000	0.000	19.677	0.781
35	2.9	A	26.825	0.000	0.000	26.825	17.617	0.000	0.000	1.523	0.000	0.000	21.390	0.000	0.000	21.390	0.797
35.1	3	A	28.500	0.000	0.000	28.500	18.155	0.000	0.000	1.570	0.000	0.000	23.191	0.000	0.000	23.191	0.814
35.2	3.1	A	30.225	0.000	0.000	30.225	18.694	0.000	0.000	1.617	0.000	0.000	25.084	0.000	0.000	25.084	0.830

= entered values

integral consulting inc.

Figure 16a
Results of Step Backwater Calculations; West Channel 25-Year Storm, Cross Section W-DB
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

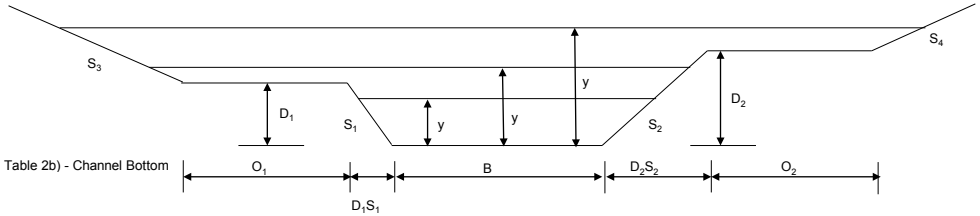
Section: W-8

Design Storm: 25-yr

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 8

Freeboard (ft)	2.6	ft	
Did the channel ov	NO		
Q =	23.00	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.1	ft	(Fig. 8)



Channel Geometry Inputs

y =	3.0	ft	Depth based on assumed WS (See Table 2b) - Channel Bottom
B =	2	ft	(Fig. 8)
Actual D1 =	4.2	ft	(Fig. 8)
Actual D2 =	4.3	ft	(Fig. 8)
Idealized D1 =	4.5	ft	(Fig. 8)
Idealized D2 =	5.6	ft	(Fig. 8)
D_1 =	4.5	ft	
D_2 =	5.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 8)
S_2 =	2.5	(ft H / ft V)	(Fig. 8)
O_1 =	169.7	ft	(Fig. 8)
O_2 =	356.3	ft	(Fig. 8)
S_3 =	0	(ft H / ft V)	(Fig. 8)
S_4 =	2	(ft H / ft V)	(Fig. 8)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.100	left	(Fig. 8)
n3 =	0.100	right	(Fig. 8)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		28.33	18.10	1.565	27.25
	A1	28.33	18.10	1.565	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

Trial and Error

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **38.1772**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
2.99	28.3133025	18.09626	1.565	1.34772465	38.1585

y_n = 2.989

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	23	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 16b

Results of Step Backwater Calculations; West Channel 25-Year Storm, Cross Section W-8
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

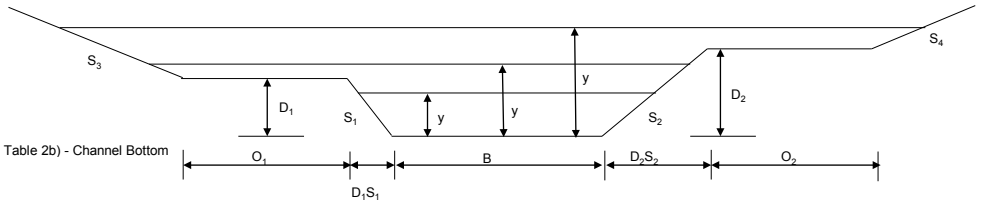
Section: **W-7**

Design Storm: **25-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 7

Freeboard (ft)	0.7	ft	
Did the channel over top?	NO		
Q =	7.12	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.4	ft	(Fig. 7)
Channel Geometry Inputs			
y =	2.9	ft	Depth based on assumed WS (See Table 2b) - Channel Bottom
B =	2	ft	(Fig. 7)
Actual D1 =	3.1	ft	(Fig. 7)
Actual D2 =	3.2	ft	(Fig. 7)
Idealized D1 =	2.8	ft	(Fig. 7)
Idealized D2 =	3.6	ft	(Fig. 7)
D_1 =	3.1	ft	
D_2 =	3.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 7)
S_2 =	2.5	(ft H / ft V)	(Fig. 7)
O_1 =	102.8	ft	(Fig. 7)
O_2 =	136.3	ft	(Fig. 7)
S_3 =	2	(ft H / ft V)	(Fig. 7)
S_4 =	0	(ft H / ft V)	(Fig. 7)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 7)
n3 =	0.1	right	(Fig. 7)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		26.01	17.35	1.499	18.75
	A1	26.01	17.35	1.499	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **11.8183**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.81	11.7771225	11.73099	1.004	1.00261981	11.8080

y_n = 1.807

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	7.12	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 16c

Results of Step Backwater Calculations; West Channel 25-Year Storm, Cross Section W-7
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

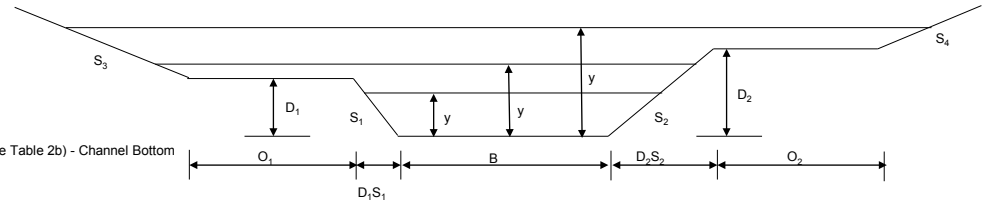
Section: **W-6**

Design Storm: **25-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 6

Freeboard (ft)	0.5	ft	
Did the channel over top?	YES		
Q =	3.01	cfs	
S_0 =	0.001	ft/ft	
α =	1.02018926		
Channel Bottom	32.8	ft	(Fig. 6)
Channel Geometry Inputs			
y =	2.5	ft	Depth based on assumed WS (See Table 2b) - Channel Bottom
B =	2	ft	(Fig. 6)
Actual D1 =	1.92	ft	(Fig. 6)
Actual D2 =	2	ft	(Fig. 6)



Idealized D1 =	1.92	ft	(Fig. 6)
Idealized D2 =	3	ft	(Fig. 6)
D_1 =	1.9	ft	(Fig. 6)
D_2 =	3	ft	(Fig. 6)
S_1 =	2.5	(ft H / ft V)	(Fig. 6)
S_2 =	2.5	(ft H / ft V)	(Fig. 6)
O_1 =	0	ft	(Fig. 6)
O_2 =	273.7	ft	(Fig. 6)
S_3 =	2	(ft H / ft V)	(Fig. 6)
S_4 =	0	(ft H / ft V)	(Fig. 6)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 6)
n3 =	0.1	right	(Fig. 6)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		20.2576	15.10	1.342	15.42
	A1	19.944	13.85	1.440	
	A2	0.3136	1.25	0.250	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **4.9962**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.23	6.20969	8.602212	0.722	0.80471084	4.9970

y_n = 1.226

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	3.01	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 16d

Results of Step Backwater Calculations; West Channel 25-Year Storm, Cross Section W-6
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

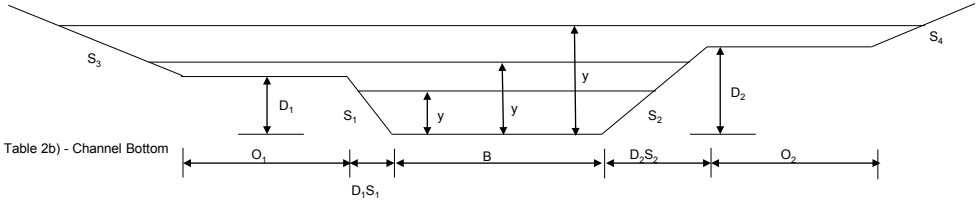
Section: **W-5**

Design Storm: **25-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 5

Freeboard (ft)	0.1	ft	
Did the channel over top?	YES		
Q =	3.01	cfs	
S_0 =	0.001	ft/ft	
α =	1.09391845		
Channel Bottom	32.9	ft	(Fig. 5)



Channel Geometry Inputs

y =	2.4	ft	Depth based on assumed WS (See Table 2b) - Channel Bottom
B =	2	ft	(Fig. 5)
Actual D1 =	1.12	ft	(Fig. 5)
Actual D2 =	1.2	ft	(Fig. 5)
Idealized D1 =	1.12	ft	(Fig. 5)
Idealized D2 =	2.5	ft	(Fig. 5)
D_1 =	1.12	ft	(Fig. 5)
D_2 =	2.5	ft	(Fig. 5)
S_1 =	2.5	(ft H / ft V)	(Fig. 5)
S_2 =	2.5	(ft H / ft V)	(Fig. 5)
O_1 =	0	ft	(Fig. 5)
O_2 =	275.6	ft	(Fig. 5)
S_3 =	2	(ft H / ft V)	(Fig. 5)
S_4 =	0	(ft H / ft V)	(Fig. 5)
n1 =	0.064	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 5)
n3 =	0.1	right	(Fig. 5)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		18.5241	14.24	1.301	13.57
	A1	16.9365	11.42	1.483	
	A2	1.5876	2.82	0.563	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **4.0995**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.12	5.3532225	8.015229	0.668	0.76406957	4.0902

y_n = 1.117

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.6844	3.01	2.5398084	0.6844169	9.86

y_c = 0.68

Figure 16e

Results of Step Backwater Calculations; West Channel 25-Year Storm, Cross Section W-5
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

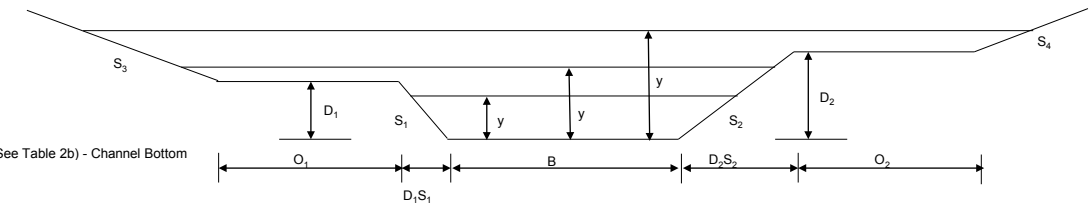
Section: **W-4**

Design Storm: **25-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 4

Freeboard (ft)	0.3	ft	
Did the channel over top?	YES		
Q =	3.01	cfs	
S_0 =	0.001	ft/ft	
α =	1.181		
Channel Bottom	33.1	ft	(Fig. 4)
Channel Geometry Inputs			
y =	2.190	ft	Depth based on assumed WS (See Table 2b) - Channel Bottom
B =	2	ft	(Fig. 4)
Actual D1 =	0.8	ft	(Fig. 4)
Actual D2 =	1.3	ft	(Fig. 4)
Idealized D1 =	0.8	ft	(Fig. 4)
Idealized D2 =	2.5	ft	(Fig. 4)
D_1 =	0.8	ft	(Fig. 4)
D_2 =	2.5	ft	(Fig. 4)
S_1 =	2.5	(ft H / ft V)	(Fig. 4)
S_2 =	2.5	(ft H / ft V)	(Fig. 4)
O_1 =	5	ft	(Fig. 4)
O_2 =	297.2	ft	(Fig. 4)
S_3 =	0.0001	(ft H / ft V)	(Fig. 4)
S_4 =	0	(ft H / ft V)	(Fig. 4)
n1 =	0.064	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 4)
n3 =	0.1	right	(Fig. 4)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		20.90522161	16.44	1.272	15.25
	A1	13.955125	10.05	1.388	
	A2	6.950	6.39	1.088	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	0.000000001	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **4.0995**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.08	6.36630514	12.33836	0.516	0.64330948	4.0955

y_n = 1.079

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.6844	3.01	2.5398084	0.6844169	9.86

y_c = 0.68

Figure 16f

Results of Step Backwater Calculations; West Channel 25-Year Storm, Cross Section W-4
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

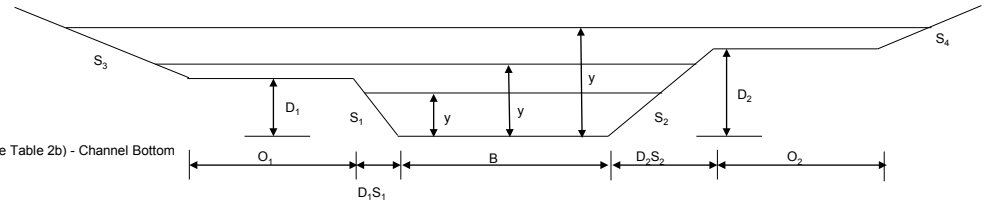
Section: **W-3**

Design Storm: **25-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 3

Freeboard (ft)	0.6	ft	
Did the channel over top?	YES		
Q =	3.01	cfs	
S_0 =	0.001	ft/ft	
α =	1.133		
Channel Bottom	33.4	ft	(Fig. 3)
Channel Geometry Inputs			
y =	1.9	ft	Depth based on assumed WS (See Table 2b) - Channel Bottom
B =	2	ft	(Fig. 3)
Actual D1 =	1.64	ft	(Fig. 3)
Actual D2 =	1.8	ft	(Fig. 3)
Idealized D1 =	1.64	ft	(Fig. 3)
Idealized D2 =	2.5	ft	(Fig. 3)
D_1 =	1.64	ft	
D_2 =	2.5	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 3)
S_2 =	2.5	(ft H / ft V)	(Fig. 3)
O_1 =	4.2	ft	(Fig. 3)
O_2 =	294.8	ft	(Fig. 3)
S_3 =	0.0001	(ft H / ft V)	(Fig. 3)
S_4 =	0	(ft H / ft V)	(Fig. 3)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 3)
n3 =	0.1	right	(Fig. 3)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		13.83250338	15.99	0.865	16.55
	A1	12.7405	11.53	1.105	
	A2	1.09200338	4.46	0.245	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **2.7543**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.93	4.0023225	6.992048	0.572	0.68940082	2.7592

y_n = 0.927

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	3.01	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 16g

Results of Step Backwater Calculations; West Channel 25-Year Storm, Cross Section W-3
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

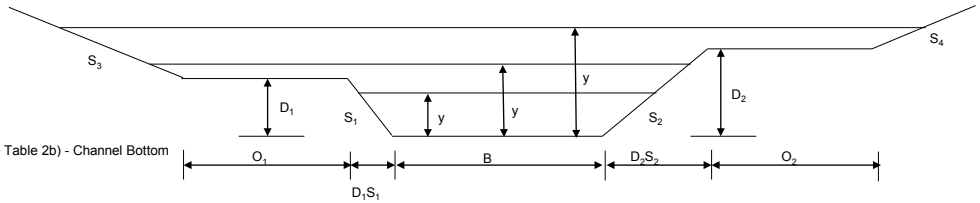
Section: **W-2**

Design Storm: **25-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 2

Freeboard (ft)	1.9	ft	
Did the channel over top?	NO		
Q =	3.01	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	33.7	ft	(Fig. 2)
Channel Geometry Inputs			
y =	1.6	ft	Depth based on assumed WS (See Table 2b) - Channel Bottom
B =	2	ft	(Fig. 2)
Actual D1 =	3.4	ft	(Fig. 2)
Actual D2 =	3.5	ft	(Fig. 2)
Idealized D1 =	3.4	ft	(Fig. 2)
Idealized D2 =	3.3	ft	(Fig. 2)
D_1 =	3.4	ft	
D_2 =	3.5	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 2)
S_2 =	2.5	(ft H / ft V)	(Fig. 2)
O_1 =	278.4	ft	(Fig. 2)
O_2 =	59.6	ft	(Fig. 2)
S_3 =	0	(ft H / ft V)	(Fig. 2)
S_4 =	0.0001	(ft H / ft V)	(Fig. 2)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 2)
n3 =	0.1	right	(Fig. 2)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		9.80	10.72	0.914	19.25
	A1	9.80	10.72	0.914	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **2.7543**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.93	4.0023225	6.992048	0.572	0.68940082	2.7592

y_n = 0.927

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	3.01	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 16h

Results of Step Backwater Calculations; West Channel 25-Year Storm, Cross Section W-2
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

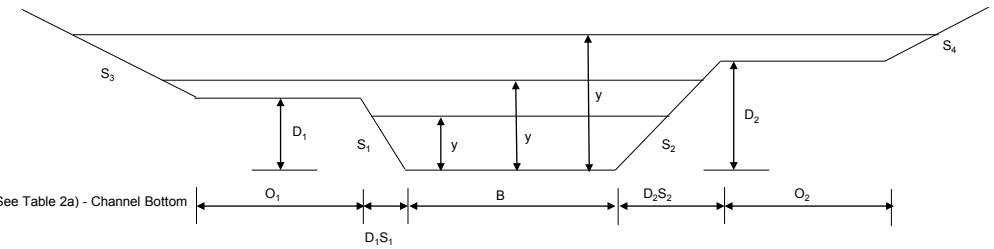
Section: **E-DB** use section W-8 for calculations

Design Storm: **25-yr** (25-yr,10-yr,5-yr,2-yr)

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 8
This spreadsheet also calculates the discharge flow (based on Manning's Equation) and compares it to the controlling depth (detention basin, from HydroCAD) to determine which is greater.

Depth, DB	34.98	ft	from HydroCAD Model
Depth, Manning's	35.29	ft	
Controlling Depth	35.29	ft	(max from above)
Freeboard (ft)	2.4	ft	
Did the channel over top?	NO		
Q =	26.85	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.1	ft	(Fig. 8)



Channel Geometry Inputs

y =	3.19	ft	Depth based on computed WS (See Table 2a) - Channel Bottom
B =	2	ft	(Fig. 8)
Actual D1 =	4.2	ft	(Fig. 8)
Actual D2 =	4.3	ft	(Fig. 8)
Idealized D1 =	4.5	ft	(Fig. 8)
Idealized D2 =	5.6	ft	(Fig. 8)
D_1 =	4.5	ft	
D_2 =	5.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 8)
S_2 =	2.5	(ft H / ft V)	(Fig. 8)
O_1 =	169.7	ft	(Fig. 8)
O_2 =	356.3	ft	(Fig. 8)
S_3 =	0	(ft H / ft V)	(Fig. 8)
S_4 =	2	(ft H / ft V)	(Fig. 8)
n1 =	0.078	channel	Channel Design Calcs.
n2 =	0.100	left	(Fig. 8)
n3 =	0.100	right	(Fig. 8)

			Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	T (channel top width at water surface)
A	**For y < D_1**		31.82	19.18	1.659	17.95
		A1	31.82	19.18	1.659	
		A2	0.00	0.00	0.000	
		A3	0.00	0.00	0.000	
B	**For $D_1 \le y < D_2$**		out of range	out of range	out of range	out of range
		A1	out of range	out of range	out of range	
		A2	out of range	out of range	out of range	
		A3	0	0.00	0.000	
C	**For y (= y_d) ≥ D_2**		out of range	out of range	out of range	out of range
		A1	out of range	out of range	out of range	
		A2	out of range	out of range	out of range	
		A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Discharge Based on Manning's Equation

			Area			Wetted Perimeter				Hydraulic Radius							
Stage	Depth (y)	A,B, C	A1	A2	A3	AT	**WP1**	WP2	WP3	RH1	RH2	RH3	Q1	Q2	Q3	Qt	V
35.29	**3.19**	**A**	**31.820**	**0.000**	**0.000**	**31.820**	**19.179**	**0.000**	**0.000**	**1.659**	**0.000**	**0.000**	**26.867**	**0.000**	**0.000**	**26.867**	**0.844**
35.79	3.69	A	41.420	0.000	0.000	41.420	21.871	0.000	0.000	1.894	0.000	0.000	38.197	0.000	0.000	38.197	0.922
36.29	4.19	A	52.270	0.000	0.000	52.270	24.564	0.000	0.000	2.128	0.000	0.000	52.098	0.000	0.000	52.098	0.997
36.79	4.69	B	64.325	32.243	0.000	96.568	26.745	169.890	0.000	2.405	0.190	0.000	69.566	5.004	0.000	74.570	0.772
37.29	5.19	B	77.125	117.093	0.000	194.218	28.091	170.390	0.000	2.746	0.687	0.000	91.104	42.849	0.000	133.953	0.690
35.2	3.1	A	30.225	0.000	0.000	30.225	18.694	0.000	0.000	1.617	0.000	0.000	25.084	0.000	0.000	25.084	0.830
34.7	2.6	A	22.100	0.000	0.000	22.100	16.001	0.000	0.000	1.381	0.000	0.000	16.512	0.000	0.000	16.512	0.747
34.76	2.66	A	23.009	0.000	0.000	23.009	16.325	0.000	0.000	1.409	0.000	0.000	17.426	0.000	0.000	17.426	0.757
35.26	3.16	A	31.284	0.000	0.000	31.284	19.017	0.000	0.000	1.645	0.000	0.000	26.264	0.000	0.000	26.264	0.840
35.76	3.66	A	40.809	0.000	0.000	40.809	21.710	0.000	0.000	1.880	0.000	0.000	37.447	0.000	0.000	37.447	0.918
36.26	4.16	A	51.584	0.000	0.000	51.584	24.402	0.000	0.000	2.114	0.000	0.000	51.187	0.000	0.000	51.187	0.992
36.76	4.66	B	63.577	27.152	0.000	90.729	26.664	169.860	0.000	2.384	0.160	0.000	68.361	3.758	0.000	72.119	0.795
37.26	5.16	B	76.339	112.002	0.000	188.341	28.010	170.360	0.000	2.725	0.657	0.000	89.735	39.794	0.000	129.529	0.688
37.76	5.66	C	89.722	196.852	21.382	307.956	29.195	170.860	356.434	3.073	1.152	0.060	114.258	101.662	1.540	217.460	0.706
38.26	6.16	C	103.348	281.702	199.842	584.891	29.195	171.360	357.552	3.540	1.644	0.559	144.616	184.386	63.719	392.722	0.671
38.76	6.66	C	116.973	366.552	378.802	862.326	29.195	171.860	358.670	4.007	2.133	1.056	177.770	285.405	184.604	647.779	0.751

[ ] = entered values

Figure 17a
Results of Step Backwater Calculations; East Channel, 25-Year Storm, Cross Section E-DB
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

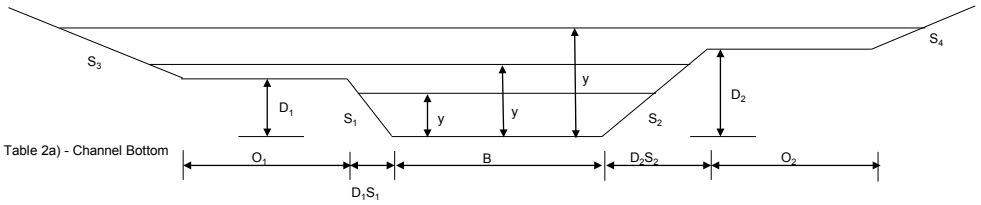
Section: **E-8 (W-8)**

Design Storm: **25-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 8

Freeboard (ft)	2.4	ft	
Did the channel over top?	NO		
Q =	26.85	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.1	ft	(Fig. 8)



Channel Geometry Inputs

y =	3.2	ft	Depth based on assumed WS (See Table 2a) - Channel Bottom
B =	2	ft	(Fig. 8)
Actual D1 =	4.2	ft	(Fig. 8)
Actual D2 =	4.3	ft	(Fig. 8)
Idealized D1 =	4.5	ft	(Fig. 8)
Idealized D2 =	5.6	ft	(Fig. 8)
D_1 =	4.5	ft	
D_2 =	5.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 8)
S_2 =	2.5	(ft H / ft V)	(Fig. 8)
O_1 =	169.7	ft	(Fig. 8)
O_2 =	356.3	ft	(Fig. 8)
S_3 =	0	(ft H / ft V)	(Fig. 8)
S_4 =	2	(ft H / ft V)	(Fig. 8)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.100	left	(Fig. 8)
n3 =	0.100	right	(Fig. 8)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		31.82	19.18	1.659	27.25
	A1	31.82	19.18	1.659	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **44.5677**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
3.19	31.82025	19.17868	1.659	1.40148993	44.5958

y_n = 3.190

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	26.85	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 17b

Results of Step Backwater Calculations; East Channel, 25-Year Storm, Cross Section E-8 (W-8)
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

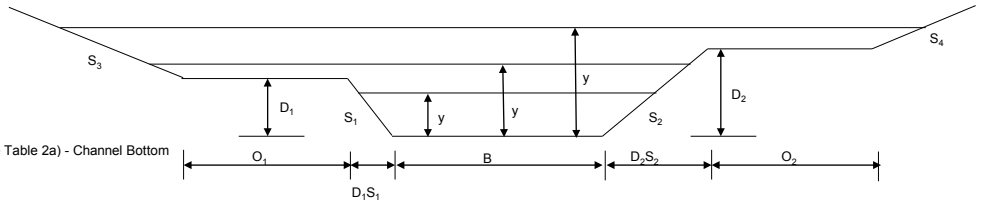
Section: **E-7**

Design Storm: **25-yr**

Calculated by: JG
Date: 9/19/2009
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 15

Freeboard (ft)	0.6	ft	
Did the channel over top?	NO		
Q =	15.88	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.8	ft	(Fig. 15)
Channel Geometry Inputs			
y =	2.6	ft	Depth based on assumed WS (See Table 2a) - Channel Bottom
B =	2	ft	(Fig. 15)
Actual D1 =	3.2	ft	(Fig. 15)
Actual D2 =	3.2	ft	(Fig. 15)
Idealized D1 =	3.2	ft	(Fig. 15)
Idealized D2 =	3.2	ft	(Fig. 15)
D_1 =	3.2	ft	
D_2 =	3.2	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 15)
S_2 =	2.5	(ft H / ft V)	(Fig. 15)
O_1 =	115.3	ft	(Fig. 15)
O_2 =	165.2	ft	(Fig. 15)
S_3 =	0	(ft H / ft V)	(Fig. 15)
S_4 =	0	(ft H / ft V)	(Fig. 15)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 15)
n3 =	0.1	right	(Fig. 15)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		21.95	15.95	1.376	18.00
	A1	21.95	15.95	1.376	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **26.3588**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
2.56	21.4596225	15.76987	1.361	1.22799343	26.3523

y_n = 2.557

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	15.88	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 17c

Results of Step Backwater Calculations; East Channel, 25-Year Storm, Cross Section E-7

Standard Step Backwater Analysis

Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

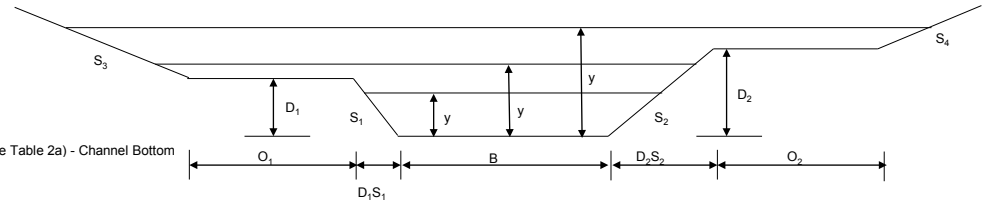
Section: **E-6**

Design Storm: **25-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 14

Freeboard (ft)	(	ft	
Did the channel over top?	NO		
Q =	15.88	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	33.2	ft	(Fig. 14)



Channel Geometry Inputs

y =	2.6	ft	Depth based on assumed WS (See Table 2a) - Channel Bottom
B =	2	ft	(Fig. 14)
Actual D1 =	2.7	ft	(Fig. 14)
Actual D2 =	2.8	ft	(Fig. 14)
Idealized D1 =	3	ft	(Fig. 14)
Idealized D2 =	3.3	ft	(Fig. 14)
D_1 =	3.0	ft	(Fig. 14)
D_2 =	3.3	ft	(Fig. 14)
S_1 =	2.5	(ft H / ft V)	(Fig. 14)
S_2 =	2.5	(ft H / ft V)	(Fig. 14)
O_1 =	296.4	ft	(Fig. 14)
O_2 =	172.1	ft	(Fig. 14)
S_3 =	0	(ft H / ft V)	(Fig. 14)
S_4 =	0	(ft H / ft V)	(Fig. 14)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 14)
n3 =	0.1	right	(Fig. 14)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		22.40	16.11	1.391	17.75
	A1	22.40	16.11	1.391	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **26.3588**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
2.56	21.4596225	15.76987	1.361	1.22799343	26.3523

y_n = 2.557

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	15.88	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 17d

Results of Step Backwater Calculations; East Channel, 25-Year Storm, Cross Section E-6

Standard Step Backwater Analysis

Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

Section: **E-5**

Design Storm: **25-yr**

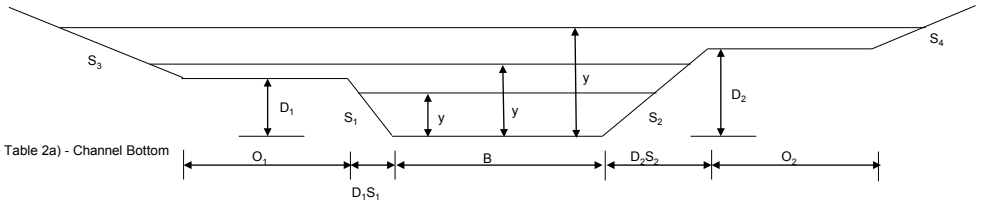
Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 13

Freeboard (ft)	0.6	ft	
Did the channel over top?	NO		
Q =	9.95	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	33.4	ft	(Fig. 13)

Channel Geometry Inputs

y =	2.5	ft	Depth based on assumed WS (See Table 2a) - Channel Bottom
B =	2	ft	(Fig. 13)
Actual D1 =	3	ft	(Fig. 13)
Actual D2 =	3.1	ft	(Fig. 13)



Idealized D1 =	2.9	ft	(Fig. 13)
Idealized D2 =	3.1	ft	(Fig. 13)
D_1 =	3	ft	(Fig. 13)
D_2 =	3.1	ft	(Fig. 13)
S_1 =	2.5	(ft H / ft V)	(Fig. 13)
S_2 =	2.5	(ft H / ft V)	(Fig. 13)
O_1 =	298.1	ft	(Fig. 13)
O_2 =	157.7	ft	(Fig. 13)
S_3 =	0	(ft H / ft V)	(Fig. 13)
S_4 =	2	(ft H / ft V)	(Fig. 13)
n1 =	0.064	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 13)
n3 =	0.1	right	(Fig. 13)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		20.63	15.46	1.334	17.25
	A1	20.63	15.46	1.334	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **13.5514**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.92	13.056	12.33952	1.058	1.03834418	13.5566

y_n = 1.920

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.6844	9.95	2.5398084	0.6844169	9.86

y_c = 0.68

Figure 17e

Results of Step Backwater Calculations; East Channel, 25-Year Storm, Cross Section E-5

Standard Step Backwater Analysis

Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

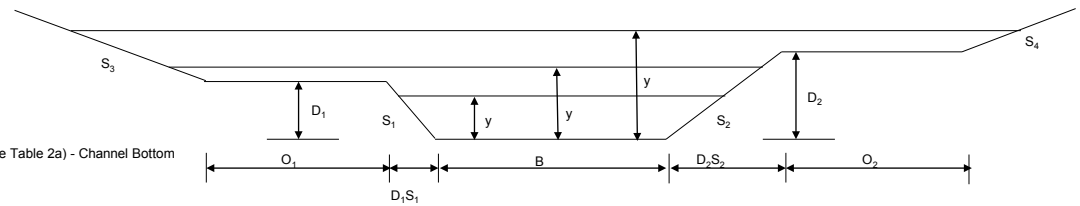
Section: **E-4**

Design Storm: **25-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 12

Freeboard (ft)	0.3	ft	
Did the channel over top?	NO		
Q =	9.95	cfs	
S_0 =	0.001	ft/ft	
α =	1.000		
Channel Bottom	33.5	ft	(Fig. 12)
Channel Geometry Inputs			
y =	2.440	ft	Depth based on assumed WS (See Table 2a) - Channel Bottom
B =	2	ft	(Fig. 12)
Actual D1 =	2.6	ft	(Fig. 12)
Actual D2 =	2.7	ft	(Fig. 12)
Idealized D1 =	2.2	ft	(Fig. 12)
Idealized D2 =	2.5	ft	(Fig. 12)
D_1 =	2.6	ft	(Fig. 12)
D_2 =	2.7	ft	(Fig. 12)
S_1 =	2.5	(ft H / ft V)	(Fig. 12)
S_2 =	2.5	(ft H / ft V)	(Fig. 12)
O_1 =	299.3	ft	(Fig. 12)
O_2 =	268.3	ft	(Fig. 12)
S_3 =	0	(ft H / ft V)	(Fig. 12)
S_4 =	2	(ft H / ft V)	(Fig. 12)
n1 =	0.064	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 12)
n3 =	0.1	right	(Fig. 12)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		19.76	15.14	1.305	15.25
	A1	19.76	15.14	1.305	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	0.000000001	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **13.5514**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.92	13.056	12.33952	1.058	1.03834418	13.5566

y_n = 1.920

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.6844	9.95	2.5398084	0.6844169	9.86

y_c = 0.68

Figure 17f

Results of Step Backwater Calculations; East Channel, 25-Year Storm, Cross Section E-4

Standard Step Backwater Analysis

Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

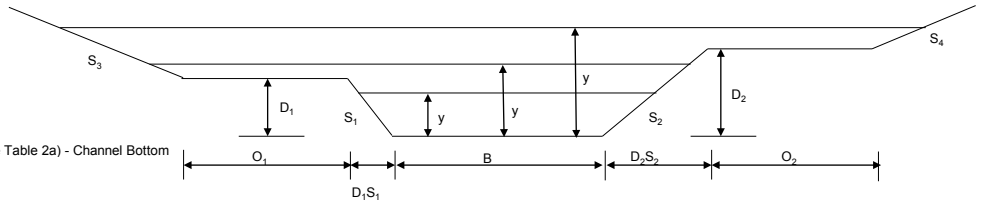
Section: **E-3**

Design Storm: **25-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 11

Freeboard (ft)	0.5	ft	
Did the channel over top?	NO		
Q =	3.92	cfs	
S_0 =	0.001	ft/ft	
α =	1.000		
Channel Bottom	33.8	ft	(Fig. 11)
Channel Geometry Inputs			
y =	2.2	ft	Depth based on assumed WS (See Table 2a) - Channel Bottom
B =	2	ft	(Fig. 11)
Actual D1 =	2.3	ft	(Fig. 11)
Actual D2 =	2.3	ft	(Fig. 11)
Idealized D1 =	2.2	ft	(Fig. 11)
Idealized D2 =	2.7	ft	(Fig. 11)
D_1 =	2.3	ft	
D_2 =	2.7	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 11)
S_2 =	2.5	(ft H / ft V)	(Fig. 11)
O_1 =	299.3	ft	(Fig. 11)
O_2 =	324.9	ft	(Fig. 11)
S_3 =	0	(ft H / ft V)	(Fig. 11)
S_4 =	2	(ft H / ft V)	(Fig. 11)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 11)
n3 =	0.1	right	(Fig. 11)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		16.37	13.79	1.187	14.50
	A1	16.37	13.79	1.187	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **3.5870**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.05	4.85625	7.654423	0.634	0.73834451	3.5856

y_n = 1.050

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	3.92	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 17g

Results of Step Backwater Calculations; East Channel, 25-Year Storm, Cross Section E-3

Standard Step Backwater Analysis

Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

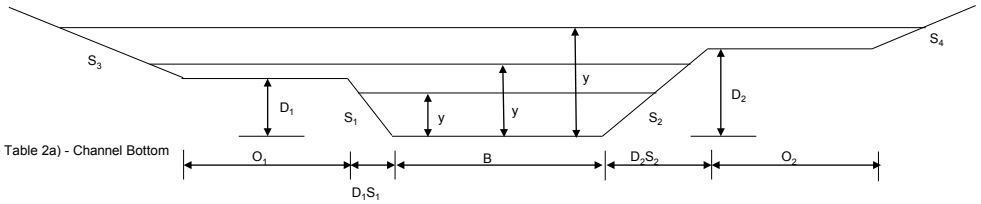
Section: **E-2**

Design Storm: **25-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 10

Freeboard (ft)	2.5	ft	
Did the channel over top?	NO		
Q =	3.92	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	34.2	ft	(Fig. 10)
Channel Geometry Inputs			
y =	1.8	ft	Depth based on assumed WS (See Table 2a) - Channel Bottom
B =	2	ft	(Fig. 10)
Actual D1 =	4.2	ft	(Fig. 10)
Actual D2 =	4.3	ft	(Fig. 10)
Idealized D1 =	3.1	ft	(Fig. 10)
Idealized D2 =	4.3	ft	(Fig. 10)
D_1 =	4.2	ft	
D_2 =	4.3	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 10)
S_2 =	2.5	(ft H / ft V)	(Fig. 10)
O_1 =	355	ft	(Fig. 10)
O_2 =	159.1	ft	(Fig. 10)
S_3 =	0	(ft H / ft V)	(Fig. 10)
S_4 =	2	(ft H / ft V)	(Fig. 10)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 10)
n3 =	0.1	right	(Fig. 10)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		11.92	11.80	1.010	23.25
	A1	11.92	11.80	1.010	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **3.5870**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.05	4.85625	7.654423	0.634	0.73834451	3.5856

y_n = 1.050

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	3.92	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 17h

Results of Step Backwater Calculations; East Channel, 25-Year Storm, Cross Section E-2

Standard Step Backwater Analysis

Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

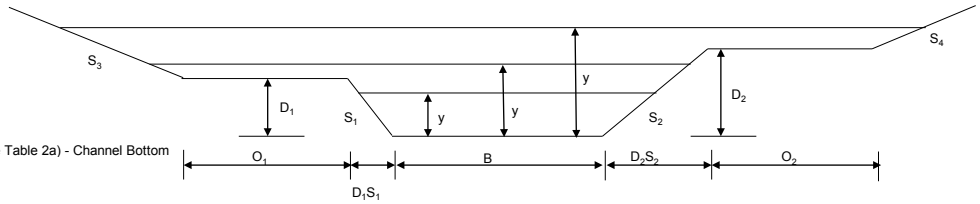
Section: **E-1**

Design Storm: **25-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 9

Freeboard (ft)	2.1	ft	
Did the channel over top?	NO		
Q =	3.92	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	34.3	ft	(Fig. 9)
Channel Geometry Inputs			
y =	1.7	ft	Depth based on assumed WS (See Table 2a) - Channel Bottom
B =	2	ft	(Fig. 9)
Actual D1 =	3.1	ft	(Fig. 9)
Actual D2 =	3.5	ft	(Fig. 9)
Idealized D1 =	3.8	ft	(Fig. 9)
Idealized D2 =	3.8	ft	(Fig. 9)
D_1 =	3.8	ft	
D_2 =	3.8	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 9)
S_2 =	2.5	(ft H / ft V)	(Fig. 9)
O_1 =	242.5	ft	(Fig. 9)
O_2 =	338.7	ft	(Fig. 9)
S_3 =	2	(ft H / ft V)	(Fig. 9)
S_4 =	0	(ft H / ft V)	(Fig. 9)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 9)
n3 =	0.1	right	(Fig. 9)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		10.94	11.32	0.967	21.00
	A1	10.94	11.32	0.967	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **3.5870**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.05	4.85625	7.654423	0.634	0.73834451	3.5856

y_n = 1.050

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	3.92	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 17i

Results of Step Backwater Calculations; East Channel, 25-Year Storm, Cross Section E-1

Standard Step Backwater Analysis

Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

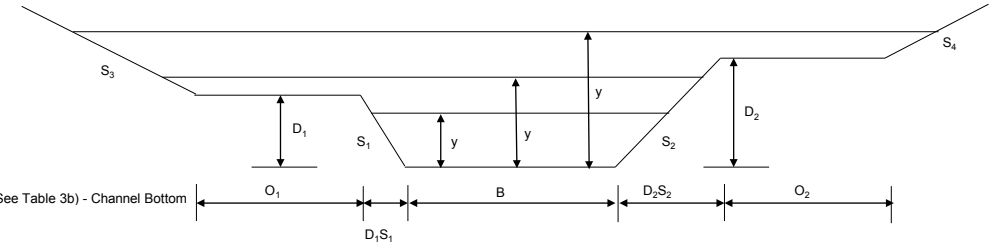
Section: **W-DB** use section W-8 for calculations

Design Storm: **10-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 8
This spreadsheet also calculates the discharge flow (based on Manning's Equation) and compares it to the controlling depth (detention basin, from HydroCAD) to determine which is greater.

Depth, DB	34.35	ft	from HydroCAD Model
Depth, Manning's	34.90	ft	
Controlling Depth	34.901	ft	(max from above)
Freeboard (ft)	2.8	ft	
Did the channel over top?	NO		
Q =	19.69	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.1	ft	(Fig. 8)



Channel Geometry Inputs

y =	2.80	ft	Depth based on computed WS (See Table 3b) - Channel Bottom
B =	2	ft	(Fig. 8)
Actual D1 =	4.2	ft	(Fig. 8)
Actual D2 =	4.3	ft	(Fig. 8)
Idealized D1 =	4.5	ft	(Fig. 8)
Idealized D2 =	5.6	ft	(Fig. 8)
D_1 =	4.5	ft	
D_2 =	5.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 8)
S_2 =	2.5	(ft H / ft V)	(Fig. 8)
O_1 =	169.7	ft	(Fig. 8)
O_2 =	356.3	ft	(Fig. 8)
S_3 =	0	(ft H / ft V)	(Fig. 8)
S_4 =	2	(ft H / ft V)	(Fig. 8)
n1 =	0.078	channel	Channel Design Calcs.
n2 =	0.100	left	(Fig. 8)
n3 =	0.100	right	(Fig. 8)

			Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	T (channel top width at water surface)
A	**For y < D_1**		25.22	17.08	1.476	16.01
		A1	25.22	17.08	1.476	
		A2	0.00	0.00	0.000	
		A3	0.00	0.00	0.000	
B	**For $D_1 \leq y < D_2$**		out of range	out of range	out of range	out of range
		A1	out of range	out of range	out of range	
		A2	out of range	out of range	out of range	
		A3	0	0.00	0.000	
C	**For y (= y_d) ≥ D_2**		out of range	out of range	out of range	out of range
		A1	out of range	out of range	out of range	
		A2	out of range	out of range	out of range	
		A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Discharge Based on Manning's Equation

Stage	Depth (y)	A,B, C	Area A1	A2	A3	Wetted Perimeter AT	WP1	WP2	WP3	Hydraulic Radius RH1	RH2	RH3	Q1	Q2	Q3	Qt	V
34.901	**2.801**	**A**	**25.216**	**0.000**	**0.000**	**25.216**	**17.084**	**0.000**	**0.000**	**1.476**	**0.000**	**0.000**	**19.694**	**0.000**	**0.000**	**19.694**	**0.781**
34.405	2.305	A	17.893	0.000	0.000	17.893	14.413	0.000	0.000	1.241	0.000	0.000	12.451	0.000	0.000	12.451	0.696
33.9	1.8	A	11.700	0.000	0.000	11.700	11.693	0.000	0.000	1.001	0.000	0.000	7.051	0.000	0.000	7.051	0.603
34	1.9	A	12.825	0.000	0.000	12.825	12.232	0.000	0.000	1.048	0.000	0.000	7.974	0.000	0.000	7.974	0.622
34.1	2	A	14.000	0.000	0.000	14.000	12.770	0.000	0.000	1.096	0.000	0.000	8.967	0.000	0.000	8.967	0.641
34.2	2.1	A	15.225	0.000	0.000	15.225	13.309	0.000	0.000	1.144	0.000	0.000	10.033	0.000	0.000	10.033	0.659
34.3	2.2	A	16.500	0.000	0.000	16.500	13.847	0.000	0.000	1.192	0.000	0.000	11.173	0.000	0.000	11.173	0.677
34.4	2.3	A	17.825	0.000	0.000	17.825	14.386	0.000	0.000	1.239	0.000	0.000	12.388	0.000	0.000	12.388	0.695
34.5	2.4	A	19.200	0.000	0.000	19.200	14.924	0.000	0.000	1.286	0.000	0.000	13.682	0.000	0.000	13.682	0.713
34.6	2.5	A	20.625	0.000	0.000	20.625	15.463	0.000	0.000	1.334	0.000	0.000	15.056	0.000	0.000	15.056	0.730
34.7	2.6	A	22.100	0.000	0.000	22.100	16.001	0.000	0.000	1.381	0.000	0.000	16.512	0.000	0.000	16.512	0.747
34.8	2.7	A	23.625	0.000	0.000	23.625	16.540	0.000	0.000	1.428	0.000	0.000	18.052	0.000	0.000	18.052	0.764
34.9	2.8	A	25.200	0.000	0.000	25.200	17.078	0.000	0.000	1.476	0.000	0.000	19.677	0.000	0.000	19.677	0.781
35	2.9	A	26.825	0.000	0.000	26.825	17.617	0.000	0.000	1.523	0.000	0.000	21.390	0.000	0.000	21.390	0.797
35.1	3	A	28.500	0.000	0.000	28.500	18.155	0.000	0.000	1.570	0.000	0.000	23.191	0.000	0.000	23.191	0.814
35.2	3.1	A	30.225	0.000	0.000	30.225	18.694	0.000	0.000	1.617	0.000	0.000	25.084	0.000	0.000	25.084	0.830

= entered values

Figure 18a
Results of Step Backwater Calculations; West Channel 10-Year Storm, Cross Section W-DB
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

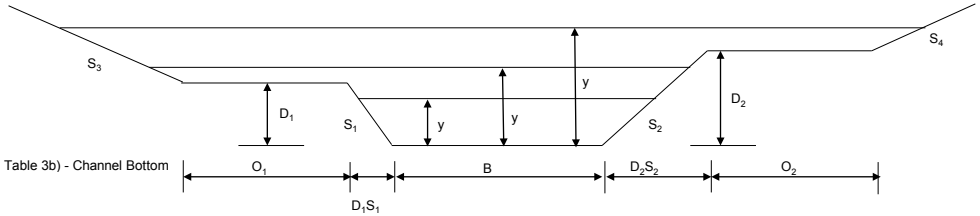
Section: W-8

Design Storm: 10-yr

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 8

Freeboard (ft)	2.8	ft	
Did the channel ov	NO		
Q =	19.69	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.1	ft	(Fig. 8)



Channel Geometry Inputs

y =	2.8	ft	Depth based on assumed WS (See Table 3b) - Channel Bottom
B =	2	ft	(Fig. 8)
Actual D1 =	4.2	ft	(Fig. 8)
Actual D2 =	4.3	ft	(Fig. 8)
Idealized D1 =	4.5	ft	(Fig. 8)
Idealized D2 =	5.6	ft	(Fig. 8)
D_1 =	4.5	ft	
D_2 =	5.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 8)
S_2 =	2.5	(ft H / ft V)	(Fig. 8)
O_1 =	169.7	ft	(Fig. 8)
O_2 =	356.3	ft	(Fig. 8)
S_3 =	0	(ft H / ft V)	(Fig. 8)
S_4 =	2	(ft H / ft V)	(Fig. 8)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.100	left	(Fig. 8)
n3 =	0.100	right	(Fig. 8)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		25.20	17.08	1.476	27.25
	A1	25.20	17.08	1.476	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

Trial and Error

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **32.6830**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
2.80	25.2	17.07846	1.476	1.29608812	32.6614

y_n = 2.800

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	19.69	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 18b

Results of Step Backwater Calculations; West Channel 10-Year Storm, Cross Section W-8
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

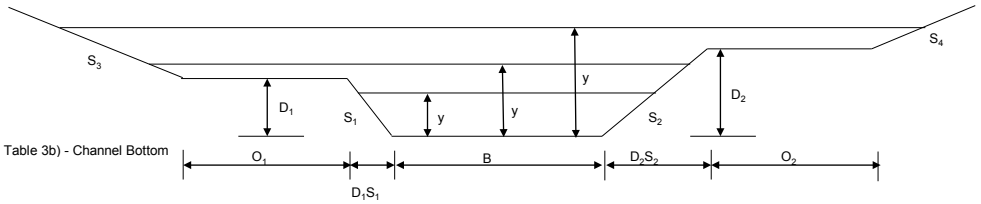
Section: **W-7**

Design Storm: **10-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 7

Freeboard (ft)	0.9	ft	
Did the channel over top?	NO		
Q =	6.10	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.4	ft	(Fig. 7)
Channel Geometry Inputs			
y =	2.7	ft	Depth based on assumed WS (See Table 3b) - Channel Bottom
B =	2	ft	(Fig. 7)
Actual D1 =	3.1	ft	(Fig. 7)
Actual D2 =	3.2	ft	(Fig. 7)
Idealized D1 =	2.8	ft	(Fig. 7)
Idealized D2 =	3.6	ft	(Fig. 7)
D_1 =	3.1	ft	
D_2 =	3.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 7)
S_2 =	2.5	(ft H / ft V)	(Fig. 7)
O_1 =	102.8	ft	(Fig. 7)
O_2 =	136.3	ft	(Fig. 7)
S_3 =	2	(ft H / ft V)	(Fig. 7)
S_4 =	0	(ft H / ft V)	(Fig. 7)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 7)
n3 =	0.1	right	(Fig. 7)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		23.01	16.32	1.409	18.75
	A1	23.01	16.32	1.409	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **10.1252**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.69	10.49936	11.09016	0.947	0.9641621	10.1231

y_n = 1.688

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	6.1	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 18c

Results of Step Backwater Calculations; West Channel 10-Year Storm, Cross Section W-7
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

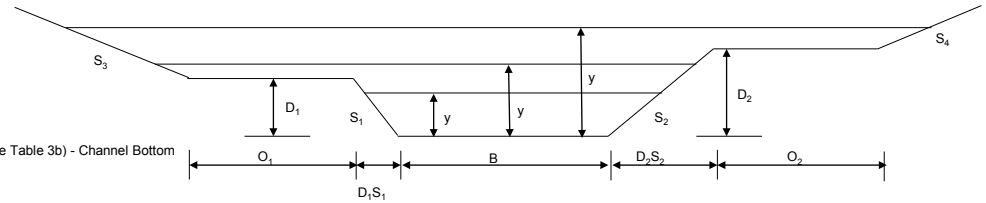
Section: **W-6**

Design Storm: **10-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 6

Freeboard (ft)	0.7	ft	
Did the channel over top?	YES		
Q =	2.58	cfs	
S_0 =	0.001	ft/ft	
α =	1.01109667		
Channel Bottom	32.8	ft	(Fig. 6)
Channel Geometry Inputs			
y =	2.3	ft	Depth based on assumed WS (See Table 3b) - Channel Bottom
B =	2	ft	(Fig. 6)
Actual D1 =	1.92	ft	(Fig. 6)
Actual D2 =	2	ft	(Fig. 6)
Idealized D1 =	1.92	ft	(Fig. 6)
Idealized D2 =	3	ft	(Fig. 6)
D_1 =	1.9	ft	(Fig. 6)
D_2 =	3	ft	(Fig. 6)
S_1 =	2.5	(ft H / ft V)	(Fig. 6)
S_2 =	2.5	(ft H / ft V)	(Fig. 6)
O_1 =	0	ft	(Fig. 6)
O_2 =	273.7	ft	(Fig. 6)
S_3 =	2	(ft H / ft V)	(Fig. 6)
S_4 =	0	(ft H / ft V)	(Fig. 6)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 6)
n3 =	0.1	right	(Fig. 6)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		17.656025	14.16	1.247	15.04
	A1	17.519125	13.34	1.314	
	A2	0.1369	0.83	0.165	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **4.2825**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.14	5.5367025	8.144473	0.680	0.77314117	4.2807

y_n = 1.141

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	2.58	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 18d

Results of Step Backwater Calculations; West Channel 10-Year Storm, Cross Section W-6
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

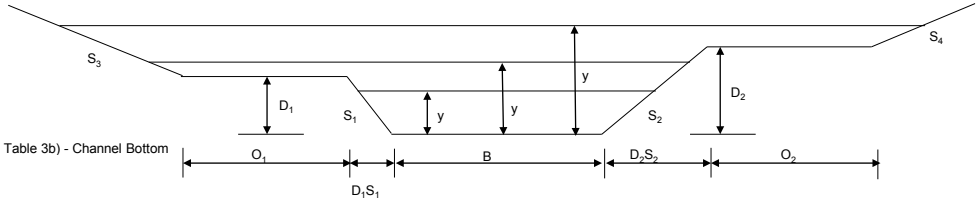
Section: **W-5**

Design Storm: **10-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 5

Freeboard (ft)	0.3	ft	
Did the channel over top?	YES		
Q =	2.58	cfs	
S_0 =	0.001	ft/ft	
α =	1.08182974		
Channel Bottom	32.9	ft	(Fig. 5)
Channel Geometry Inputs			
y =	2.2	ft	Depth based on assumed WS (See Table 3b) - Channel Bottom
B =	2	ft	(Fig. 5)
Actual D1 =	1.12	ft	(Fig. 5)
Actual D2 =	1.2	ft	(Fig. 5)



Idealized D1 =	1.12	ft	(Fig. 5)
Idealized D2 =	2.5	ft	(Fig. 5)
D_1 =	1.12	ft	(Fig. 5)
D_2 =	2.5	ft	(Fig. 5)
S_1 =	2.5	(ft H / ft V)	(Fig. 5)
S_2 =	2.5	(ft H / ft V)	(Fig. 5)
O_1 =	0	ft	(Fig. 5)
O_2 =	275.6	ft	(Fig. 5)
S_3 =	2	(ft H / ft V)	(Fig. 5)
S_4 =	0	(ft H / ft V)	(Fig. 5)
n1 =	0.064	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 5)
n3 =	0.1	right	(Fig. 5)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		16.2084	13.35	1.214	13.21
	A1	15.042	10.94	1.375	
	A2	1.1664	2.41	0.483	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **3.5138**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.04	4.784	7.600571	0.629	0.73445178	3.5136

y_n = 1.040

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.6844	2.58	2.5398084	0.6844169	9.86

y_c = 0.68

Figure 18e

Results of Step Backwater Calculations; West Channel 10-Year Storm, Cross Section W-5
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

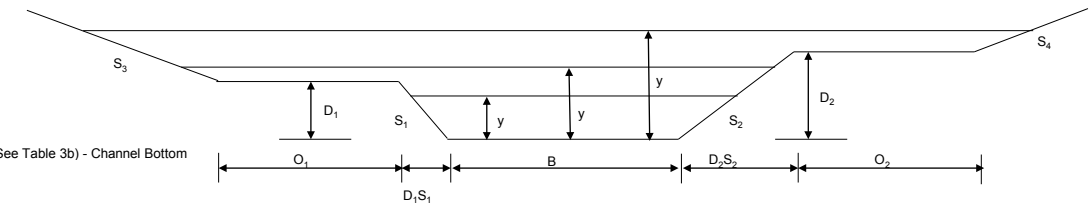
Section: **W-4**

Design Storm: **10-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 4

Freeboard (ft)	0.5	ft	
Did the channel over top?	YES		
Q =	2.58	cfs	
S_0 =	0.001	ft/ft	
α =	1.191		
Channel Bottom	33.1	ft	(Fig. 4)
Channel Geometry Inputs			
y =	2.000	ft	Depth based on assumed WS (See Table 3b) - Channel Bottom
B =	2	ft	(Fig. 4)
Actual D1 =	0.8	ft	(Fig. 4)
Actual D2 =	1.3	ft	(Fig. 4)
Idealized D1 =	0.8	ft	(Fig. 4)
Idealized D2 =	2.5	ft	(Fig. 4)
D_1 =	0.8	ft	(Fig. 4)
D_2 =	2.5	ft	(Fig. 4)
S_1 =	2.5	(ft H / ft V)	(Fig. 4)
S_2 =	2.5	(ft H / ft V)	(Fig. 4)
O_1 =	5	ft	(Fig. 4)
O_2 =	297.2	ft	(Fig. 4)
S_3 =	0.0001	(ft H / ft V)	(Fig. 4)
S_4 =	0	(ft H / ft V)	(Fig. 4)
n1 =	0.064	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 4)
n3 =	0.1	right	(Fig. 4)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		18.200072	15.74	1.156	15.25
	A1	12.2	9.54	1.279	
	A2	6.000	6.20	0.968	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	0.000000001	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **3.5138**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.03	5.7729826	12.15004	0.475	0.60890332	3.5152

y_n = 1.028

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.6844	2.58	2.5398084	0.6844169	9.86

y_c = 0.68

Figure 18f

Results of Step Backwater Calculations; West Channel 10-Year Storm, Cross Section W-4
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

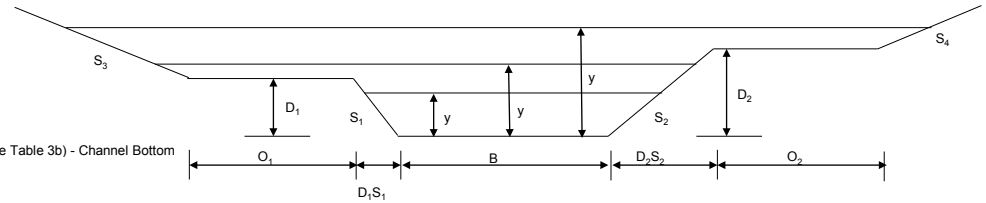
Section: **W-3**

Design Storm: **10-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 3

Freeboard (ft)	0.8	ft	
Did the channel over top?	YES		
Q =	2.58	cfs	
S_0 =	0.001	ft/ft	
α =	1.055		
Channel Bottom	33.4	ft	(Fig. 3)
Channel Geometry Inputs			
y =	1.7	ft	Depth based on assumed WS (See Table 3b) - Channel Bottom
B =	2	ft	(Fig. 3)
Actual D1 =	1.64	ft	(Fig. 3)
Actual D2 =	1.8	ft	(Fig. 3)
Idealized D1 =	1.64	ft	(Fig. 3)
Idealized D2 =	2.5	ft	(Fig. 3)
D_1 =	1.64	ft	
D_2 =	2.5	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 3)
S_2 =	2.5	(ft H / ft V)	(Fig. 3)
O_1 =	4.2	ft	(Fig. 3)
O_2 =	294.8	ft	(Fig. 3)
S_3 =	0.0001	(ft H / ft V)	(Fig. 3)
S_4 =	0	(ft H / ft V)	(Fig. 3)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 3)
n3 =	0.1	right	(Fig. 3)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		11.16400032	15.33	0.728	16.55
	A1	10.828	11.05	0.980	
	A2	0.33600032	4.28	0.079	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **2.3609**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.86	3.569	6.631242	0.538	0.66165936	2.3615

y_n = 0.860

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	2.58	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 18g

Results of Step Backwater Calculations; West Channel 10-Year Storm, Cross Section W-3
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

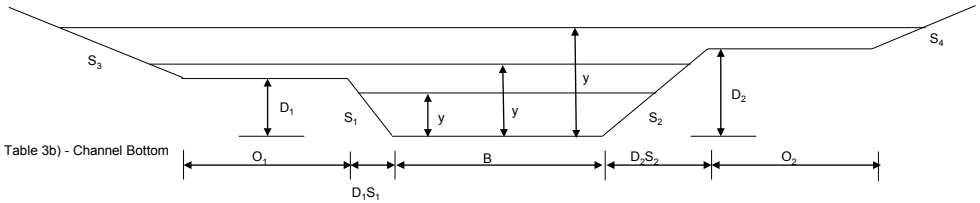
Section: **W-2**

Design Storm: **10-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 2

Freeboard (ft)	2.1	ft	
Did the channel over top?	NO		
Q =	2.58	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	33.7	ft	(Fig. 2)
Channel Geometry Inputs			
y =	1.4	ft	Depth based on assumed WS (See Table 3b) - Channel Bottom
B =	2	ft	(Fig. 2)
Actual D1 =	3.4	ft	(Fig. 2)
Actual D2 =	3.5	ft	(Fig. 2)
Idealized D1 =	3.4	ft	(Fig. 2)
Idealized D2 =	3.3	ft	(Fig. 2)
D_1 =	3.4	ft	
D_2 =	3.5	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 2)
S_2 =	2.5	(ft H / ft V)	(Fig. 2)
O_1 =	278.4	ft	(Fig. 2)
O_2 =	59.6	ft	(Fig. 2)
S_3 =	0	(ft H / ft V)	(Fig. 2)
S_4 =	0.0001	(ft H / ft V)	(Fig. 2)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 2)
n3 =	0.1	right	(Fig. 2)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		8.06	9.75	0.827	19.25
	A1	8.06	9.75	0.827	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **2.3609**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.86	3.569	6.631242	0.538	0.66165936	2.3615

y_n = 0.860

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	2.58	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 18h

Results of Step Backwater Calculations; West Channel 10-Year Storm, Cross Section W-2
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

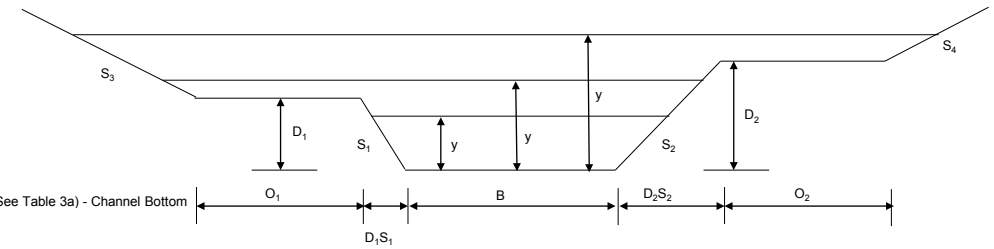
Section: **E-DB** use section W-8 for calculations

Design Storm: **10-yr** (25-yr,10-yr,5-yr,2-yr)

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 8
This spreadsheet also calculates the discharge flow (based on Manning's Equation) and compares it to the controlling depth (detention basin, from HydroCAD) to determine which is greater.

Depth, DB	34.35	ft	from HydroCAD Model
Depth, Manning's	35.08	ft	
Controlling Depth	35.077	ft	(max from above)
Freeboard (ft)	2.6	ft	
Did the channel over top?	NO		
Q =	22.77	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.1	ft	(Fig. 8)



Channel Geometry Inputs

y =	2.98	ft	Depth based on computed WS (See Table 3a) - Channel Bottom
B =	2	ft	(Fig. 8)
Actual D1 =	4.2	ft	(Fig. 8)
Actual D2 =	4.3	ft	(Fig. 8)
Idealized D1 =	4.5	ft	(Fig. 8)
Idealized D2 =	5.6	ft	(Fig. 8)
D_1 =	4.5	ft	
D_2 =	5.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 8)
S_2 =	2.5	(ft H / ft V)	(Fig. 8)
O_1 =	169.7	ft	(Fig. 8)
O_2 =	356.3	ft	(Fig. 8)
S_3 =	0	(ft H / ft V)	(Fig. 8)
S_4 =	2	(ft H / ft V)	(Fig. 8)
n1 =	0.078	channel	Channel Design Calcs.
n2 =	0.100	left	(Fig. 8)
n3 =	0.100	right	(Fig. 8)

			Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	T (channel top width at water surface)
A	**For y < D_1**		28.11	18.03	1.559	16.89
		A1	28.11	18.03	1.559	
		A2	0.00	0.00	0.000	
		A3	0.00	0.00	0.000	
B	**For $D_1 \leq y < D_2$**		out of range	out of range	out of range	out of range
		A1	out of range	out of range	out of range	
		A2	out of range	out of range	out of range	
		A3	0	0.00	0.000	
C	**For y (= y_d) ≥ D_2**		out of range	out of range	out of range	out of range
		A1	out of range	out of range	out of range	
		A2	out of range	out of range	out of range	
		A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Discharge Based on Manning's Equation

			Area			Wetted Perimeter				Hydraulic Radius							
Stage	Depth (y)	A,B, C	A1	A2	A3	AT	**WP1**	WP2	WP3	RH1	RH2	RH3	Q1	Q2	Q3	Qt	V
35.077	**2.977**	**A**	**28.110**	**0.000**	**0.000**	**28.110**	**18.032**	**0.000**	**0.000**	**1.559**	**0.000**	**0.000**	**22.769**	**0.000**	**0.000**	**22.769**	**0.810**
34.855	2.755	A	24.485	0.000	0.000	24.485	16.836	0.000	0.000	1.454	0.000	0.000	18.935	0.000	0.000	18.935	0.773
35.355	3.255	A	32.998	0.000	0.000	32.998	19.529	0.000	0.000	1.690	0.000	0.000	28.202	0.000	0.000	28.202	0.855
35.855	3.755	A	42.760	0.000	0.000	42.760	22.221	0.000	0.000	1.924	0.000	0.000	39.854	0.000	0.000	39.854	0.932
36.355	4.255	A	53.773	0.000	0.000	53.773	24.914	0.000	0.000	2.158	0.000	0.000	54.104	0.000	0.000	54.104	1.006
35.2	3.1	A	30.225	0.000	0.000	30.225	18.694	0.000	0.000	1.617	0.000	0.000	25.084	0.000	0.000	25.084	0.830
34.7	2.6	A	22.100	0.000	0.000	22.100	16.001	0.000	0.000	1.381	0.000	0.000	16.512	0.000	0.000	16.512	0.747
34.76	2.66	A	23.009	0.000	0.000	23.009	16.325	0.000	0.000	1.409	0.000	0.000	17.426	0.000	0.000	17.426	0.757
35.26	3.16	A	31.284	0.000	0.000	31.284	19.017	0.000	0.000	1.645	0.000	0.000	26.264	0.000	0.000	26.264	0.840
35.76	3.66	A	40.809	0.000	0.000	40.809	21.710	0.000	0.000	1.880	0.000	0.000	37.447	0.000	0.000	37.447	0.918
36.26	4.16	A	51.584	0.000	0.000	51.584	24.402	0.000	0.000	2.114	0.000	0.000	51.187	0.000	0.000	51.187	0.992
36.76	4.66	B	63.577	27.152	0.000	90.729	26.664	169.860	0.000	2.384	0.160	0.000	68.361	3.758	0.000	72.119	0.795
37.26	5.16	B	76.339	112.002	0.000	188.341	28.010	170.360	0.000	2.725	0.657	0.000	89.735	39.794	0.000	129.529	0.688
37.76	5.66	C	89.722	196.852	21.382	307.956	29.195	170.860	356.434	3.073	1.152	0.060	114.258	101.662	1.540	217.460	0.706
38.26	6.16	C	103.348	281.702	199.842	584.891	29.195	171.360	357.552	3.540	1.644	0.559	144.616	184.386	63.719	392.722	0.671
38.76	6.66	C	116.973	366.552	378.802	862.326	29.195	171.860	358.670	4.007	2.133	1.056	177.770	285.405	184.604	647.779	0.751

= entered values

Figure 19a
Results of Step Backwater Calculations; East Channel 10-Year Storm, Cross Section E-DB
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

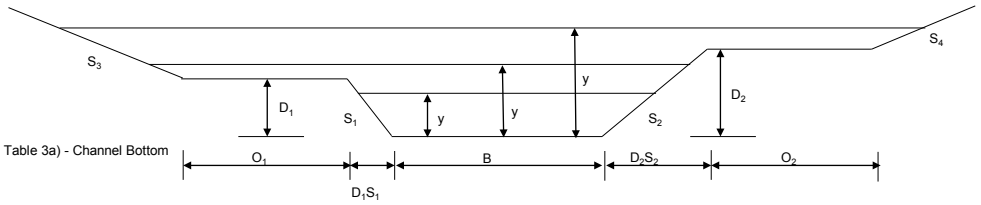
Section: **E-8 (W-8)**

Design Storm: **10-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 8

Freeboard (ft)	2.6	ft	
Did the channel over top?	NO		
Q =	22.77	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.1	ft	(Fig. 8)



Channel Geometry Inputs

y =	3.0	ft	Depth based on assumed WS (See Table 3a) - Channel Bottom
B =	2	ft	(Fig. 8)
Actual D1 =	4.2	ft	(Fig. 8)
Actual D2 =	4.3	ft	(Fig. 8)
Idealized D1 =	4.5	ft	(Fig. 8)
Idealized D2 =	5.6	ft	(Fig. 8)
D_1 =	4.5	ft	
D_2 =	5.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 8)
S_2 =	2.5	(ft H / ft V)	(Fig. 8)
O_1 =	169.7	ft	(Fig. 8)
O_2 =	356.3	ft	(Fig. 8)
S_3 =	0	(ft H / ft V)	(Fig. 8)
S_4 =	2	(ft H / ft V)	(Fig. 8)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.100	left	(Fig. 8)
n3 =	0.100	right	(Fig. 8)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		28.16	18.05	1.560	27.25
	A1	28.16	18.05	1.560	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **37.7954**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
2.98	28.1103225	18.03164	1.559	1.34447832	37.7937

y_n = 2.977

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	22.77	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 19b

Results of Step Backwater Calculations; East Channel 10-Year Storm, Cross Section E-8 (W-8)
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

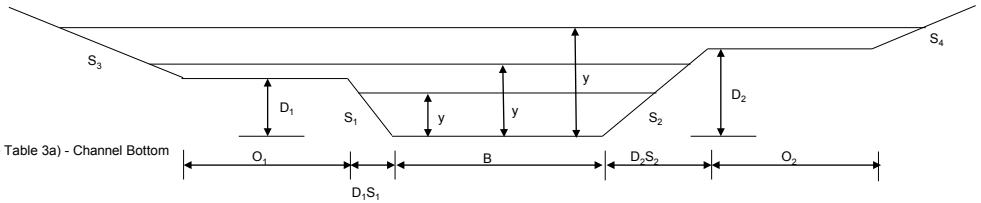
Section: **E-7**

Design Storm: **10-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 15

Freeboard (ft)	0.8	ft	
Did the channel over top?	NO		
Q =	13.59	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.8	ft	(Fig. 15)
Channel Geometry Inputs			
y =	2.4	ft	Depth based on assumed WS (See Table 3a) - Channel Bottom
B =	2	ft	(Fig. 15)
Actual D1 =	3.2	ft	(Fig. 15)
Actual D2 =	3.2	ft	(Fig. 15)
Idealized D1 =	3.2	ft	(Fig. 15)
Idealized D2 =	3.2	ft	(Fig. 15)
D_1 =	3.2	ft	
D_2 =	3.2	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 15)
S_2 =	2.5	(ft H / ft V)	(Fig. 15)
O_1 =	115.3	ft	(Fig. 15)
O_2 =	165.2	ft	(Fig. 15)
S_3 =	0	(ft H / ft V)	(Fig. 15)
S_4 =	0	(ft H / ft V)	(Fig. 15)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 15)
n3 =	0.1	right	(Fig. 15)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		18.92	14.82	1.277	18.00
	A1	18.92	14.82	1.277	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **22.5577**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
2.39	19.11609	14.89208	1.284	1.1811246	22.5785

y_n = 2.394

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	13.59	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 19c

Results of Step Backwater Calculations; East Channel 10-Year Storm, Cross Section E-7
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

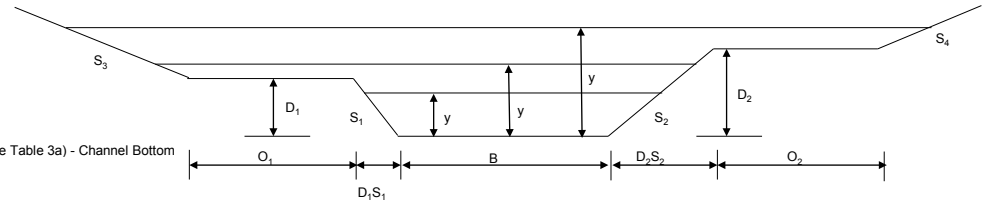
Section: **E-6**

Design Storm: **10-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 14

Freeboard (ft)	0.9	ft	
Did the channel over top?	NO		
Q =	13.59	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	33.2	ft	(Fig. 14)



Channel Geometry Inputs

y =	2.4	ft	Depth based on assumed WS (See Table 3a) - Channel Bottom
B =	2	ft	(Fig. 14)
Actual D1 =	2.7	ft	(Fig. 14)
Actual D2 =	2.8	ft	(Fig. 14)
Idealized D1 =	3	ft	(Fig. 14)
Idealized D2 =	3.3	ft	(Fig. 14)
D_1 =	3.0	ft	(Fig. 14)
D_2 =	3.3	ft	(Fig. 14)
S_1 =	2.5	(ft H / ft V)	(Fig. 14)
S_2 =	2.5	(ft H / ft V)	(Fig. 14)
O_1 =	296.4	ft	(Fig. 14)
O_2 =	172.1	ft	(Fig. 14)
S_3 =	0	(ft H / ft V)	(Fig. 14)
S_4 =	0	(ft H / ft V)	(Fig. 14)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 14)
n3 =	0.1	right	(Fig. 14)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		19.76	15.14	1.305	17.75
	A1	19.76	15.14	1.305	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **22.5577**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
2.39	19.1021225	14.8867	1.283	1.18083388	22.5564

y_n = 2.393

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	13.59	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 19d

Results of Step Backwater Calculations; East Channel 10-Year Storm, Cross Section E-6
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

Section: **E-5**

Design Storm: **10-yr**

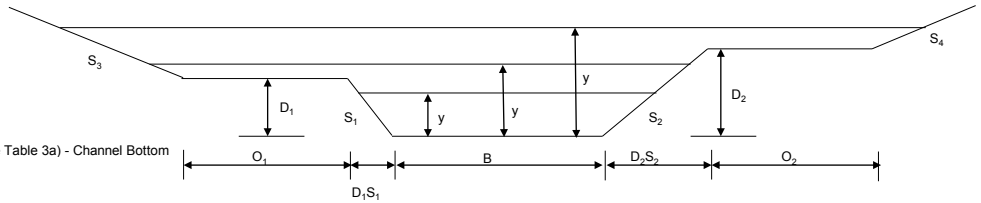
Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 13

Freeboard (ft)	0.8	ft	
Did the channel over top?	NO		
Q =	8.49	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	33.4	ft	(Fig. 13)

Channel Geometry Inputs

y =	2.3	ft	Depth based on assumed WS (See Table 3a) - Channel Bottom
B =	2	ft	(Fig. 13)
Actual D1 =	3	ft	(Fig. 13)
Actual D2 =	3.1	ft	(Fig. 13)



Idealized D1 =	2.9	ft	(Fig. 13)
Idealized D2 =	3.1	ft	(Fig. 13)
D_1 =	3	ft	(Fig. 13)
D_2 =	3.1	ft	(Fig. 13)
S_1 =	2.5	(ft H / ft V)	(Fig. 13)
S_2 =	2.5	(ft H / ft V)	(Fig. 13)
O_1 =	298.1	ft	(Fig. 13)
O_2 =	157.7	ft	(Fig. 13)
S_3 =	0	(ft H / ft V)	(Fig. 13)
S_4 =	2	(ft H / ft V)	(Fig. 13)
n1 =	0.064	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 13)
n3 =	0.1	right	(Fig. 13)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		18.10	14.49	1.249	17.25
	A1	18.10	14.49	1.249	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **11.5630**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.79	11.5957256	11.64214	0.996	0.99734053	11.5649

y_n = 1.791

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.6844	8.49	2.5398084	0.6844169	9.86

y_c = 0.68

Figure 19e

Results of Step Backwater Calculations; East Channel 10-Year Storm, Cross Section E-5
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

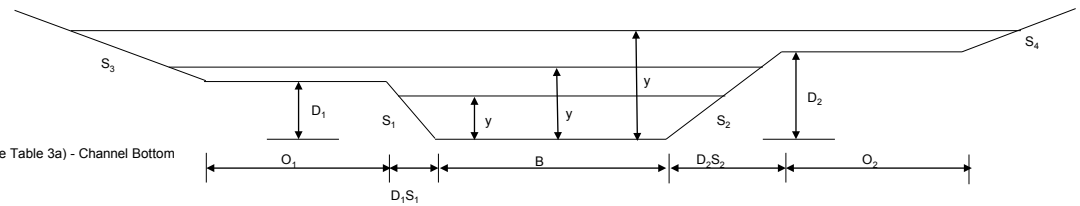
Section: **E-4**

Design Storm: **10-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 12

Freeboard (ft)	0.4	ft	
Did the channel over top?	NO		
Q =	8.49	cfs	
S_0 =	0.001	ft/ft	
α =	1.000		
Channel Bottom	33.5	ft	(Fig. 12)
Channel Geometry Inputs			
y =	2.270	ft	Depth based on assumed WS (See Table 3a) - Channel Bottom
B =	2	ft	(Fig. 12)
Actual D1 =	2.6	ft	(Fig. 12)
Actual D2 =	2.7	ft	(Fig. 12)
Idealized D1 =	2.2	ft	(Fig. 12)
Idealized D2 =	2.5	ft	(Fig. 12)
D_1 =	2.6	ft	(Fig. 12)
D_2 =	2.7	ft	(Fig. 12)
S_1 =	2.5	(ft H / ft V)	(Fig. 12)
S_2 =	2.5	(ft H / ft V)	(Fig. 12)
O_1 =	299.3	ft	(Fig. 12)
O_2 =	268.3	ft	(Fig. 12)
S_3 =	0	(ft H / ft V)	(Fig. 12)
S_4 =	2	(ft H / ft V)	(Fig. 12)
n1 =	0.064	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 12)
n3 =	0.1	right	(Fig. 12)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		17.42	14.22	1.225	15.25
	A1	17.42	14.22	1.225	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	0.000000001	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **11.5630**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.79	11.5957256	11.64214	0.996	0.99734053	11.5649

y_n = 1.791

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.6844	8.49	2.5398084	0.6844169	9.86

y_c = 0.68

Figure 19f

Results of Step Backwater Calculations; East Channel 10-Year Storm, Cross Section E-4
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

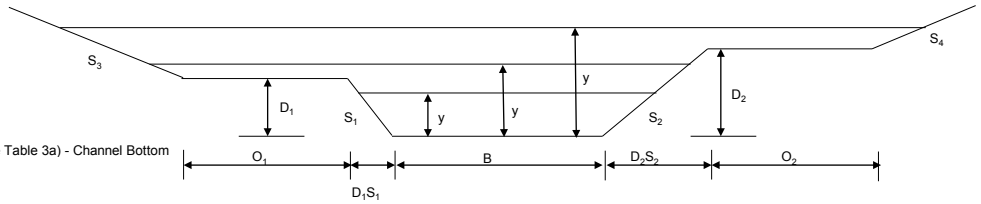
Section: **E-3**

Design Storm: **10-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 11

Freeboard (ft)	0.7	ft	
Did the channel over top?	NO		
Q =	3.33	cfs	
S_0 =	0.001	ft/ft	
α =	1.000		
Channel Bottom	33.8	ft	(Fig. 11)



Channel Geometry Inputs

y =	2.0	ft	Depth based on assumed WS (See Table 3a) - Channel Bottom
B =	2	ft	(Fig. 11)
Actual D1 =	2.3	ft	(Fig. 11)
Actual D2 =	2.3	ft	(Fig. 11)
Idealized D1 =	2.2	ft	(Fig. 11)
Idealized D2 =	2.7	ft	(Fig. 11)
D_1 =	2.3	ft	
D_2 =	2.7	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 11)
S_2 =	2.5	(ft H / ft V)	(Fig. 11)
O_1 =	299.3	ft	(Fig. 11)
O_2 =	324.9	ft	(Fig. 11)
S_3 =	0	(ft H / ft V)	(Fig. 11)
S_4 =	2	(ft H / ft V)	(Fig. 11)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 11)
n3 =	0.1	right	(Fig. 11)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		14.24	12.88	1.106	14.50
	A1	14.24	12.88	1.106	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **3.0472**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.97	4.2991025	7.228995	0.595	0.70718534	3.0403

y_n = 0.971

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	3.33	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 19g

Results of Step Backwater Calculations; East Channel 10-Year Storm, Cross Section E-3
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

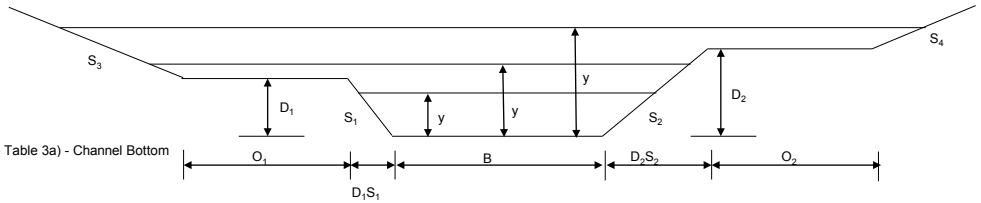
Section: **E-2**

Design Storm: **10-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 10

Freeboard (ft)	2.7	ft	
Did the channel over top?	NO		
Q =	3.33	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	34.2	ft	(Fig. 10)
Channel Geometry Inputs			
y =	1.7	ft	Depth based on assumed WS (See Table 3a) - Channel Bottom
B =	2	ft	(Fig. 10)
Actual D1 =	4.2	ft	(Fig. 10)
Actual D2 =	4.3	ft	(Fig. 10)
Idealized D1 =	3.1	ft	(Fig. 10)
Idealized D2 =	4.3	ft	(Fig. 10)
D_1 =	4.2	ft	
D_2 =	4.3	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 10)
S_2 =	2.5	(ft H / ft V)	(Fig. 10)
O_1 =	355	ft	(Fig. 10)
O_2 =	159.1	ft	(Fig. 10)
S_3 =	0	(ft H / ft V)	(Fig. 10)
S_4 =	2	(ft H / ft V)	(Fig. 10)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 10)
n3 =	0.1	right	(Fig. 10)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		10.11	10.89	0.928	23.25
	A1	10.11	10.89	0.928	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **3.0472**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.97	4.2991025	7.228995	0.595	0.70718534	3.0403

y_n = 0.971

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	3.33	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 19h

Results of Step Backwater Calculations; East Channel 10-Year Storm, Cross Section E-2
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

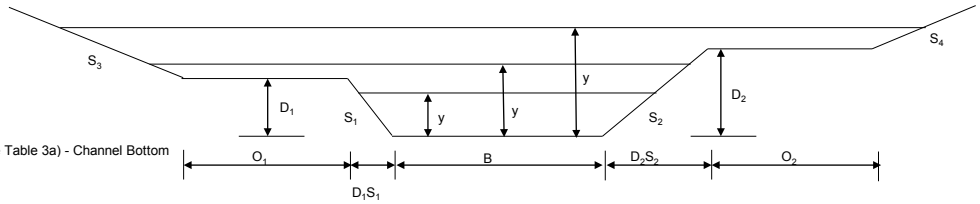
Section: **E-1**

Design Storm: **10-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 9

Freeboard (ft)	2.3	ft	
Did the channel over top?	NO		
Q =	3.33	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	34.3	ft	(Fig. 9)
Channel Geometry Inputs			
y =	1.6	ft	Depth based on assumed WS (See Table 3a) - Channel Bottom
B =	2	ft	(Fig. 9)
Actual D1 =	3.1	ft	(Fig. 9)
Actual D2 =	3.5	ft	(Fig. 9)
Idealized D1 =	3.8	ft	(Fig. 9)
Idealized D2 =	3.8	ft	(Fig. 9)
D_1 =	3.8	ft	
D_2 =	3.8	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 9)
S_2 =	2.5	(ft H / ft V)	(Fig. 9)
O_1 =	242.5	ft	(Fig. 9)
O_2 =	338.7	ft	(Fig. 9)
S_3 =	2	(ft H / ft V)	(Fig. 9)
S_4 =	0	(ft H / ft V)	(Fig. 9)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 9)
n3 =	0.1	right	(Fig. 9)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		9.11	10.35	0.880	21.00
	A1	9.11	10.35	0.880	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **3.0472**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.97	4.2991025	7.228995	0.595	0.70718534	3.0403

y_n = 0.971

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	3.33	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 19i

Results of Step Backwater Calculations; East Channel 10-Year Storm, Cross Section E-1
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

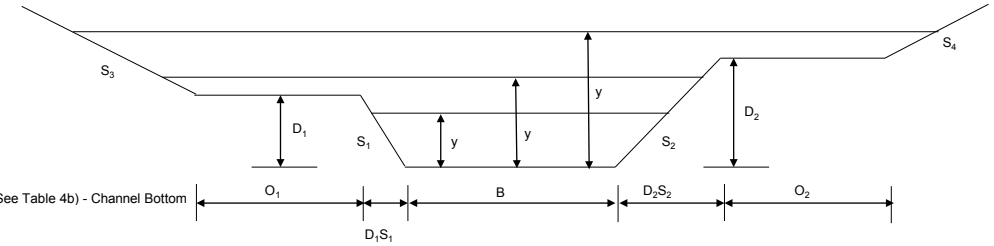
Section: **W-DB** use section W-8 for calculations

Design Storm: **5-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 8
This spreadsheet also calculates the discharge flow (based on Manning's Equation) and compares it to the controlling depth (detention basin, from HydroCAD) to determine which is greater.

Depth, DB	33.89	ft	from HydroCAD Model
Depth, Manning's	34.69	ft	
Controlling Depth	34.69	ft	(max from above)
Freeboard (ft)	3.0	ft	
Did the channel over top?	NO		
Q =	16.37	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.1	ft	(Fig. 8)



Channel Geometry Inputs

y =	2.59	ft	Depth based on computed WS (See Table 4b) - Channel Bottom
B =	2	ft	(Fig. 8)
Actual D1 =	4.2	ft	(Fig. 8)
Actual D2 =	4.3	ft	(Fig. 8)
Idealized D1 =	4.5	ft	(Fig. 8)
Idealized D2 =	5.6	ft	(Fig. 8)
D_1 =	4.5	ft	
D_2 =	5.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 8)
S_2 =	2.5	(ft H / ft V)	(Fig. 8)
O_1 =	169.7	ft	(Fig. 8)
O_2 =	356.3	ft	(Fig. 8)
S_3 =	0	(ft H / ft V)	(Fig. 8)
S_4 =	2	(ft H / ft V)	(Fig. 8)
n1 =	0.078	channel	Channel Design Calcs.
n2 =	0.100	left	(Fig. 8)
n3 =	0.100	right	(Fig. 8)

			Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	T (channel top width at water surface)
A	**For y < D_1**		21.95	15.95	1.376	14.95
		A1	21.95	15.95	1.376	
		A2	0.00	0.00	0.000	
		A3	0.00	0.00	0.000	
B	**For $D_1 \leq y < D_2$**		out of range	out of range	out of range	out of range
		A1	out of range	out of range	out of range	
		A2	out of range	out of range	out of range	
		A3	0	0.00	0.000	
C	**For y (= y_d) ≥ D_2**		out of range	out of range	out of range	out of range
		A1	out of range	out of range	out of range	
		A2	out of range	out of range	out of range	
		A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Discharge Based on Manning's Equation

			Area			Wetted Perimeter				Hydraulic Radius							
Stage	Depth (y)	A,B, C	A1	A2	A3	AT	**WP1**	WP2	WP3	RH1	RH2	RH3	Q1	Q2	Q3	Qt	V
34.69	**2.59**	**A**	**21.950**	**0.000**	**0.000**	**21.950**	**15.948**	**0.000**	**0.000**	**1.376**	**0.000**	**0.000**	**16.363**	**0.000**	**0.000**	**16.363**	**0.745**
34.405	2.305	A	17.893	0.000	0.000	17.893	14.413	0.000	0.000	1.241	0.000	0.000	12.451	0.000	0.000	12.451	0.696
33.9	1.8	A	11.700	0.000	0.000	11.700	11.693	0.000	0.000	1.001	0.000	0.000	7.051	0.000	0.000	7.051	0.603
34	1.9	A	12.825	0.000	0.000	12.825	12.232	0.000	0.000	1.048	0.000	0.000	7.974	0.000	0.000	7.974	0.622
34.1	2	A	14.000	0.000	0.000	14.000	12.770	0.000	0.000	1.096	0.000	0.000	8.967	0.000	0.000	8.967	0.641
34.2	2.1	A	15.225	0.000	0.000	15.225	13.309	0.000	0.000	1.144	0.000	0.000	10.033	0.000	0.000	10.033	0.659
34.3	2.2	A	16.500	0.000	0.000	16.500	13.847	0.000	0.000	1.192	0.000	0.000	11.173	0.000	0.000	11.173	0.677
34.4	2.3	A	17.825	0.000	0.000	17.825	14.386	0.000	0.000	1.239	0.000	0.000	12.388	0.000	0.000	12.388	0.695
34.5	2.4	A	19.200	0.000	0.000	19.200	14.924	0.000	0.000	1.286	0.000	0.000	13.682	0.000	0.000	13.682	0.713
34.6	2.5	A	20.625	0.000	0.000	20.625	15.463	0.000	0.000	1.334	0.000	0.000	15.056	0.000	0.000	15.056	0.730
34.7	2.6	A	22.100	0.000	0.000	22.100	16.001	0.000	0.000	1.381	0.000	0.000	16.512	0.000	0.000	16.512	0.747
34.8	2.7	A	23.625	0.000	0.000	23.625	16.540	0.000	0.000	1.428	0.000	0.000	18.052	0.000	0.000	18.052	0.764
34.9	2.8	A	25.200	0.000	0.000	25.200	17.078	0.000	0.000	1.476	0.000	0.000	19.677	0.000	0.000	19.677	0.781
35	2.9	A	26.825	0.000	0.000	26.825	17.617	0.000	0.000	1.523	0.000	0.000	21.390	0.000	0.000	21.390	0.797
35.1	3	A	28.500	0.000	0.000	28.500	18.155	0.000	0.000	1.570	0.000	0.000	23.191	0.000	0.000	23.191	0.814
35.2	3.1	A	30.225	0.000	0.000	30.225	18.694	0.000	0.000	1.617	0.000	0.000	25.084	0.000	0.000	25.084	0.830

= entered values

integral consulting inc.

Figure 20a
Results of Step Backwater Calculations; West Channel 5-Year Storm, Cross Section W-DB
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

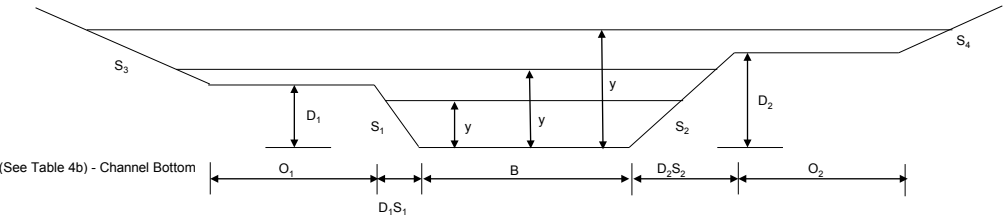
Section: W-8

Design Storm: 5-yr

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 8

Freeboard (ft)	3.0	ft	
Did the channel ov	NO		
Q =	16.37	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.1	ft	(Fig. 8)



Channel Geometry Inputs

y =	2.6	ft	Depth based on assumed WS (See Table 4b) - Channel Bottom
B =	2	ft	(Fig. 8)
Actual D1 =	4.2	ft	(Fig. 8)
Actual D2 =	4.3	ft	(Fig. 8)
Idealized D1 =	4.5	ft	(Fig. 8)
Idealized D2 =	5.6	ft	(Fig. 8)
D_1 =	4.5	ft	
D_2 =	5.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 8)
S_2 =	2.5	(ft H / ft V)	(Fig. 8)
O_1 =	169.7	ft	(Fig. 8)
O_2 =	356.3	ft	(Fig. 8)
S_3 =	0	(ft H / ft V)	(Fig. 8)
S_4 =	2	(ft H / ft V)	(Fig. 8)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.100	left	(Fig. 8)
n3 =	0.100	right	(Fig. 8)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		21.95	15.95	1.376	27.25
	A1	21.95	15.95	1.376	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

Trial and Error

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **27.1722**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
2.59	21.9652025	15.95296	1.377	1.23764451	27.1851

y_n = 2.591

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	16.37	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 20b

Results of Step Backwater Calculations; West Channel 5-Year Storm, Cross Section W-8
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

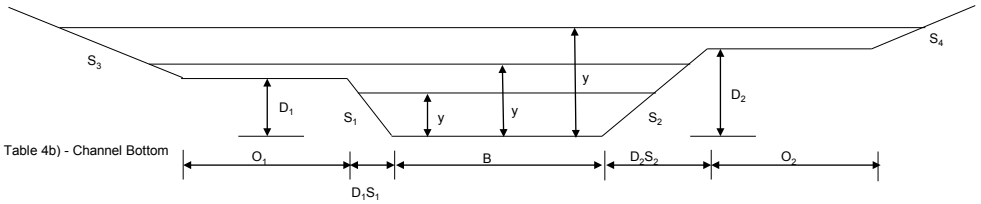
Section: **W-7**

Design Storm: **5-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 7

Freeboard (ft)	1.2	ft	
Did the channel over top?	NO		
Q =	5.07	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.4	ft	(Fig. 7)
Channel Geometry Inputs			
y =	2.5	ft	Depth based on assumed WS (See Table 4b) - Channel Bottom
B =	2	ft	(Fig. 7)
Actual D1 =	3.1	ft	(Fig. 7)
Actual D2 =	3.2	ft	(Fig. 7)
Idealized D1 =	2.8	ft	(Fig. 7)
Idealized D2 =	3.6	ft	(Fig. 7)
D_1 =	3.1	ft	
D_2 =	3.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 7)
S_2 =	2.5	(ft H / ft V)	(Fig. 7)
O_1 =	102.8	ft	(Fig. 7)
O_2 =	136.3	ft	(Fig. 7)
S_3 =	2	(ft H / ft V)	(Fig. 7)
S_4 =	0	(ft H / ft V)	(Fig. 7)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 7)
n3 =	0.1	right	(Fig. 7)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		19.91	15.19	1.310	18.75
	A1	19.91	15.19	1.310	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **8.4156**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.55	9.14529	10.36855	0.882	0.9197146	8.4111

y_n = 1.554

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	5.07	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 20c

Results of Step Backwater Calculations; West Channel 5-Year Storm, Cross Section W-7
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

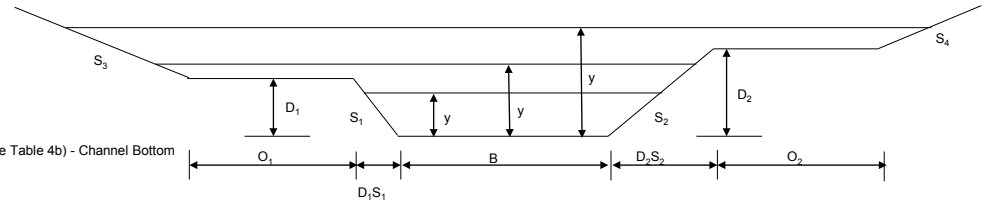
Section: **W-6**

Design Storm: **5-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 6

Freeboard (ft)	0.9	ft	
Did the channel over top?	YES		
Q =	2.23	cfs	
S_0 =	0.001	ft/ft	
α =	1.00280807		
Channel Bottom	32.8	ft	(Fig. 6)
Channel Geometry Inputs			
y =	2.1	ft	Depth based on assumed WS (See Table 4b) - Channel Bottom
B =	2	ft	(Fig. 6)
Actual D1 =	1.92	ft	(Fig. 6)
Actual D2 =	2	ft	(Fig. 6)
Idealized D1 =	1.92	ft	(Fig. 6)
Idealized D2 =	3	ft	(Fig. 6)
D_1 =	1.9	ft	(Fig. 6)
D_2 =	3	ft	(Fig. 6)
S_1 =	2.5	(ft H / ft V)	(Fig. 6)
S_2 =	2.5	(ft H / ft V)	(Fig. 6)
O_1 =	0	ft	(Fig. 6)
O_2 =	273.7	ft	(Fig. 6)
S_3 =	2	(ft H / ft V)	(Fig. 6)
S_4 =	0	(ft H / ft V)	(Fig. 6)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 6)
n3 =	0.1	right	(Fig. 6)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		14.9696	13.13	1.140	14.62
	A1	14.944	12.77	1.170	
	A2	0.0256	0.36	0.072	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **3.7015**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.07	4.97289	7.740586	0.642	0.7445434	3.7025

y_n = 1.066

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	2.23	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 20d

Results of Step Backwater Calculations; West Channel 5-Year Storm, Cross Section W-6
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

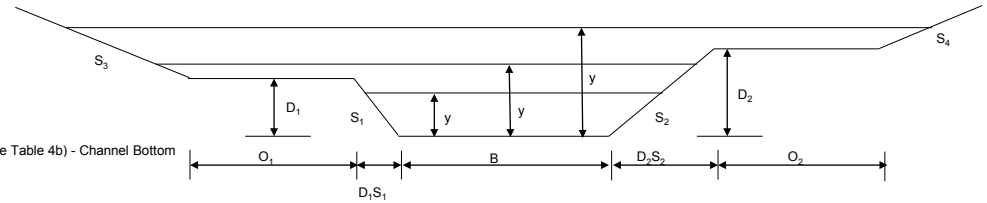
Section: **W-5**

Design Storm: **5-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 5

Freeboard (ft)	0.5	ft	
Did the channel over top?	YES		
Q =	2.23	cfs	
S_0 =	0.001	ft/ft	
α =	1.06607429		
Channel Bottom	32.9	ft	(Fig. 5)
Channel Geometry Inputs			
y =	2.0	ft	Depth based on assumed WS (See Table 4b) - Channel Bottom
B =	2	ft	(Fig. 5)
Actual D1 =	1.12	ft	(Fig. 5)
Actual D2 =	1.2	ft	(Fig. 5)



Idealized D1 =	1.12	ft	(Fig. 5)
Idealized D2 =	2.5	ft	(Fig. 5)
D_1 =	1.12	ft	(Fig. 5)
D_2 =	2.5	ft	(Fig. 5)
S_1 =	2.5	(ft H / ft V)	(Fig. 5)
S_2 =	2.5	(ft H / ft V)	(Fig. 5)
O_1 =	0	ft	(Fig. 5)
O_2 =	275.6	ft	(Fig. 5)
S_3 =	2	(ft H / ft V)	(Fig. 5)
S_4 =	0	(ft H / ft V)	(Fig. 5)
n1 =	0.064	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 5)
n3 =	0.1	right	(Fig. 5)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		13.691025	12.32	1.111	12.79
	A1	12.934125	10.37	1.247	
	A2	0.7569	1.95	0.389	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **3.0371**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.97	4.29567563	7.226302	0.594	0.70698505	3.0370

y_n = 0.971

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.6844	2.23	2.5398084	0.6844169	9.86

y_c = 0.68

Figure 20e

Results of Step Backwater Calculations; West Channel 5-Year Storm, Cross Section W-5
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

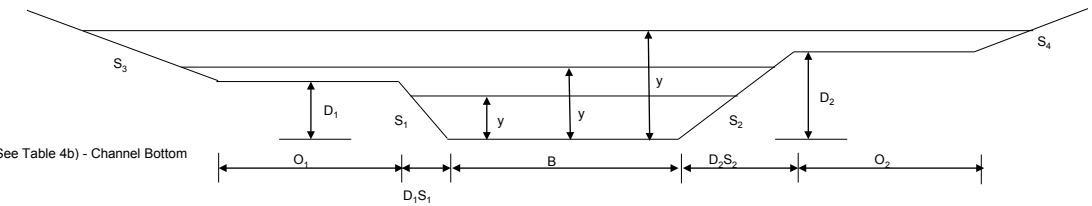
Section: **W-4**

Design Storm: **5-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 4

Freeboard (ft)	0.7	ft	
Did the channel over top?	YES		
Q =	2.16	cfs	
S_0 =	0.001	ft/ft	
α =	1.205		
Channel Bottom	33.1	ft	(Fig. 4)
Channel Geometry Inputs			
y =	1.790	ft	Depth based on assumed WS (See Table 4b) - Channel Bottom
B =	2	ft	(Fig. 4)
Actual D1 =	0.8	ft	(Fig. 4)
Actual D2 =	1.3	ft	(Fig. 4)
Idealized D1 =	0.8	ft	(Fig. 4)
Idealized D2 =	2.5	ft	(Fig. 4)
D_1 =	0.8	ft	(Fig. 4)
D_2 =	2.5	ft	(Fig. 4)
S_1 =	2.5	(ft H / ft V)	(Fig. 4)
S_2 =	2.5	(ft H / ft V)	(Fig. 4)
O_1 =	5	ft	(Fig. 4)
O_2 =	297.2	ft	(Fig. 4)
S_3 =	0.0001	(ft H / ft V)	(Fig. 4)
S_4 =	0	(ft H / ft V)	(Fig. 4)
n1 =	0.064	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 4)
n3 =	0.1	right	(Fig. 4)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		15.31517401	14.96	1.023	15.25
	A1	10.365125	8.97	1.155	
	A2	4.950	5.99	0.826	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	0.000000001	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **2.9418**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.97	5.15184651	11.95064	0.431	0.57066487	2.9400

y_n = 0.974

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.6844	2.16	2.5398084	0.6844169	9.86

y_c = 0.68

Figure 20f

Results of Step Backwater Calculations; West Channel 5-Year Storm, Cross Section W-4

Standard Step Backwater Analysis

Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

Section: **W-3**

Design Storm: **5-yr**

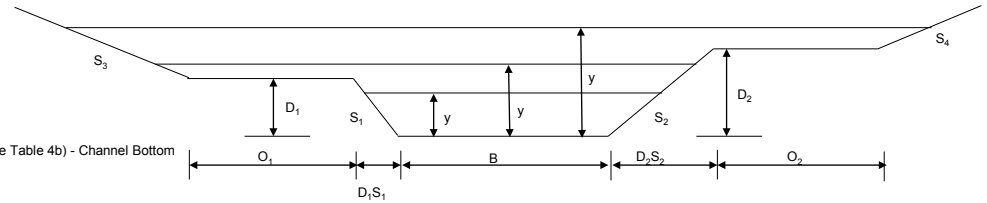
Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 3

Freeboard (ft)	1.0	ft	
Did the channel over top?	NO		
Q =	2.16	cfs	
S_0 =	0.001	ft/ft	
α =	1.000		
Channel Bottom	33.4	ft	(Fig. 3)

Channel Geometry Inputs

y =	1.5	ft	Depth based on assumed WS (See Table 4b) - Channel Bottom
B =	2	ft	(Fig. 3)
Actual D1 =	1.64	ft	(Fig. 3)
Actual D2 =	1.8	ft	(Fig. 3)



Idealized D1 =	1.64	ft	(Fig. 3)
Idealized D2 =	2.5	ft	(Fig. 3)
D_1 =	1.64	ft	
D_2 =	2.5	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 3)
S_2 =	2.5	(ft H / ft V)	(Fig. 3)
O_1 =	4.2	ft	(Fig. 3)
O_2 =	294.8	ft	(Fig. 3)
S_3 =	0.0001	(ft H / ft V)	(Fig. 3)
S_4 =	0	(ft H / ft V)	(Fig. 3)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 3)
n3 =	0.1	right	(Fig. 3)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		8.72	10.13	0.861	12.35
	A1	8.72	10.13	0.861	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **1.9765**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.79	3.12836	6.24351	0.501	0.6308488	1.9735

y_n = 0.788

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	2.16	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 20g

Results of Step Backwater Calculations; West Channel 5-Year Storm, Cross Section W-3
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

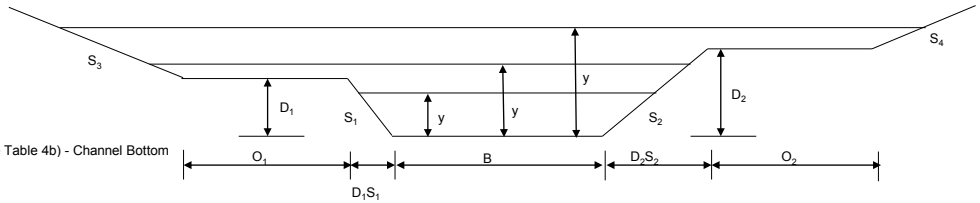
Section: **W-2**

Design Storm: **5-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 2

Freeboard (ft)	2.3	ft	
Did the channel over top?	NO		
Q =	2.16	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	33.7	ft	(Fig. 2)
Channel Geometry Inputs			
y =	1.2	ft	Depth based on assumed WS (See Table 4b) - Channel Bottom
B =	2	ft	(Fig. 2)
Actual D1 =	3.4	ft	(Fig. 2)
Actual D2 =	3.5	ft	(Fig. 2)
Idealized D1 =	3.4	ft	(Fig. 2)
Idealized D2 =	3.3	ft	(Fig. 2)
D_1 =	3.4	ft	
D_2 =	3.5	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 2)
S_2 =	2.5	(ft H / ft V)	(Fig. 2)
O_1 =	278.4	ft	(Fig. 2)
O_2 =	59.6	ft	(Fig. 2)
S_3 =	0	(ft H / ft V)	(Fig. 2)
S_4 =	0.0001	(ft H / ft V)	(Fig. 2)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 2)
n3 =	0.1	right	(Fig. 2)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		6.32	8.68	0.729	19.25
	A1	6.32	8.68	0.729	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **1.9765**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.79	3.12836	6.24351	0.501	0.6308488	1.9735

y_n = 0.788

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	2.16	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 20h

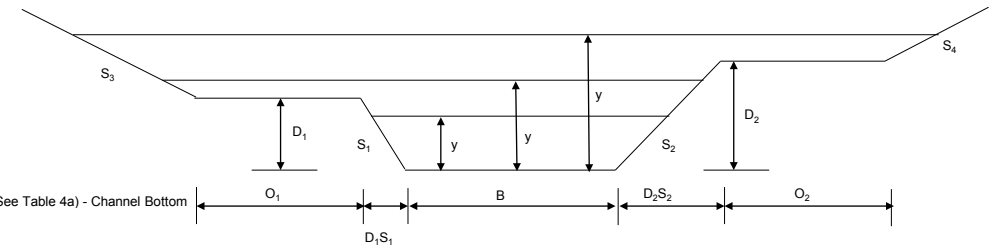
Results of Step Backwater Calculations; West Channel 5-Year Storm, Cross Section W-2
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

Section:	**E-DB**	use section W-8 for calculations	Calculated by:	JG
Design Storm:	**5-yr**	(25-yr,10-yr,5-yr,2-yr)	Date:	9/19/2011
			Checked by:	MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 8
This spreadsheet also calculates the discharge flow (based on Manning's Equation) and compares it to the controlling depth (detention basin, from HydroCAD) to determine which is greater.

Depth, DB	33.89	ft	from HydroCAD Model
Depth, Manning's	34.84	ft	
Controlling Depth	34.84	ft	(max from above)
Freeboard (ft)	2.9	ft	
Did the channel over top?	NO		
Q =	18.70	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.1	ft	(Fig. 8)



Channel Geometry Inputs

y =	2.74	ft	Depth based on computed WS (See Table 4a) - Channel Bottom
B =	2	ft	(Fig. 8)
Actual D1 =	4.2	ft	(Fig. 8)
Actual D2 =	4.3	ft	(Fig. 8)

						Computed Area (A) (ft^2)	**Computed Wetted Perimeter (P) (ft)**	**Hydraulic Mean Radius (R) (ft)**	**T (channel top width at water surface)**
Idealized D1 =	4.5	ft	(Fig. 8)	A	**For y < D_1**	24.25	16.76	1.447	15.70
Idealized D2 =	5.6	ft	(Fig. 8)		**A1**	24.25	16.76	1.447	
D_1 =	4.5	ft			**A2**	0.00	0.00	0.000	
D_2 =	5.6	ft			**A3**	0.00	0.00	0.000	
S_1 =	2.5	(ft H / ft V)	(Fig. 8)	**B**	**For $D_1 \le y < D_2$**	out of range	out of range	out of range	out of range
S_2 =	2.5	(ft H / ft V)	(Fig. 8)		**A1**	out of range	out of range	out of range	
O_1 =	169.7	ft	(Fig. 8)		**A2**	out of range	out of range	out of range	
O_2 =	356.3	ft	(Fig. 8)		**A3**	0	0.00	0.000	
S_3 =	0	(ft H / ft V)	(Fig. 8)	C	**For y (= y_d) ≥ D_2**	out of range	out of range	out of range	out of range
S_4 =	2	(ft H / ft V)	(Fig. 8)		**A1**	out of range	out of range	out of range	
n1 =	0.078	channel	Channel Design Calcs.		**A2**	out of range	out of range	out of range	
n2 =	0.100	left	(Fig. 8)		**A3**	out of range	out of range	out of range	
n3 =	0.100	right	(Fig. 8)						

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Discharge Based on Manning's Equation

			Area			Wetted Perimeter				Hydraulic Radius							
Stage	Depth (y)	A,B, C	A1	A2	A3	AT	**WP1**	WP2	WP3	RH1	RH2	RH3	Q1	Q2	Q3	Qt	V
34.84	**2.74**	**A**	**24.249**	**0.000**	**0.000**	**24.249**	**16.755**	**0.000**	**0.000**	**1.447**	**0.000**	**0.000**	**18.692**	**0.000**	**0.000**	**18.692**	**0.771**
35	2.9	A	26.825	0.000	0.000	26.825	17.617	0.000	0.000	1.523	0.000	0.000	21.390	0.000	0.000	21.390	0.797
35.5	3.4	A	35.700	0.000	0.000	35.700	20.310	0.000	0.000	1.758	0.000	0.000	31.326	0.000	0.000	31.326	0.877
36	3.9	A	45.825	0.000	0.000	45.825	23.002	0.000	0.000	1.992	0.000	0.000	43.710	0.000	0.000	43.710	0.954
36.5	4.4	A	57.200	0.000	0.000	57.200	25.695	0.000	0.000	2.226	0.000	0.000	58.752	0.000	0.000	58.752	1.027
35.2	3.1	A	30.225	0.000	0.000	30.225	18.694	0.000	0.000	1.617	0.000	0.000	25.084	0.000	0.000	25.084	0.830
34.7	2.6	A	22.100	0.000	0.000	22.100	16.001	0.000	0.000	1.381	0.000	0.000	16.512	0.000	0.000	16.512	0.747
34.76	2.66	A	23.009	0.000	0.000	23.009	16.325	0.000	0.000	1.409	0.000	0.000	17.426	0.000	0.000	17.426	0.757
35.26	3.16	A	31.284	0.000	0.000	31.284	19.017	0.000	0.000	1.645	0.000	0.000	26.264	0.000	0.000	26.264	0.840
35.76	3.66	A	40.809	0.000	0.000	40.809	21.710	0.000	0.000	1.880	0.000	0.000	37.447	0.000	0.000	37.447	0.918
36.26	4.16	A	51.584	0.000	0.000	51.584	24.402	0.000	0.000	2.114	0.000	0.000	51.187	0.000	0.000	51.187	0.992
36.76	4.66	B	63.577	27.152	0.000	90.729	26.664	169.860	0.000	2.384	0.160	0.000	68.361	3.758	0.000	72.119	0.795
37.26	5.16	B	76.339	112.002	0.000	188.341	28.010	170.360	0.000	2.725	0.657	0.000	89.735	39.794	0.000	129.529	0.688
37.76	5.66	C	89.722	196.852	21.382	307.956	29.195	170.860	356.434	3.073	1.152	0.060	114.258	101.662	1.540	217.460	0.706
38.26	6.16	C	103.348	281.702	199.842	584.891	29.195	171.360	357.552	3.540	1.644	0.559	144.616	184.386	63.719	392.722	0.671
38.76	6.66	C	116.973	366.552	378.802	862.326	29.195	171.860	358.670	4.007	2.133	1.056	177.770	285.405	184.604	647.779	0.751

[ ] = entered values

Figure 21a
Results of Step Backwater Calculations; East Channel 5-Year Storm, Cross Section E-DB
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

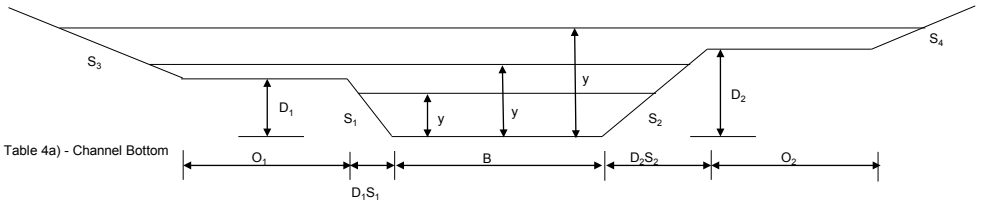
Section: **E-8 (W-8)**

Design Storm: **5-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 8

Freeboard (ft)	2.9	ft	
Did the channel over top?	NO		
Q =	18.70	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.1	ft	(Fig. 8)



Channel Geometry Inputs

y =	2.7	ft	Depth based on assumed WS (See Table 4a) - Channel Bottom
B =	2	ft	(Fig. 8)
Actual D1 =	4.2	ft	(Fig. 8)
Actual D2 =	4.3	ft	(Fig. 8)
Idealized D1 =	4.5	ft	(Fig. 8)
Idealized D2 =	5.6	ft	(Fig. 8)
D_1 =	4.5	ft	
D_2 =	5.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 8)
S_2 =	2.5	(ft H / ft V)	(Fig. 8)
O_1 =	169.7	ft	(Fig. 8)
O_2 =	356.3	ft	(Fig. 8)
S_3 =	0	(ft H / ft V)	(Fig. 8)
S_4 =	2	(ft H / ft V)	(Fig. 8)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.100	left	(Fig. 8)
n3 =	0.100	right	(Fig. 8)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		24.25	16.76	1.447	27.25
	A1	24.25	16.76	1.447	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **31.0397**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
2.74	24.249	16.75535	1.447	1.27946043	31.0256

y_n = 2.740

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	18.7	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 21b

Results of Step Backwater Calculations; East Channel 5-Year Storm, Cross Section E-8 (W-8)
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

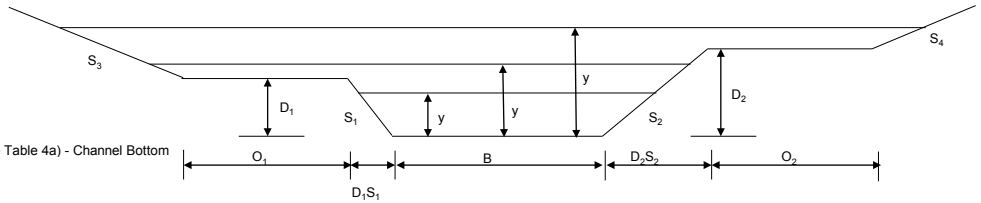
Section: **E-7**

Design Storm: **5-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 15

Freeboard (ft)	1.0	ft	
Did the channel over top?	NO		
Q =	11.30	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.8	ft	(Fig. 15)
Channel Geometry Inputs			
y =	2.2	ft	Depth based on assumed WS (See Table 4a) - Channel Bottom
B =	2	ft	(Fig. 15)
Actual D1 =	3.2	ft	(Fig. 15)
Actual D2 =	3.2	ft	(Fig. 15)
Idealized D1 =	3.2	ft	(Fig. 15)
Idealized D2 =	3.2	ft	(Fig. 15)
D_1 =	3.2	ft	
D_2 =	3.2	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 15)
S_2 =	2.5	(ft H / ft V)	(Fig. 15)
O_1 =	115.3	ft	(Fig. 15)
O_2 =	165.2	ft	(Fig. 15)
S_3 =	0	(ft H / ft V)	(Fig. 15)
S_4 =	0	(ft H / ft V)	(Fig. 15)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 15)
n3 =	0.1	right	(Fig. 15)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		15.86	13.58	1.168	18.00
	A1	15.86	13.58	1.168	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **18.7566**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
2.21	16.63025	13.90121	1.196	1.12693109	18.7411

y_n = 2.210

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	11.3	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 21c

Results of Step Backwater Calculations; East Channel 5-Year Storm, Cross Section E-7
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

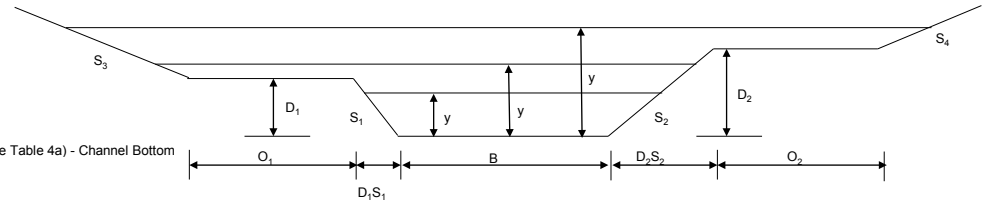
Section: **E-6**

Design Storm: **5-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 14

Freeboard (ft)	1.1	ft	
Did the channel over top?	NO		
Q =	11.30	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	33.2	ft	(Fig. 14)



Channel Geometry Inputs

y =	2.2	ft	Depth based on assumed WS (See Table 4a) - Channel Bottom
B =	2	ft	(Fig. 14)
Actual D1 =	2.7	ft	(Fig. 14)
Actual D2 =	2.8	ft	(Fig. 14)
Idealized D1 =	3	ft	(Fig. 14)
Idealized D2 =	3.3	ft	(Fig. 14)
D_1 =	3.0	ft	(Fig. 14)
D_2 =	3.3	ft	(Fig. 14)
S_1 =	2.5	(ft H / ft V)	(Fig. 14)
S_2 =	2.5	(ft H / ft V)	(Fig. 14)
O_1 =	296.4	ft	(Fig. 14)
O_2 =	172.1	ft	(Fig. 14)
S_3 =	0	(ft H / ft V)	(Fig. 14)
S_4 =	0	(ft H / ft V)	(Fig. 14)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 14)
n3 =	0.1	right	(Fig. 14)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		16.89	14.01	1.206	17.75
	A1	16.89	14.01	1.206	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **18.7566**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
2.21	16.63025	13.90121	1.196	1.12693109	18.7411

y_n = 2.210

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	11.3	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 21d

Results of Step Backwater Calculations; East Channel 5-Year Storm, Cross Section E-6
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

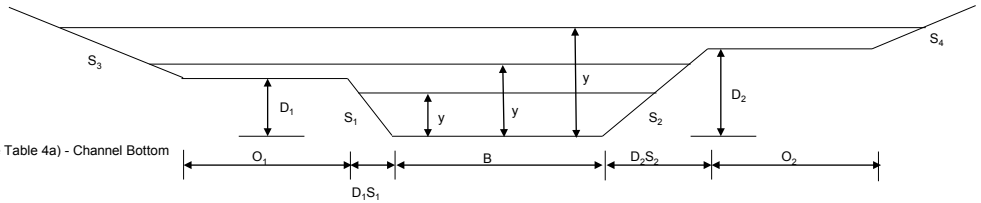
Section: **E-5**

Design Storm: **5-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 13

Freeboard (ft)	1.0	ft	
Did the channel over top?	NO		
Q =	7.01	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	33.4	ft	(Fig. 13)



Channel Geometry Inputs

y =	2.1	ft	Depth based on assumed WS (See Table 4a) - Channel Bottom
B =	2	ft	(Fig. 13)
Actual D1 =	3	ft	(Fig. 13)
Actual D2 =	3.1	ft	(Fig. 13)
Idealized D1 =	2.9	ft	(Fig. 13)
Idealized D2 =	3.1	ft	(Fig. 13)
D_1 =	3	ft	(Fig. 13)
D_2 =	3.1	ft	(Fig. 13)
S_1 =	2.5	(ft H / ft V)	(Fig. 13)
S_2 =	2.5	(ft H / ft V)	(Fig. 13)
O_1 =	298.1	ft	(Fig. 13)
O_2 =	157.7	ft	(Fig. 13)
S_3 =	0	(ft H / ft V)	(Fig. 13)
S_4 =	2	(ft H / ft V)	(Fig. 13)
n1 =	0.064	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 13)
n3 =	0.1	right	(Fig. 13)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		15.60	13.47	1.158	17.25
	A1	15.60	13.47	1.158	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **9.5473**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.65	10.0550625	10.8586	0.926	0.95003746	9.5527

y_n = 1.645

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.6844	7.01	2.5398084	0.6844169	9.86

y_c = 0.68

Figure 21e

Results of Step Backwater Calculations; East Channel 5-Year Storm, Cross Section E-5
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

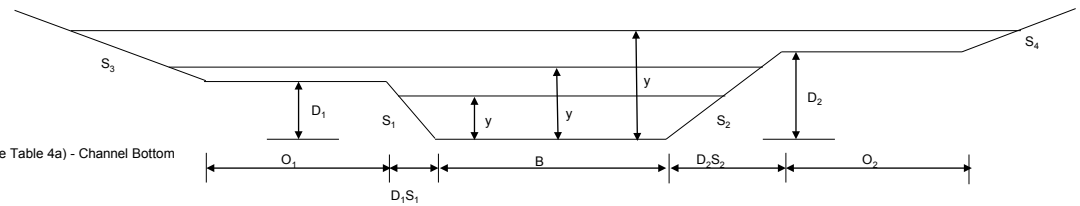
Section: **E-4**

Design Storm: **5-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 12

Freeboard (ft)	0.6	ft	
Did the channel over top?	NO		
Q =	7.01	cfs	
S_0 =	0.001	ft/ft	
α =	1.000		
Channel Bottom	33.5	ft	(Fig. 12)
Channel Geometry Inputs			
y =	2.070	ft	Depth based on assumed WS (See Table 4a) - Channel Bottom
B =	2	ft	(Fig. 12)
Actual D1 =	2.6	ft	(Fig. 12)
Actual D2 =	2.7	ft	(Fig. 12)
Idealized D1 =	2.2	ft	(Fig. 12)
Idealized D2 =	2.5	ft	(Fig. 12)
D_1 =	2.6	ft	(Fig. 12)
D_2 =	2.7	ft	(Fig. 12)
S_1 =	2.5	(ft H / ft V)	(Fig. 12)
S_2 =	2.5	(ft H / ft V)	(Fig. 12)
O_1 =	299.3	ft	(Fig. 12)
O_2 =	268.3	ft	(Fig. 12)
S_3 =	0	(ft H / ft V)	(Fig. 12)
S_4 =	2	(ft H / ft V)	(Fig. 12)
n1 =	0.064	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 12)
n3 =	0.1	right	(Fig. 12)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		14.85	13.15	1.130	15.25
	A1	14.85	13.15	1.130	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	0.000000001	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **9.5473**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.65	10.0550625	10.8586	0.926	0.95003746	9.5527

y_n = 1.645

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.6844	7.01	2.5398084	0.6844169	9.86

y_c = 0.68

Figure 21f

Results of Step Backwater Calculations; East Channel 5-Year Storm, Cross Section E-4

Standard Step Backwater Analysis

Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

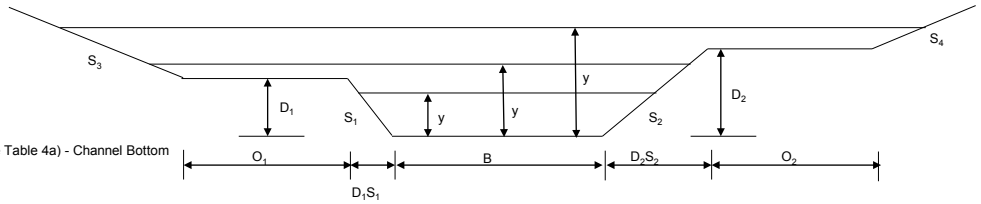
Section: **E-3**

Design Storm: **5-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 11

Freeboard (ft)	0.9	ft	
Did the channel over top?	NO		
Q =	2.74	cfs	
S_0 =	0.001	ft/ft	
α =	1.000		
Channel Bottom	33.8	ft	(Fig. 11)
Channel Geometry Inputs			
y =	1.8	ft	Depth based on assumed WS (See Table 4a) - Channel Bottom
B =	2	ft	(Fig. 11)
Actual D1 =	2.3	ft	(Fig. 11)
Actual D2 =	2.3	ft	(Fig. 11)
Idealized D1 =	2.2	ft	(Fig. 11)
Idealized D2 =	2.7	ft	(Fig. 11)
D_1 =	2.3	ft	
D_2 =	2.7	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 11)
S_2 =	2.5	(ft H / ft V)	(Fig. 11)
O_1 =	299.3	ft	(Fig. 11)
O_2 =	324.9	ft	(Fig. 11)
S_3 =	0	(ft H / ft V)	(Fig. 11)
S_4 =	2	(ft H / ft V)	(Fig. 11)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 11)
n3 =	0.1	right	(Fig. 11)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		12.03	11.85	1.015	14.50
	A1	12.03	11.85	1.015	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **2.5073**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.89	3.7280625	6.765871	0.551	0.67210891	2.5057

y_n = 0.885

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	2.74	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 21g

Results of Step Backwater Calculations; East Channel 5-Year Storm, Cross Section E-3
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

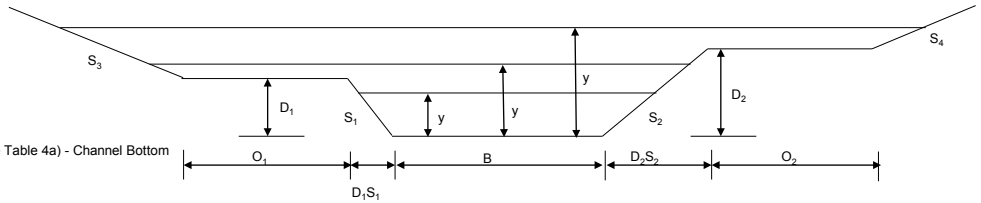
Section: **E-2**

Design Storm: **5-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 10

Freeboard (ft)	2.8	ft	
Did the channel over top?	NO		
Q =	2.74	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	34.2	ft	(Fig. 10)
Channel Geometry Inputs			
y =	1.5	ft	Depth based on assumed WS (See Table 4a) - Channel Bottom
B =	2	ft	(Fig. 10)
Actual D1 =	4.2	ft	(Fig. 10)
Actual D2 =	4.3	ft	(Fig. 10)
Idealized D1 =	3.1	ft	(Fig. 10)
Idealized D2 =	4.3	ft	(Fig. 10)
D_1 =	4.2	ft	
D_2 =	4.3	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 10)
S_2 =	2.5	(ft H / ft V)	(Fig. 10)
O_1 =	355	ft	(Fig. 10)
O_2 =	159.1	ft	(Fig. 10)
S_3 =	0	(ft H / ft V)	(Fig. 10)
S_4 =	2	(ft H / ft V)	(Fig. 10)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 10)
n3 =	0.1	right	(Fig. 10)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		8.25	9.86	0.836	23.25
	A1	8.25	9.86	0.836	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **2.5073**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.89	3.7280625	6.765871	0.551	0.67210891	2.5057

y_n = 0.885

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	2.74	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 21h

Results of Step Backwater Calculations; East Channel 5-Year Storm, Cross Section E-2
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

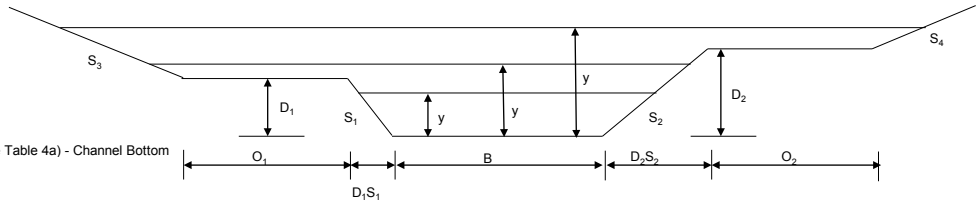
Section: **E-1**

Design Storm: **5-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 9

Freeboard (ft)	2.4	ft	
Did the channel over top?	NO		
Q =	2.74	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	34.3	ft	(Fig. 9)
Channel Geometry Inputs			
y =	1.4	ft	Depth based on assumed WS (See Table 4a) - Channel Bottom
B =	2	ft	(Fig. 9)
Actual D1 =	3.1	ft	(Fig. 9)
Actual D2 =	3.5	ft	(Fig. 9)
Idealized D1 =	3.8	ft	(Fig. 9)
Idealized D2 =	3.8	ft	(Fig. 9)
D_1 =	3.8	ft	
D_2 =	3.8	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 9)
S_2 =	2.5	(ft H / ft V)	(Fig. 9)
O_1 =	242.5	ft	(Fig. 9)
O_2 =	338.7	ft	(Fig. 9)
S_3 =	2	(ft H / ft V)	(Fig. 9)
S_4 =	0	(ft H / ft V)	(Fig. 9)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 9)
n3 =	0.1	right	(Fig. 9)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		7.52	9.43	0.797	21.00
	A1	7.52	9.43	0.797	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **2.5073**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.89	3.7280625	6.765871	0.551	0.67210891	2.5057

y_n = 0.885

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	2.74	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 21i

Results of Step Backwater Calculations; East Channel 5-Year Storm, Cross Section E-1
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

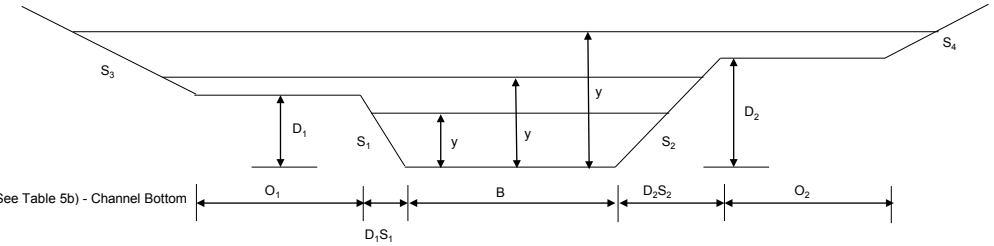
Section: **W-DB** use section W-8 for calculations

Design Storm: **2-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 8
This spreadsheet also calculates the discharge flow (based on Manning's Equation) and compares it to the controlling depth (detention basin, from HydroCAD) to determine which is greater.

Depth, DB	33.77	ft	from HydroCAD Model
Depth, Manning's	34.45	ft	
Controlling Depth	34.45	ft	(max from above)
Freeboard (ft)	3.3	ft	
Did the channel over top?	NO		
Q =	13.03	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.1	ft	(Fig.8)



Channel Geometry Inputs

y =	2.35	ft	Depth based on computed WS (See Table 5b) - Channel Bottom
B =	2	ft	(Fig.8)
Actual D1 =	4.2	ft	(Fig.8)
Actual D2 =	4.3	ft	(Fig.8)
Idealized D1 =	4.5	ft	(Fig.8)
Idealized D2 =	5.6	ft	(Fig.8)
D_1 =	4.5	ft	
D_2 =	5.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig.8)
S_2 =	2.5	(ft H / ft V)	(Fig.8)
O_1 =	169.7	ft	(Fig.8)
O_2 =	356.3	ft	(Fig.8)
S_3 =	0	(ft H / ft V)	(Fig.8)
S_4 =	2	(ft H / ft V)	(Fig.8)
n1 =	0.078	channel	Channel Design Calcs.
n2 =	0.100	left	(Fig.8)
n3 =	0.100	right	(Fig.8)

			Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	T (channel top width at water surface)
A	**For y < D_1**		18.51	14.66	1.263	13.75
		A1	18.51	14.66	1.263	
		A2	0.00	0.00	0.000	
		A3	0.00	0.00	0.000	
B	**For $D_1 \leq y < D_2$**		out of range	out of range	out of range	out of range
		A1	out of range	out of range	out of range	
		A2	out of range	out of range	out of range	
		A3	0	0.00	0.000	
C	**For y (= y_d) ≥ D_2**		out of range	out of range	out of range	out of range
		A1	out of range	out of range	out of range	
		A2	out of range	out of range	out of range	
		A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Discharge Based on Manning's Equation

			Area			Wetted Perimeter				Hydraulic Radius							
Stage	Depth (y)	A,B, C	A1	A2	A3	AT	**WP1**	WP2	WP3	RH1	RH2	RH3	Q1	Q2	Q3	Qt	V
34.45	**2.35**	**A**	**18.506**	**0.000**	**0.000**	**18.506**	**14.655**	**0.000**	**0.000**	**1.263**	**0.000**	**0.000**	**13.026**	**0.000**	**0.000**	**13.026**	**0.704**
34.405	2.305	A	17.893	0.000	0.000	17.893	14.413	0.000	0.000	1.241	0.000	0.000	12.451	0.000	0.000	12.451	0.696
33.9	1.8	A	11.700	0.000	0.000	11.700	11.693	0.000	0.000	1.001	0.000	0.000	7.051	0.000	0.000	7.051	0.603
34	1.9	A	12.825	0.000	0.000	12.825	12.232	0.000	0.000	1.048	0.000	0.000	7.974	0.000	0.000	7.974	0.622
34.1	2	A	14.000	0.000	0.000	14.000	12.770	0.000	0.000	1.096	0.000	0.000	8.967	0.000	0.000	8.967	0.641
34.2	2.1	A	15.225	0.000	0.000	15.225	13.309	0.000	0.000	1.144	0.000	0.000	10.033	0.000	0.000	10.033	0.659
34.3	2.2	A	16.500	0.000	0.000	16.500	13.847	0.000	0.000	1.192	0.000	0.000	11.173	0.000	0.000	11.173	0.677
34.4	2.3	A	17.825	0.000	0.000	17.825	14.386	0.000	0.000	1.239	0.000	0.000	12.388	0.000	0.000	12.388	0.695
34.5	2.4	A	19.200	0.000	0.000	19.200	14.924	0.000	0.000	1.286	0.000	0.000	13.682	0.000	0.000	13.682	0.713
34.6	2.5	A	20.625	0.000	0.000	20.625	15.463	0.000	0.000	1.334	0.000	0.000	15.056	0.000	0.000	15.056	0.730
34.7	2.6	A	22.100	0.000	0.000	22.100	16.001	0.000	0.000	1.381	0.000	0.000	16.512	0.000	0.000	16.512	0.747
34.8	2.7	A	23.625	0.000	0.000	23.625	16.540	0.000	0.000	1.428	0.000	0.000	18.052	0.000	0.000	18.052	0.764
34.9	2.8	A	25.200	0.000	0.000	25.200	17.078	0.000	0.000	1.476	0.000	0.000	19.677	0.000	0.000	19.677	0.781
35	2.9	A	26.825	0.000	0.000	26.825	17.617	0.000	0.000	1.523	0.000	0.000	21.390	0.000	0.000	21.390	0.797
35.1	3	A	28.500	0.000	0.000	28.500	18.155	0.000	0.000	1.570	0.000	0.000	23.191	0.000	0.000	23.191	0.814
35.2	3.1	A	30.225	0.000	0.000	30.225	18.694	0.000	0.000	1.617	0.000	0.000	25.084	0.000	0.000	25.084	0.830

= entered values

integral consulting inc.

Figure 22a
Results of Step Backwater Calculations, West Channel 2-Year Storm, Cross Section W-DB
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

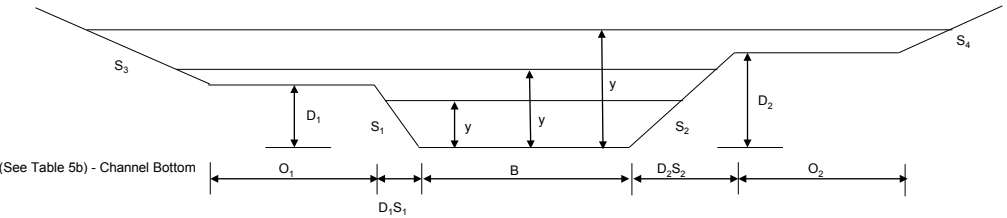
Section: W-8

Design Storm: 2-yr

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 8

Freeboard (ft)	3.3	ft	
Did the channel ov	NO		
Q =	13.03	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.1	ft	(Fig. 8)



Channel Geometry Inputs

y =	2.4	ft	Depth based on assumed WS (See Table 5b) - Channel Bottom
B =	2	ft	(Fig. 8)
Actual D1 =	4.2	ft	(Fig. 8)
Actual D2 =	4.3	ft	(Fig. 8)
Idealized D1 =	4.5	ft	(Fig. 8)
Idealized D2 =	5.6	ft	(Fig. 8)
D_1 =	4.5	ft	
D_2 =	5.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 8)
S_2 =	2.5	(ft H / ft V)	(Fig. 8)
O_1 =	169.7	ft	(Fig. 8)
O_2 =	356.3	ft	(Fig. 8)
S_3 =	0	(ft H / ft V)	(Fig. 8)
S_4 =	2	(ft H / ft V)	(Fig. 8)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.100	left	(Fig. 8)
n3 =	0.100	right	(Fig. 8)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		18.51	14.66	1.263	27.25
	A1	18.51	14.66	1.263	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **21.6282**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
2.35	18.53376	14.66591	1.264	1.16887946	21.6637

y_n = 2.352

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	13.03	3.524270869	0.7500581	15.00

y_c = 0.85

integral consulting inc.

Figure 22b

Results of Step Backwater Calculations, West Channel 2-Year Storm, Cross Section W-8
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

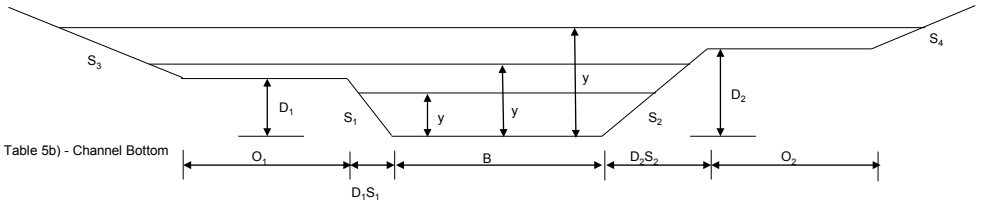
Section: **W-7**

Design Storm: **2-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 7

Freeboard (ft)	1.4	ft	
Did the channel over top?	NO		
Q =	4.04	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.4	ft	(Fig. 7)
Channel Geometry Inputs			
y =	2.2	ft	Depth based on assumed WS (See Table 5b) - Channel Bottom
B =	2	ft	(Fig. 7)
Actual D1 =	3.1	ft	(Fig. 7)
Actual D2 =	3.2	ft	(Fig. 7)



Idealized D1 =	2.8	ft	(Fig. 7)
Idealized D2 =	3.6	ft	(Fig. 7)
D_1 =	3.1	ft	
D_2 =	3.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 7)
S_2 =	2.5	(ft H / ft V)	(Fig. 7)
O_1 =	102.8	ft	(Fig. 7)
O_2 =	136.3	ft	(Fig. 7)
S_3 =	2	(ft H / ft V)	(Fig. 7)
S_4 =	0	(ft H / ft V)	(Fig. 7)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 7)
n3 =	0.1	right	(Fig. 7)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		16.63	13.90	1.196	18.75
	A1	16.63	13.90	1.196	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **6.7059**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.40	7.7270225	9.555386	0.809	0.86797914	6.7069

y_n = 1.403

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	4.04	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 22c

Results of Step Backwater Calculations, West Channel 2-Year Storm, Cross Section W-7
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

Section: **W-6**

Design Storm: **2-yr**

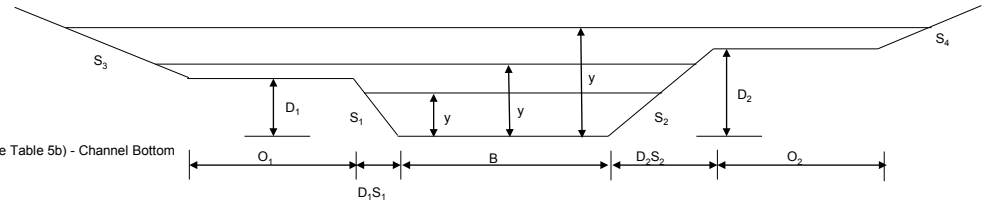
Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 6

Freeboard (ft)	1.2	ft	
Did the channel over top?	NO		
Q =	1.79	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.8	ft	(Fig. 6)

Channel Geometry Inputs

y =	1.9	ft	Depth based on assumed WS (See Table 5b) - Channel Bottom
B =	2	ft	(Fig. 6)
Actual D1 =	1.92	ft	(Fig. 6)
Actual D2 =	2	ft	(Fig. 6)



Idealized D1 =	1.92	ft	(Fig. 6)
Idealized D2 =	3	ft	(Fig. 6)
D_1 =	1.9	ft	(Fig. 6)
D_2 =	3	ft	(Fig. 6)
S_1 =	2.5	(ft H / ft V)	(Fig. 6)
S_2 =	2.5	(ft H / ft V)	(Fig. 6)
O_1 =	0	ft	(Fig. 6)
O_2 =	273.7	ft	(Fig. 6)
S_3 =	2	(ft H / ft V)	(Fig. 6)
S_4 =	0	(ft H / ft V)	(Fig. 6)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 6)
n3 =	0.1	right	(Fig. 6)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		12.26	11.96	1.025	14.30
	A1	12.26	11.96	1.025	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **2.9712**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.96	4.2308025	7.175143	0.590	0.7031718	2.9750

y_n = 0.961

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	1.79	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 22d

Results of Step Backwater Calculations, West Channel 2-Year Storm, Cross Section W-6
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

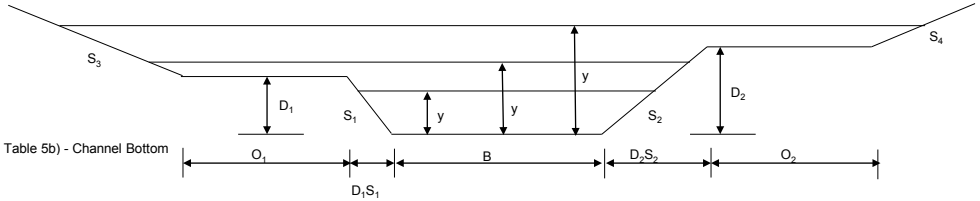
Section: **W-5**

Design Storm: **2-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 5

Freeboard (ft)	0.8	ft	
Did the channel over top?	YES		
Q =	1.79	cfs	
S_0 =	0.001	ft/ft	
α =	1.04601854		
Channel Bottom	32.9	ft	(Fig. 5)
Channel Geometry Inputs			
y =	1.8	ft	Depth based on assumed WS (See Table 5b) - Channel Bottom
B =	2	ft	(Fig. 5)
Actual D1 =	1.12	ft	(Fig. 5)
Actual D2 =	1.2	ft	(Fig. 5)



Idealized D1 =	1.12	ft	(Fig. 5)
Idealized D2 =	2.5	ft	(Fig. 5)
D_1 =	1.12	ft	(Fig. 5)
D_2 =	2.5	ft	(Fig. 5)
S_1 =	2.5	(ft H / ft V)	(Fig. 5)
S_2 =	2.5	(ft H / ft V)	(Fig. 5)
O_1 =	0	ft	(Fig. 5)
O_2 =	275.6	ft	(Fig. 5)
S_3 =	2	(ft H / ft V)	(Fig. 5)
S_4 =	0	(ft H / ft V)	(Fig. 5)
n1 =	0.064	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 5)
n3 =	0.1	right	(Fig. 5)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		11.057025	11.14	0.993	12.31
	A1	10.660125	9.73	1.096	
	A2	0.3969	1.41	0.282	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **2.4379**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.87	3.6513225	6.701249	0.545	0.66710823	2.4358

y_n = 0.873

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.6844	1.79	2.5398084	0.6844169	9.86

y_c = 0.68

Figure 22e

Results of Step Backwater Calculations, West Channel 2-Year Storm, Cross Section W-5

Standard Step Backwater Analysis

Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

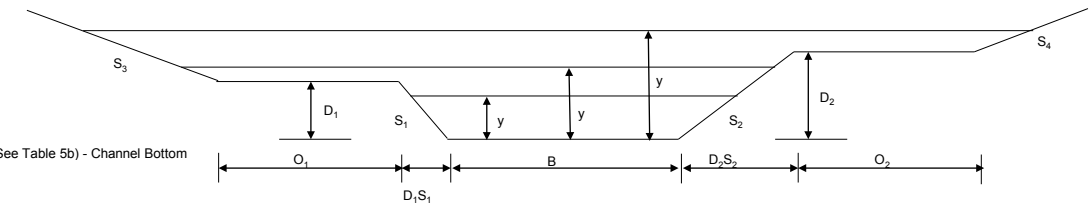
Section: **W-4**

Design Storm: **2-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 4

Freeboard (ft)	0.9	ft	
Did the channel over top?	YES		
Q =	1.73	cfs	
S_0 =	0.001	ft/ft	
α =	1.227		
Channel Bottom	33.1	ft	(Fig. 4)
Channel Geometry Inputs			
y =	1.560	ft	Depth based on assumed WS (See Table 5b) - Channel Bottom
B =	2	ft	(Fig. 4)
Actual D1 =	0.8	ft	(Fig. 4)
Actual D2 =	1.3	ft	(Fig. 4)
Idealized D1 =	0.8	ft	(Fig. 4)
Idealized D2 =	2.5	ft	(Fig. 4)
D_1 =	0.8	ft	(Fig. 4)
D_2 =	2.5	ft	(Fig. 4)
S_1 =	2.5	(ft H / ft V)	(Fig. 4)
S_2 =	2.5	(ft H / ft V)	(Fig. 4)
O_1 =	5	ft	(Fig. 4)
O_2 =	297.2	ft	(Fig. 4)
S_3 =	0.0001	(ft H / ft V)	(Fig. 4)
S_4 =	0	(ft H / ft V)	(Fig. 4)
n1 =	0.064	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 4)
n3 =	0.1	right	(Fig. 4)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		12.28202888	14.11	0.870	15.25
	A1	8.482	8.35	1.015	
	A2	3.800	5.76	0.660	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	0.000000001	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **2.3562**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.92	4.48153191	11.73278	0.382	0.52644185	2.3593

y_n = 0.915

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.6844	1.73	2.5398084	0.6844169	9.86

y_c = 0.68

Figure 22f

Results of Step Backwater Calculations, West Channel 2-Year Storm, Cross Section W-4
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

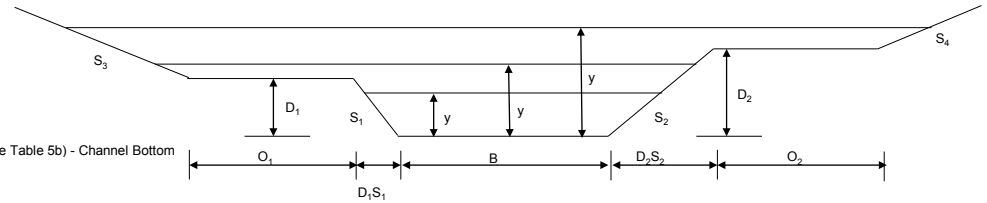
Section: **W-3**

Design Storm: **2-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 3

Freeboard (ft)	1.2	ft	
Did the channel over top?	NO		
Q =	1.73	cfs	
S_0 =	0.001	ft/ft	
α =	1.000		
Channel Bottom	33.4	ft	(Fig. 3)



Channel Geometry Inputs

y =	1.3	ft	Depth based on assumed WS (See Table 5b) - Channel Bottom
B =	2	ft	(Fig. 3)
Actual D1 =	1.64	ft	(Fig. 3)
Actual D2 =	1.8	ft	(Fig. 3)
Idealized D1 =	1.64	ft	(Fig. 3)
Idealized D2 =	2.5	ft	(Fig. 3)
D_1 =	1.64	ft	
D_2 =	2.5	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 3)
S_2 =	2.5	(ft H / ft V)	(Fig. 3)
O_1 =	4.2	ft	(Fig. 3)
O_2 =	294.8	ft	(Fig. 3)
S_3 =	0.0001	(ft H / ft V)	(Fig. 3)
S_4 =	0	(ft H / ft V)	(Fig. 3)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 3)
n3 =	0.1	right	(Fig. 3)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		6.66	8.89	0.748	12.35
	A1	6.66	8.89	0.748	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **1.5831**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.71	2.66916	5.812697	0.459	0.59520234	1.5887

y_n = 0.708

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	1.73	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 22g

Results of Step Backwater Calculations, West Channel 2-Year Storm, Cross Section W-3
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

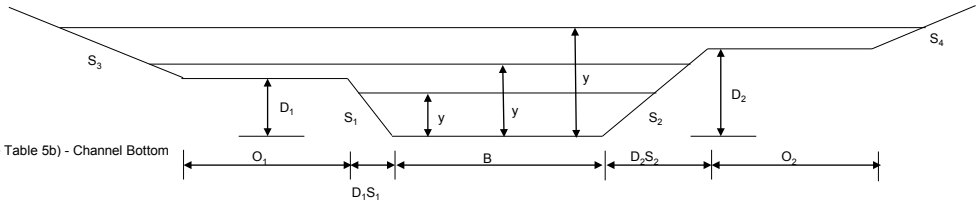
Section: **W-2**

Design Storm: **2-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 2

Freeboard (ft)	2.5	ft	
Did the channel over top?	NO		
Q =	1.73	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	33.7	ft	(Fig. 2)
Channel Geometry Inputs			
y =	1.0	ft	Depth based on assumed WS (See Table 5b) - Channel Bottom
B =	2	ft	(Fig. 2)
Actual D1 =	3.4	ft	(Fig. 2)
Actual D2 =	3.5	ft	(Fig. 2)
Idealized D1 =	3.4	ft	(Fig. 2)
Idealized D2 =	3.3	ft	(Fig. 2)
D_1 =	3.4	ft	
D_2 =	3.5	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 2)
S_2 =	2.5	(ft H / ft V)	(Fig. 2)
O_1 =	278.4	ft	(Fig. 2)
O_2 =	59.6	ft	(Fig. 2)
S_3 =	0	(ft H / ft V)	(Fig. 2)
S_4 =	0.0001	(ft H / ft V)	(Fig. 2)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 2)
n3 =	0.1	right	(Fig. 2)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		4.64	7.49	0.619	19.25
	A1	4.64	7.49	0.619	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **1.5831**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.71	2.66916	5.812697	0.459	0.59520234	1.5887

y_n = 0.708

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	1.73	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 22h

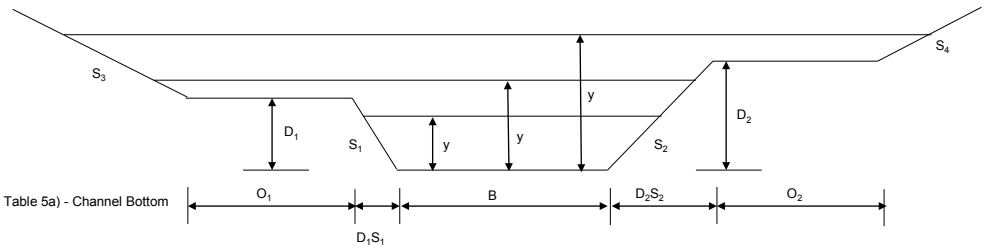
Results of Step Backwater Calculations, West Channel 2-Year Storm, Cross Section W-2
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

Section:	**E-DB**	use section W-8 for calculations	Calculated by:	JG
Design Storm:	**2-yr**	(25-yr,10-yr,5-yr,2-yr)	Date:	9/19/2011
			Checked by:	MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 8
This spreadsheet also calculates the discharge flow (based on Manning's Equation) and compares it to the controlling depth (detention basin, from HydroCAD) to determine which is greater.

Depth, DB	33.77	ft	from HydroCAD Model
Depth, Manning's	34.57	ft	
Controlling Depth	34.57	ft	(max from above)
Freeboard (ft)	3.1	ft	
Did the channel over top?	NO		
Q =	14.64	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.1	ft	(Fig. 8)



Channel Geometry Inputs

y =	2.47	ft	Depth based on computed WS (See Table 5a) - Channel Bottom
B =	2	ft	(Fig. 8)
Actual D1 =	4.2	ft	(Fig. 8)
Actual D2 =	4.3	ft	(Fig. 8)
Idealized D1 =	4.5	ft	(Fig. 8)
Idealized D2 =	5.6	ft	(Fig. 8)
D_1 =	4.5	ft	
D_2 =	5.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 8)
S_2 =	2.5	(ft H / ft V)	(Fig. 8)
O_1 =	169.7	ft	(Fig. 8)
O_2 =	356.3	ft	(Fig. 8)
S_3 =	0	(ft H / ft V)	(Fig. 8)
S_4 =	2	(ft H / ft V)	(Fig. 8)
n1 =	0.078	channel	Channel Design Calcs.
n2 =	0.100	left	(Fig. 8)
n3 =	0.100	right	(Fig. 8)

			Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	T (channel top width at water surface)
A	**For y < D_1**		20.19	15.30	1.320	14.35
		A1	20.19	15.30	1.320	
		A2	0.00	0.00	0.000	
		A3	0.00	0.00	0.000	
B	**For $D_1 \leq y < D_2$**		out of range	out of range	out of range	out of range
		A1	out of range	out of range	out of range	
		A2	out of range	out of range	out of range	
		A3	0	0.00	0.000	
C	**For y (= y_d) ≥ D_2**		out of range	out of range	out of range	out of range
		A1	out of range	out of range	out of range	
		A2	out of range	out of range	out of range	
		A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Discharge Based on Manning's Equation

			Area			Wetted Perimeter				Hydraulic Radius							
Stage	Depth (y)	A,B, C	A1	A2	A3	AT	**WP1**	WP2	WP3	RH1	RH2	RH3	Q1	Q2	Q3	Qt	V
34.57	**2.47**	**A**	**20.192**	**0.000**	**0.000**	**20.192**	**15.301**	**0.000**	**0.000**	**1.320**	**0.000**	**0.000**	**14.636**	**0.000**	**0.000**	**14.636**	**0.725**
35.07	2.97	A	27.992	0.000	0.000	27.992	17.994	0.000	0.000	1.556	0.000	0.000	22.641	0.000	0.000	22.641	0.809
35.57	3.47	A	37.042	0.000	0.000	37.042	20.687	0.000	0.000	1.791	0.000	0.000	32.907	0.000	0.000	32.907	0.888
36.07	3.97	A	47.342	0.000	0.000	47.342	23.379	0.000	0.000	2.025	0.000	0.000	45.651	0.000	0.000	45.651	0.964
36.57	4.47	A	58.892	0.000	0.000	58.892	26.072	0.000	0.000	2.259	0.000	0.000	61.081	0.000	0.000	61.081	1.037
35.2	3.1	A	30.225	0.000	0.000	30.225	18.694	0.000	0.000	1.617	0.000	0.000	25.084	0.000	0.000	25.084	0.830
34.7	2.6	A	22.100	0.000	0.000	22.100	16.001	0.000	0.000	1.381	0.000	0.000	16.512	0.000	0.000	16.512	0.747
34.76	2.66	A	23.009	0.000	0.000	23.009	16.325	0.000	0.000	1.409	0.000	0.000	17.426	0.000	0.000	17.426	0.757
35.26	3.16	A	31.284	0.000	0.000	31.284	19.017	0.000	0.000	1.645	0.000	0.000	26.264	0.000	0.000	26.264	0.840
35.76	3.66	A	40.809	0.000	0.000	40.809	21.710	0.000	0.000	1.880	0.000	0.000	37.447	0.000	0.000	37.447	0.918
36.26	4.16	A	51.584	0.000	0.000	51.584	24.402	0.000	0.000	2.114	0.000	0.000	51.187	0.000	0.000	51.187	0.992
36.76	4.66	B	63.577	27.152	0.000	90.729	26.664	169.860	0.000	2.384	0.160	0.000	68.361	3.758	0.000	72.119	0.795
37.26	5.16	B	76.339	112.002	0.000	188.341	28.010	170.360	0.000	2.725	0.657	0.000	89.735	39.794	0.000	129.529	0.688
37.76	5.66	C	89.722	196.852	21.382	307.956	29.195	170.860	356.434	3.073	1.152	0.060	114.258	101.662	1.540	217.460	0.706
38.26	6.16	C	103.348	281.702	199.842	584.891	29.195	171.360	357.552	3.540	1.644	0.559	144.616	184.386	63.719	392.722	0.671
38.76	6.66	C	116.973	366.552	378.802	862.326	29.195	171.860	358.670	4.007	2.133	1.056	177.770	285.405	184.604	647.779	0.751

[ ] = entered values

Figure 23a
Results of Step Backwater Calculations, East Channel 2-Year Storm, Cross Section E-DB
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

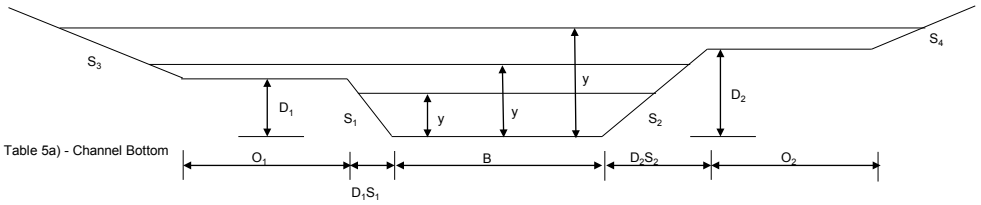
Section: **E-8 (W-8)**

Design Storm: **2-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 8

Freeboard (ft)	3.1	ft	
Did the channel over top?	NO		
Q =	14.64	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.1	ft	(Fig. 8)



Channel Geometry Inputs

y =	2.5	ft	Depth based on assumed WS (See Table 5a) - Channel Bottom
B =	2	ft	(Fig. 8)
Actual D1 =	4.2	ft	(Fig. 8)
Actual D2 =	4.3	ft	(Fig. 8)
Idealized D1 =	4.5	ft	(Fig. 8)
Idealized D2 =	5.6	ft	(Fig. 8)
D_1 =	4.5	ft	
D_2 =	5.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 8)
S_2 =	2.5	(ft H / ft V)	(Fig. 8)
O_1 =	169.7	ft	(Fig. 8)
O_2 =	356.3	ft	(Fig. 8)
S_3 =	0	(ft H / ft V)	(Fig. 8)
S_4 =	2	(ft H / ft V)	(Fig. 8)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.100	left	(Fig. 8)
n3 =	0.100	right	(Fig. 8)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		20.19	15.30	1.320	27.25
	A1	20.19	15.30	1.320	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **24.3006**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
2.47	20.19225	15.30136	1.320	1.20310402	24.2934

y_n = 2.470

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	14.64	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 23b

Results of Step Backwater Calculations, East Channel 2-Year Storm, Cross Section E-8 (W-8)
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

Section: **E-7**

Design Storm: **2-yr**

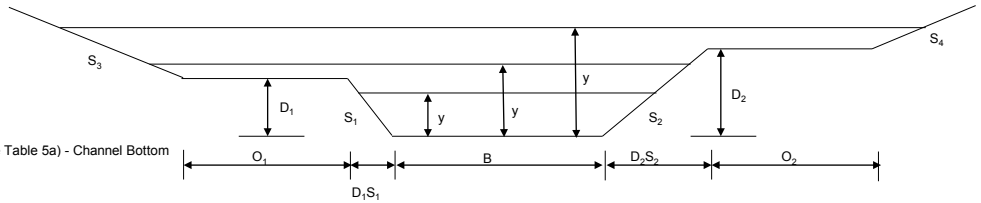
Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 15

Freeboard (ft)	1.3	ft	
Did the channel over top?	NO		
Q =	8.99	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.8	ft	(Fig. 15)

Channel Geometry Inputs

y =	1.9	ft	Depth based on assumed WS (See Table 5a) - Channel Bottom
B =	2	ft	(Fig. 15)
Actual D1 =	3.2	ft	(Fig. 15)
Actual D2 =	3.2	ft	(Fig. 15)



Idealized D1 =	3.2	ft	(Fig. 15)
Idealized D2 =	3.2	ft	(Fig. 15)
D_1 =	3.2	ft	
D_2 =	3.2	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 15)
S_2 =	2.5	(ft H / ft V)	(Fig. 15)
O_1 =	115.3	ft	(Fig. 15)
O_2 =	165.2	ft	(Fig. 15)
S_3 =	0	(ft H / ft V)	(Fig. 15)
S_4 =	0	(ft H / ft V)	(Fig. 15)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 15)
n3 =	0.1	right	(Fig. 15)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		12.71	12.18	1.044	18.00
	A1	12.71	12.18	1.044	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **14.9223**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
2.00	14.0360225	12.78649	1.098	1.06413139	14.9362

y_n = 2.003

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	8.99	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 23c

Results of Step Backwater Calculations, East Channel 2-Year Storm, Cross Section E-7
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

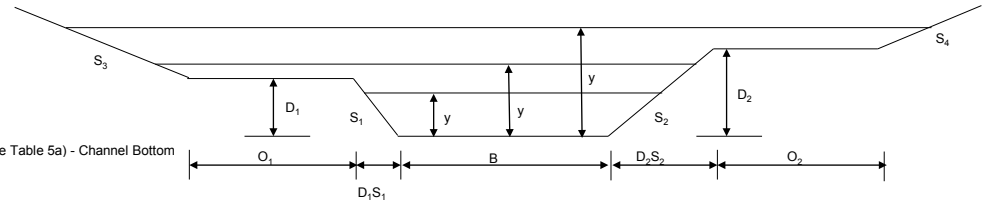
Section: **E-6**

Design Storm: **2-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 14

Freeboard (ft)	1.3	ft	
Did the channel over top?	NO		
Q =	8.99	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	33.2	ft	(Fig. 14)



Channel Geometry Inputs

y =	2.0	ft	Depth based on assumed WS (See Table 5a) - Channel Bottom
B =	2	ft	(Fig. 14)
Actual D1 =	2.7	ft	(Fig. 14)
Actual D2 =	2.8	ft	(Fig. 14)
Idealized D1 =	3	ft	(Fig. 14)
Idealized D2 =	3.3	ft	(Fig. 14)
D_1 =	3.0	ft	(Fig. 14)
D_2 =	3.3	ft	(Fig. 14)
S_1 =	2.5	(ft H / ft V)	(Fig. 14)
S_2 =	2.5	(ft H / ft V)	(Fig. 14)
O_1 =	296.4	ft	(Fig. 14)
O_2 =	172.1	ft	(Fig. 14)
S_3 =	0	(ft H / ft V)	(Fig. 14)
S_4 =	0	(ft H / ft V)	(Fig. 14)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 14)
n3 =	0.1	right	(Fig. 14)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		14.24	12.88	1.106	17.75
	A1	14.24	12.88	1.106	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **14.9223**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
2.00	14.0360225	12.78649	1.098	1.06413139	14.9362

y_n = 2.003

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	8.99	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 23d

Results of Step Backwater Calculations, East Channel 2-Year Storm, Cross Section E-6
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

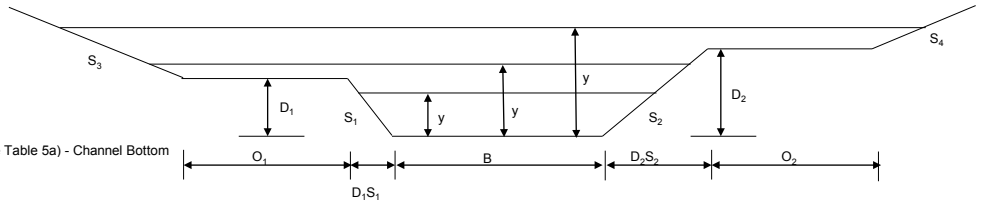
Section: **E-5**

Design Storm: **2-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 13

Freeboard (ft)	1.2	ft	
Did the channel over top?	NO		
Q =	5.54	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	33.4	ft	(Fig. 13)
Channel Geometry Inputs			
y =	1.9	ft	Depth based on assumed WS (See Table 5a) - Channel Bottom
B =	2	ft	(Fig. 13)
Actual D1 =	3	ft	(Fig. 13)
Actual D2 =	3.1	ft	(Fig. 13)



Idealized D1 =	2.9	ft	(Fig. 13)
Idealized D2 =	3.1	ft	(Fig. 13)
D_1 =	3	ft	(Fig. 13)
D_2 =	3.1	ft	(Fig. 13)
S_1 =	2.5	(ft H / ft V)	(Fig. 13)
S_2 =	2.5	(ft H / ft V)	(Fig. 13)
O_1 =	298.1	ft	(Fig. 13)
O_2 =	157.7	ft	(Fig. 13)
S_3 =	0	(ft H / ft V)	(Fig. 13)
S_4 =	2	(ft H / ft V)	(Fig. 13)
n1 =	0.064	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 13)
n3 =	0.1	right	(Fig. 13)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		12.83	12.23	1.048	17.25
	A1	12.83	12.23	1.048	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **7.5452**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.48	8.436	9.970044	0.846	0.89459473	7.5468

y_n = 1.480

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.6844	5.54	2.5398084	0.6844169	9.86

y_c = 0.68

integral consulting inc.

Figure 23e

Results of Step Backwater Calculations, East Channel 2-Year Storm, Cross Section E-5
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

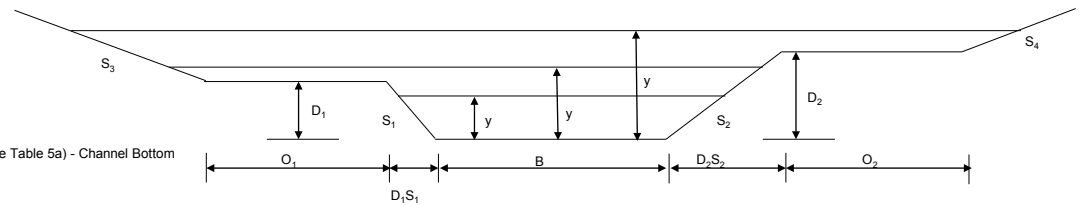
Section: **E-4**

Design Storm: **2-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 12

Freeboard (ft)	0.8	ft	
Did the channel over top?	NO		
Q =	5.54	cfs	
S_0 =	0.001	ft/ft	
α =	1.000		
Channel Bottom	33.5	ft	(Fig. 12)
Channel Geometry Inputs			
y =	1.850	ft	Depth based on assumed WS (See Table 5a) - Channel Bottom
B =	2	ft	(Fig. 12)
Actual D1 =	2.6	ft	(Fig. 12)
Actual D2 =	2.7	ft	(Fig. 12)
Idealized D1 =	2.2	ft	(Fig. 12)
Idealized D2 =	2.5	ft	(Fig. 12)
D_1 =	2.6	ft	(Fig. 12)
D_2 =	2.7	ft	(Fig. 12)
S_1 =	2.5	(ft H / ft V)	(Fig. 12)
S_2 =	2.5	(ft H / ft V)	(Fig. 12)
O_1 =	299.3	ft	(Fig. 12)
O_2 =	268.3	ft	(Fig. 12)
S_3 =	0	(ft H / ft V)	(Fig. 12)
S_4 =	2	(ft H / ft V)	(Fig. 12)
n1 =	0.064	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 12)
n3 =	0.1	right	(Fig. 12)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		12.26	11.96	1.025	15.25
	A1	12.26	11.96	1.025	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	0.000000001	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **7.5452**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.48	8.436	9.970044	0.846	0.89459473	7.5468

y_n = 1.480

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.6844	5.54	2.5398084	0.6844169	9.86

y_c = 0.68

Figure 23f

Results of Step Backwater Calculations, East Channel 2-Year Storm, Cross Section E-4

Standard Step Backwater Analysis

Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

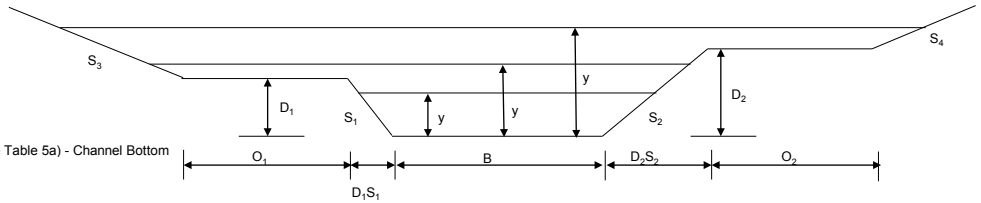
Section: **E-3**

Design Storm: **2-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 11

Freeboard (ft)	1.1	ft	
Did the channel over top?	NO		
Q =	2.15	cfs	
S_0 =	0.001	ft/ft	
α =	1.000		
Channel Bottom	33.8	ft	(Fig. 11)



Channel Geometry Inputs

y =	1.6	ft	Depth based on assumed WS (See Table 5a) - Channel Bottom
B =	2	ft	(Fig. 11)
Actual D1 =	2.3	ft	(Fig. 11)
Actual D2 =	2.3	ft	(Fig. 11)
Idealized D1 =	2.2	ft	(Fig. 11)
Idealized D2 =	2.7	ft	(Fig. 11)
D_1 =	2.3	ft	
D_2 =	2.7	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 11)
S_2 =	2.5	(ft H / ft V)	(Fig. 11)
O_1 =	299.3	ft	(Fig. 11)
O_2 =	324.9	ft	(Fig. 11)
S_3 =	0	(ft H / ft V)	(Fig. 11)
S_4 =	2	(ft H / ft V)	(Fig. 11)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 11)
n3 =	0.1	right	(Fig. 11)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		9.70	10.67	0.909	14.50
	A1	9.70	10.67	0.909	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **1.9674**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.79	3.1224225	6.238125	0.501	0.63041288	1.9684

y_n = 0.787

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	2.15	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 23g

Results of Step Backwater Calculations, East Channel 2-Year Storm, Cross Section E-3
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

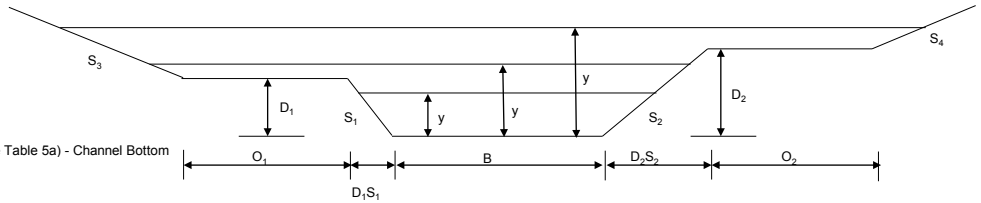
Section: **E-2**

Design Storm: **2-yr**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 10

Freeboard (ft)	3.1	ft	
Did the channel over top?	NO		
Q =	2.15	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	34.2	ft	(Fig. 10)
Channel Geometry Inputs			
y =	1.3	ft	Depth based on assumed WS (See Table 5a) - Channel Bottom
B =	2	ft	(Fig. 10)
Actual D1 =	4.2	ft	(Fig. 10)
Actual D2 =	4.3	ft	(Fig. 10)
Idealized D1 =	3.1	ft	(Fig. 10)
Idealized D2 =	4.3	ft	(Fig. 10)
D_1 =	4.2	ft	
D_2 =	4.3	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 10)
S_2 =	2.5	(ft H / ft V)	(Fig. 10)
O_1 =	355	ft	(Fig. 10)
O_2 =	159.1	ft	(Fig. 10)
S_3 =	0	(ft H / ft V)	(Fig. 10)
S_4 =	2	(ft H / ft V)	(Fig. 10)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 10)
n3 =	0.1	right	(Fig. 10)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		6.41	8.73	0.734	23.25
	A1	6.41	8.73	0.734	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **1.9674**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.79	3.1224225	6.238125	0.501	0.63041288	1.9684

y_n = 0.787

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	2.15	1.2362025	0.5528223	3.88

y_c = 0.41

integral consulting inc.

Figure 23h

Results of Step Backwater Calculations, East Channel 2-Year Storm, Cross Section E-2
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

Section: **E-1**

Design Storm: **2-yr**

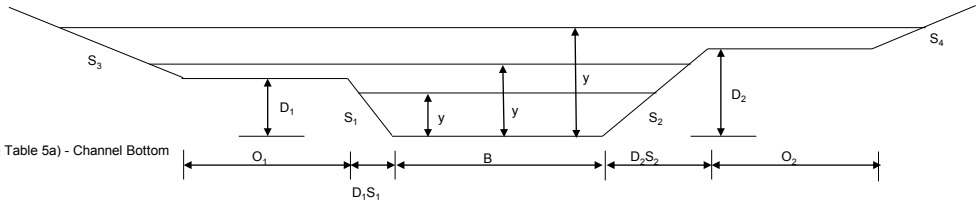
Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 9

Freeboard (ft)	2.6	ft	
Did the channel over top?	NO		
Q =	2.15	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	34.3	ft	(Fig. 9)

Channel Geometry Inputs

y =	1.2	ft	Depth based on assumed WS (See Table 5a) - Channel Bottom
B =	2	ft	(Fig. 9)
Actual D1 =	3.1	ft	(Fig. 9)
Actual D2 =	3.5	ft	(Fig. 9)



Idealized D1 =	3.8	ft	(Fig. 9)
Idealized D2 =	3.8	ft	(Fig. 9)
D_1 =	3.8	ft	
D_2 =	3.8	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 9)
S_2 =	2.5	(ft H / ft V)	(Fig. 9)
O_1 =	242.5	ft	(Fig. 9)
O_2 =	338.7	ft	(Fig. 9)
S_3 =	2	(ft H / ft V)	(Fig. 9)
S_4 =	0	(ft H / ft V)	(Fig. 9)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 9)
n3 =	0.1	right	(Fig. 9)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		5.76	8.30	0.694	21.00
	A1	5.76	8.30	0.694	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **1.9674**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.79	3.1224225	6.238125	0.501	0.63041288	1.9684

y_n = 0.787

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	2.15	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 23i

Results of Step Backwater Calculations, East Channel 2-Year Storm, Cross Section E-1

Standard Step Backwater Analysis

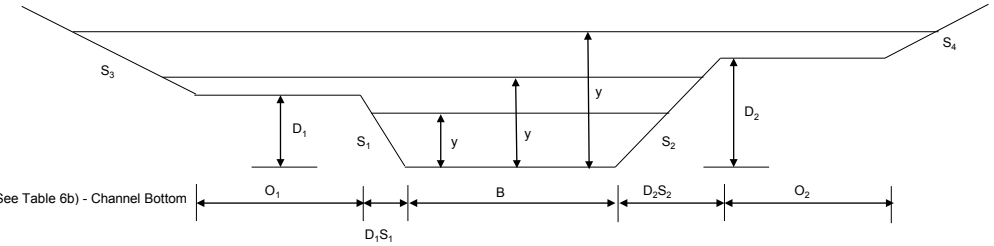
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

Section:	**W-DB**	use section W-8 for calculations	Calculated by:	JG
Design Storm:	**1-inch**		Date:	9/19/2011
			Checked by:	MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 8
This spreadsheet also calculates the discharge flow (based on Manning's Equation) and compares it to the controlling depth (detention basin, from HydroCAD) to determine which is greater.

Depth, DB	31.97	ft	from HydroCAD Model
Depth, Manning's	33.23	ft	
Controlling Depth	33.23	ft	(max from above)
Freeboard (ft)	4.5	ft	
Did the channel over top?	NO		
Q =	3.90	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.1	ft	(Fig. 8)



Channel Geometry Inputs

y =	1.13	ft	Depth based on computed WS (See Table 6b) - Channel Bottom
B =	4	ft	(Fig. 8)
Actual D1 =	4.2	ft	(Fig. 8)
Actual D2 =	4.3	ft	(Fig. 8)
Idealized D1 =	4.5	ft	(Fig. 8)
Idealized D2 =	5.6	ft	(Fig. 8)
D_1 =	4.5	ft	
D_2 =	5.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 8)
S_2 =	2.5	(ft H / ft V)	(Fig. 8)
O_1 =	169.7	ft	(Fig. 8)
O_2 =	356.3	ft	(Fig. 8)
S_3 =	0	(ft H / ft V)	(Fig. 8)
S_4 =	2	(ft H / ft V)	(Fig. 8)
n1 =	0.078	channel	Channel Design Calcs.
n2 =	0.100	left	(Fig. 8)
n3 =	0.100	right	(Fig. 8)

			Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	T (channel top width at water surface)
A	**For y < D_1**		7.71	10.09	0.765	9.65
		A1	7.71	10.09	0.765	
		A2	0.00	0.00	0.000	
		A3	0.00	0.00	0.000	
B	**For $D_1 \leq y < D_2$**		out of range	out of range	out of range	out of range
		A1	out of range	out of range	out of range	
		A2	out of range	out of range	out of range	
		A3	0	0.00	0.000	
C	**For y (= y_d) ≥ D_2**		out of range	out of range	out of range	out of range
		A1	out of range	out of range	out of range	
		A2	out of range	out of range	out of range	
		A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Discharge Based on Manning's Equation

			Area			Wetted Perimeter				Hydraulic Radius							
Stage	Depth (y)	A,B, C	A1	A2	A3	AT	**WP1**	WP2	WP3	RH1	RH2	RH3	Q1	Q2	Q3	Qt	V
33.23217218	**1.13217218**	**A**	**7.733**	**0.000**	**0.000**	**7.733**	**10.097**	**0.000**	**0.000**	**0.766**	**0.000**	**0.000**	**3.900**	**0.000**	**0.000**	**3.900**	**0.504**
34.405	2.305	A	22.503	0.000	0.000	22.503	16.413	0.000	0.000	1.371	0.000	0.000	16.731	0.000	0.000	16.731	0.744
33.9	1.8	A	15.300	0.000	0.000	15.300	13.693	0.000	0.000	1.117	0.000	0.000	9.925	0.000	0.000	9.925	0.649
34	1.9	A	16.625	0.000	0.000	16.625	14.232	0.000	0.000	1.168	0.000	0.000	11.109	0.000	0.000	11.109	0.668
34.1	2	A	18.000	0.000	0.000	18.000	14.770	0.000	0.000	1.219	0.000	0.000	12.372	0.000	0.000	12.372	0.687
34.2	2.1	A	19.425	0.000	0.000	19.425	15.309	0.000	0.000	1.269	0.000	0.000	13.716	0.000	0.000	13.716	0.706
34.3	2.2	A	20.900	0.000	0.000	20.900	15.847	0.000	0.000	1.319	0.000	0.000	15.142	0.000	0.000	15.142	0.725
34.4	2.3	A	22.425	0.000	0.000	22.425	16.386	0.000	0.000	1.369	0.000	0.000	16.653	0.000	0.000	16.653	0.743
34.5	2.4	A	24.000	0.000	0.000	24.000	16.924	0.000	0.000	1.418	0.000	0.000	18.250	0.000	0.000	18.250	0.760
34.6	2.5	A	25.625	0.000	0.000	25.625	17.463	0.000	0.000	1.467	0.000	0.000	19.935	0.000	0.000	19.935	0.778
34.7	2.6	A	27.300	0.000	0.000	27.300	18.001	0.000	0.000	1.517	0.000	0.000	21.710	0.000	0.000	21.710	0.795
34.8	2.7	A	29.025	0.000	0.000	29.025	18.540	0.000	0.000	1.566	0.000	0.000	23.576	0.000	0.000	23.576	0.812
34.9	2.8	A	30.800	0.000	0.000	30.800	19.078	0.000	0.000	1.614	0.000	0.000	25.536	0.000	0.000	25.536	0.829
35	2.9	A	32.625	0.000	0.000	32.625	19.617	0.000	0.000	1.663	0.000	0.000	27.590	0.000	0.000	27.590	0.846
35.1	3	A	34.500	0.000	0.000	34.500	20.155	0.000	0.000	1.712	0.000	0.000	29.741	0.000	0.000	29.741	0.862
35.2	3.1	A	36.425	0.000	0.000	36.425	20.694	0.000	0.000	1.760	0.000	0.000	31.991	0.000	0.000	31.991	0.878

[ ] = entered values

integral consulting inc.

Figure 24a
Results of Step Backwater Calculations, West Channel 1-inch Storm, Cross Section W-DB
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

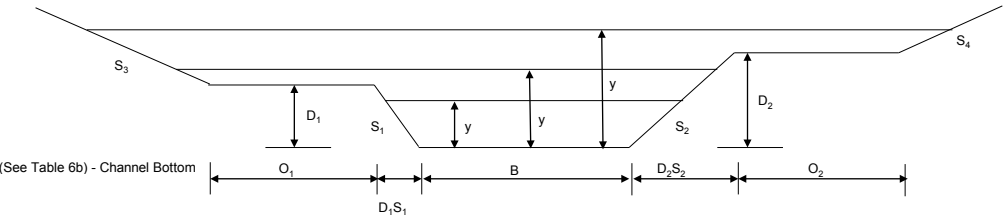
Section: W-8

Design Storm: 1-inch

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 8

Freeboard (ft)	4.5	ft	
Did the channel ov	NO		
Q =	3.90	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.1	ft	(Fig. 8)



Channel Geometry Inputs

y =	1.1	ft	Depth based on assumed WS (See Table 6b) - Channel Bottom
B =	2	ft	(Fig. 8)
Actual D1 =	4.2	ft	(Fig. 8)
Actual D2 =	4.3	ft	(Fig. 8)
Idealized D1 =	4.5	ft	(Fig. 8)
Idealized D2 =	5.6	ft	(Fig. 8)
D_1 =	4.5	ft	
D_2 =	5.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 8)
S_2 =	2.5	(ft H / ft V)	(Fig. 8)
O_1 =	169.7	ft	(Fig. 8)
O_2 =	356.3	ft	(Fig. 8)
S_3 =	0	(ft H / ft V)	(Fig. 8)
S_4 =	2	(ft H / ft V)	(Fig. 8)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.100	left	(Fig. 8)
n3 =	0.100	right	(Fig. 8)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		5.45	8.09	0.674	27.25
	A1	5.45	8.09	0.674	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **6.4735**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.38	7.5299025	9.436913	0.798	0.86027958	6.4778

y_n = 1.381

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	3.9	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 24b

Results of Step Backwater Calculations, West Channel 1-inch Storm, Cross Section W-8
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

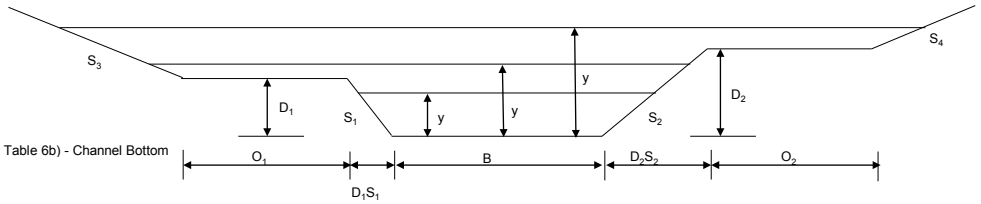
Section: **W-7**

Design Storm: **1-inch**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 7

Freeboard (ft)	2.4	ft	
Did the channel over top?	NO		
Q =	1.19	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.4	ft	(Fig. 7)
Channel Geometry Inputs			
y =	1.2	ft	Depth based on assumed WS (See Table 6b) - Channel Bottom
B =	2	ft	(Fig. 7)
Actual D1 =	3.1	ft	(Fig. 7)
Actual D2 =	3.2	ft	(Fig. 7)
Idealized D1 =	2.8	ft	(Fig. 7)
Idealized D2 =	3.6	ft	(Fig. 7)
D_1 =	3.1	ft	
D_2 =	3.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 7)
S_2 =	2.5	(ft H / ft V)	(Fig. 7)
O_1 =	102.8	ft	(Fig. 7)
O_2 =	136.3	ft	(Fig. 7)
S_3 =	2	(ft H / ft V)	(Fig. 7)
S_4 =	0	(ft H / ft V)	(Fig. 7)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 7)
n3 =	0.1	right	(Fig. 7)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		6.00	8.46	0.709	18.75
	A1	6.00	8.46	0.709	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **1.9753**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.79	3.12836	6.24351	0.501	0.6308488	1.9735

y_n = 0.788

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	1.19	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 24c

Results of Step Backwater Calculations, West Channel 1-inch Storm, Cross Section W-7
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

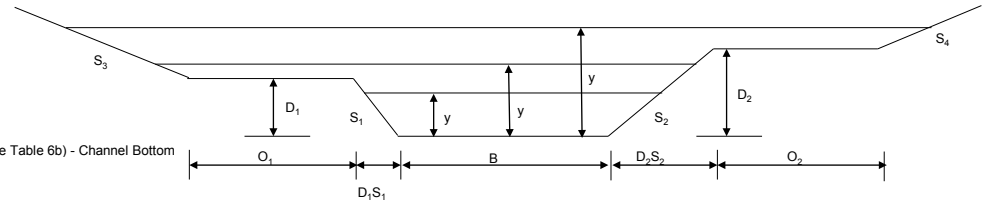
Section: **W-6**

Design Storm: **1-inch**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 6

Freeboard (ft)	2.1	ft	
Did the channel over top?	NO		
Q =	0.54	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.8	ft	(Fig. 6)
Channel Geometry Inputs			
y =	0.9	ft	Depth based on assumed WS (See Table 6b) - Channel Bottom
B =	2	ft	(Fig. 6)
Actual D1 =	1.92	ft	(Fig. 6)
Actual D2 =	2	ft	(Fig. 6)
Idealized D1 =	1.92	ft	(Fig. 6)
Idealized D2 =	3	ft	(Fig. 6)
D_1 =	1.9	ft	(Fig. 6)
D_2 =	3	ft	(Fig. 6)
S_1 =	2.5	(ft H / ft V)	(Fig. 6)
S_2 =	2.5	(ft H / ft V)	(Fig. 6)
O_1 =	0	ft	(Fig. 6)
O_2 =	273.7	ft	(Fig. 6)
S_3 =	2	(ft H / ft V)	(Fig. 6)
S_4 =	0	(ft H / ft V)	(Fig. 6)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 6)
n3 =	0.1	right	(Fig. 6)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		3.57	6.63	0.538	14.30
	A1	3.57	6.63	0.538	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **0.8963**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.53	1.76225	4.854137	0.363	0.5089053	0.8968

y_n = 0.530

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	0.54	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 24d

Results of Step Backwater Calculations, West Channel 1-inch Storm, Cross Section W-6

Standard Step Backwater Analysis

Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

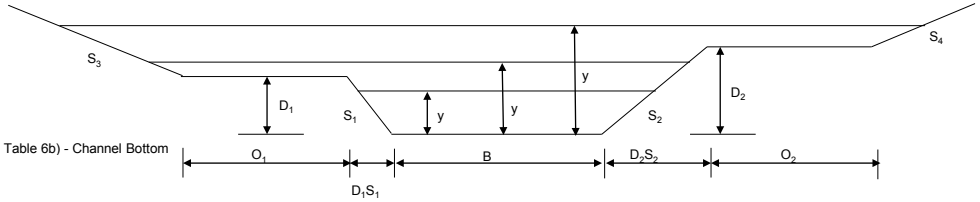
Section: **W-5**

Design Storm: **1-inch**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 5

Freeboard (ft)	1.7	ft	
Did the channel over top?	NO		
Q =	0.54	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.9	ft	(Fig. 5)
Channel Geometry Inputs			
y =	0.8	ft	Depth based on assumed WS (See Table 6b) - Channel Bottom
B =	2	ft	(Fig. 5)
Actual D1 =	1.12	ft	(Fig. 5)
Actual D2 =	1.2	ft	(Fig. 5)
Idealized D1 =	1.12	ft	(Fig. 5)
Idealized D2 =	2.5	ft	(Fig. 5)
D_1 =	1.12	ft	(Fig. 5)
D_2 =	2.5	ft	(Fig. 5)
S_1 =	2.5	(ft H / ft V)	(Fig. 5)
S_2 =	2.5	(ft H / ft V)	(Fig. 5)
O_1 =	0	ft	(Fig. 5)
O_2 =	275.6	ft	(Fig. 5)
S_3 =	2	(ft H / ft V)	(Fig. 5)
S_4 =	0	(ft H / ft V)	(Fig. 5)
n1 =	0.064	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 5)
n3 =	0.1	right	(Fig. 5)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		3.14	6.25	0.502	11.05
	A1	3.14	6.25	0.502	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **0.7355**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.48	1.52721	4.574109	0.334	0.48127671	0.7350

y_n = 0.478

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.6844	0.54	2.5398084	0.6844169	9.86

y_c = 0.68

Figure 24e

Results of Step Backwater Calculations, West Channel 1-inch Storm, Cross Section W-5

Standard Step Backwater Analysis

Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

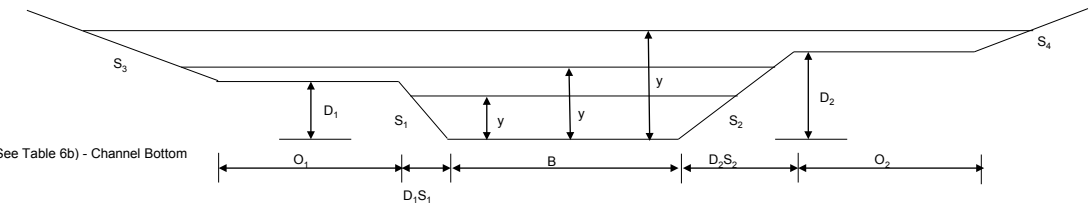
Section: **W-4**

Design Storm: **1-inch**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 4

Freeboard (ft)	1.9	ft	
Did the channel over top?	NO		
Q =	0.54	cfs	
S_0 =	0.001	ft/ft	
α =	1.000		
Channel Bottom	33.1	ft	(Fig. 4)
Channel Geometry Inputs			
y =	0.630	ft	Depth based on assumed WS (See Table 6b) - Channel Bottom
B =	2	ft	(Fig. 4)
Actual D1 =	0.8	ft	(Fig. 4)
Actual D2 =	1.3	ft	(Fig. 4)
Idealized D1 =	0.8	ft	(Fig. 4)
Idealized D2 =	2.5	ft	(Fig. 4)
D_1 =	0.8	ft	(Fig. 4)
D_2 =	2.5	ft	(Fig. 4)
S_1 =	2.5	(ft H / ft V)	(Fig. 4)
S_2 =	2.5	(ft H / ft V)	(Fig. 4)
O_1 =	5	ft	(Fig. 4)
O_2 =	297.2	ft	(Fig. 4)
S_3 =	0.0001	(ft H / ft V)	(Fig. 4)
S_4 =	0	(ft H / ft V)	(Fig. 4)
n1 =	0.064	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 4)
n3 =	0.1	right	(Fig. 4)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		2.25	5.39	0.418	10.25
	A1	2.25	5.39	0.418	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	0.000000001	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **0.7355**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.48	1.52721	4.574109	0.334	0.48127671	0.7350

y_n = 0.478

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.6844	0.54	2.5398084	0.6844169	9.86

y_c = 0.68

Figure 24f

Results of Step Backwater Calculations, West Channel 1-inch Storm, Cross Section W-4
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

Section: **W-3**

Design Storm: **1-inch**

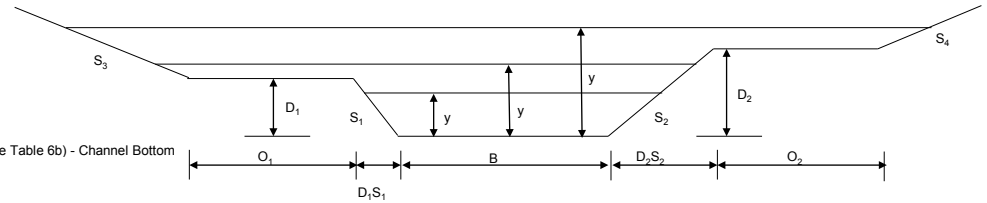
Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 3

Freeboard (ft)	2.0	ft	
Did the channel over top?	NO		
Q =	0.54	cfs	
S_0 =	0.001	ft/ft	
α =	1.000		
Channel Bottom	33.4	ft	(Fig. 3)

Channel Geometry Inputs

y =	0.5	ft	Depth based on assumed WS (See Table 6b) - Channel Bottom
B =	2	ft	(Fig. 3)
Actual D1 =	1.64	ft	(Fig. 3)
Actual D2 =	1.8	ft	(Fig. 3)
Idealized D1 =	1.64	ft	(Fig. 3)
Idealized D2 =	2.5	ft	(Fig. 3)
D_1 =	1.64	ft	
D_2 =	2.5	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 3)
S_2 =	2.5	(ft H / ft V)	(Fig. 3)
O_1 =	4.2	ft	(Fig. 3)
O_2 =	294.8	ft	(Fig. 3)
S_3 =	0.0001	(ft H / ft V)	(Fig. 3)
S_4 =	0	(ft H / ft V)	(Fig. 3)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 3)
n3 =	0.1	right	(Fig. 3)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		1.45	4.48	0.324	12.35
	A1	1.45	4.48	0.324	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **0.4941**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.39	1.1484225	4.084059	0.281	0.42921327	0.4929

y_n = 0.387

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	0.54	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 24g

Results of Step Backwater Calculations, West Channel 1-inch Storm, Cross Section W-3
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

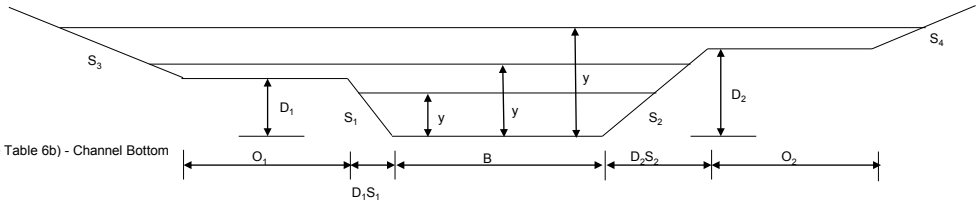
Section: **W-2**

Design Storm: **1-inch**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 2

Freeboard (ft)	3.1	ft	
Did the channel over top?	NO		
Q =	0.54	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	33.7	ft	(Fig. 2)
Channel Geometry Inputs			
y =	0.4	ft	Depth based on assumed WS (See Table 6b) - Channel Bottom
B =	2	ft	(Fig. 2)
Actual D1 =	3.4	ft	(Fig. 2)
Actual D2 =	3.5	ft	(Fig. 2)
Idealized D1 =	3.4	ft	(Fig. 2)
Idealized D2 =	3.3	ft	(Fig. 2)
D_1 =	3.4	ft	
D_2 =	3.5	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 2)
S_2 =	2.5	(ft H / ft V)	(Fig. 2)
O_1 =	278.4	ft	(Fig. 2)
O_2 =	59.6	ft	(Fig. 2)
S_3 =	0	(ft H / ft V)	(Fig. 2)
S_4 =	0.0001	(ft H / ft V)	(Fig. 2)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 2)
n3 =	0.1	right	(Fig. 2)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		1.12	4.05	0.277	19.25
	A1	1.12	4.05	0.277	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **0.4941**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.39	1.1484225	4.084059	0.281	0.42921327	0.4929

y_n = 0.387

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	0.54	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 24h

Results of Step Backwater Calculations, West Channel 1-inch Storm, Cross Section W-2
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

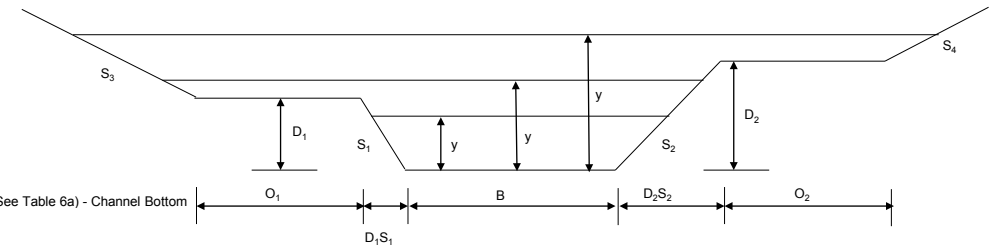
Section: **E-DB** use section W-8 for calculations

Design Storm: **1-inch** (25-yr,10-yr,5-yr,2-yr)

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 8
This spreadsheet also calculates the discharge flow (based on Manning's Equation) and compares it to the controlling depth (detention basin, from HydroCAD) to determine which is greater.

Depth, DB	31.97	ft	from HydroCAD Model
Depth, Manning's	33.23	ft	
Controlling Depth	33.23	ft	(max from above)
Freeboard (ft)	4.5	ft	
Did the channel over top?	NO		
Q =	3.90	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.1	ft	(Fig. 8)



Channel Geometry Inputs

y =	1.13	ft	Depth based on computed WS (See Table 6a) - Channel Bottom
B =	4	ft	(Fig. 8)
Actual D1 =	4.2	ft	(Fig. 8)
Actual D2 =	4.3	ft	(Fig. 8)
Idealized D1 =	4.5	ft	(Fig. 8)
Idealized D2 =	5.6	ft	(Fig. 8)
D_1 =	4.5	ft	
D_2 =	5.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 8)
S_2 =	2.5	(ft H / ft V)	(Fig. 8)
O_1 =	169.7	ft	(Fig. 8)
O_2 =	356.3	ft	(Fig. 8)
S_3 =	0	(ft H / ft V)	(Fig. 8)
S_4 =	2	(ft H / ft V)	(Fig. 8)
n1 =	0.078	channel	Channel Design Calcs.
n2 =	0.100	left	(Fig. 8)
n3 =	0.100	right	(Fig. 8)

			Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	T (channel top width at water surface)
A	**For y < D_1**		7.71	10.09	0.765	9.65
		A1	7.71	10.09	0.765	
		A2	0.00	0.00	0.000	
		A3	0.00	0.00	0.000	
B	**For $D_1 \le y < D_2$**		out of range	out of range	out of range	out of range
		A1	out of range	out of range	out of range	
		A2	out of range	out of range	out of range	
		A3	0	0.00	0.000	
C	**For y (= y_d) ≥ D_2**		out of range	out of range	out of range	out of range
		A1	out of range	out of range	out of range	
		A2	out of range	out of range	out of range	
		A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Discharge Based on Manning's Equation

Stage	Depth (y)	A,B, C	Area A1	Area A2	Area A3	Wetted Perimeter AT	Wetted Perimeter **WP1**	Wetted Perimeter WP2	Wetted Perimeter WP3	Hydraulic Radius RH1	Hydraulic Radius RH2	Hydraulic Radius RH3	Q1	Q2	Q3	Qt	V
33.23217218	**1.13217218**	**A**	**7.733**	**0.000**	**0.000**	**7.733**	**10.097**	**0.000**	**0.000**	**0.766**	**0.000**	**0.000**	**3.900**	**0.000**	**0.000**	**3.900**	**0.504**
33.73217218	1.63217218	A	13.189	0.000	0.000	13.189	12.790	0.000	0.000	1.031	0.000	0.000	8.110	0.000	0.000	8.110	0.615
34.23217218	2.13217218	A	19.894	0.000	0.000	19.894	15.482	0.000	0.000	1.285	0.000	0.000	14.166	0.000	0.000	14.166	0.712
34.73217218	2.63217218	A	27.850	0.000	0.000	27.850	18.175	0.000	0.000	1.532	0.000	0.000	22.300	0.000	0.000	22.300	0.801
35.23217218	3.13217218	A	37.055	0.000	0.000	37.055	20.867	0.000	0.000	1.776	0.000	0.000	32.736	0.000	0.000	32.736	0.883
35.2	3.1	A	36.425	0.000	0.000	36.425	20.694	0.000	0.000	1.760	0.000	0.000	31.991	0.000	0.000	31.991	0.878
34.7	2.6	A	27.300	0.000	0.000	27.300	18.001	0.000	0.000	1.517	0.000	0.000	21.710	0.000	0.000	21.710	0.795
34.76	2.66	A	28.329	0.000	0.000	28.329	18.325	0.000	0.000	1.546	0.000	0.000	22.819	0.000	0.000	22.819	0.805
35.26	3.16	A	37.604	0.000	0.000	37.604	21.017	0.000	0.000	1.789	0.000	0.000	33.389	0.000	0.000	33.389	0.888
35.76	3.66	A	48.129	0.000	0.000	48.129	23.710	0.000	0.000	2.030	0.000	0.000	46.486	0.000	0.000	46.486	0.966
36.26	4.16	A	59.904	0.000	0.000	59.904	26.402	0.000	0.000	2.269	0.000	0.000	62.315	0.000	0.000	62.315	1.040
36.76	4.66	B	72.897	27.152	0.000	100.049	28.664	169.860	0.000	2.543	0.160	0.000	81.824	3.758	0.000	85.582	0.855
37.26	5.16	B	86.659	112.002	0.000	198.661	30.010	170.360	0.000	2.888	0.657	0.000	105.869	39.794	0.000	145.663	0.733
37.76	5.66	C	101.043	196.852	21.382	319.276	31.195	170.860	356.434	3.239	1.152	0.060	133.262	101.662	1.540	236.464	0.741
38.26	6.16	C	115.668	281.702	199.842	597.211	31.195	171.360	357.552	3.708	1.644	0.559	166.937	184.386	63.719	415.042	0.695
38.76	6.66	C	130.293	366.552	378.802	875.646	31.195	171.860	358.670	4.177	2.133	1.056	203.579	285.405	184.604	673.588	0.769

[ ] = entered values

Figure 25a
Results of Step Backwater Calculations, East Channel 1-inch Storm, Cross Section E-DB
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

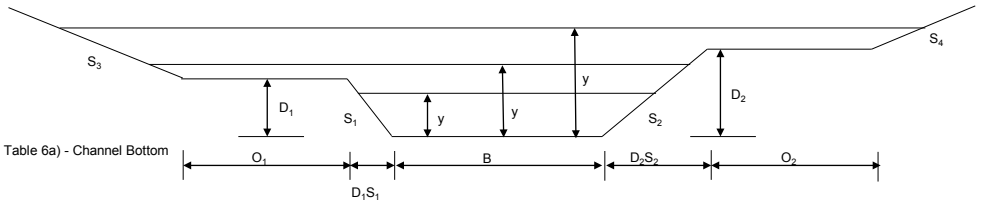
Section: **E-8 (W-8)**

Design Storm: **1-inch**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 8

Freeboard (ft)	4.5	ft	
Did the channel over top?	NO		
Q =	3.90	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.1	ft	(Fig. 8)



Channel Geometry Inputs

y =	1.1	ft	Depth based on assumed WS (See Table 6a) - Channel Bottom
B =	2	ft	(Fig. 8)
Actual D1 =	4.2	ft	(Fig. 8)
Actual D2 =	4.3	ft	(Fig. 8)
Idealized D1 =	4.5	ft	(Fig. 8)
Idealized D2 =	5.6	ft	(Fig. 8)
D_1 =	4.5	ft	
D_2 =	5.6	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 8)
S_2 =	2.5	(ft H / ft V)	(Fig. 8)
O_1 =	169.7	ft	(Fig. 8)
O_2 =	356.3	ft	(Fig. 8)
S_3 =	0	(ft H / ft V)	(Fig. 8)
S_4 =	2	(ft H / ft V)	(Fig. 8)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.100	left	(Fig. 8)
n3 =	0.100	right	(Fig. 8)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		5.45	8.09	0.674	27.25
	A1	5.45	8.09	0.674	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **6.4735**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.38	7.5299025	9.436913	0.798	0.86027958	6.4778

y_n = 1.381

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	3.9	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 25b

Results of Step Backwater Calculations, East Channel 1-inch Storm, Cross Section E-8 (W-8)
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

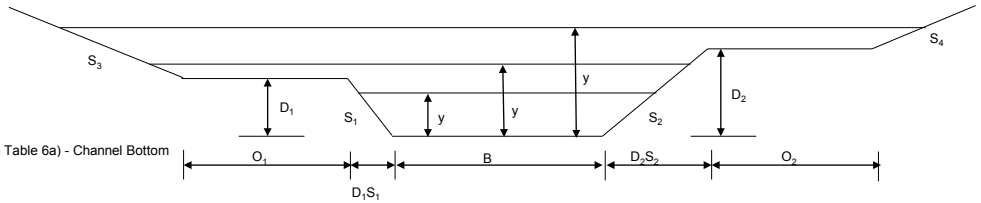
Section: **E-7**

Design Storm: **1-inch**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 15

Freeboard (ft)	2.4	ft	
Did the channel over top?	NO		
Q =	2.64	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	32.8	ft	(Fig. 15)
Channel Geometry Inputs			
y =	0.8	ft	Depth based on assumed WS (See Table 6a) - Channel Bottom
B =	2	ft	(Fig. 15)
Actual D1 =	3.2	ft	(Fig. 15)
Actual D2 =	3.2	ft	(Fig. 15)



Idealized D1 =	3.2	ft	(Fig. 15)
Idealized D2 =	3.2	ft	(Fig. 15)
D_1 =	3.2	ft	
D_2 =	3.2	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 15)
S_2 =	2.5	(ft H / ft V)	(Fig. 15)
O_1 =	115.3	ft	(Fig. 15)
O_2 =	165.2	ft	(Fig. 15)
S_3 =	0	(ft H / ft V)	(Fig. 15)
S_4 =	0	(ft H / ft V)	(Fig. 15)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 15)
n3 =	0.1	right	(Fig. 15)

		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		3.20	6.31	0.507	18.00
	A1	3.20	6.31	0.507	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **4.3821**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.15	5.63729	8.21448	0.686	0.77802495	4.3860

y_n = 1.154

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	2.64	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 25c

Results of Step Backwater Calculations, East Channel 1-inch Storm, Cross Section E-7
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

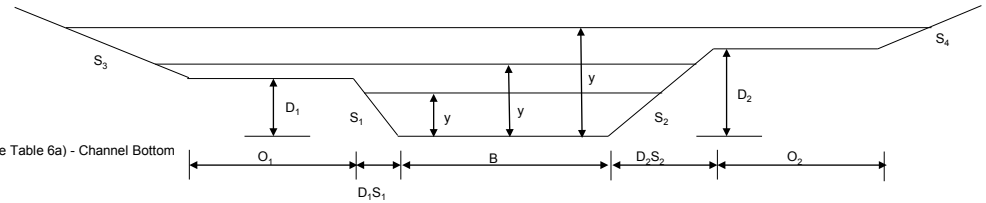
Section: **E-6**

Design Storm: **1-inch**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 14

Freeboard (ft)	1.8	ft	
Did the channel over top?	NO		
Q =	2.64	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	33.2	ft	(Fig. 14)
Channel Geometry Inputs			
y =	1.5	ft	Depth based on assumed WS (See Table 6a) - Channel Bottom
B =	2	ft	(Fig. 14)
Actual D1 =	2.7	ft	(Fig. 14)
Actual D2 =	2.8	ft	(Fig. 14)
Idealized D1 =	3	ft	(Fig. 14)
Idealized D2 =	3.3	ft	(Fig. 14)
D_1 =	3.0	ft	(Fig. 14)
D_2 =	3.3	ft	(Fig. 14)
S_1 =	2.5	(ft H / ft V)	(Fig. 14)
S_2 =	2.5	(ft H / ft V)	(Fig. 14)
O_1 =	296.4	ft	(Fig. 14)
O_2 =	172.1	ft	(Fig. 14)
S_3 =	0	(ft H / ft V)	(Fig. 14)
S_4 =	0	(ft H / ft V)	(Fig. 14)
n1 =	0.078	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 14)
n3 =	0.1	right	(Fig. 14)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		9.01	10.29	0.875	17.75
	A1	9.01	10.29	0.875	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **4.3821**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
1.15	5.63729	8.21448	0.686	0.77802495	4.3860

y_n = 1.154

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.852880021	2.64	3.524270869	0.7500581	15.00

y_c = 0.85

Figure 25d

Results of Step Backwater Calculations, East Channel 1-inch Storm, Cross Section E-6
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

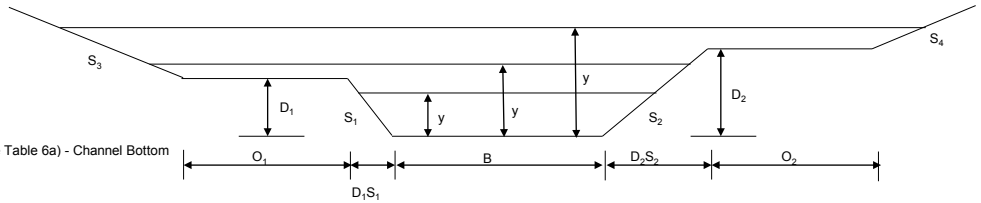
Section: **E-5**

Design Storm: **1-inch**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 13

Freeboard (ft)	1.7	ft	
Did the channel over top?	NO		
Q =	1.50	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	33.4	ft	(Fig. 13)
Channel Geometry Inputs			
y =	1.4	ft	Depth based on assumed WS (See Table 6a) - Channel Bottom
B =	2	ft	(Fig. 13)
Actual D1 =	3	ft	(Fig. 13)
Actual D2 =	3.1	ft	(Fig. 13)
Idealized D1 =	2.9	ft	(Fig. 13)
Idealized D2 =	3.1	ft	(Fig. 13)
D_1 =	3	ft	(Fig. 13)
D_2 =	3.1	ft	(Fig. 13)
S_1 =	2.5	(ft H / ft V)	(Fig. 13)
S_2 =	2.5	(ft H / ft V)	(Fig. 13)
O_1 =	298.1	ft	(Fig. 13)
O_2 =	157.7	ft	(Fig. 13)
S_3 =	0	(ft H / ft V)	(Fig. 13)
S_4 =	2	(ft H / ft V)	(Fig. 13)
n1 =	0.064	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 13)
n3 =	0.1	right	(Fig. 13)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		7.52	9.43	0.797	17.25
	A1	7.52	9.43	0.797	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **2.0429**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.80	3.21201	6.318902	0.508	0.63692775	2.0458

y_n = 0.802

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.6844	1.5	2.5398084	0.6844169	9.86

y_c = 0.68

Figure 25e

Results of Step Backwater Calculations, East Channel 1-inch Storm, Cross Section E-5
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

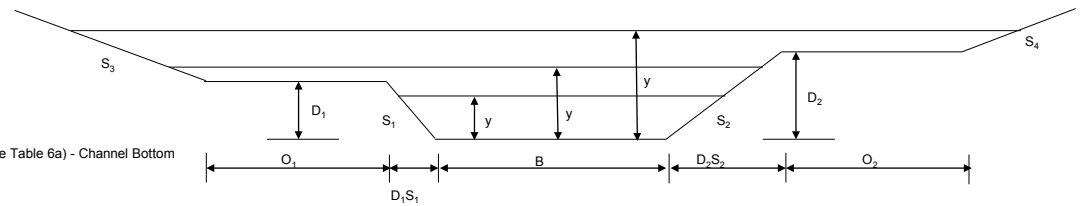
Section: **E-4**

Design Storm: **1-inch**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 12

Freeboard (ft)	1.4	ft	
Did the channel over top?	NO		
Q =	1.50	cfs	
S_0 =	0.001	ft/ft	
α =	1.000		
Channel Bottom	33.5	ft	(Fig. 12)
Channel Geometry Inputs			
y =	1.290	ft	Depth based on assumed WS (See Table 6a) - Channel Bottom
B =	2	ft	(Fig. 12)
Actual D1 =	2.6	ft	(Fig. 12)
Actual D2 =	2.7	ft	(Fig. 12)
Idealized D1 =	2.2	ft	(Fig. 12)
Idealized D2 =	2.5	ft	(Fig. 12)
D_1 =	2.6	ft	(Fig. 12)
D_2 =	2.7	ft	(Fig. 12)
S_1 =	2.5	(ft H / ft V)	(Fig. 12)
S_2 =	2.5	(ft H / ft V)	(Fig. 12)
O_1 =	299.3	ft	(Fig. 12)
O_2 =	268.3	ft	(Fig. 12)
S_3 =	0	(ft H / ft V)	(Fig. 12)
S_4 =	2	(ft H / ft V)	(Fig. 12)
n1 =	0.064	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 12)
n3 =	0.1	right	(Fig. 12)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		6.74	8.95	0.753	15.25
	A1	6.74	8.95	0.753	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \le y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	0.000000001	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **2.0429**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.80	3.21201	6.318902	0.508	0.63692775	2.0458

y_n = 0.802

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.6844	1.5	2.5398084	0.6844169	9.86

y_c = 0.68

Figure 25f

Results of Step Backwater Calculations, East Channel 1-inch Storm, Cross Section E-4
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

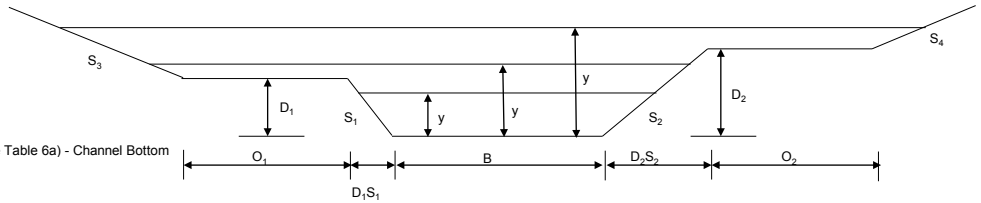
Section: **E-3**

Design Storm: **1-inch**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 11

Freeboard (ft)	1.7	ft	
Did the channel over top?	NO		
Q =	0.55	cfs	
S_0 =	0.001	ft/ft	
α =	1.000		
Channel Bottom	33.8	ft	(Fig. 11)
Channel Geometry Inputs			
y =	1.0	ft	Depth based on assumed WS (See Table 6a) - Channel Bottom
B =	2	ft	(Fig. 11)
Actual D1 =	2.3	ft	(Fig. 11)
Actual D2 =	2.3	ft	(Fig. 11)
Idealized D1 =	2.2	ft	(Fig. 11)
Idealized D2 =	2.7	ft	(Fig. 11)
D_1 =	2.3	ft	
D_2 =	2.7	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 11)
S_2 =	2.5	(ft H / ft V)	(Fig. 11)
O_1 =	299.3	ft	(Fig. 11)
O_2 =	324.9	ft	(Fig. 11)
S_3 =	0	(ft H / ft V)	(Fig. 11)
S_4 =	2	(ft H / ft V)	(Fig. 11)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 11)
n3 =	0.1	right	(Fig. 11)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		4.57	7.44	0.614	14.50
	A1	4.57	7.44	0.614	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **0.5033**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.39	1.16025	4.100214	0.283	0.43101927	0.5001

y_n = 0.390

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	0.55	1.2362025	0.5528223	3.88

y_c = 0.41

integral consulting inc.

Figure 25g

Results of Step Backwater Calculations, East Channel 1-inch Storm, Cross Section E-3
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

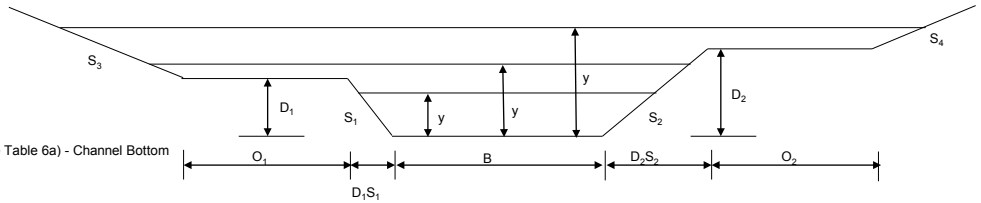
Section: **E-2**

Design Storm: **1-inch**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 10

Freeboard (ft)	3.7	ft	
Did the channel over top?	NO		
Q =	0.55	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	34.2	ft	(Fig. 10)
Channel Geometry Inputs			
y =	0.6	ft	Depth based on assumed WS (See Table 6a) - Channel Bottom
B =	2	ft	(Fig. 10)
Actual D1 =	4.2	ft	(Fig. 10)
Actual D2 =	4.3	ft	(Fig. 10)
Idealized D1 =	3.1	ft	(Fig. 10)
Idealized D2 =	4.3	ft	(Fig. 10)
D_1 =	4.2	ft	
D_2 =	4.3	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 10)
S_2 =	2.5	(ft H / ft V)	(Fig. 10)
O_1 =	355	ft	(Fig. 10)
O_2 =	159.1	ft	(Fig. 10)
S_3 =	0	(ft H / ft V)	(Fig. 10)
S_4 =	2	(ft H / ft V)	(Fig. 10)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 10)
n3 =	0.1	right	(Fig. 10)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		2.36	5.50	0.428	23.25
	A1	2.36	5.50	0.428	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **0.5033**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.39	1.16025	4.100214	0.283	0.43101927	0.5001

y_n = 0.390

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	0.55	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 25h

Results of Step Backwater Calculations, East Channel 1-inch Storm, Cross Section E-2
Standard Step Backwater Analysis
Stormwater Source Control Measures

Cross Section Area, Wetted Perimeter and Hydraulic Radius Calculations

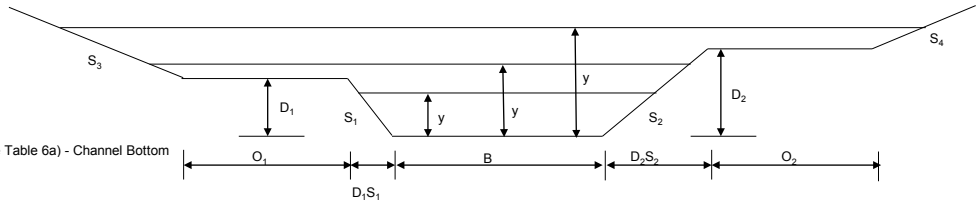
Section: **E-1**

Design Storm: **1-inch**

Calculated by: JG
Date: 9/19/2011
Checked by: MM

This spreadsheet calculates the Area, Wetted Perimeter, and Hydraulic Radius for the referenced cross section from Figure 9

Freeboard (ft)	3.2	ft	
Did the channel over top?	NO		
Q =	0.55	cfs	
S_0 =	0.001	ft/ft	
α =	1		
Channel Bottom	34.3	ft	(Fig. 9)
Channel Geometry Inputs			
y =	0.6	ft	Depth based on assumed WS (See Table 6a) - Channel Bottom
B =	2	ft	(Fig. 9)
Actual D1 =	3.1	ft	(Fig. 9)
Actual D2 =	3.5	ft	(Fig. 9)
Idealized D1 =	3.8	ft	(Fig. 9)
Idealized D2 =	3.8	ft	(Fig. 9)
D_1 =	3.8	ft	
D_2 =	3.8	ft	
S_1 =	2.5	(ft H / ft V)	(Fig. 9)
S_2 =	2.5	(ft H / ft V)	(Fig. 9)
O_1 =	242.5	ft	(Fig. 9)
O_2 =	338.7	ft	(Fig. 9)
S_3 =	2	(ft H / ft V)	(Fig. 9)
S_4 =	0	(ft H / ft V)	(Fig. 9)
n1 =	0.043	channel	Channel Design Calcs
n2 =	0.1	left	(Fig. 9)
n3 =	0.1	right	(Fig. 9)



		Computed Area (A) (ft^2)	Computed Wetted Perimeter (P) (ft)	Hydraulic Mean Radius (R) (ft)	Channel Top Width (ft)
For y < D_1		1.90	5.02	0.380	21.00
	A1	1.90	5.02	0.380	
	A2	0.00	0.00	0.000	
	A3	0.00	0.00	0.000	
For $D_1 \leq y < D_2$		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	0	0.00	0.000	
For y (= y_d) ≥ D_2		out of range	out of range	out of range	out of range
	A1	out of range	out of range	out of range	
	A2	out of range	out of range	out of range	
	A3	out of range	out of range	out of range	

Note: The formulas for area, wetted perimeter, and hydraulic mean radius listed above are applicable for a range of values of "y" up to the maximum depth

Solution for Normal Depth (y_n)

Trial and Error

$Q = 1.486/n \times AR^{2/3} \times S^{0.5}$

$AR^{2/3} = Q \times n / 1.486 \times S^{0.5} =$ **0.5033**

y (trial)	A	P	R	$R^{2/3}$	$AR^{2/3}$
0.39	1.16025	4.100214	0.283	0.43101927	0.5001

y_n = 0.390

Solution for Critical Depth (y_c)

$Q / g^{0.5} = A \times D^{0.5}$

$Q = g^{0.5} \times A \times D^{0.5}$

y (trial)	Q	A	$D^{0.5}$	$g^{0.5} \times A \times D^{0.5}$
0.409	0.55	1.2362025	0.5528223	3.88

y_c = 0.41

Figure 25i

Results of Step Backwater Calculations, East Channel 1-inch Storm, Cross Section E-1

Standard Step Backwater Analysis

Stormwater Source Control Measures

TABLES

Table 1a. Detention Basin Elevations and Discharge Rate by Reach

Design Storm Recurrence Interval	Maximum Detention Basin Elevation (feet)	Discharge Rates by Reach (cfs)					
		1	2	3	4	5	6
1-inch	31.97	0.55	1.50	2.64	0.54	1.19	3.90
2-yr	33.81	2.06	5.42	8.40	1.79	4.06	14.64
5-yr	33.91	2.66	6.90	10.62	2.23	5.10	18.70
10-yr	34.43	3.26	8.39	12.82	2.66	6.13	22.77
25-yr	35.09	3.87	9.86	15.00	3.10	7.16	26.85

Notes:
cfs = cubic feet per second

Table 1b. Detention Basin Elevations and Discharge Rate by Cross Section

		Discharge Rates by Cross Section														
		Reach 1			Reach 2		Reach 3		Reach 6	Reach 4					Reach 5	
Design Storm Recurrence Interval	Maximum Detention Basin Elevation (feet)	E1	E2	E3	E4	E5	E6	E7	E8	W2	W3	W4	W5	W6	W7	W8
1-inch	31.97	0.55	0.55	0.55	1.5	1.5	2.64	2.64	3.9	0.54	0.54	0.54	0.54	0.54	1.19	3.9
2	33.77	2.15	2.15	2.15	5.54	5.54	8.99	8.99	14.64	1.73	1.73	1.73	1.79	1.79	4.04	13.03
5	33.89	2.74	2.74	2.74	7.01	7.01	11.30	11.30	18.70	2.16	2.16	2.16	2.23	2.23	5.07	16.37
10	34.35	3.33	3.33	3.33	8.49	8.49	13.59	13.59	22.77	2.58	2.58	2.58	2.58	2.58	6.10	19.69
25	34.98	3.92	3.92	3.92	9.95	9.95	15.88	15.88	26.85	3.01	3.01	3.01	3.01	3.01	7.12	23.00

Notes:
Flows at E8/W8 (as represented by Figure 8) are calculated as sum of discharge at E7 and W7.

Table 2a. Calculated Model Parameters for 25-Year Storm, East Channel

Standard Step Calculations — Standard Step Calculations: East Channel
Design Storm — Design Storm: 25-yr **Options: 25-yr, 10-yr, 5-yr, 2-yr**

X-Sect. ID	X-Sect. Sta	Assumed WS (ft)	Comp. WS (ft)	Q (cfs)	Total - Area (ft^2)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Roughness n	Conveyance K	K_{avg}	Friction Slope S_f (ft/ft)	Avg. S_f (ft/ft)	Length L (ft)	Friction Headloss h_f (ft)	$[K_i(K_i/A_i)^2]$	α	Velocity V (ft/s)	Velocity Head $\alpha(V^2/2g)_{ave}$	$\Delta\text{-}\alpha(V2/2g)_{ave}$	H_o (ft)	Change in water surface ΔWS	Froude F_r
DB	1640.05		35.29	26.85																		
			A1		31.82	19.18	1.66	0.078	849.6						605684							
			A2		0.00	0.00	0.00	0.100	0.0						0							
			A3		0.00	0.00	0.00	0.100	0.0						0							
					31.82				849.6		0.0010				605684	1	0.844	0.011				
E8	1640.05	35.29	35.29	26.85																		
			A1		31.82	19.18	1.66	0.078	849.6						605684							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					31.82				849.6	849.61	0.0010	0.0010	0	0	605684	1	0.844	0.011	0	0	0	0.138
E7	1532.25	35.39	35.39	15.88																		
			A1		21.95	15.95	1.38	0.078	517.4						287542							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					21.95				517.4	683.52	0.0009	0.0010	108	0.105	287542	1	0.723	0.008	-2.93E-03	0	0.102	0.115
E6	1069.18	35.82	35.82	15.88																		
			A1		22.40	16.11	1.39	0.078	531.7						299523							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					22.40				531.7	524.56	0.0009	0.0009	463	0.425	299523	1	0.709	0.008	-3.24E-04	0	0.424	0.111
E5	925.79	35.9	35.90	9.95																		
			A1		20.63	15.46	1.33	0.064	580.3						459320							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					20.63				580.3	555.98	0.0003	0.0006	143	0.085	459320	1	0.482	0.004	-4.19E-03	0	0.081	0.078
E4	789.77	35.94	35.94	9.95																		
			A1		19.76	15.14	1.31	0.064	548.1						421600							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					19.76				548.1	564.2	0.0003	0.0003	136	0.042	421600	1	0.503	0.004	3.22E-04	0.0004	0.043	0.078
E3	484.31	35.99	35.99	3.92																		
			A1		16.37	13.79	1.19	0.043	634.2						951628							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					16.37				634.2	591.14	0.00004	0.0002	305	0.056	951628	1	0.239	0.001	-3.05E-03	0.0007	0.054	0.040
E2	121.71	36.02	36.02	3.92																		
			A1		11.92	11.80	1.01	0.043	414.8						502055							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					11.92				414.8	524.45	0.00009	0.0001	363	0.023	502055	1	0.329	0.002	7.89E-04	0	0.024	0.081
E1	19.77	36.03	36.03	3.92																		
			A1		10.94	11.32	0.97	0.043	369.8						422240							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					10.94				369.8	392.26	0.00011	0.0001	102	0.010	422240	1	0.358	0.002	3.14E-04	0	0.011	0.087

Table 2b. Calculated Model Parameters for 25-Year Storm, West Channel

Standard Step Calculations — Standard Step Calculations: West Channel
Design Storm — Design Storm: 25-yr **Options: 25-yr, 10-yr, 5-yr, 2-yr**

X-Sect. ID	X-Sect. Sta	Assumed WS (ft)	Comp. WS (ft)	Q (cfs)	Total - Area (ft^2)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Roughness n	Conveyance K	K_{avg}	Friction Slope S_f (ft/ft)	Avg. S_f (ft/ft)	Length L (ft)	Friction Headloss h_f (ft)	$[K_i(K_i/A_i)^2]$	α	Velocity V (ft/s)	Velocity Head $\alpha(V^2/2g)_{ave}$	$\Delta-\alpha(V2/2g)_{ave}$	H_o (ft)	Change in water surface ΔWS	Froude F_r
DB	1640.05		35.09	23.00																		
			A1		28.33	18.10	1.57	0.078	727.6						479831							
			A2		0.00	0.00	0.00	0.100	0.0						0							
			A3		0.00	0.00	0.00	0.100	0.0						0							
					28.33				727.6		0.0010				479831	1	0.812	0.010				
W8	1640.05	35.09	35.09	23.00																		
			A1		28.33	18.10	1.57	0.078	727.6						479831							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					28.33				727.6	727.55	0.0010	0.001	0	0	479831	1	0.812	0.010	0	0	0	0.1403
W7	1343.64	35.25	35.25	7.12																		
			A1		26.01	17.35	1.50	0.078	649.0						404130							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					26.01				649.0	688.26	0.0001	0.00056	296.4	0.166	404130	1	0.274	0.001	-9.07E-03	0	0.1569	0.0410
W6	955.62	35.28	35.28	3.01																		
			A1		19.94	13.85	1.44	0.078	484.6						286072							
			A2		0.31	1.25	0.25	0.1	1.9						65							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					20.26				486.4	567.7	0.00004	7.9E-05	388.0	0.031	286136	1.02	0.149	0.0003	-8.14E-04	0	0.0300	0.0228
W5	809.9	35.28	35.28	3.01																		
			A1		16.94	11.42	1.48	0.064	511.3						465960							
			A2		1.59	2.82	0.56	0.1	16.1						1654							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					18.52				527.4	506.91	0.00003	3.5E-05	145.7	0.005	467614	1.094	0.162	0.0004	9.87E-05	0	0.0053	0.0245
W4	666.07	35.29	35.29	3.01																		
			A1		13.96	10.05	1.39	0.064	403.3						336755							
			A2		6.95	6.39	1.09	0.1	109.2						26979							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					20.91				512.5	519.94	0.00003	3.4E-05	143.8	0.005	363735	1.181	0.144	0.0004	-6.83E-05	0.00004	0.0048	0.0217
W3	356.3	35.30	35.30	3.01																		
			A1		12.74	11.53	1.10	0.043	470.5						641831							
			A2		1.09	4.46	0.24	0.1	6.4						215							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					13.83				476.9	494.69	0.00004	3.7E-05	309.8	0.012	642046	1.133	0.218	0.001	4.53E-04	0.0002	0.0121	0.0419
W2	76.64	35.32	35.32	3.01																		
			A1		9.80	10.72	0.91	0.043	319.0						337871							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					9.80				319.0	397.94	0.00009	6.4E-05	279.7	0.018	337871	1	0.307	0.001	6.32E-04	0	0.0187	0.0758

Notes:
Green indicates channel overflow.

Table 3a. Calculated Model Parameters for 10-Year Storm, East Channel

Standard Step Calculations — Standard Step Calculations: East Channel
Design Storm — Design Storm: 10-yr **Options: 25-yr, 10-yr, 5-yr, 2-yr**

X-Sect. ID	X-Sect. Sta	Assumed WS (ft)	Comp. WS (ft)	Q (cfs)	Total - Area (ft^2)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Roughness n	Conveyance K	K_{avg}	Friction Slope S_f (ft/ft)	Avg. S_f (ft/ft)	Length L (ft)	Friction Headloss h_f (ft)	$[K_i(K_i/A_i)^2]$	α	Velocity V (ft/s)	Velocity Head $\alpha(V^2/2g)_{ave}$	$\Delta\text{-}\alpha(V2/2g)_{ave}$	H_o (ft)	Change in water surface ΔWS	Froude F_r
DB	1640.05		35.08	22.77																		
			A1		28.11	18.03	1.56	0.078	720.0						472389							
			A2		0.00	0.00	0.00	0.100	0.0						0							
			A3		0.00	0.00	0.00	0.100	0.0						0							
					28.11				720.0		0.0010				472389	1	0.810	0.010				
E8	1640.05	35.08	35.08	22.77																		
			A1		28.16	18.05	1.56	0.078	721.8						474099							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					28.16				721.8	720.89	0.0010	0.001	0	0	474099	1	0.809	0.010	-3.66E-05	0	-3.66E-05	0.140
E7	1532.25	35.18	35.18	13.59																		
			A1		18.92	14.82	1.28	0.078	424.3						213355							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					18.92				424.3	573.02	0.0010	0.00101	107.8	0.109	213355	1	0.718	0.008	-2.14E-03	0	1.07E-01	0.123
E6	1069.18	35.64	35.63	13.59																		
			A1		19.76	15.14	1.31	0.078	449.7						232893							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					19.76				449.7	437.02	0.0009	0.00097	463.1	0.449	232893	1	0.688	0.007	-6.69E-04	0	4.48E-01	0.115
E5	925.79	35.72	35.72	8.49																		
			A1		18.10	14.49	1.25	0.064	487.2						353112							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					18.10				487.2	468.47	0.0003	0.00061	143.4	0.087	353112	1	0.469	0.003	-3.92E-03	0	8.33E-02	0.081
E4	789.77	35.77	35.76	8.49																		
			A1		17.42	14.22	1.22	0.064	463.1						327164							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					17.42				463.1	475.13	0.0003	0.00032	136.0	0.044	327164	1	0.487	0.004	2.69E-04	0.0004	4.41E-02	0.080
E3	484.31	35.82	35.81	3.33																		
			A1		14.24	12.88	1.11	0.043	526.3						718743							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					14.24				526.3	494.68	0.00004	0.00019	305.5	0.057	718743	1	0.234	0.001	-2.84E-03	0.0007	5.53E-02	0.042
E2	121.71	35.85	35.84	3.33																		
			A1		10.11	10.89	0.93	0.043	332.4						359520							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					10.11				332.4	429.33	0.00010	7E-05	362.6	0.025	359520	1	0.329	0.002	8.37E-04	0	2.63E-02	0.088
E1	19.77	35.85	35.85	3.33																		
			A1		9.11	10.35	0.88	0.043	289.0						291099							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					9.11				289.0	310.69	0.00013	0.00012	101.9	0.012	291099	1	0.366	0.002	3.91E-04	0	1.23E-02	0.098

Table 3b. Calculated Model Parameters for 10-year Storm, West Channel

Standard Step Calculations — Standard Step Calculations: West Channel
Design Storm — Design Storm: 10-yr **Options: 25-yr, 10-yr, 5-yr, 2-yr**

X-Sect. ID	X-Sect. Sta	Assumed WS (ft)	Comp. WS (ft)	Q (cfs)	Total - Area (ft^2)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Roughness n	Conveyance K	K_{avg}	Friction Slope S_f (ft/ft)	Avg. S_f (ft/ft)	Length L (ft)	Friction Headloss h_f (ft)	$[K_i(K_i/A_i)^2]$	α	Velocity V (ft/s)	Velocity Head $\alpha(V^2/2g)_{ave}$	$\Delta\text{-}\alpha(V2/2g)_{ave}$	H_o (ft)	Change in water surface ΔWS	Froude F_r
DB	1640.05		34.90	19.69																		
			A1		25.22	17.08	1.48	0.078	622.8						379866							
			A2		0.00	0.00	0.00	0.100	0.0						0							
			A3		0.00	0.00	0.00	0.100	0.0						0							
					25.22				622.8		0.0010				379866	1	0.781	9.47E-03				
W8	1640.05	34.90	34.90	19.69																		
			A1		25.20	17.08	1.48	0.078	622.2						379382							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					25.20				622.2	622.51	0.0010	0.001	0	0	379382	1	0.781	9.48E-03	1.20284E-05	0	1.20E-05	0.143
W7	1343.64	35.06	35.06	6.10																		
			A1		23.01	16.32	1.41	0.078	551.1						316071							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					23.01				551.1	586.65	0.0001	0.00056	296.4	0.1666	316071	1	0.265	1.09E-03	-0.00838853	0	1.58E-01	0.042
W6	955.62	35.09	35.09	2.58																		
			A1		17.52	13.34	1.31	0.078	400.3						209061							
			A2		0.14	0.83	0.17	0.1	0.6						12							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					17.66				401.0	476	0.0000	8.2E-05	388.0	0.0318	209074	1.011	0.146	3.35E-04	-0.00075614	0	3.11E-02	0.024
W5	809.9	35.10	35.10	2.58																		
			A1		15.04	10.94	1.38	0.064	431.9						355999							
			A2		1.17	2.41	0.48	0.1	10.7						893							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					16.21				442.5	421.75	0.00003	3.8E-05	145.7	0.0055	356892	1.082	0.159	4.26E-04	9.03864E-05	0	5.58E-03	0.025
W4	666.07	35.10	35.10	2.58																		
			A1		12.20	9.54	1.28	0.064	333.8						249787							
			A2		6.00	6.20	0.97	0.1	87.2						18439							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					18.20				421.0	431.77	0.00004	3.6E-05	143.8	0.0051	268226	1.191	0.142	3.72E-04	-5.4062E-05	0.00004	5.13E-03	0.023
W3	356.3	35.12	35.11	2.58																		
			A1		10.83	11.05	0.98	0.043	369.2						429340							
			A2		0.34	4.28	0.08	0.1	0.9						7							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					11.16				370.1	395.57	0.00005	4.3E-05	309.8	0.0133	429346	1.055	0.231	8.75E-04	0.000503492	0.0002	1.40E-02	0.050
W2	76.64	35.14	35.14	2.58																		
			A1		8.06	9.75	0.83	0.043	245.5						227447							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					8.06				245.5	307.81	0.00011	8E-05	279.7	0.0222	227447	1	0.320	1.59E-03	0.000714411	0	2.30E-02	0.087

Notes:
Green indicates channel overflow.

Table 4a. Calculated Model Parameters for 5-Year Storm, East Channel

Standard Step Calculations — Standard Step Calculations: East Channel
Design Storm — Design Storm: 5-yr **Options: 25-yr, 10-yr, 5-yr, 2-yr**

X-Sect. ID	X-Sect. Sta	Assumed WS (ft)	Comp. WS (ft)	Q (cfs)	Total - Area (ft^2)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Roughness n	Conveyance K	K_{avg}	Friction Slope S_f (ft/ft)	Avg. S_f (ft/ft)	Length L (ft)	Friction Headloss h_f (ft)	$[K_i(K_i/A_i)^2]$	α	Velocity V (ft/s)	Velocity Head $\alpha(V^2/2g)_{ave}$	$\Delta\text{-}\alpha(V2/2g)_{ave}$	H_o (ft)	Change in water surface ΔWS	Froude F_r
DB	1640.05		34.84	18.70																		
			A1		24.25	16.76	1.45	0.078	591.1						351194							
			A2		0.00	0.00	0.00	0.100	0.0						0							
			A3		0.00	0.00	0.00	0.100	0.0						0							
					24.25				591.1		0.0010				351194	1	0.771	0.009				
E8	1640.05	34.84	34.84	18.70																		
			A1		24.25	16.76	1.45	0.078	591.1						351194							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					24.25				591.1	591.08	0.0010	0.001	0	0	351194	1	0.771	0.009	0.00E+00	0	0.000E+00	0.144
E7	1532.25	34.95	34.95	11.30																		
			A1		15.86	13.58	1.17	0.078	335.0						149519							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					15.86				335.0	463.03	0.0011	0.00107	107.8	0.115	149519	1	0.713	0.008	-1.35E-03	0	1.139E-01	0.134
E6	1069.18	35.43	35.44	11.30																		
			A1		16.89	14.01	1.21	0.078	364.6						169835							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					16.89				364.6	349.79	0.0010	0.00105	463.1	0.486	169835	1	0.669	0.007	-9.38E-04	0	4.849E-01	0.121
E5	925.79	35.53	35.53	7.01																		
			A1		15.60	13.47	1.16	0.064	399.5						262010							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					15.60				399.5	382.06	0.0003	0.00063	143.4	0.091	262010	1	0.449	0.003	-3.81E-03	0	8.713E-02	0.083
E4	789.77	35.57	35.57	7.01																		
			A1		14.85	13.15	1.13	0.064	374.1						237258							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					14.85				374.1	386.8	0.0004	0.00033	136.0	0.045	237258	1	0.472	0.003	3.25E-04	0.0003	4.548E-02	0.084
E3	484.31	35.63	35.63	2.74																		
			A1		12.03	11.85	1.01	0.043	420.0						511563							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					12.03				420.0	397	0.00004	0.0002	305.5	0.060	511563	1	0.228	0.001	-2.65E-03	0.0006	5.813E-02	0.044
E2	121.71	35.66	35.66	2.74																		
			A1		8.25	9.86	0.84	0.043	253.1						238174							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					8.25				253.1	336.51	0.00012	8E-05	362.6	0.029	238174	1	0.332	0.002	9.08E-04	0	2.988E-02	0.098
E1	19.77	35.68	35.67	2.74																		
			A1		7.52	9.43	0.80	0.043	223.5						197385							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					7.52				223.5	238.29	0.00015	0.00013	101.9	0.014	197385	1	0.364	0.002	3.48E-04	0	1.398E-02	0.107

Table 4b. Calculated Model Parameters for 5-Year Storm, West Channel

Standard Step Calculations
Design Storm

Standard Step Calculations: West Channel
Design Storm: 5-yr **Options: 25-yr, 10-yr, 5-yr, 2-yr**

X-Sect. ID	X-Sect. Sta	Assumed WS (ft)	Comp. WS (ft)	Q (cfs)	Total - Area (ft^2)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Roughness n	Conveyance K	K_{avg}	Friction Slope S_f (ft/ft)	Avg. S_f (ft/ft)	Length L (ft)	Friction Headloss h_f (ft)	$[K_i(K_i/A_i)^2]$	α	Velocity V (ft/s)	Velocity Head $\alpha(V^2/2g)_{ave}$	$\Delta\text{-}\alpha(V2/2g)_{ave}$	H_o (ft)	Change in water surface ΔWS	Froude F_r
DB	1640.05		34.69	16.37																		
			A1		21.95	15.95	1.38	0.08	517.4						287542							
			A2		0.00	0.00	0.00	0.10	0.0						0							
			A3		0.00	0.00	0.00	0.10	0.0						0							
					21.95				517.4		0.0010				287542	1	0.746	0.009				
W8	1640.05	34.69	34.69	16.37																		
			A1		21.95	15.95	1.38	0.08	517.4						287542							
			A2		0.00	0.00	0.00	0.10	0.0						0							
			A3		0.00	0.00	0.00	0.10	0.0						0							
					21.95				517.4	517.4	0.0010	0.001	0	0	287542	1	0.746	0.009	0.00E+00	0	0.00E+00	0.146
W7	1343.64	34.85	34.85	5.07																		
			A1		19.91	15.19	1.31	0.08	454.1						236274							
			A2		0.00	0.00	0.00	0.10	0.0						0							
			A3		0.00	0.00	0.00	0.10	0.0						0							
					19.91				454.1	485.8	0.0001	0.00056	296.4	0.167	236274	1	0.255	0.001	-7.63E-03	0	1.59E-01	0.044
W6	955.62	34.88	34.88	2.23																		
			A1		14.94	12.77	1.17	0.08	316.2						141504							
			A2		0.03	0.36	0.07	0.10	0.1						0							
			A3		0.00	0.00	0.00	0.10	0.0						0							
					14.97				316.2	385.2	0.0000	8.7E-05	388.0	0.034	141505	1.00	0.149	0.000	-6.62E-04	0	3.32E-02	0.026
W5	809.9	34.89	34.89	2.23																		
			A1		12.93	10.37	1.25	0.06	347.9						251675							
			A2		0.76	1.95	0.39	0.10	6.0						376							
			A3		0.00	0.00	0.00	0.10	0.0						0							
					13.69				353.9	335.1	0.00004	4.5E-05	145.7	0.007	252051	1.07	0.163	0.000	9.36E-05	0	6.61E-03	0.028
W4	666.07	34.89	34.89	2.16																		
			A1		10.37	8.97	1.16	0.06	264.9						173097							
			A2		4.95	5.99	0.83	0.10	64.8						11093							
			A3		0.00	0.00	0.00	0.10	0.0						0							
					15.32				329.7	341.8	0.00004	4.1E-05	143.8	0.006	184189	1.21	0.141	0.000	-6.69E-05	0.0000	5.92E-03	0.025
W3	356.3	34.91	34.91	2.16																		
			A1		8.72	10.13	0.86	0.04	272.7						266613							
			A2		0.00	0.00	0.00	0.10	0.0						0							
			A3		0.00	0.00	0.00	0.10	0.0						0							
					8.72				272.7	301.2	0.00006	5.3E-05	309.8	0.016	266613	1	0.248	0.001	5.80E-04	0.0002	1.71E-02	0.052
W2	76.64	34.94	34.94	2.16																		
			A1		6.32	8.68	0.73	0.04	177.0						138620							
			A2		0.00	0.00	0.00	0.10	0.0						0							
			A3		0.00	0.00	0.00	0.10	0.0						0							
					6.32				177.0	224.8	0.00015	0.00011	279.7	0.030	138620	1	0.342	0.002	8.59E-04	0	3.05E-02	0.105

Notes:
Green indicates channel overflow.

Table 5a. Calculated Model Parameters for 2-Year Storm, East Channel

Standard Step Calculations — Standard Step Calculations: East Channel
Design Storm — Design Storm: 2-yr **Options: 25-yr, 10-yr, 5-yr, 2-yr**

X-Sect. ID	X-Sect. Sta	Assumed WS (ft)	Comp. WS (ft)	Q (cfs)	Total - Area (ft^2)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Roughness n	Conveyance K	K_{avg}	Friction Slope S_f (ft/ft)	Avg. S_f (ft/ft)	Length L (ft)	Friction Headloss h_f (ft)	$[K_i(K_i/A_i)^2]$	α	Velocity V (ft/s)	Velocity Head $\alpha(V^2/2g)_{ave}$	$\Delta\text{-}\alpha(V2/2g)_{ave}$	H_o (ft)	Change in water surface ΔWS	Froude F_r
DB	1640.05		34.57	14.64																		
			A1		20.19	15.30	1.32	0.078	462.8						243146							
			A2		0.00	0.00	0.00	0.100	0.0						0							
			A3		0.00	0.00	0.00	0.100	0.0						0							
					20.19				462.8		0.0010				243146	1	0.725	0.008				
E8	1640.05	34.57	34.57	14.64																		
			A1		20.19	15.30	1.32	0.078	462.8						243146							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					20.19				462.8	462.8	0.0010	0.0010	0	0	243146	1	0.725	0.008	0.00E+00	0	0.00E+00	0.148
E7	1532.25	34.69	34.69	8.99																		
			A1		12.71	12.18	1.04	0.078	249.2						95738							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					12.71				249.2	356.0	0.0013	0.0012	107.8	0.124	95738	1	0.707	0.008	-3.94E-04	0	1.24E-01	0.148
E6	1069.18	35.22	35.22	8.99																		
			A1		14.24	12.88	1.11	0.078	290.1						120419							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					14.24				290.1	269.6	0.0010	0.0011	463.07	0.524	120419	1	0.631	0.006	-1.58E-03	0	5.22E-01	0.124
E5	925.79	35.3	35.30	5.54																		
			A1		12.83	12.23	1.05	0.064	307.3						176485							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					12.83				307.3	298.7	0.0003	0.0006	143.39	0.092	176485	1	0.432	0.003	-3.29E-03	0	8.88E-02	0.088
E4	789.77	35.35	35.35	5.54																		
			A1		12.26	11.96	1.02	0.064	289.2						161043							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					12.26				289.2	298.3	0.0004	0.0003	136.02	0.047	161043	1	0.452	0.003	2.75E-04	0.0003	4.76E-02	0.089
E3	484.31	35.41	35.41	2.15																		
			A1		9.70	10.67	0.91	0.043	314.6						330873							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					9.70				314.6	301.9	0.00005	0.0002	305.46	0.063	330873	1	0.222	0.001	-2.41E-03	0.0006	6.14E-02	0.048
E2	121.71	35.45	35.45	2.15																		
			A1		6.41	8.73	0.73	0.043	180.1						142328							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					6.41				180.1	247.3	0.00014	0.0001	362.6	0.034	142328	1	0.336	0.002	9.86E-04	0	3.53E-02	0.113
E1	19.77	35.47	35.47	2.15																		
			A1		5.76	8.30	0.69	0.043	156.1						114605							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					5.76				156.1	168.1	0.00019	0.0002	101.94	0.017	114605	1	0.373	0.002	4.13E-04	0	1.73E-02	0.126

Table 5b. Calculated Model Parameters for 2-Year Storm, West Channel

Standard Step Calculations — Standard Step Calculations: West Channel
Design Storm — Design Storm: 2-yr **Options: 25-yr, 10-yr, 5-yr, 2-yr**

X-Sect. ID	X-Sect. Sta	Assumed WS (ft)	Comp. WS (ft)	Q (cfs)	Total - Area (ft^2)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Roughness n	Conveyance K	K_{avg}	Friction Slope S_f (ft/ft)	Avg. S_f (ft/ft)	Length L (ft)	Friction Headloss h_f (ft)	$[K_i(K_i/A_i)^2]$	α	Velocity V (ft/s)	Velocity Head $\alpha(V^2/2g)_{ave}$	$\Delta\text{-}\alpha(V2/2g)_{ave}$	H_o (ft)	Change in water surface ΔWS	Froude F_r
DB	1640.05		34.45	13.03																		
			A1		18.51	14.66	1.26	0.078	411.9						204055							
			A2		0.00	0.00	0.00	0.100	0.0						0							
			A3		0.00	0.00	0.00	0.100	0.0						0							
					18.51				411.9		0.0010				204055	1	0.704	0.008				
W8	1640.05	34.45	34.45	13.03																		
			A1		18.51	14.66	1.26	0.078	411.9						204055							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					18.51				411.9	411.9	0.0010	0.00100	0	0	204055	1	0.704	0.008	0.00E+00	0	0.00E+00	0.151
W7	1343.64	34.61	34.61	4.04																		
			A1		16.63	13.90	1.20	0.078	357.0						164575							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					16.63				357.0	384.5	0.0001	0.00056	296.4	0.1673	164575	1	0.243	0.001	-6.78E-03	0	1.61E-01	0.045
W6	955.62	34.65	34.65	1.79																		
			A1		12.26	11.96	1.02	0.078	237.3						88961							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					12.26				237.3	297.2	0.0001	0.00009	388.0	0.0359	88961	1	0.146	0.0003	-5.85E-04	0	3.53E-02	0.028
W5	809.9	34.65	34.65	1.79																		
			A1		10.66	9.73	1.10	0.064	263.1						160244							
			A2		0.40	1.41	0.28	0.1	2.5						103							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					11.06				265.6	251.5	0.0000	0.00005	145.7	0.0075	160347	1.05	0.162	0.0004	9.45E-05	0	7.55E-03	0.030
W4	666.07	34.66	34.66	1.73																		
			A1		8.48	8.35	1.02	0.064	198.9						109439							
			A2		3.80	5.76	0.66	0.1	42.8						5427							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					12.28				241.7	253.7	0.0001	0.00005	143.8	0.0069	114866	1.23	0.141	0.0004	-4.78E-05	0.0000	6.94E-03	0.028
W3	356.3	34.68	34.68	1.73																		
			A1		6.66	8.89	0.75	0.043	189.6						153884							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					6.66				189.6	215.7	0.00008	0.00007	309.8	0.0208	153884	1	0.260	0.001	6.71E-04	0.0002	2.17E-02	0.062
W2	76.64	34.72	34.73	1.73																		
			A1		4.64	7.49	0.62	0.043	116.5						73483							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					4.64				116.5	153.1	0.00022	0.00015	279.7	0.0425	73483	1	0.373	0.002	1.11E-03	0	4.36E-02	0.134

Notes:
Green indicates channel overflow.

Table 6a. Calculated Model Parameters for 1-inch Storm, East Channel

Standard Step Calculations — Standard Step Calculations: East Channel
Design Storm — Design Storm: 1-inch **Options: 25-yr, 10-yr, 5-yr, 2-yr**

X-Sect. ID	X-Sect. Sta	Assumed WS (ft)	Comp. WS (ft)	Q (cfs)	Total - Area (ft^2)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Roughness n	Conveyance K	K_{avg}	Friction Slope S_f (ft/ft)	Avg. S_f (ft/ft)	Length L (ft)	Friction Headloss h_f (ft)	$[K_i(K_i/A_i)^2]$	α	Velocity V (ft/s)	Velocity Head $\alpha(V^2/2g)_{ave}$	$\Delta\text{-}\alpha(V2/2g)_{ave}$	H_o (ft)	Change in water surface ΔWS	Froude F_r
DB	1640.05		33.23	3.90																		
			A1		7.71	10.09	0.76	0.078	122.9						31185							
			A2		0.00	0.00	0.00	0.100	0.0						0							
			A3		0.00	0.00	0.00	0.100	0.0						0							
					7.71				122.9		0.0010				31185	1	0.506	0.004				
E8	1640.05	33.23	33.23	3.90																		
			A1		5.45	8.09	0.67	0.078	79.9						17144							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					5.45				79.9	101.4	0.0024	0.0017	0	0	17144	1	0.715	0.008	3.97E-03	0	3.97E-03	0.282
E7	1532.25	33.6	33.61	2.64																		
			A1		3.20	6.31	0.51	0.078	38.8						5694							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					3.20				38.8	59.3	0.0046	0.0035	107.8	0.378	5694	1	0.825	0.011	2.62E-03	0	3.81E-01	0.345
E6	1069.18	34.74	34.74	2.64																		
			A1		9.01	10.29	0.88	0.078	157.0						47721							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					9.01				157.0	97.9	0.0003	0.0025	463.07	1.139	47721	1	0.293	0.001	-9.24E-03	0	1.13E+00	0.072
E5	925.79	34.78	34.77	1.50																		
			A1		7.52	9.43	0.80	0.064	150.2						59866							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					7.52				150.2	153.6	0.0001	0.0002	143.39	0.027	59866	1	0.199	0.001	-7.16E-04	0	2.67E-02	0.053
E4	789.77	34.79	34.79	1.50																		
			A1		6.74	8.95	0.75	0.064	129.6						47885							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					6.74				129.6	139.9	0.0001	0.0001	136.02	0.016	47885	1	0.223	0.001	1.51E-04	0.0001	1.61E-02	0.059
E3	484.31	34.81	34.81	0.55																		
			A1		4.57	7.44	0.61	0.043	114.1						71193							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					4.57				114.1	121.9	0.00002	0.0001	305.46	0.024	71193	1	0.120	0.000	-5.44E-04	0.0001	2.36E-02	0.038
E2	121.71	34.85	34.84	0.55																		
			A1		2.36	5.50	0.43	0.043	46.3						17846							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					2.36				46.3	80.2	0.00014	0.0001	362.6	0.030	17846	1	0.233	0.001	6.21E-04	0	3.04E-02	0.129
E1	19.77	34.86	34.86	0.55																		
			A1		1.90	5.02	0.38	0.043	34.5						11324							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					1.90				34.5	40.4	0.00025	0.0002	101.94	0.020	11324	1	0.289	0.001	4.50E-04	0	2.06E-02	0.169

Table 6b. Calculated Model Parameters for 1-inch Storm, West Channel

Standard Step Calculations — Standard Step Calculations: West Channel
Design Storm — Design Storm: 1-inch **Options: 25-yr, 10-yr, 5-yr, 2-yr**

X-Sect. ID	X-Sect. Sta	Assumed WS (ft)	Comp. WS (ft)	Q (cfs)	Total - Area (ft^2)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Roughness n	Conveyance K	K_{avg}	Friction Slope S_f (ft/ft)	Avg. S_f (ft/ft)	Length L (ft)	Friction Headloss h_f (ft)	$[K_i(K_i/A_i)^2]$	α	Velocity V (ft/s)	Velocity Head $\alpha(V^2/2g)_{ave}$	$\Delta\text{-}\alpha(V2/2g)_{ave}$	H_o (ft)	Change in water surface ΔWS	Froude F_r
DB	1640.05		33.23	3.90																		
			A1		7.71	10.09	0.76	0.078	122.9						31185							
			A2		0.00	0.00	0.00	0.100	0.0						0							
			A3		0.00	0.00	0.00	0.100	0.0						0							
					7.71				122.9		0.0010				31185	1	0.506	0.004				
W8	1640.05	33.23	33.23	3.90																		
			A1		5.45	8.09	0.67	0.078	79.9						17144							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					5.45				79.9	101.4	0.0024	0.00170	0	0	17144	1	0.715	0.008	3.97E-03	0	3.97E-03	0.282
W7	1343.64	33.60	33.61	1.19																		
			A1		6.00	8.46	0.71	0.078	90.9						20857							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					6.00				90.9	85.4	0.0002	0.00128	296.4	0.3787	20857	1	0.198	0.001	-7.33E-03	0	3.71E-01	0.062
W6	955.62	33.66	33.67	0.54																		
			A1		3.57	6.63	0.54	0.078	45.0						7149							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					3.57				45.0	67.9	0.0001	0.00016	388.0	0.0612	7149	1	0.151	0.0004	-2.55E-04	0	6.10E-02	0.053
W5	809.9	33.69	33.69	0.54																		
			A1		3.14	6.25	0.50	0.064	46.1						9910							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					3.14				46.1	45.5	0.0001	0.00014	145.7	0.0205	9910	1.00	0.172	0.0005	1.04E-04	0	2.06E-02	0.057
W4	666.07	33.73	33.72	0.54																		
			A1		2.25	5.39	0.42	0.064	29.2						4918							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					2.25				29.2	37.6	0.0003	0.00024	143.8	0.0344	4918	1.00	0.240	0.0009	4.33E-04	0.0001	3.49E-02	0.090
W3	356.3	33.86	33.86	0.54																		
			A1		1.45	4.48	0.32	0.043	23.6						6264							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					1.45				23.6	26.4	0.00052	0.00043	309.8	0.1340	6264	1	0.373	0.002	1.26E-03	0.0005	1.36E-01	0.192
W2	76.64	34.08	34.08	0.54																		
			A1		1.12	4.05	0.28	0.043	16.5						3551							
			A2		0.00	0.00	0.00	0.1	0.0						0							
			A3		0.00	0.00	0.00	0.1	0.0						0							
					1.12				16.5	20.0	0.00108	0.00080	279.7	0.2236	3551	1	0.482	0.004	1.45E-03	0	2.25E-01	0.352

APPENDIX L

SEDCAM RECONTAMINATION MODELING REPORT

SEDCAM RECONTAMINATION MODELING REPORT
FOR
STORMWATER SOURCE CONTROL MEASURES

Former Arkema Inc. Facility
Portland, Oregon

Prepared for
Legacy Site Services LLC
468 Thomas Jones Way
Exton, PA 19341-2528

Prepared by

integral consulting inc.
319 SW Washington St
Suite 1150
Portland, OR 97204

September 30, 2011

CONTENTS

LIST OF FIGURES ..... **iii**

LIST OF TABLES ..... **iv**

ACRONYMS AND ABBREVIATIONS ..... **v**

1 INTRODUCTION **1-1**

2 SEDCAM MODEL **2-1**

3 MODEL SETUP **3-1**

3.1 STORMWATER LOADS 3-1
3.2 UPSTREAM LOADS 3-3
3.3 SEDCAM MODEL PARAMETERS 3-3

4 MODEL RESULTS **4-1**

5 SUMMARY **5-1**

6 REFERENCES **6-1**

LIST OF FIGURES

Figure 1. Predicted DDT Surficial Sediment Concentrations, High and Low Net Sediment Deposition Rates

Figure 2. Predicted DDE Surficial Sediment Concentrations, High and Low Net Sediment Deposition Rates

Figure 3. Predicted DDD Surficial Sediment Concentrations, High and Low Net Sediment Deposition Rates

Figure 4. Predicted DDT Surficial Sediment Concentrations, "Best Estimate" Sedimentation Rate

Figure 5. Predicted DDE Surficial Sediment Concentrations, "Best Estimate" Sedimentation Rate

Figure 6. Predicted DDD Surficial Sediment Concentrations, "Best Estimate" Sedimentation Rate

Figure 7. Predicted DDT Surficial Sediment Concentrations Assuming an Upstream Sediment Concentration = 0

Figure 8. Predicted DDE Surficial Sediment Concentrations Assuming an Upstream Sediment Concentration = 0

Figure 9. Predicted DDD Surficial Sediment Concentrations Assuming an Upstream Sediment Concentration = 0

LIST OF TABLES

Table 1. Inputs for Runoff Volume Estimation using Simple Method

Table 2. Arkema Site Stormwater Loads

Table 3. Upstream Sediment Concentrations

Table 4. Comparison of Model-Predicted Fully Mixed Surficial Sediment Concentrations with Portland Harbor Sediment PRGs and RALs

ACRONYMS AND ABBREVIATIONS

COPC	chemicals of potential concern
EPA	U.S. Environmental Protection Agency
FS	feasibility study
PRG	preliminary remediation goal
RAL	remedial action level
RI/FS	remedial investigation/feasibility study
SCM	source control measure

1 INTRODUCTION

A screening level analysis was performed to evaluate the potential for recontamination of the nearshore sediments following the implementation of the new stormwater source control measures (SCMs). The potential recontamination of sediment downstream of Outfall 004 following the proposed U.S. Environmental Protection Agency (EPA) early action was evaluated. The stormwater SCMs design reduces chemical of potential concern (COPC) concentrations prior to discharge and routes discharge to the downstream edge of the proposed early action area. The stormwater SCMs are expected to minimize sediment recontamination to levels that meet or are below draft Portland Harbor remedial action levels (RALs) or preliminary remediation goals (PRGs). This screening level analysis was performed to support this premise.

Note that the use of draft Portland Harbor PRGs and RALs as comparison values in this recontamination analysis does not denote LSS' endorsement of these values. LSS use of these values is only intended for perspective, to relate this recontamination analysis to the harbor-wide remedial actions that are being evaluated as part of the Portland Harbor Feasibility Study (FS).

A mathematical mass balance model, SEDCAM (Jacobs et al. 1988), was applied to evaluate potential recontamination. SEDCAM predicts surficial sediment contaminant concentrations over time. The model assumes that the source inputs of sediments are fully mixed within the surficial layer over the area of potential recontamination. Model inputs include sediment concentrations of incoming (upstream) sediments, sediment load and concentration in the stormwater discharge from the site, initial surficial sediment concentration over the area of potential recontamination, and sedimentation rate. Model input parameters were developed from available site data. Where parameters were uncertain, a range of values were evaluated to provide a bounding estimate of potential sediment concentrations.

The model was set up to evaluate DDD, DDE, and DDT, the primary COPCs in the stormwater discharging from the site. The interim stormwater SCMs will discharge treated stormwater, with target concentrations described in Section 3 of the Final Design Report. The recontamination analysis evaluated both the target concentrations as well as the existing previously measured stormwater concentrations measured at Outfalls 001 through 004. The latter analysis provides a prediction of potential recontamination, assuming no treatment of the discharged stormwater, to provide a "no-action" baseline scenario.

2 SEDCAM MODEL

The SEDCAM model was developed to estimate natural recovery of contaminated sediments due to burial by cleaner sediments. SEDCAM has frequently been applied to evaluate recontamination following dredging or capping remedial activities. The model provides conservative estimates of surficial sediment concentrations in a mixed layer as a function of incoming loads and initial contaminant concentrations. The SEDCAM mass balance equation is:

$$C_{COPC}(t) = \frac{1}{1+kT_s} * C_{COPC,DEP} * \left(1 - e^{\frac{-(1+kT_s)t}{T_s}}\right) + C_{COPC}(0) * e^{\frac{-(1+kT_s)t}{T_s}}$$

Where:

$C_{COPC}(t)$	=	COPC concentration in mixed layer sediment at time *t* (COPC mass/sediment mass)
$C_{COPC,DEP}$	=	weighted average of COPC concentration in sediment deposited over cap area (COPC mass/sediment mass)
$C_{COPC}(0)$	=	initial COPC concentration in cap (COPC mass/sediment mass)
k	=	combined first-order decay and diffusion rate constant for COPC loss ($year^{-1}$)
t	=	time (years)
T_s	=	ML / R_s
ML	=	mixed layer thickness (cm)
R_s	=	net sedimentation rate (cm/year)

Model inputs (e.g., stormwater loadings) are assumed constant over time. The model results are predictions of the fully-mixed sediment contaminant concentrations in the mixed layer over time.

3 MODEL SETUP

The model input parameters were estimated as average values based on site-specific data collected as part of the ongoing Arkema stormwater SCMs and the Portland Harbor remedial investigation/feasibility study (RI/FS). The model inputs, including data used and assumptions, for stormwater loads, upstream loads, and model parameters are described below.

The model setup assumes that all stormwater from the Arkema site is discharged through Outfall 004, which is located at the downstream end of the proposed early action area. The nearshore sediments in the depositional area downstream of Outfall 004 are not within the proposed early action area, but are subject to the broader Portland Harbor sediment remedy. For this recontamination analysis, Integral Consulting conservatively assumed that surficial sediments in the downstream depositional area have an initial COPC concentration of zero, i.e., they have been remediated. This analysis could represent a potential future remediation scenario that extends beyond the existing proposed early action area based on a final Portland Harbor remedy. More realistically, the surficial sediments below Outfall 004 will have measureable concentrations of the relevant COPCs following the completion of the stormwater SCMs treatment system.

3.1 STORMWATER LOADS

Stormwater loads from the Arkema site were calculated from measured concentrations of COPCs within existing stormwater and from target treatment concentrations. To estimate these loads, the runoff volume was first estimated using the Simple Method (Schueler 1987), which is applicable to small watersheds such as that draining the Arkema site. This method has been used in the Portland Harbor Draft Remedial Investigation Report prepared by the Lower Willamette Group (Integral et al. 2009), and in previous stormwater SCMs decision documents, including the Draft Focused Feasibility Study (Integral 2008) and the Draft Stormwater Source Control Measure Design & Implementation Work Plan (Integral 2009).

Runoff volume is calculated as follows:

$$V_{RO} = P * 0.9 * A * R_v$$

V_{RO}	=	annual runoff volume (cubic feet)
P	=	annual rainfall (feet)
0.9	=	fraction of rainfall that produces runoff, standard (unitless)
A	=	site's drainage area (square feet)
R_v	=	runoff coefficient (unitless)

$$R_v = 0.05 + 0.9 * I_a$$

I_a = impervious fraction of the drainage area

The values utilized to find the runoff volume are presented in Table 1 and described below.

Table 1. Inputs for Runoff Volume Estimation Using Simple Method

Parameter	Value
Drainage Area	41.88 acres
Impervious Area	21.48 acres
Impervious Fraction, I_a	0.51
Runoff Coefficient, R_v	0.51
Average Annual Rainfall, P	36.3 inches/year
Average Annual Runoff Volume, V_{RO}	2,540,000 cubic feet/year

The drainage area and its impervious portions were calculated from data within the Final Design Report of the stormwater SCMs (see main report). The average annual rainfall was obtained from the National Oceanic and Atmospheric Administration's value for Portland, Oregon's "normal" for the period of record of 1961–1990 (http://www.wrh.noaa.gov/pqr/pdxclimate/PG105.html).

COPC loads from the Arkema site were calculated based on the estimated runoff volume and stormwater COPC concentrations. COPC loads for existing and target conditions (following installation of the stormwater treatment system) were developed for model input. Stormwater quality data collected in 2007 were averaged to characterize existing stormwater COPC loadings. Target COPC loadings were estimated assuming a treated concentration of 0.05 µg/L. The estimated stormwater concentrations and loads are presented in Table 2.

Table 2. Arkema Site Stormwater Loads

COPC	Existing Stormwater Concentration (µg/L)	Existing Stormwater Load (µg/year)	Target Stormwater Target Concentration (µg/L)	Target Stormwater Load (µg/year)
DDT	0.188	13,500,000	0.05	3,600,000
DDE	0.167	12,000,000	0.05	3,600,000
DDD	0.0328	2,360,000	0.05	3,600,000

3.2 UPSTREAM LOADS

Resuspension of upstream sediments will contribute to the depositional load within and downstream of the Arkema early action area. Surficial (≤15 cm) sediment concentrations collected between RM 8 and 9, upstream of the Arkema site, during the Portland Harbor RI/FS and other studies were averaged to characterize upstream sediment concentrations for model input (Table 3). Data were limited to samples collected post-1996, when a high flow event occurred and eroded surficial sediments in the lower Willamette River, which are therefore not considered representative of existing surficial sediment concentrations.

Table 3. Upstream Sediment Concentrations

COPC	Upstream Sediment Concentration (µg/kg)
DDT	7.3
DDE	13.5
DDD	11.7

Estimates of the upstream sediment deposition load will vary as it is calculated from the difference of the net sedimentation load and the mass loading from the Arkema site's stormwater solids:

Net Sedimentation Load = Upstream Sedimentation Load + Arkema Site Stormwater Load

where the net sedimentation load is estimated as the net sedimentation rate multiplied by the depositional area. The depositional area was estimated at 9.55 acres, assumed to extend from the riverbank to the navigation channel and from Outfall 004 to the northern end of Lot 1.

3.3 SEDCAM MODEL PARAMETERS

SEDCAM Model parameters include the mixed layer depth, net sedimentation rate, initial surficial sediment concentration, and sediment density. These parameters are described below.

Mixed Layer – Bioturbation, anthropogenic activity, and natural forces contribute to the mixing of surficial sediments. To account for the Willamette River's high amount of ship traffic and relatively fast currents, the thickness of the surficial sediment's mixed layer was assumed to be 15 cm, consistent with the mixing layer assumed in the Portland Harbor RI/FS.

Net Sedimentation Rate – The net sedimentation rate was estimated by evaluation of depth differences between sequential bathymetric surveys. The bathymetric data collected in 2002 and 2009 were evaluated to characterize net deposition rates over the nearshore sediments

adjacent to the Arkema site. The depth difference map indicates net sedimentation rates over the proposed early action area ranging from 0 to approximately 30 cm/year in local areas.

Sediment cores collected within the proposed early action area were also evaluated to better understand local sedimentation patterns. The downcore DDT concentration patterns for several sediment cores located within the proposed early action area (WB-9, WB-36, WB-48, WB-50, WB-51, WB-52, WB-53, and WB-66) were evaluated. In all of these cores, the peak DDx concentrations, which are assumed to correspond to DDT manufacturing operations at the site between approximately 1947 and 1954, were buried with depth in the sediment, located at depths ranging from approximately 2 to 10 ft below the sediment-water interface. These data indicate a long-term net depositional environment, and suggest an average local net deposition rate of 3.3 cm/year.

The available site data generally indicate a depositional environment, although the ongoing net depositional rate is not well characterized in the nearshore areas. Therefore, to evaluate potential recontamination, a range of net deposition rates from a low of 1 cm/year to a high of 5 cm/year was evaluated.

Initial Surficial Sediment Concentrations – The initial surficial sediment concentration in the depositional area was conservatively assumed to be 0, representing a remediated (e.g., capped) scenario.

Sediment Density – The average dry bulk density of sediment was measured to be 0.92 g/cm^3 from samples collected within the preliminary removal action area boundary at the Arkema site.

4 MODEL RESULTS

Model-predicted surficial sediment concentrations within the estimated depositional area are presented for DDT (Figure 1), DDE (Figure 2), and DDD (Figure 3). Predictions are presented as a function of time, where the initial surficial sediment concentration in the depositional area is assumed to be zero at time = 0. For each isomer, model predicted concentrations are presented for the existing and the goal stormwater ("SW") concentrations and for the estimated high and low net sedimentation rates. The diffuser on Outfall 004 will also diffuse the solids. Therefore, even these estimated high and low net sedimentation rates are unrealistically biased high. The conservative high and low net sedimentation rates provide bounds on the expected results, and the "best estimate" rate (3 cm/yr), which falls in between these endpoint values is presented in Figures 4 through 6. Also included on the figures are the predicted surficial sediment concentrations in the depositional area without the contribution of the site stormwater load ("no SW"). These values represent the predicted recontamination due to the upstream loads only. The predicted surficial sediment concentrations in the depositional area without the contribution of the Willamette upriver load ("Target SW Concentration, Zero Upstream Concentration) are also shown on Figures 4 through 6. The latter values represent the predicted recontamination due to the stormwater load only.

Model predictions were compared to the draft Portland Harbor sediment RALs and PRGs currently being used for FS evaluations. The RALs, PRGs, and the fully mixed, steady state, predicted surficial sediment concentrations are summarized in Table 4. All of the predicted surficial sediment concentrations, with the exception of DDE at the existing stormwater concentrations and the draft "Alternative F" RAL, meet or are below the draft LWG RALs and all are below the draft PRGs.

The screening level analysis was applied to predict recontamination resulting from stormwater discharge from the site. For this analysis, it was assumed that the upstream sediment load remained unchanged, but that the COPC concentration of these sediments was zero. Model predictions for DDT (Figure 7), DDE (Figure 8), and DDD (Figure 9) indicate that the recontamination from the stormwater discharge with and without contaminant contribution from upstream is similar, and that the predicted recontamination is lower for the scenarios without the upstream contribution.

Table 4. Comparison of Model-Predicted Fully Mixed Surficial Sediment Concentrations with Portland Harbor Sediment PRGs and RALs

	PH Draft PRGs	PH Draft RALs					Model Predicted Existing Conditions	Model Predicted Meeting Stormwater Effluent Goals
Analyte	PRG[a] (µg/kg)	LWG Alt. B[b] (µg/kg)	LWG Alt. C[b] (µg/kg)	LWG Alt. D[b] (µg/kg)	EPA Alt. E[b] RAL (µg/kg)	EPA Alt. F[b] RAL (µg/kg)	Predicted Sediment Concentration (µg/kg) for "Best Estimate" Sedimentation Rate	Target Sediment Concentration (µg/kg) for "Best Estimate" Sedimentation Rate
Sum DDT	62.9	NA	NA	NA	150	60	19.8	10.6
Sum DDE	31.3	1,000	1,000	200	50	20	24.6	16.8
Sum DDD	28	NA	NA	NA	100	50	13.8	15.0

Notes:

PH = Portland Harbor
PRG = preliminary remediation goal
RAL = remedial action level

[a] These benthic ecological PRG values are highly conservative. The DDx no-effect level to the benthic community was presented in the proceedings of the 2011 Battelle Sediment Conference in New Orleans by Becker et al. (see below). Based on the false-positive responses caused by other sediment contaminants (non-DDx related), a conservatively estimated no-effect level of 4.6 ppm (4,600 µg/kg) DDx was calculated.

Becker, S., L. Williams, and M. Aldea. 2011. Site-specific evaluation of the Portland Harbor sediment quality guidelines. Paper presented at the Sixth International Conference on Remediation of Contaminated Sediments, New Orleans, LA. Integral Consulting Inc., Seattle, WA.

[b] Wyatt, B. 2011. Personal communication from the LWG (letter to K. Koch, U.S. Environmental Protection Agency, Seattle, WA, dated August 23, 2011, regarding EPA letter dated August 11, 2011 providing direction to the LWG on alternatives to be evaluated in the Draft Feasibility Study). Lower Willamette Group, Portland, OR.

5 SUMMARY

The screening level analysis provides predictions of sediment recontamination resulting from stormwater discharge from the site. The model predictions indicate that the stormwater load (both existing and treated) contributes to potential recontamination of fully remediated surficial sediments. However, the predicted sediment concentrations meet or are below the draft LWG RALs, with the exception of one scenario, DDE in existing stormwater. These results suggest that any recontamination of sediments that may result from site stormwater discharge will not cause any additional remediation activities or result in unacceptable risk.

The screening level analysis incorporated many conservative assumptions that likely result in higher predicted recontamination from the site stormwater discharge than will actually be observed. Conservative assumptions assume that the depositional area is composed of initially clean sediments. As discussed above, the actual location of the discharge is downstream of the proposed remedial area, and the initial surficial sediment concentrations will be higher, resulting in lower net recontamination from site stormwater discharge.

6 REFERENCES

Jacobs, L., Barrick, R., and Ginn, T. 1988. Application of a mathematical model (SEDCAM) to evaluate the effects of source control on sediment contamination in Commencement Bay. pp. 677-684. In: Proceedings: First Annual Meeting on Puget Sound Research, Puget Sound Water Quality Authority, Seattle, WA.

Schueler, T. 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*. Metropolitan Washington Council of Governments, Washington, DC.

Integral. 2008. Stormwater Interim Remedial Measures Focused Feasibility Study Report, Arkema Portland Facility. Draft. Prepared for Legacy Site Services LLC, Exton, PA. Integral Consulting Inc, Portland, OR. July 3, 2008.

Integral. 2009. Draft Stormwater Source Control Measure Design & Implementation Work Plan, Former Arkema Portland Facility. Prepared for Legacy Site Services LLC, Exton, PA. Integral Consulting Inc, Broomfield, CO. October 7, 2009.

Integral, Windward, Kennedy/Jenks, and Anchor. 2009. Portland Harbor RI/FS Remedial Investigation Report. Draft. IC09-0003. Prepared for The Lower Willamette Group, Portland, OR. Integral Consulting Inc., Portland, OR; Windward Environmental LLC, Seattle, WA; Kennedy/Jenks Consultants, Portland, OR; and Anchor QEA, LLC, Seattle, WA. Vol. 1–14. October 27, 2009.

FIGURES

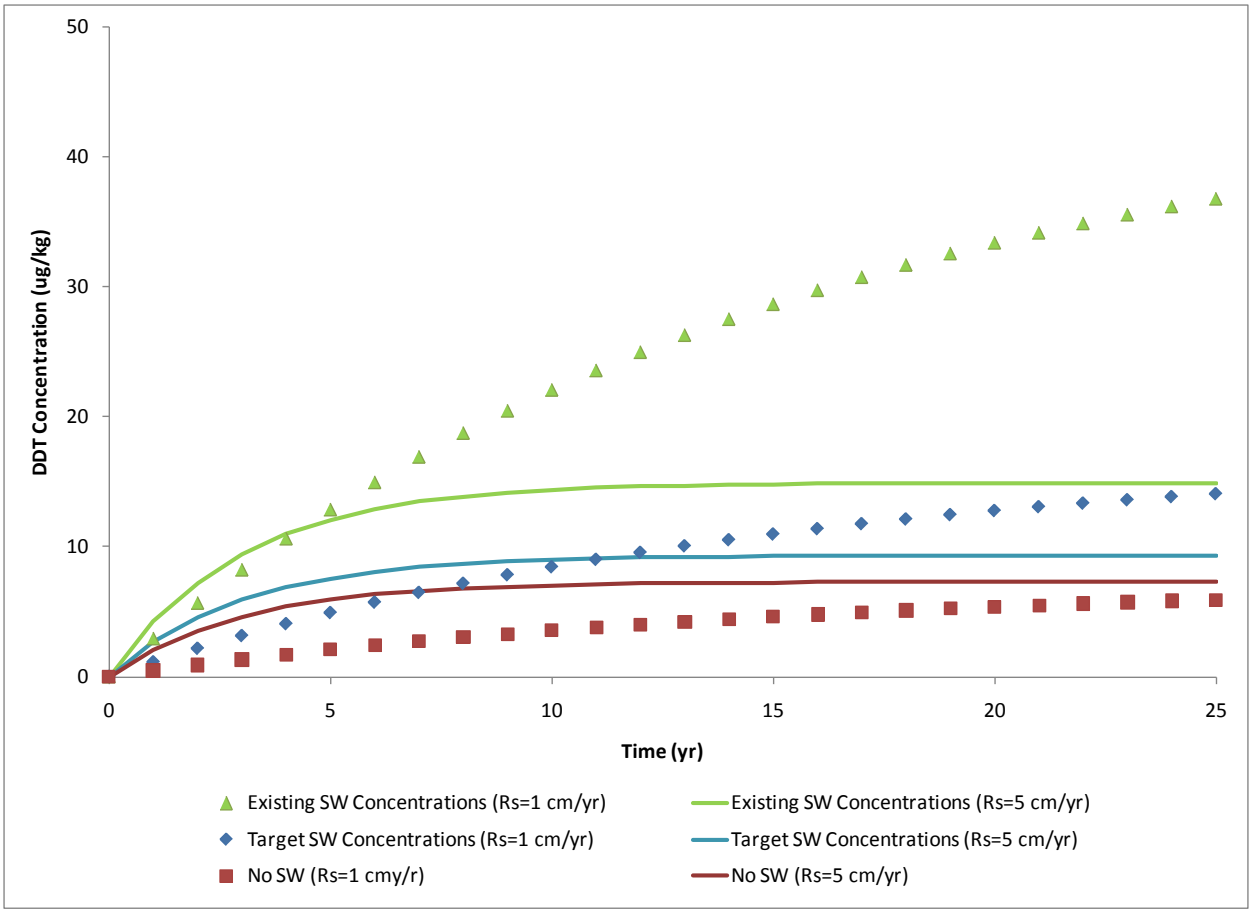


Figure 1
Predicted DDT Surficial Sediment Concentrations
High and Low Net Sediment Deposition Rates
SEDCAM Recontamination Modeling Report
Stormwater Source Control Measures

integral consulting inc.

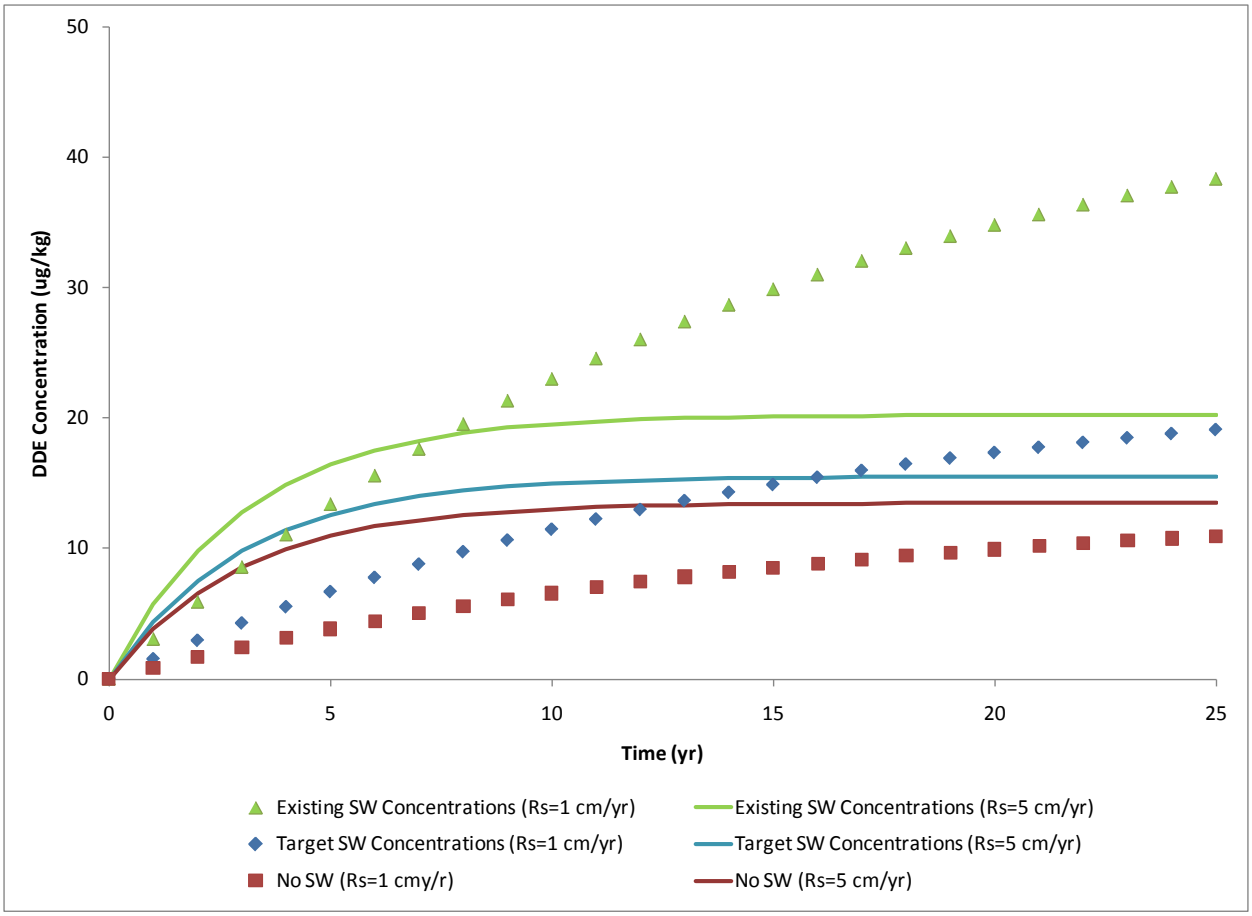
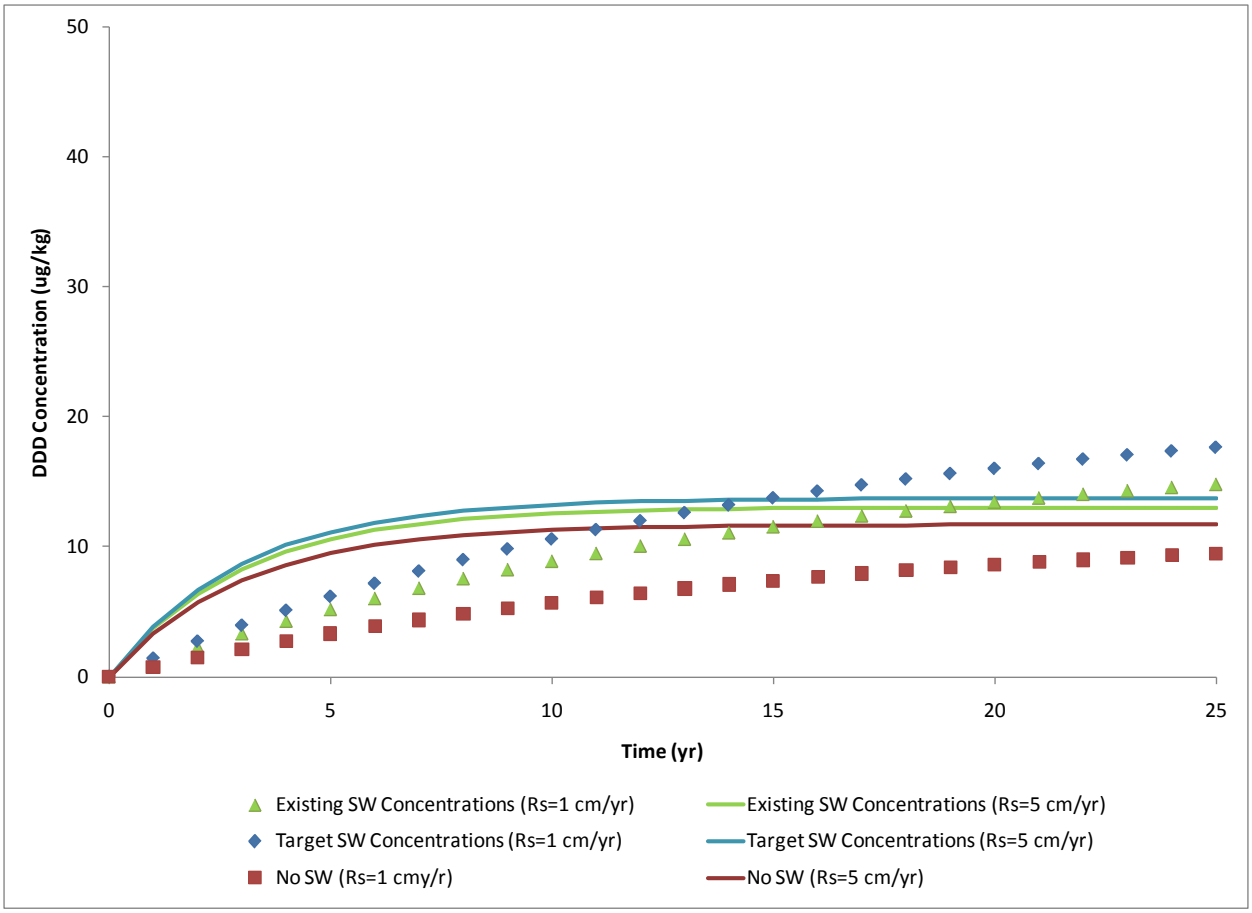


Figure 2
Predicted DDE Surficial Sediment Concentrations
High and Low Net Sediment Deposition Rates
SEDCAM Recontamination Modeling Report
Stormwater Source Control Measures

integral consulting inc.



Note that the existing stormwater concentration based on the 2007 data is lower than the target concentration.

Figure 3
Predicted DDD Surficial Sediment Concentrations
High and Low Net Sediment Deposition Rates
SEDCAM Recontamination Modeling Report
Stormwater Source Control Measures

integral consulting inc.

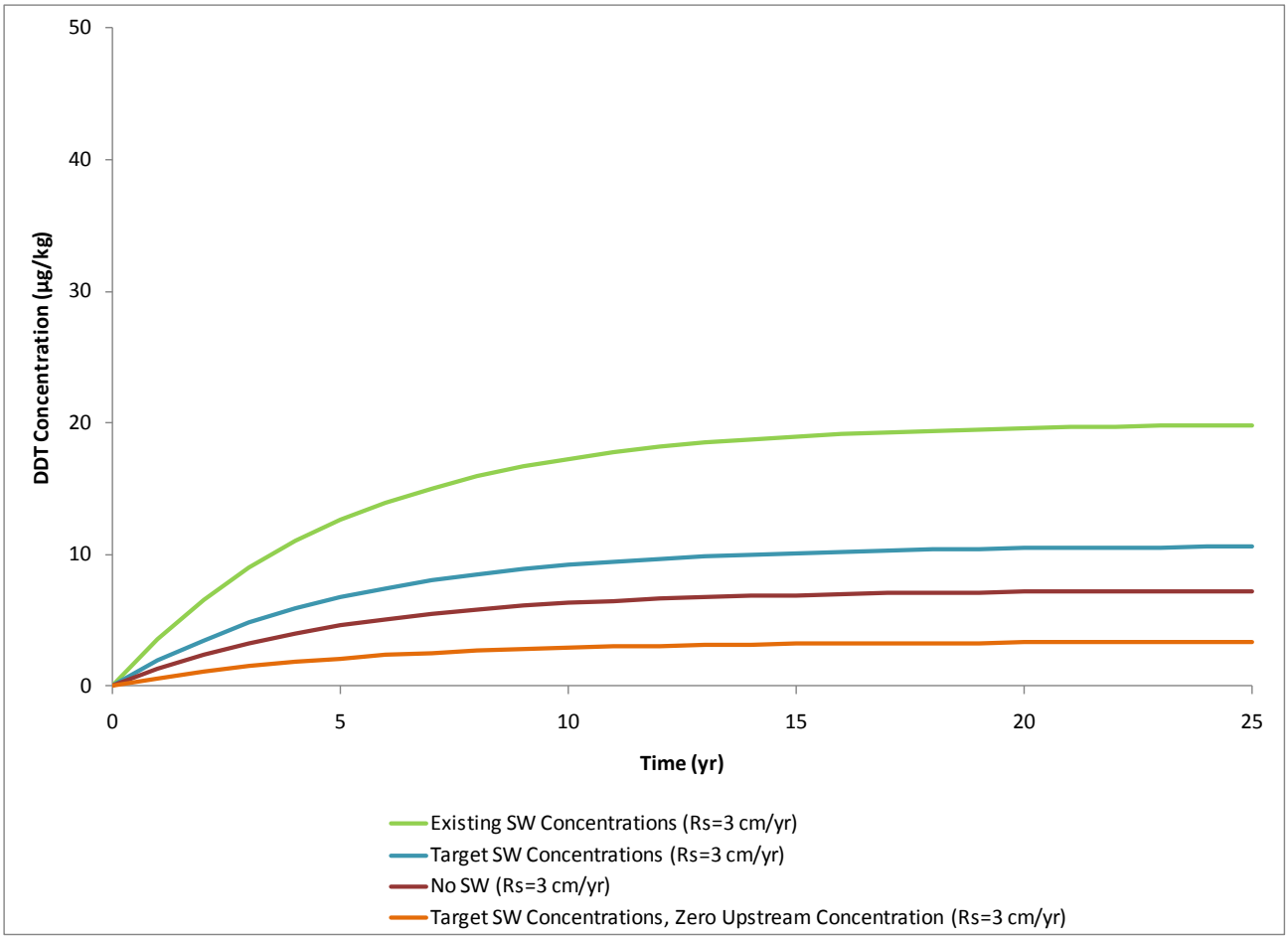


Figure 4
Predicted DDT Surficial Sediment Concentrations
"Best Estimate" Sedimentation Rate
SEDCAM Recontamination Modeling Report
Stormwater Source Control Measures

integral consulting inc.

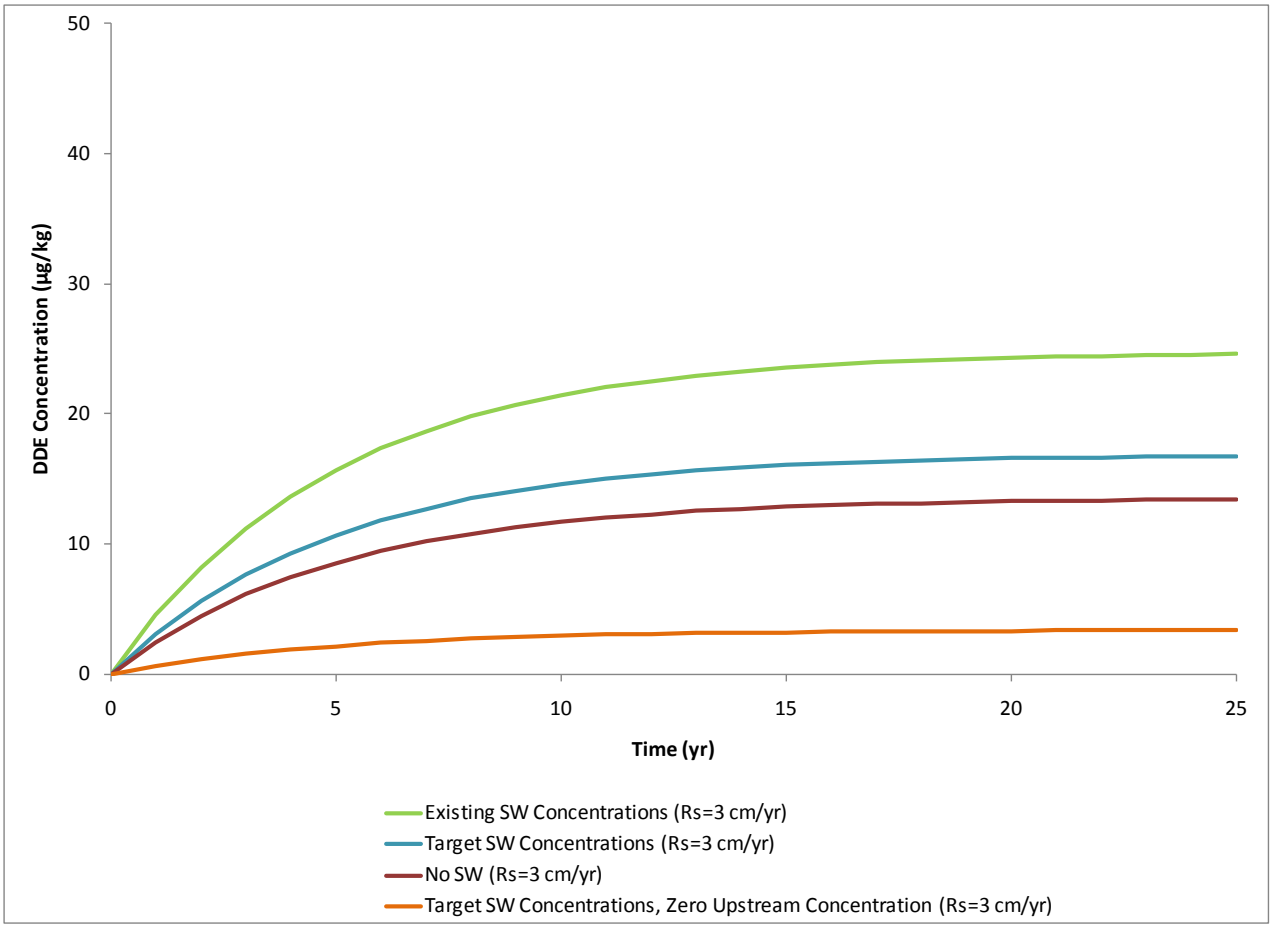


Figure 5
Predicted DDE Surficial Sediment Concentrations
"Best Estimate" Sedimentation Rate
SEDCAM Recontamination Modeling Report
Stormwater Source Control Measures

integral consulting inc.

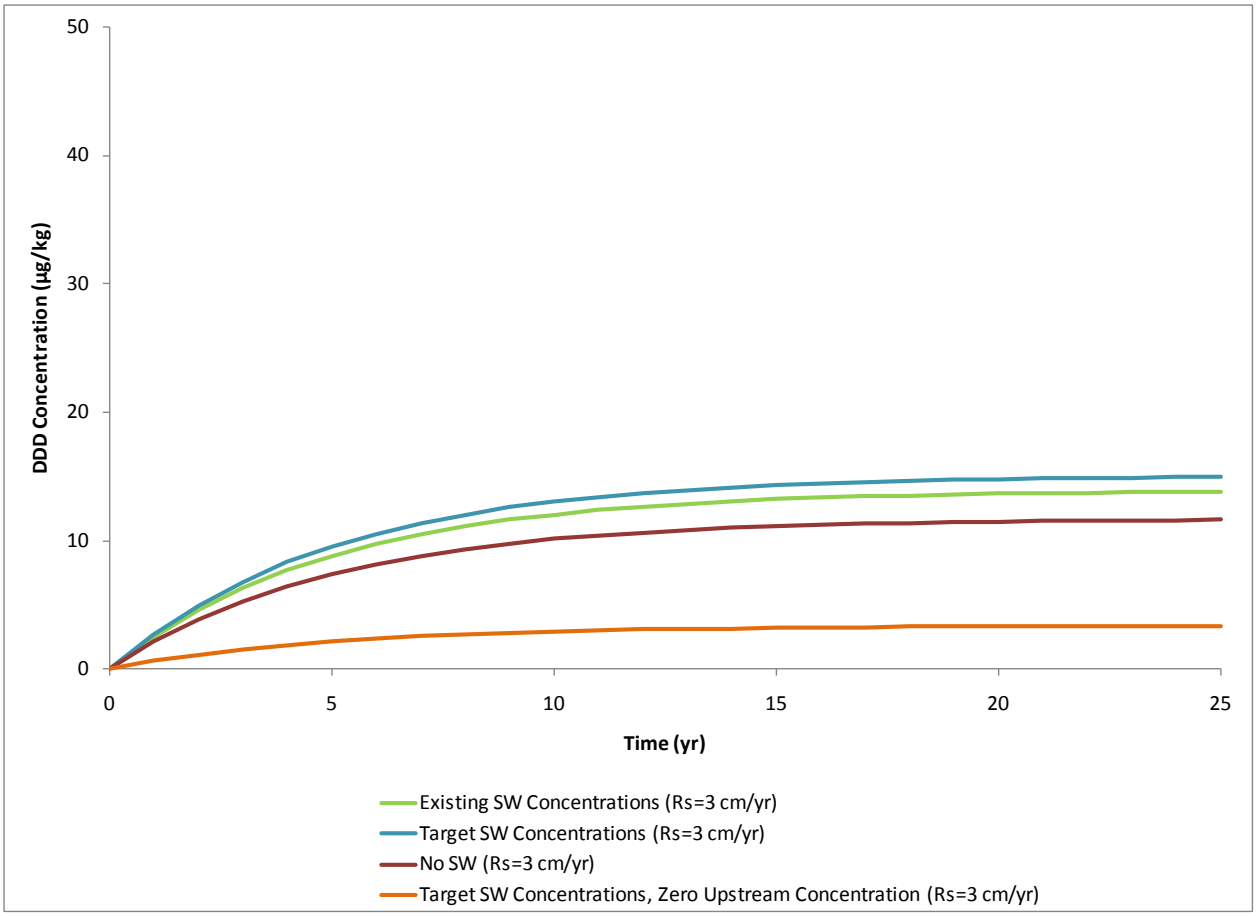


Figure 6
Predicted DDD Surficial Sediment Concentrations
"Best Estimate" Sedimentation Rate
SEDCAM Recontamination Modeling Report
Stormwater Source Control Measures

integral consulting inc.

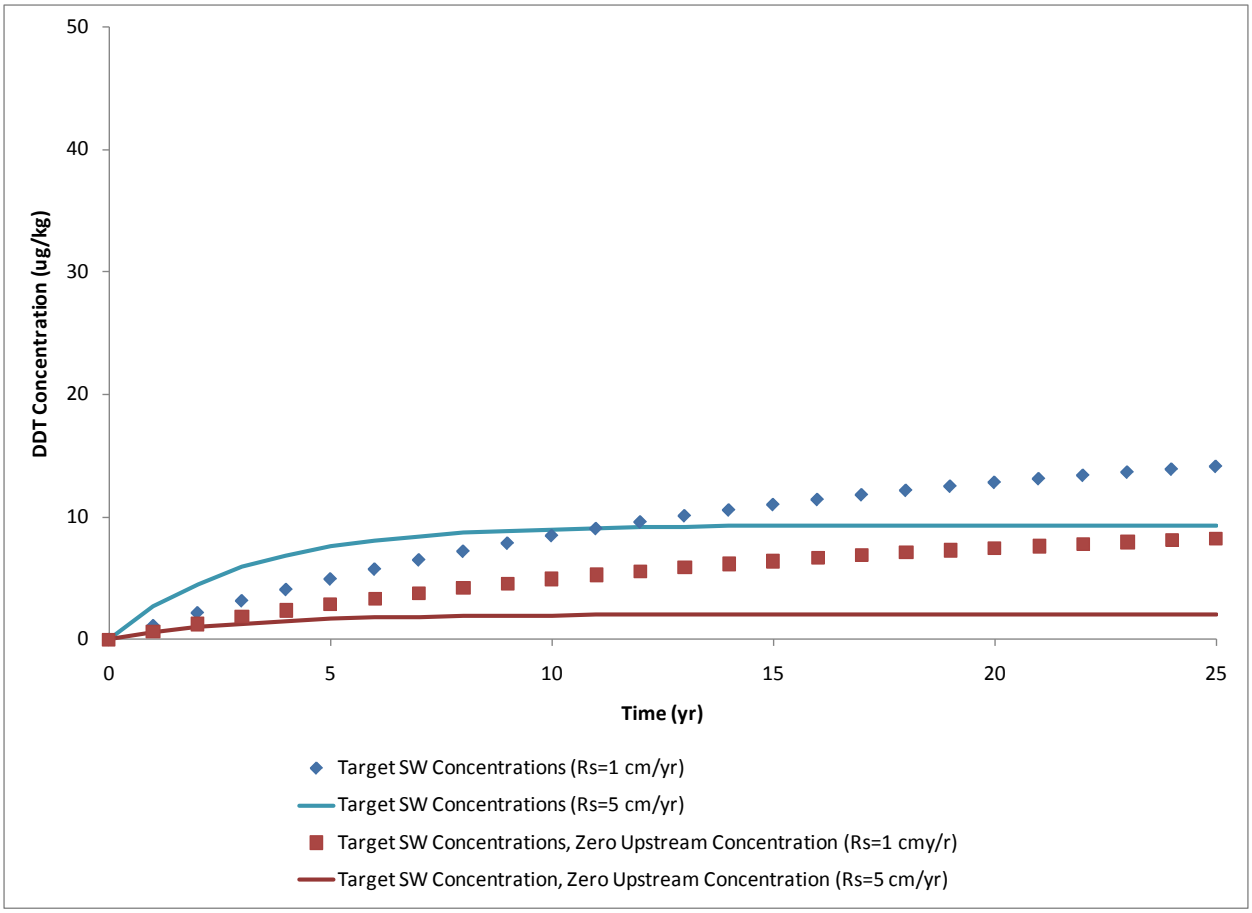


Figure 7
Predicted DDT Surficial Sediment Concentrations
Assuming an Upstream Sediment Concentration = 0
SEDCAM Recontamination Modeling Report
Stormwater Source Control Measures

integral consulting inc.

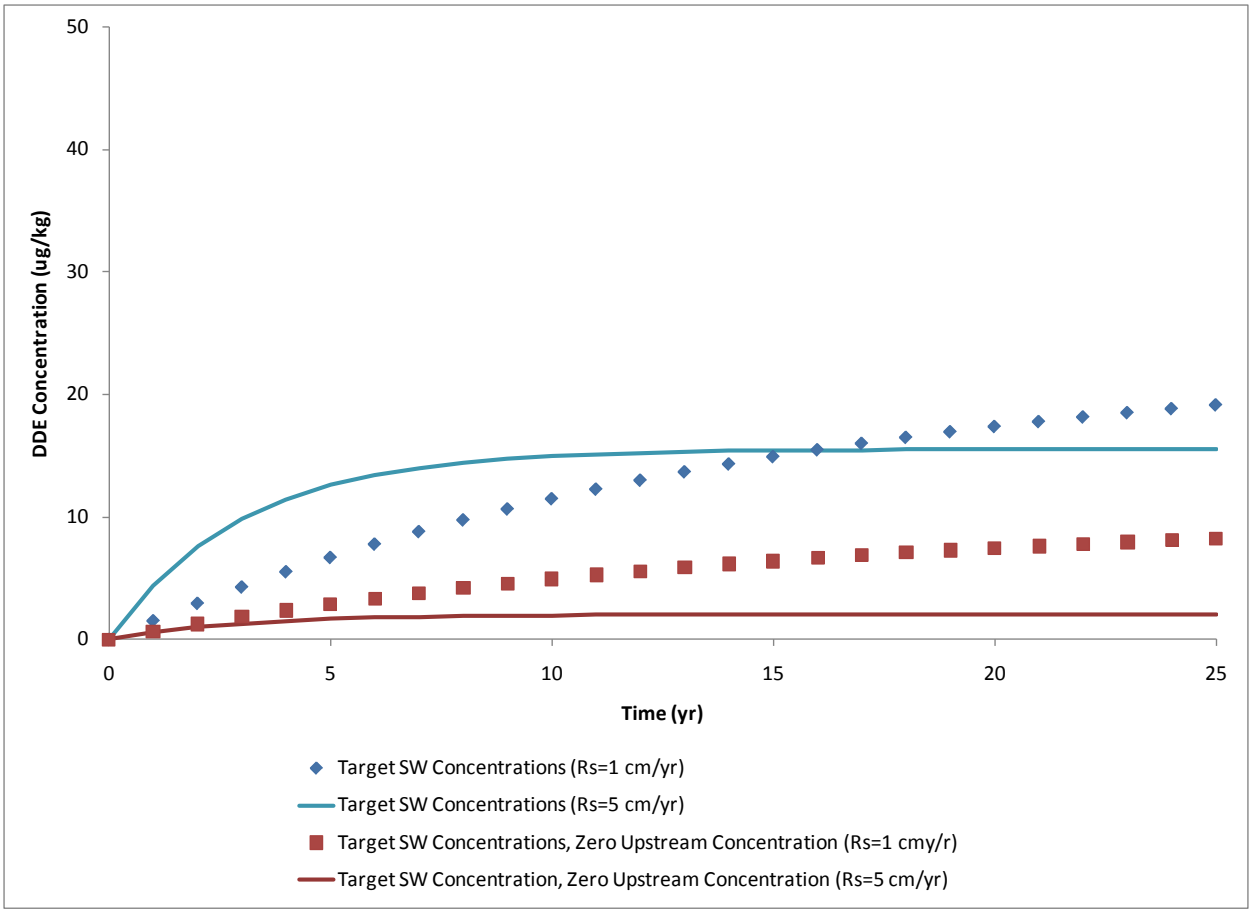


Figure 8
Predicted DDE Surficial Sediment Concentrations
Assuming an Upstream Sediment Concentration = 0
SEDCAM Recontamination Modeling Report
Stormwater Source Control Measures

integral consulting inc.

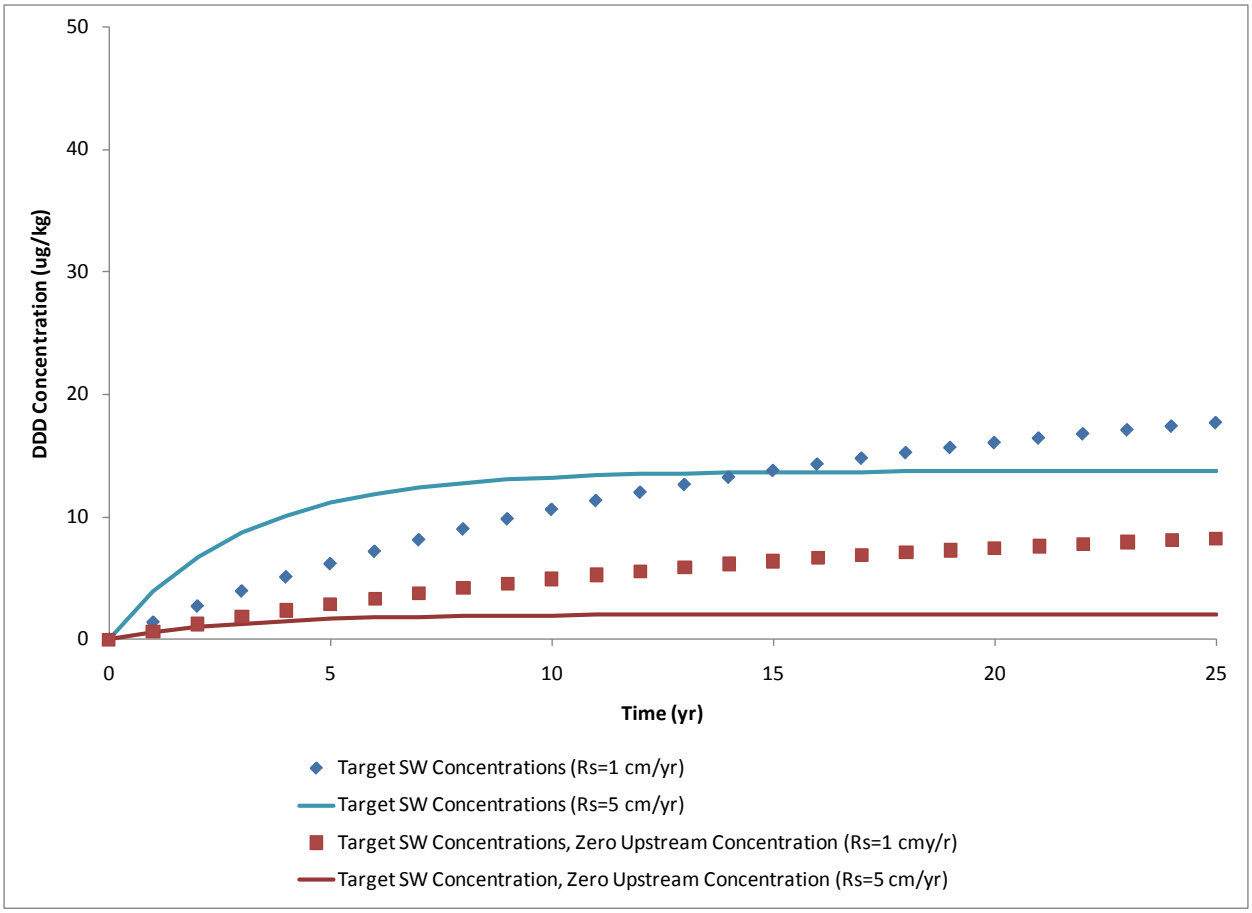


Figure 9
Predicted DDD Surficial Sediment Concentrations
Assuming an Upstream Sediment Concentration = 0
SEDCAM Recontamination Modeling Report
Stormwater Source Control Measures

integral consulting inc.

APPENDIX M

BASIN STABILITY ANALYSIS

TO: Mike Martin – Integral Consulting

FROM: Mike Byers, P.E. – CRETE Consulting Inc.

PROJECT: Stormwater Source Control Measures – Former Arkema Facility

SUBJECT: Basin Stability Analysis

DATE: September 28, 2011

This memorandum describes the results of stability analyses performed on the current configuration of the detention basin and the sand filter basin (together referred to herein as basins). These basins are components of a larger stormwater source collection and control system contemplated for the site along the Willamette River near Portland, Oregon. Our work was completed under our existing work order and authorized by Mr. Mike Martin.

The scope of our services was to perform a stability analysis of the planned basins to determine the factor of safety for the planned excavations and to evaluate whether the planned basins will adversely affect the stability of the river shoreline. This study was performed using existing subsurface information provided by Integral Consulting Inc. for conditions in the vicinity of the basins and laboratory soil testing results performed by others for soil in the immediate vicinity of the basins.

Basin location and configuration details. The two basins consist of a larger detention basin with a bottom elevation of 29.5 feet (datum is AMSL NAVD 88) and plan dimensions of 160 feet by 300 feet. The detention basin is planned to be excavated below the existing grade, which ranges between elevation 38 and 39 feet, so the bottom of the basin will be around 8.5 to 9.5 feet below the surrounding site grades. The smaller sand filter basin is about 160 feet by 90 feet in plan dimension and planned to have a bottom elevation of 27 feet, or about 10 feet below the surrounding site grades. Both basins are designed to have side slopes of 4H:1V (4 Horizontal to 1 Vertical) or about 14 degrees off horizontal. The basins will be built with an internal liner so that stormwater in the basins remains separate from the soil below the basins. The basins are configured next to each other with the long axis of the sand filter basin and the short axis of the detention basin running parallel to the river bank. The basins are set back from the river by a minimum of 100 feet. The basins are planned to be in place until the final site remedy is determined, and, although considered temporary, they could be in place for up to 25 years.

Subsurface Conditions. Subsurface conditions in the vicinity of the basins were obtained from two sources (supplied by Integral Consulting).

1. Specific soil and groundwater information at the location of the basins was determined by reviewing geologic cross section and boring log information contained in a 2010 RI/SCE report for the RP – Portland Site completed by amec Earth & Environmental (amec).

2. Additional subsurface information and specific laboratory testing results were obtained from a report completed by ERM titled "Subsurface Debris Investigation", July 29, 2010 and an appendix where geotechnical laboratory testing results were reported (ERM).

The amec and ERM reports suggest that the basins will be constructed in artificial fill material that was encountered at most locations across the site. The fill encountered in a boring within the footprint of the detention basin describes the fill as medium dense, brown to gray, fine sand with minor and varying amounts of gravel and silt. The fill apparently extends down to just below the bottom of the basins where medium dense, gray fine sand with trace silt was encountered. This lower unit was logged as a natural fine grained alluvium. The water table is shown as occurring several feet below the bottom of the basins and soil in the natural alluvium was logged as wet. Laboratory strength testing of fill samples was conducted for the ERM study where a fine grained and a granular fill sample were testied for strength. The granular sample tested for the ERM study appeared to be relatively consistent with the description of the fill encountered in the boring within the footprint of the basins, so soil strength properties from the granular fill were used in the stability study for the basins.

Specific soil properties utilized in the stability analysis were derived from the direct shear testing of the granular fill and the soil strength was factored to account for the fact that the properties were peak properties. The properties used for the analyses included:

Natural unit weight =	110 pounds per cubic foot
Soil frictional strength =	38.5 degrees
Soil cohesion =	0 psf
Pseudo-static coefficient =	0.15

These same properties were used for the underlying natural alluvial soil since the boring log description (including soil relative density) were reported to be very similar or the same as the overlying granular fill. Groundwater was assumed to be at elevation 20 feet based on the subsurface cross sections.

Stability Analyses. Static and pseudostatic limit equilibrium analyses were performed using the stability program UTEXAS3 (Shinoak Software, Stephen G. Wright). The program computes a factor of safety defined as the numerical value of the available shear strength of the soil divided by the shear strength required for just-stable equilibrium. The factor of safety is computed for an assumed shear (potential sliding) surface and, in the case where a search is performed, different shear surfaces are developed and the factor of safety for each surface compared until the lowest factor of safety is determined for a given set of conditions. Seismic forces are included in the analysis by adding a pseudo-static horizontal force equal to the weight of the soil times a pseudo-static coefficient that is typically taken at 1/3 to 1/2 times the maximum ground acceleration. This approach accounts for the fact that slopes can typically undergo a small amount of deformation before reaching a condition of full failure, so an acceleration less than the maximum acceleration is typically used for soil slopes.

Results

The static factor of safety for the soil, groundwater and slope configurations described herein resulted in a minimum factor of safety of 3.2 with the critical failure surface being determined to be a relatively shallow circular failure on the slope. The factor of safety was calculated to be 2.0 when the seismic factor was added to the stability study. Note that the soil strength parameters were maintained to be the same for both the static and seismic calculations. This approach is considered to be appropriate given the granular nature of the soil. Figure 1 shows the analyses for static stability. Figure 2 shows the results for seismic stability.

Evaluation of River Bank Stability. The riverbank for the Willamette River is 100 feet from the closest edge of the basins. The topography for the river bank in the vicinity of the basins indicates that the river bank slope is somewhere around 20 feet tall and somewhere between 1H:1V to 2H:1V. Given that the basins are only up to 10 feet deep, and that they are situated no closer than 100 feet from the about 20 feet tall river bank, it is our opinion that the basins will have no adverse affect on the stability of the riverbank. The basins will be lined so that there will be no adverse affect on the groundwater levels that could result in bank instability.

Conclusions

The minimum static factor of safety calculated for the basins was 3.2. This number is well above typical acceptable minimum factors of safety for similar structures (2.0 to 2.5). Likewise the minimum calculated seismic factor of safety (2.0) is above typical acceptable minimum seismic factors of safety for similar structures (1.1 to 1.5). The basins are not considered to have any adverse affects on the river bank stability. It should be noted that this analysis did not independently determine the riverbank stability. Conclusions were drawn based on the current minimum basin setback from the river.

This report was prepared for the exclusive use of Integral Consulting Inc. for use on this project. The analyses were performed using soil conditions supplied by Integral based on subsurface explorations completed by others. Although the subsurface conditions provided were used for the analysis, they were not independently verified and the stability results will be different if the soil conditions in the field vary from those presented herein. The conditions should be verified before or as the excavations are made for the basins. If conditions are found to differ, this analysis should be repeated using the actual soil conditions encountered during construction.

REGISTERED PROFESSIONAL ENGINEER
64468PE
OREGON
SEPT 25, 2000
MICHAEL GIRARD BYERS

EXPIRATION DATE: 12/31/2011

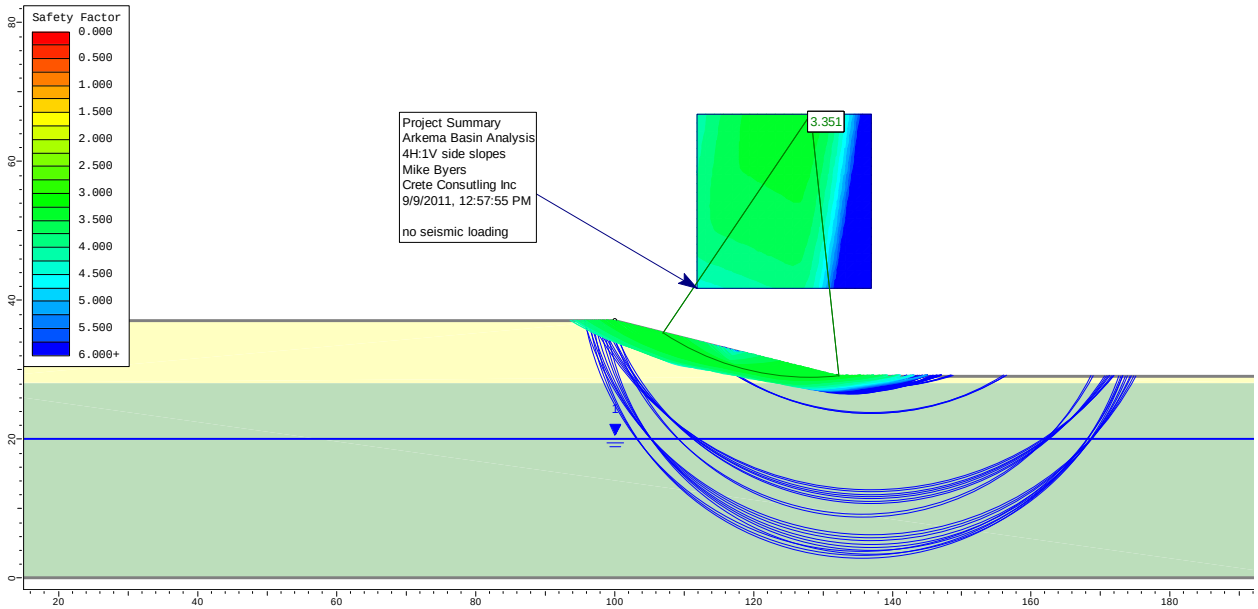


Figure 1 – Static Slope Stability Results

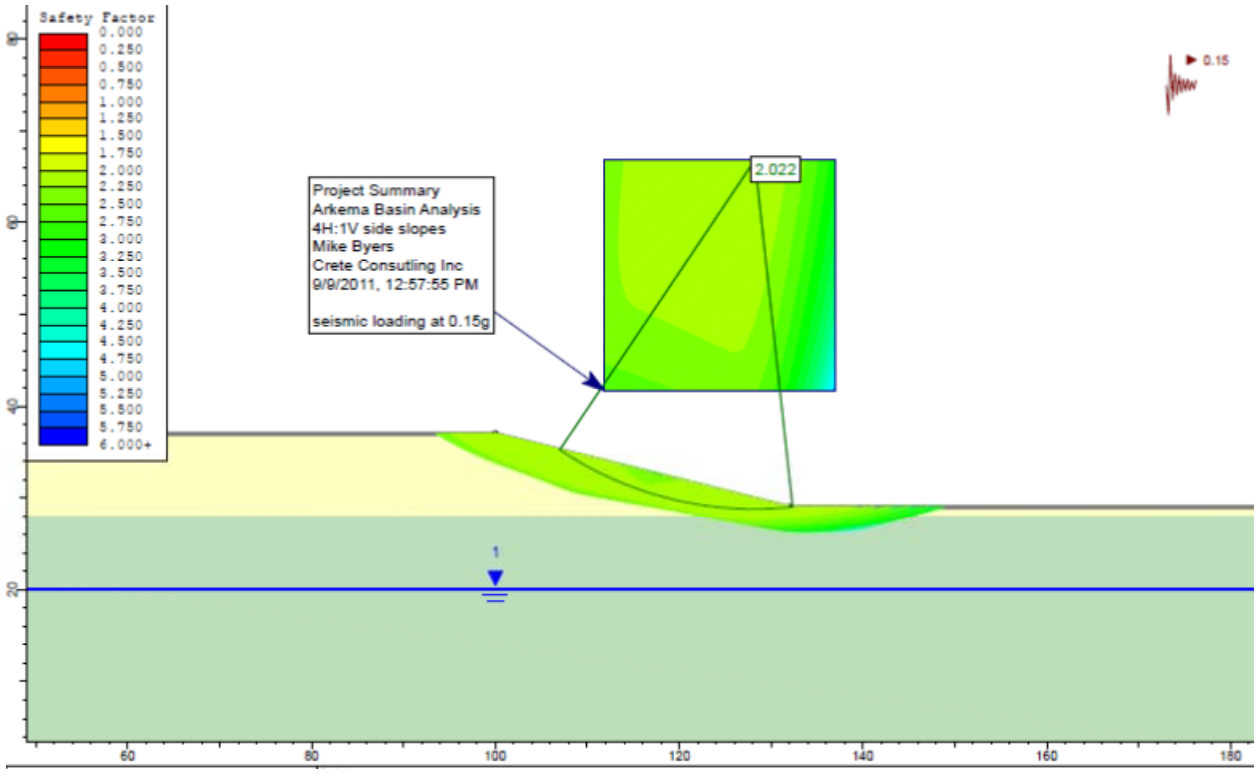


Figure 2 – Seismic Slope Stability Results

APPENDIX N

DRAFT DESIGN REPORT COMMENT AND RESPONSE SUMMARY

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	DEQ Comments				
	General Comments				
1	DEQ has two primary objectives for the Arkema new stormwater system which are: • Comply with the 2010 DEQ Water Quality Mutual Agreement and Order (MAO). • Establish stormwater source control to support the anticipated early sediment action adjacent to the Arkema facility with is overseen by the Environmental Protection Agency. <u>MAO Objectives</u> The purpose of the MAO was to allow for the construction, operation and monitoring of a new stormwater system prior to renewal of the facility National Pollutant Discharge Elimination System (NPDES) permit. Effluent monitoring data will be used by DEQ and Arkema to evaluate the need for system modifications and/or improvements and by DEQ in the permit renewal process. The inclusion of benchmarks or system treatment goals was a topic of considerable negotiation during the negotiation of the MAO. DEQ finally agreed to not include them in the MAO with the understanding that they would be identified in subsequent correspondence and workplans. The purpose of which was to provide a basis for design of the stormwater treatment system and to evaluate system performance and the need for system modifications. While Table 1-1 Stormwater Treatment System Effluent Levels is presented in the Draft Design report, the document notes that these values were "not part of the design basis	**Effluent limits similar to those presented in Table 1-1 were first proposed in DEQ's original comments[1] to the Draft Stormwater Interim Remedial Measures Focused Feasibility Study (Integral 2008). LSS responded to these proposed limits in a March 18, 2009 letter from Todd Slater to Matt McClincy of DEQ (March 18th Letter). In the March 18th Letter, LSS stated "Therefore, in order to attempt to meet the DEQ stated effluent limits, additional sampling and treatability studies are required to assess the nature of the DDx discharges in stormwater." Further, the letter addressed the issue that mechanical treatment technologies, designed specifically for stormwater, have rarely been applied at the scale required for implementation at the Arkema site (i.e., the 25-year, 24-hour storm), and have generally not been applied to achieve the reductions in stormwater concentrations necessary to meet DEQ's proposed effluent limits, therefore rendering the DEQ proposed effluent limits technically impracticable to achieve. If the agency has knowledge of a treatment technology that has been demonstrated capable of meeting the Table 1-1 values for a stormwater system with inputs commensurate with the Arkema site, LSS would agree to conduct an evaluation and, pending the evaluation, implement the agency-recommended stormwater system.** **The need for treatability studies was**	A. Water Quality Mutual Agreement and Order (MAO) Objectives DEQ reiterates that the purpose of the MAO was to allow for the construction, operation and monitoring of the new stormwater system prior to the renewal of the facility National Pollutant Discharge Elimination System (NPDES) Permit. Given that the Table 1-1 values represent draft NPDES permit effluent levels it was clearly understood by both LSS and DEQ that these values, to the extent practical, would be the basis for the initial system design, performance monitoring and system modification. DEQ understands that there is uncertainty associated with the nature of the stormwater influent and effectiveness of treatment alternatives on stormwater. While it is the intent of the MAO to provide for the management of this engineering uncertainty, as noted during our May 10, 2011 discussion, DEQ is reconsidering moving forward with the stormwater system under the MAO given the unsupported initial design/performance monitoring program and responses to the review comments. DEQ"s decision to maintain the MAO is contingent on the revisions to the stormwater design report. The revised stormwater design needs to identify the treatment objectives (i.e., Table 1-1 values), design assumptions	LSS will state that Table 1-1 values are <u>goals</u> of the treatment system; however, LSS will further state that these goals may not ultimately be achievable (technical practicability) given the treatment technologies that are being implemented for stormwater control as per the MAO. Also, LSS will add the fact that Table 1-1 values were not used as the basis for the design of the treatment system. LSS will state the assumption that DDx in stormwater is associated with particulates (reasonable assumption given others have used TSS as surrogate for evaluating DDT removal; Johnson Creek TMDL, City of Portland, OR and Milwaukie, OR MS4 permits). LSS will state that the particle size distribution (PSD) and partitioning of DDT within the PSD is currently unknown. Therefore, it is unknown how this system will perform. However, an attempt will be made to determine a best estimate as to PSD and relative treatment performance. LSS agrees to incorporate this information (identify treatment goals, design assumptions, and anticipated design element performance, to the extent possible, including bullets) into the design report. LSS will state that Table 1-1 values may be unachievable goals.	<u>Revision:</u> The Final Design Report was modified to identify treatment objectives, design assumptions, and anticipated design element performance. In addition, the Performance Monitoring Plan (PMP) was updated to identify design assumptions and technologies, to identify additional monitoring needed to assess system performance, and included a decision tree that integrates potential modifications of the treatment system with the performance monitoring program. This general comment is addressed in more detail in the specific comments presented below. <u>Location:</u> Final Design Report, Sections 3 and 8; Appendix F (PMP); Appendix G (Quality Assurance Project Plan); Specifications; Drawings.

[1] Letter from Matt McClincy, Oregon DEQ, to Todd Slater, LSS, dated December 18, 2008, RE: Draft Stormwater Interim Remedial Measures Focused Feasibility Study Report, Arkema Portland Plant.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	for the source control measure", and that the objective of the source control measure "is a reduction of DDT in stormwater discharges to the Willamette River from the site". DEQ expects that the Table 1-1 levels will be included as a basis for the final system design, will be used in the evaluation of system performance, and that substantive system modification will be proposed if the Table 1-1 levels are not achieved. Absent these efforts, Arkema should expect that DEQ will move forward with permit renewal after submittal of the initial June monitoring report.	**further discussed in the Draft Stormwater Source Control Measures Design and Implementation Work Plan (Draft Work Plan; Integral 2009). The Draft Work Plan proposed a 15-month treatability study program to evaluate stormwater treatment technologies and, specifically, their ability to meet the DEQ proposed effluent limitations. The results of these treatability studies could have then been used as the basis of the Stormwater SCMs design. The Draft Work Plan also identified the need to expedite the Stormwater SCMs (due to the installation of the Groundwater SCMs and the need to decommission the existing stormwater system to install the Groundwater SCMs) and, therefore, established an alternative to conducting treatability testing by establishing benchmarks based on TSS removal as a surrogate parameter. LSS presented the precedence of using TSS removal as a surrogate parameter to establish DDT removal levels in other locations (City of Milwaukie and City of Portland MS4 permits). However, DEQ declined this approach and, instead agreed to an approach based upon treatment technology (i.e., selective capping, collection system decommissioning, stormwater detention and filtration) which would then be implemented as a full-scale pilot test.** **In a December 15, 2009 letter, DEQ decided to enter into an MAO "to manage the engineering uncertainty associated with the treatment of site stormwater…". Based on discussions with DEQ, the MAO would allow for the implementation of the treatment technologies as presented in the Draft Work Plan without the evidence that the technologies could in fact meet the levels**	(and their basis) and anticipated design element performance. For example, the following should be clearly described: • Design storm event for detention basin • Suspended particulate size detention basin is designed to settle • Basis for assumed particulate size range • Nature of DDX in influent (i.e., particulate or dissolved) • Design storm event for sand filter system • Target particulate size for sand filter and specifications for sand In addition to the LSS proposed modifications to the performance monitoring plan, the plan needs to: • Identify the design assumptions that are subject to verification through the performance monitoring program (e.g., nature of DDX in stormwater influent - dissolved versus particulate). • Identify technologies which will be evaluated for system modification if the Table 1-1 values are not achieved, data necessary to evaluate their effective application to the Arkema system (data should be collected prior to discharge compliance failure), and schedules to conduct such evaluation and implementation. • Include a decision tree that integrates potential modifications of the treatment system with the performance monitoring program. For example, what are the next	The majority of this information has been agreed to (May 10, 2011 meeting). Please note it will be difficult to predict events that exceed the sand filter capacity prior to their occurrence so that sampling can occur. DEQ acknowledges this difficulty.	

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
		presented in Table 1-1 (i.e., treatability studies). Instead, an adaptive management approach was agreed upon. The treatment technologies would be implemented and effluent monitoring would be conducted post-implementation. The stormwater treatment system could then be modified, on an as-needed basis as approved by DEQ, to improve effluent water quality. In the December 15, 2009 letter, DEQ agreed with the three components of the site stormwater program, including temporary capping, decommissioning of the existing stormwater collection system, and the installation of stormwater conveyance and treatment systems. The stormwater conveyance and treatment design was to include surface collection of stormwater via channels, detention of stormwater, and filtration of stormwater. **Because treatability testing was not conducted, the levels presented in Table 1-1 are not a basis for the design of the SCMs, and possibly in the case of DDx, technically impracticable to achieve. Further, these levels could not and can not be incorporated as a basis of the final design without conducting the previously proposed treatability testing.** **It has been LSS' understanding that, pending a determination of technical infeasibility and/or impracticability, it is DEQ's intent that the SCMs achieve the levels set forth in Table 1-1. In an attempt to meet this intent, LSS has proposed effluent monitoring that, as per Section 3 of the Performance Monitoring Plan, "the levels [presented in Table 3-1[2]] will be used to measure the progress/removal efficiency of the**	steps if the initial monitoring shows the influent contains significant dissolved DDX which is inconsistent with the initial system design assumption? What are the next steps if the Table 1-1 values for DDX are not achieved and the influent contains DDX associated with suspended particulates? • Include monitoring between the detention basin and sand filter, per the decision tree, to evaluate the effectiveness of the detention basin. This sampling point should be integrated into the decision tree. • Include monitoring during events that exceed the sand filter hydraulic capacity (i.e., during sand filter bypass conditions). **See EPA's response to DEQ general comment 1 in Attachment A.**		

[2] Table 3-1 of the Performance Monitoring Plan is identical to Table 1-1 of the Draft Design Report.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
		stormwater system during performance monitoring." LSS agrees that the stated objective (in Section 7 of the Draft Design Report and Sections 1 and 3 of the Performance Monitoring Plan) of "a reduction of DDT in stormwater discharges from the site" may not encompass the entire objective of the SCMs. Therefore, LSS proposes to modify the objective in the final design report as follows: "The objective of the Stormwater Source Control Measures is to implement an adaptive management approach for addressing site COPCs in stormwater discharges. This adaptive management approach includes the implementation of structural and treatment BMPs as agreed to in the MAO, ongoing performance monitoring of these BMPs, and modification of these BMPs to the practical limit of the technologies, if necessary, as outlined in the Performance Monitoring Plan." **Further, LSS proposes to modify Section 3 of the Performance Monitoring Plan to include a step-wise approach for system modification. This approach would include:** • **Performance monitoring of concentrations of site COPCs at the influent of the treatment system (i.e., influent to the detention basin) and the effluent of the treatment system (i.e., after the sand filter) to calculate a percent removal. Please refer to EPA general comment 2 for proposed modifications to the Performance Monitoring Plan in regards to influent and effluent sampling.** • **Comparison of effluent**			

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
		concentrations to levels presented in Table 1-1 (or Table 3-1 of the Performance Monitoring Plan). • **Comparison of effluent concentrations to levels that may potentially recontaminate site sediments (see below).** • **Evaluation of all influent and effluent data to assess the limits of sedimentation and filtration treatment technology to remove site COPCs from stormwater discharges. This may include, but will not necessarily be limited to:** - **Comparison of total concentrations of COPCs in site stormwater water to soluble/aqueous phase concentrations in both the influent and effluent data** - **Evaluation of particle size distributions, considering varied stormwater flows, in site stormwater discharges in both the influent and effluent data** - **Evaluation of site COPC concentrations in differing particle size ranges (i.e., partitioning of COPCs based on particle size).** **Based on these evaluations and as necessary, LSS will provide recommendations for modification of the SCMs that will maximize the efficiency of the stormwater treatment system. Modifications will potentially include, but are not necessarily limited to, the following:** • **Addition of carbon to address aqueous phase constituents**			

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
		• **Addition of coagulants to enhance sedimentation and filtration of particulates** • **Additional filtration (e.g., addition of a silt curtain on the downgradient edge of the detention basin) for smaller particulate removal** • **Additional capping to control sources of stormwater COPCs to site runoff.** **Recommendations for SCMs modifications and implementation schedules will be submitted to DEQ for review and approval.** **Criteria for implementing system modifications cannot be specified at this point as they will be highly dependent on initial sampling results. General examples of criteria include:** • **If significant concentrations of site COPCs are determined to be soluble (i.e., post-filtration) as compared to be associated with particulates, addition of a carbon adsorption layer to the sand filter would be a preferred approach.** • **If it is determined that site COPCs are associated almost exclusively with sub-micron particulates, additional capping may be preferred over enhanced sedimentation via a coagulant addition.** **While additional sampling at this point may provide some insight to these issues, given the extensive reconfiguration of the stormwater collection system and the extent of temporary capping planned for**			

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
		the site, adequate data for establishing what will be the new baseline criteria cannot be collected until these modifications are completed.			
	Stormwater Source Control The second objective of the new (interim) stormwater system is to prevent recontamination of Willamette River sediment (post EPA early action) adjacent to the Arkema facility. It is DEQ's expectation that the rerouting of stormwater to the downstream edge of the early action area (yet to be finalized) and the reduction of contaminants to the Table 1-1 levels or close to them will be sufficient to prevent sediment recontamination in early action area. However, this assumption needs to be supported, and DEQ requests that Arkema conduct a sediment recontamination analysis to support this conclusion. DEQ is working with other parties that are currently conducting recontamination evaluations and can provide more information on the approaches.	**A sediment recontamination analysis is currently being conducted as part of the Engineering Evaluation and Cost Analysis (EE/CA) for the sediments portion of the site. In addition, the data needed to complete the recontamination assessment will not be available until the stormwater SCMs have been implemented. Therefore, as part of the post-implementation evaluation of the SCMs, a comparison of effluent data to levels established as part of the recontamination analysis prepared for the EE/CA will be completed.**	B. Recontamination Analysis Based on our May 10 discussion, DEQ understands that LSS will conduct a screening level recontamination evaluation to support the conclusion that the proposed interim stormwater system should prevent recontamination of river sediment. We discussed the use of the SEDCAM model for this assessment. Enclosed for reference is a *Draft Recontamination Evaluation Work Plan*, for the Zidell Waterfront Property and work plan review letters from DEQ and EPA. This plan is based on the SEDCAM model. A work plan for the Arkema screening assessment is not required. However, the evaluation needs to identify and support the basis for the model inputs and provide a working copy of the SEDCAM model (spreadsheet) to allow reviewers to evaluate alternative inputs.	Agreement to use the SEDCAM model during the May 10, 2011 meeting.	Revision: A SEDCAM model was developed for the recontamination assessment. Location: Final Design Report, Section 2.1.5; Appendix L (SEDCAM Recontamination Modeling Report).
2	Based on pre-MAO discussions, it was understood that the stormwater system would collect and treat stormwater prior to discharge to the river. The objective is to only directly discharge stormwater that has been through an advanced treatment system that is expected to treat to the Table 1-1 levels. Stormwater flows exceeding the system treatment capacity would be allowed to periodically backup onto the uplands and directly infiltrate. Bypass of the advanced treatment system and direct discharge of stormwater to the Willamette River is not acceptable to DEQ. DEQ does not consider the treatment provided by the detention basin alone sufficient to meet the advanced treatment objective. As designed, the sand filter concrete block weir for the effluent is set at	**In additional to treatment via settling, the significant extension of the areas that will be temporarily capped coupled with the decommissioning and replacement of the existing stormwater collection system are important source control factors that will address COPCs in site discharges for storm events of any size. Further, designing the filtration basin to fully pass the 25-year, 24-hour storm would result in a filtration basin approximately the size of the detention basin (~150 ft x 300ft, assuming the current configuration of the sand filter as per Section 5.4.3 and a maximum flow rate from the detention basin of 5.51 cfs). Current filtration of the 2-year, 24-hour storm represents treatment of a maximum precipitation**	The elevation of the sand filter concrete block weir in the draft design appears to be based on an elevation that will prevent/limit backup of stormwater beyond the conveyance channels. As previously noted, DEQ agreed to allow backup of stormwater beyond the channels and pond on-site. The hydraulic analysis needs to be updated to determine a maximum weir elevation that will provide for additional stormwater sand filter treatment. The existing design will result in frequent backup beyond the detention basin into the conveyance channel. The updated design needs to line the lower portion of the conveyance channel so that the lower	DEQ acknowledges that DEQ's allowance of a backup of stormwater on the site is in direct contradiction with some of the hydraulic performance criteria in EPA's comments.	Revision: The elevation of the sand filter was raised so that water from the 25 year storm will flow through the sand filter without overflow. This change will back up storms onsite within a limited area near the former BPA substation. The design was changed based on hydraulic modeling using HydroCAD Version 9.1. Channels not behind the groundwater barrier wall will be lined. Location: Final Design Report, Sections 3.0 and 6.3; Appendix J (HydroCAD Modeling Reports); Appendix K (Standard Step Backwater Analysis); Specifications; Drawings.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	31 feet which is 5 feet below the top of the sand filter basin. This design allows discharge of only partially treated stormwater under a range of storm conditions. The system needs to be redesigned so that all stormwater directly discharged through outfalls to the river meets the advanced treatment goals.	**intensity of 0.78 in/hr[3]. This is almost 5 times the intensity of storm that would represent treatment of 90% of the annual runoff in accordance with the City of Portland's Stormwater Management Manual (0.16 in/hr, Exhibit 1-6). Further, comparison of this intensity with Figure 4 of Appendix E in the Stormwater Management Manual indicates that treatment of this storm intensity would represent treatment of greater than 98% of the annual stormwater runoff. Also note that the calculation of the percent of annual average runoff treated presented in Appendix E assumes no partial treatment of larger storms, which would occur by the stormwater SCMs system, as designed. LSS does not agree that installing a system to treat a minimal amount of the projected annual average runoff is warranted for a temporary system that will be replaced as part of the final remedy for the site. LSS proposes to modify the Performance Monitoring Plan to attempt to target sampling of at least one storm greater than the 2-year storm to assess the effects of this type of storm on COPC loading to the Willamette River. If deemed necessary, LSS would then propose a more efficient measure, such as additional temporary capping, to address these larger storm events.**	channel does not infiltrate. The lower portion of the channel is that portion from which infiltrating stormwater would not reasonably be captured by the planned groundwater containment system. The updated design needs to include a table, which is supported by hydraulic analyses, that identifies system performance under various storm and river stage conditions and estimates the frequency that such an event may occur. The table should include at a minimum: • Storm event that exceeds design residency time in the detention basin • Storm event that results in overflow of the sand filter • Storm event that exceeds conveyance channel capacity • Storm event that exceeds site storage capacity and result in runoff from the site • River stage (e.g., flood event?) that impairs discharge of the stormwater system. • River stage that prevents discharge of the stormwater system	LSS will provide the stormwater quantity (i.e., inches over 24 hours) and relative frequency (as compared to modeled events, e.g., 2, 5, 10, & 25 year storm). DEQ has agreed that LSS is to give the rationale for using these storm events as design criteria. DEQ is not as concerned about the specific storm events (i.e., a 10-yr vs. a 25-yr) as they are about the rationale behind the chosen storm events (i.e., why was a 10-yr storm chosen).	
3	Because potential modifications to the treatment system (i.e., adaptive management changes) may be necessary to meet effluent limits, DEQ requests that the design identify the likely modifications/technology changes that will be considered, and provide a discussion of the system compatibility with	**Please refer to LSS' response to DEQ general 1, MAO objectives for a preliminary list of modifications/technology changes that will be considered under the adaptive management approach. The Final Design Report will include likely**	Response is approved.		Revision: The Final Design Report was expanded to discuss potential future modifications to the treatment system based on the development of the current treatment system design. In addition, a discussion of the data needed to assess the feasibility of

[3] This intensity was calculated assuming a Type IA storm and a time of concentration of 10 minutes.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	these modifications.	**modifications/technology changes that will be considered as well as system compatibility with these potential changes.**			implementing these measures and the current system compatibility with these modifications was also added to the text. Location: Final Design Report, Section 8; Appendix F (Performance Monitoring Plan).
4	The final design should be 1) printed double sided, and 2) stamped by an Oregon professional engineer.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is approved.		Revision: None required. The Final Design Report will be printed double sided and stamped by an Oregon professional engineer.
	Specific Comments				
	Section 1.2 Selected Source Control Measure, Page 1-2 – The objective of the stormwater source control measure is not limited to the management of DDX (the sum of 2,4' and 4,4' DDT, DDD, and DDE). However, DEQ understands that DDX management is a focus given the widespread presence in site soils, and technologies employed to manage DDX are expected to manage most other site contaminants.	**LSS proposes to modify the objective of the SCMs as stated in LSS' response to DEQ general comment 1 in regards to the MAO objectives.**	See DEQ review of response to general comment 1.	Monitoring will be conducted as per Attachment A to the MAO (dated 08/04/2010) including additional monitoring as per the decision tree. However, evaluation of performance will be focused on DDx unless monitoring indicates evaluation of other COPCs in Attachment A are warranted. LSS expects that for any detections of COPCs (other than DDx) that concentration limits would consider a mixing zone because the Willamette River is not 303(d) listed for those other COPCs.	Revision: Please see the revision summary to DEQ's General Comment 1.
	Section 3.0 Temporary Capping, Page 3-3				
1	In addition to the surface soils underlying asphalt in the Acid Plant area, DEQ considers the asphalt itself to be a likely DDX source to stormwater. DDX concentrations in Acid Plant area surface soils are very high (commonly in excess of 1,000 mg/Kg). Given this and the pre-removal concentrations in the areas where soil was removed in 2000 and 2001 there is a high likely hood that DDX was tracked onto and imbedded in asphalt surfaces. DEQ requests that Arkema evaluate options to encapsulate, seal or cap the asphalt	**To date, no data exist that indicate the asphalt surfaces in the Acid Plant area are a source of DDx to stormwater. Further, significant repaving of the asphalt plant area has been accomplished since the Soil IRM conducted in 2000 and plant demolition in 2004 (see attached Figure 1). LSS will conduct a survey of the asphalt pavement to log all cracks that require sealing. These locations will be noted in the drawings in the Final Design Report submittal and marked**	Comment 1- Response is approved.		Revision: A field survey was conducted on August 25, 2011 to assess the condition of the asphalt paving in the Acid Plant area. Design drawings were updated with the results of this survey. Location: Drawings, sheet 11 and Specifications, Exhibit 3.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	surfaces in the Acid Plant area and include a recommendation in the final stormwater system design.	**prior to construction. Further, and if necessary, LSS will evaluate the potential for the asphalt surfaces in the Acid Plant to be a source of DDx to stormwater during the performance monitoring of SCMs. Encapsulation, sealing, and/or capping the asphaltic surfaces could then be implemented, post-SCMs implementation, as part of the adaptive management approach.**			
2	DEQ also requests that a temporary cap, as proposed for the former DDT manufacturing building foundation and former DDT storage area, be constructed for the former No. 2 warehouse foundation. DDT product was milled and bagged in warehouse No. 2. Consistent with the testing done for the demolition of the former DDT manufacturing building, DDX was also present in the brick walls of the warehouse No. 2, and all demolition debris from the No. 2 warehouse was managed as a DDT containing hazardous waste (U061).	**As part of the demolition that occurred in 2005, the concrete foundation of the former No. 2 warehouse foundation was sealed with a liquid concrete sealer. LSS proposes to modify the Operation and Maintenance Plan to monitor the condition of the foundation and the sealer. If it is determined that the foundation is a source of DDx to stormwater discharges at the site, the foundation could either be resealed or capped as part of the adaptive management approach.**	Comment 2 - Available sealant information from the manufacture should be reviewed for the longevity of the concrete sealer in an outdoor environment. Manufacture recommendations for resealing should be followed. If no manufacture information is available, the revised design needs to identify a testing and monitoring protocol for determining if the No. 2 warehouse foundation is contributing DDX to stormwater.	LSS agrees that if manufacturer information is not available, it will re-seal after construction activities.	Revision: The Warehouse No. 2 building foundation will be inspected and re-sealed as necessary according to the Operation and Maintenance Plan (Appendix E). If the foundation is re-sealed, then an epoxy-type concrete sealer will be used with a minimum life of 10 years as determined by the manufacturer. Location: Final Design Report, Section 4.3.5 and Figure 4-3; Appendix E (Operation and Maintenance Plan).
	Section 5.4.3 Sand Filter, Page 5-9				
1	As designed, site topography indicates that local stormwater runoff can flow into the sandfilter basin directly. The design needs to incorporate a berm structure or other means to prevent direct stormwater flow into the sand filter basin.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Comment 1 – Response is approved.		Revision: Soil berms will be added around the sand filter to prevent direct stormwater flow into the sand filter basin. Location: Final Design Report Drawings, sheet 9.
2	Based on discussions with Arkema during the MAO negotiations, it was DEQ's expectation that the sand filter would include an activated carbon component consistent with the discussed concept of advanced treatment technology. Please provide a discussion for the basis of the sand filter design that addresses the objective of meeting the Table 1-1 values.	**Carbon would be effective at removal of any soluble component of COPCs in site stormwater discharge. While existing data do indicate a soluble component of DDx in stormwater discharges, these data do not reflect concentrations or flows that will be observed after the implementation of the SCMs. This is due, not only to the addition of treatment, but also to the fact**	Comment 2 – Response is approved.		Revision: The following text was added to the Final Design Report: "The sand filter media could potentially be modified to either include a layer of filter media with a smaller diameter or with the addition of a carbon phase (e.g., granular activated carbon) to enhance adsorption of COPCs that exceed effluent criteria." A decision

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
		that the entire existing stormwater collection is being decommissioned and replaced, and extensive temporary capping is planned for the site. It is LSS' intent to evaluate the potential need for carbon addition during the performance monitoring of SCMs. Carbon addition could be easily added to the filter media of the sand filter as part of the adaptive management approach, if it is determined that, post-SCMs implementation, there is a substantial soluble component of COPCs in site stormwater.			tree was added to the Performance Monitoring Plan to identify the monitoring and adaptive management that will be required. Location: Final Design Report, Section 8.0; Appendix F (PMP), Table 5.
3	Elevations identified in Sheet 14 Detention Basin and Sand Filter Details are not consistent with the elevations referenced in this section and other detail sheets.	**Comment noted. All elevations will be consistent between report, figures, and drawings in the Final Design Report submittal.**	Comment 3 – Response is approved.		Revision: Elevations were revised to be consistent between the drawings and Final Design Report Text. Location: Final Design Report, Sections 6.4.2 and 6.4.3; Drawings.
	Section 6.1 Local Permitting, Page 6-1 – Sebrina Nelson-Deal, (503) 823-5843, at the City of Portland requested that she be contacted to ensure coordination regarding applicable permits for the project.	**Comment noted. Since the project is being conducted under an Order with DEQ, the project can be implemented through the exempt process; however, the substantive requirements of the City of Portland permits must be met. To meet these requirements, the City of Portland will be contacted, as necessary, to coordinate the substantive requirements of the permits for the project.**	Response is approved.		Revision: None necessary. Comment noted.
	Section 7 Performance Monitoring, Page 7-1 – See DEQ MAO comments under the General Comments section.	**Please refer to LSS' response to DEQ general comment 1 in regards to the MAO objectives.**	See DEQ review of response to general comment 1.		Revision: Please see revisions associated with DEQ's General Comment 1.
	Figures 2-4 DDX Concentrations in Surface Soil (0 ft – Approximately 1 ft bgs) and 2-5 DDX Concentrations in Surface Soil (ft – Approximately 10 ft bgs) should clarify if soil sample concentrations represent pre or post removal in the IRM soil removal areas.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is approved.		Revision: Soil sample locations that were sampled prior to removal in the Acid Plant area interim remedial measure (IRM) were labeled as such. Location: Final Design Report, Figures 2-4 and 2-5.
	Figure 5-11 Sand Filter Cross Sections – The water flow path on the figure is not clear. Water distribution at the top of the sand filter	**Comment noted. Flow lines will be added to clarify the water flow path in the Final Design Report submittal. Note that**	Response is approved.		Revision: Flow lines were added to the figures and drawings to clarify the water flow paths.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	using diffusers should be considered to minimize sand erosion.	**water will be evenly spread over the top of the sand filter via the concrete blocks on the upstream side of the sand filter. Diffusers are not required to minimize erosion.**			Location: Final Design Report, Figure 6-11; Drawing sheets 17 and 18.
	Construction Quality Assurance Plan Figure 2-1, Project Organization Chart – Add a box for a DEQ field representative that has lines of communication to either the contractor project manager or the owner's site representative and the DEQ project manager.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is approved.		Revision: The Oregon DEQ field representative was added to the Project Organization Chart. Location: Appendix A (Construction Quality Assurance Plan), Figure 1.
.	Draft Contaminated Material Management Plan Section 1 Introduction, Page 1-1 – The last paragraph on this page states that most of the soil and other excavated materials on the site are not considered contaminated. DEQ does not agree with this statement, and considers all site soil and debris contaminated. Certain portions of the site are more contaminated than others (e.g., Acid Plant area).	**LSS does not agree that all site soils and debris are contaminated; however, the paragraph is proposed to be modified as follows:** **"In order to be comprehensive, this plan addresses the handling of all material to be excavated as part of the installation of the SCMs, regardless of the existence of contamination."**	Response is approved.		Revision: The following sentence was added to the plan: "In order to be comprehensive, this plan addresses the handling of all material to be excavated as part of the installation of the stormwater SCMs, regardless of the existence of contamination." Location: Appendix B (CMMP), Section 1.
	Section 2.2 Soil Screening, Page 2-1				
1	Second paragraph, first sentence – Strike the word *strong* so that the sentence reads contamination, or odors.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Comment 1 – Response is approved.		Revision: The word "strong" was removed from two sentences. Location: Appendix B (CMMP), Sections 2.2 and 3.1.
2	Vapor monitoring in the breathing zone is not an appropriate method to screen for potentially contaminated soil. Soil vapor screening should be conducted using a headspace test, and the revised plan should provide an updated standard operating procedure for conducting head space tests from previously approved site remedial investigation workplans (e.g., SOP 68 from the Elf Atochem Acid Plant Area Remedial Investigation and Feasibility Study Workplan). Soil from the channels should be screened (head space tests) every truck load	**Comment noted. The Contaminated Material Management Plan will be modified to state that soil that exhibits field evidence of contamination will be staged separately from other soil and debris. Field observations to establish contamination will include visual, olfactory, and vapor monitoring within the breathing zone as well as within open excavations.**	Comment 2 – Response is disapproved. The following is a directed change to the Contaminated Material Management Plan. Modify the Contaminated Material Management Plan to state that soil that exhibits field evidence of contamination will be staged separately from other soil and debris. Field observations to establish contamination will include visual, olfactory and vapor monitoring (i.e., sample jar headspace test). Soil will be screened every truck load or 10 cubic	LSS will treat the Acid Plant soils separately in Stockpile Area 1. Each location of excavation will be screened periodically, approximately every 30 minutes, using a photoionization detector (PID) and/or flame ionization detector (FID) meter within 6 in. of the freshly excavated soil. LSS will consider the material contaminated if it is 10 units over background and holds for 10 seconds. Then, LSS will initiate jar test as per DEQ specifications. DEQ agrees with	Revision: The text was revised to state that soil that exhibits field evidence of contamination will be staged separately from other soil and debris. Each location of excavation will be screened periodically, approximately every 30 minutes, using a PID and/or FID meter within 6 in. of the freshly excavated soil. Sample jar headspace screening will be conducted if initial PID/FID screening of freshly excavated soil is 10 ppm over background for 10 seconds. A site-specific operating

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	or 10 cubic yards whichever is greater. Soil which results in a response above 10 meter units on the organic vapor monitor should be considered potentially contaminated.		meters whichever is greater. For the purposes of the Contaminated Material Management Plan soil from a load will be managed as contaminated if the sample jar headspace test yields a detector response of 10 meter units or greater. Sample Jar Headspace Testing Protocol. • Partially fill (one third to half full) a sample jar with soil to be screened. • Collect the sample from a freshly uncovered location (i.e., immediately prior to sample collection). • Cover the jar with clean aluminum foil and tightly seal the jar lid. • Allow headspace vapors to develop in the jar (at least 10 minutes from sample collection but no greater than 1 hour). • Shake or agitate containers for 15 seconds at the beginning and end of the headspace development period to assist volatilization. Temperatures of the headspace must be warmed to at least 40F (approximately 5C) with instruments calibrated for the temperature used. • Calibrate vapor monitor per manufacture instructions. • Use either a flame ionization detector or a photoionization detector with an11.7 eV lamp. • After headspace development, insert the instrument sampling probe to a point about one-half the headspace depth. The container opening must be minimized. • After probe insertion, record the highest meter reading. This normally will occur between two	the option to use FID in lieu of a PID. LSS will include specifications in the document.	procedure for sample jar headspace testing was added to the plan. <u>Location:</u> Appendix B (CMMP), Section 2.2 and Attachment B.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
			and five seconds after probe insertion. • Complete headspace field screening within one hour from the time of sample collection.		
3	No details of the organic vapor monitor are provided. Please provide specifications for the monitor and an evaluation of its ability to detect volatile organic substances detected in site soil and groundwater.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is approved, see directed comment above regarding the use of either a flame ionization detector or a photoionization detector with an11.7 eV lamp.	See DEQ Specific Comment 2 to Section 2.2 Soil Screening, Page 2-1 (above)	Revision: Specifications and response factors for the proposed PID and FID meters were added to the plan. Location: Appendix B (CMMP), Attachment A.
	Section 2.3 Soil Handling, Page 2-2				
1	Soil spoils from the portion of the east channel crossing the Acid Plant area (i.e., rail track to rail track are likely to be heavily impacted and considered a state only listed hazardous waste. These spoils need to be either: a. Managed off-site at a permitted waste disposal facility consistent with disposal requirements for State of Oregon pesticide residue. b. Managed within the Acid Plant area. Waste piles constructed within the Acid Plant area need to in accordance with 40 CFR 265.250, 265.251, 265.253, and 265.54 (less leachate collection system). c. Managed outside of the Acid Plant area in a DEQ approved location and in waste piles constructed in accordance with 40 CFR 265.250 – 265.251 and 265.253 -265.260.	**Comment noted. LSS does not presume that soils within these areas are a state hazardous waste at this point; however, LSS does propose to amend the Contaminated Materials Management Plan to manage soils excavated from the eastern channel within the Acid Plant area as follows:** • **Temporary (i.e. < 180 days) stockpiling of excavated materials from these areas in stock pile area 1 as indicated in the Draft Design Report.** • **Characterization of stockpiled materials.** • **Proper disposal/management of stockpiled materials based upon characterization, including following points a, b, and/or c requirements listed in DEQ comment to Section 2.3 of the Contaminated Material Management Plan (see above) for all soils determined to be state only listed hazardous waste.**	Comment 1 – DEQ notes that per the June 28, 2000 letter from ATOFINA Chemicals (attached for reference), Arkema agreed to manage all investigation derived wastes from the general Acid Plant, with the exception of wastes from operational areas potentially impacted with commercial product (i.e., U061 waste), either as a characteristic waste or as a state only waste pesticide residue. The LSS response is presented in three bullets. The first bullet "Temporary (i.e., <180 days) stockpiling of excavated materials from these areas in stock pile area 1 as indicated in the Draft Design Report." is disapproved. LSS is directed to modify the Contaminated Materials Management Plan to state: Soil spoils from the portion of the east channel crossing the Acid Plant area (i.e., rail track to rail track) will be managed consistent with the substantive requirements for managing hazardous waste until demonstrated by a DEQ approved characterization plan to not exhibit the characteristics of hazardous waste or contain a hazardous waste. Spoils	LSS agrees not to use a leachate collection system. LSS will lay down plastic on the salt pads prior to placing soils and cover it up at a frequency no less than daily. The Acid Plant area will be treated as an Oregon pesticide residue. Soils for the detention basin/sand filter and channels not in the Acid Plant area are the same as Lots 1 & 2 and will be managed on site as fill. Anything visually observed to have a pink color will be handled the same as Acid Plant area soils. LSS will state that it will automatically assume that all soils in Stockpile 1 (Acid Plant area, pinkish color, etc) are to be handled as state-only pesticide residue. LSS will develop a RCRA characterization plan (estimate cubic yards, number samples, etc) after stockpiling to determine RCRA hazardous characteristics if any.	Revision: The plan notes that all soils from the Acid Plan area will be initially treated as State-only pesticide residue and will be stored in Stockpile Area 1 for additional characterization. LSS will develop a Resource Conservation and Recovery Act (RCRA) characterization and management plan after stockpiling to complete characterization and provide a plan for managing the waste. The plan will be submitted to DEQ for review and approval. The soil in Stockpile Areas 1 and 2 will be managed in accordance with 40 Code of Federal Regulations 265.250, 265.251, and 265.253 through 265.260 (without the leachate collection system). Location: Appendix B (CMMP), Sections 2.3 and 4.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
			from this area will either be: a. Managed in containers. b. Managed off-site at a permitted waste disposal facility consistent with disposal requirements for State of Oregon pesticide residue. c. Managed within the Acid Plant area. Waste piles constructed within the Acid Plant area need to be constructed in accordance with 40 CFR 265.250, 265.251, 265.253 and 265.54 (less leachate collection system) d. Managed outside the Acid Plant area stock pile area 1, or a DEQ approved alternative location, and in a waste pile constructed in accordance with 40 CFR 265.250 - 265.251 and 265.253 – 265.260. Second Bullet – Response is approved. The revised design report needs to include a sampling and analysis plan to characterize soil stock piles constructed in area 1 or DEQ approved alternative locations. Third Bullet – The response is disapproved, and LSS is directed to modify the Contaminated Materials Management Plan to state: After characterization of soil in stock pile area 1, LSS will submit for DEQ approval a plan for on-site management or off-site disposal of the stock pile area 1 soil.		
2	Soils in the Old Caustic Tank Farm area are impacted by oil and diesel range petroleum in addition to the area of elevated DDX identified on Figure 5-18. Because of the elevated DDX soil in the Old Caustic Tank Farm area, DEQ requires the spoils from this portion of the east channel area to be managed with the Acid Plant area soils as a	**Comment noted. LSS will amend the Contaminated Materials Management Plan to manage soils excavated from the Old Caustic Tank Farm with the soils excavated from the eastern channel within the Acid Plant area as described above.**	Comment 2 – The response is disapproved. LSS is directed to modify the Contaminated Materials Management Plan such that soil from the Old Caustic Tank Farm area will be managed consistent with the directed comments for soil spoils excavated from the eastern channel within the Acid Plant area.	See DEQ Specific Comment 1 to Section 2.3 Soil Handling, Page 2-2.	Revision: The plan notes that soil and debris from the old Caustic Tank Farm area that are excavated for the east channel may contain elevated concentrations of DDT and oil and diesel-range petroleum hydrocarbons. All of these soils will be initially treated as State-only pesticide residue

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	state only hazardous waste.				and will be stored in Stockpile Area 1 for additional characterization, consistent with the management of Acid Plant area soils (see response to DEQ General Comment 1). Location: Appendix B (CMMP), Sections 2.3 and 4.
3	Soil temporarily staged adjacent to the excavation needs to be covered with plastic sheeting at the end of the work day.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Comment 3 – Response is approved.		Revision: The following sentence was added to the plan: "The temporarily staged soil will also be covered with 6 mil low-density polyethylene (LDPE) sheeting at the end of each work day." Location: Appendix B (CMMP), Sections 2.3 and 4.
	Section 4 Material Segregation and Stockpiling				
1	All soil stockpiles need to be covered at the end of the work day.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Comment 1 – Response is approved.		Revision: The following sentence was added to the plan: "The temporarily staged soil will also be covered with 6 mil low-density polyethylene (LDPE) sheeting at the end of each work day." Location: Appendix B (CMMP), Sections 2.3 and 4.
2	Stockpile 1, which is to receive any soil exhibiting field indications of contamination, needs to be constructed with a base liner.	**Currently, stockpile 1 is proposed to be located on the former salt pads. These salt pads were constructed of an asphalt liner that is approximately 8 to 9 inches thick. Prior to placement of any soils on the former salt pads, their condition will be assessed and any cracking will be sealed with a liquid sealant, similar to what is to be completed in the former Acid Plant area as part of the temporary capping protocol.**	Comment 2 – Response is approved provided the revised design includes either the removal of the pad with the stockpile or a proposal to clean the pad and conduct verification sampling.		Revision: The following sentences were added to the plan: "Prior to the placement of any soil in Stockpile Areas 1 and 2, the condition of the northern Salt Pad area will be assessed and any cracking will be sealed with a liquid sealant, following the temporary capping protocol in Specification Section 02510 – Temporary Environmental Cap. Soil in Stockpile Areas 1 and 2 will be placed on a heavy duty plastic (minimum 20 mil) tear resistant (fiber reinforced) plastic liner." Location: Appendix B (CMMP), Section 4.
3	In the event soil exhibiting field indications of contamination are encountered, DEQ needs to be notified and consulted to confirm that	**Comment noted. Please refer to LSS' response to DEQ comment 2 on Section 2.3 for LSS' proposed modifications to**	Comment 3 – Based on discussions during the May 10, 2011 meeting, DEQ understands that LSS has agreed to		Revision: The following sentence was added to the plan: "DEQ representatives will be notified when

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	management of the soil in stockpile 1 is appropriate.	**soil handling. LSS also proposes to modify the Contaminated Materials Management Plan to include that final disposition of the site soils will be made in conjunction with and with approval of DEQ for determination of proper disposal/management.**	provide DEQ notice when field screening indicates the possible presence of unanticipated contaminated soil. Based on this understanding, the response is approved.		field observations indicate the possible presence of unanticipated contaminated material." Location: Appendix B (CMMP), Section 2.2.
4	Section 3.3.4 of the draft design report notes that small aboveground structures on the former DDT manufacturing building foundation will be demolished. Based on the phase II demolition workplan for the facility, it is assumed that this debris contains a U061 hazardous waste. This demolition debris needs to be segregated, and specifics of the debris management identified in the workplan. DEQ recommends that this debris be managed at an appropriate off-site disposal facility.	**LSS will amend the Contaminated Materials Management Plan to specify that construction debris from the former DDT manufacturing building foundation will be segregated from all other excavated soils and debris and will be managed at an appropriate off-site disposal facility.**	Comment 4 – Response is approved.		Revision: The following sentence was added to the plan: "Demolition debris from the former DDT manufacturing building will be assumed to contain U061 hazardous waste and will be transported to an appropriate offsite disposal facility." Location: Appendix B (CMMP), Section 4.
	Air Monitoring Plan **Part B – Air Monitoring for Contaminated Soil Segregation.**				
1	As previously noted, specifications of the organic vapor monitor need to be provided to confirm that it can detect volatile organic compounds that have been detected in site soil and groundwater.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Comment 1- Response is approved, see directed comment above regarding the use of either a flame ionization detector or a photoionization detector with an11.7 eV lamp.	See DEQ Specific Comment 2 to Section 2.2 Soil Screening, Page 2-1 (above)	Revision: The following clarification was made to the plan: "Air monitoring will be conducted during excavation and stockpiling of soils using a photo-ionization detector (PID) equipped with an 11.7 eV lamp and/or a flame ionization detector (FID). Specifications and response factors for the selected PID and FID meters are presented in the CMM plan (Appendix B, Attachment A)." Location: Appendix D (Air Monitoring Plan), Part B.
2	Monitoring in the breathing zone is not an appropriate method for identifying potentially contaminated soil. See previous comment 2 under Section 2.2 of the draft contaminated material management plan.	**Please refer to LSS' response to DEQ comment 3, under Section 2.2 of the Contaminated Materials Management Plan.**	Comment 2 – Response is disapproved. See DEQ directed comment to LSS response to DEQ comment 2 under Section 2.2 of the Contaminated Materials Management Plan	See DEQ Specific Comment 1 to Section 2.3 Soil Handling, Page 2-2.	Revision: Clarification on the field screening procedures was made to the air monitoring plan, consistent with the requirements of the CMMP (Appendix B). Location: Appendix D (Air Monitoring Plan), Part B.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
3	Air monitoring needs to be done during all excavation activities for health and safety purposes and to screen site soil not just in areas known to be impacted by volatile organic compounds.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Comment 3 – Response is approved.		Revision: The following sentence was added to the plan: "Air monitoring will be conducted during all excavation activities in accordance with the SHSP (Appendix H of the Final Design Report)." Location: Appendix D (Air Monitoring Plan), Part A.
4	DEQ considers all site surface and near surface soils to be potentially contaminated with DDX and dioxin/furans, and we do not agree that elevated organic vapor monitor readings suggest the presence of elevated DDX concentrations. The exception to this is if the source of the elevated vapor readings is believed to be chlorobenzene which could be related to DDT manufacturing wastes.	**Comment noted.**	Comment 4 – Response is approved.		Revision: None required. Comment noted.
	Draft Operation and Maintenance Plan				
1	Section 2.2 Cap Maintenance, Page 2-1 The plan should define a significant storm event.	**LSS will amend the Operation and Maintenance Plan to define a significant storm event to be any storm which generates greater than 1.0 inch over any 24-hour period.**	Comment 1 – Response is approved.		Revision: The plan was updated to note that cap inspections will be conducted after storm events that generate greater than 1.0 in. of precipitation over a 24-hour time period. Location: Appendix E (Operation and Maintenance Plan), Section 2.2.
2	Cap inspections should also be conducted after an earthquake.	**LSS will amend the Operation and Maintenance Plan to include cap inspections after seismic activity that registers 4.0 or higher on the Richter scale.**	Comment 2 – Response is approved.		Revision: The plan was updated to note that cap inspections will be conducted after seismic activity that registers 4.0 or higher on the Richter scale. Location: Appendix E (Operation and Maintenance Plan), Section 2.2.
	Section 2.3 Future Work, Page 2-1 – DEQ needs to be notified prior to any work beneath the caps, and the work needs to be done in accordance with a DEQ approved workplan.	**LSS will amend the Operation and Maintenance Plan to include DEQ notification prior to any work beneath the cap, and all future work beneath the caps will be conducted in accordance with a DEQ-approved work plan.**	Response is approved.		Revision: The plan was updated to note that DEQ will be notified prior to any work beneath the cap. Location: Appendix E (Operation and Maintenance Plan), Section 2.3.
	Section 4 Stormwater Conveyance and Treatment System				
1	This plan or the Contaminated Materials	**Comment noted. The recommendation**	Comment 1 – Response is approved.		Revision: Routine maintenance of

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	Management Plan need to identify how maintenance materials from the conveyance channels/berms and treatment systems (e.g.., sediment, debris and vegetation) will be stored, characterized and managed.	**will be incorporated into the Final Design Report submittal.**			conveyance and treatment systems will generate waste materials that must be properly disposed. Removed vegetation will be collected and transported to a nearby transfer facility where it will be recycled as yard waste. Accumulated sediment, trash, debris and damaged lining materials that have no recyclable value will be collected and transported to a Subtitle D landfill. Water collected during routine maintenance (e.g., via vactor truck) will be stored onsite until maintenance is complete and then discharged to the sediment forebay portion of the detention basin. Location: Appendix E (Operation and Maintenance Plan), Section 4.3.
2	Inspections of the conveyance and treatment systems also need to identify and report the use of these systems by wildlife. If DEQ determines that the systems are an attractive nuisance for wildlife (e.g., open water feature) wildlife deterrent measures may be require	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Comment 2 – Response is approved.		Revision: The time, date, weather, and site conditions of vector activity will be recorded. If mosquito or rodent vectors are observed, Multnomah County Vector Control will be contacted for assistance in eradicating those vectors. Contact will be made to the Oregon Department of Wildlife for species other than rodents and mosquitoes. Location: Appendix E (Operation and Maintenance Plan), Section 4.4.
	Section 4.2.1 Conveyance System, Page 4-1 – Sheet 15 which illustrates the berm and channel details does not identify the geotextile for the berm construction referenced in Section 4.2.1.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is approved.		Revision: A geotextile was added to the channel berms. Location: Drawings, sheet 19.
	Draft Performance Monitoring Plan				
1	Section 1.1 Performance Monitoring Plan Framework, Page 1-1 The plan needs to identify the possible treatment system modifications/technologies that will be considered if the Table 1-1 values are not achieved. It also needs to identify and collect the data necessary to evaluate and	**Please refer to LSS' response to DEQ's general comment in regards to the MAO and LSS' response to EPA general comment 2 for proposed modifications to the Performance Monitoring Plan in regards to influent and effluent sampling.**	Comment 1 – DEQ understands, based on discussions held on May 10, 2011, that LSS has agreed to modify the performance monitoring plan to address the DEQ review of the response to general comment 1.		Revision: A decision tree was added to the plan to identify the monitoring and adaptive management that will be required. Location: Appendix F (PMP), Table 5.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	select system modifications.				
2	DEQ requests that samples be collected between the retention basin and sand filter in order to evaluate the performance of the both treatment systems and aid in the selection of adaptive management treatment should it be necessary.	**LSS has committed in the Draft Performance Monitoring Plan to conduct sampling on the influent and at the effluent of the treatment system. Please refer to EPA general comment 2 for proposed modifications to the Performance Monitoring Plan. Additional sampling will be completed to aid in the selection of adaptive management treatment on an as needed basis. This sampling could involve any number of sample locations, frequencies and types pending the results of the influent and effluent sampling. Therefore, LSS does not feel that setting specific parameters on additional sampling is warranted at this time.**	Comment 2 – DEQ understands, based on discussions held on May 10, 2011 that LSS agreed to incorporate this request into a decision matrix that will incorporated into the performance monitoring plan.		Revision: Stormwater influent and effluent will be sampled as part of the stormwater SCMs compliance and performance monitoring program. In addition to the evaluation of the stormwater SCMs effectiveness and stormwater concentration trends, the monthly discharge reports and the performance monitoring report will assess the need for modification and/or optimization of the stormwater treatment system (i.e., adaptive management). A decision tree (Table 5) will be followed in evaluation of performance issues. Location: Appendix F (PMP), Section 2.1, Table 5.
3	Change the plan to read the reductions of performance monitoring plan elements (e.g., influent data) are subject to DEQ approval.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Comment 3 – Response is approved.		Revision: Discontinuation of analysis of any COPC will be made in agreement with DEQ. Location: Appendix F (PMP), Section 3.2.
4	See earlier general comments on the system performance objectives.	**Please refer to LSS' response to DEQ's general comment in regards to the MAO.**	Comment 4 – See DEQ response to review of response to general comment 1.	Comment 4 – See discussion to DEQ response to review of response to General Comment 1.	Revision: Please see revisions associated with DEQ's General Comment 1.
	Section 2 Stormwater Sampling, Page 2-1 - Please provide clarification on how the comparison contaminant concentrations to measured total suspended solids and stormwater system flow rates will help assess sources of contaminants in stormwater.	**Please refer to LSS' response to DEQ's general comment in regards to the MAO.**	This response is disapproved as it did not directly address the comment. DEQ expects that the revised design and monitoring program will identify the system uncertainties, assumptions and the logic behind the monitoring program to verify the stormwater system parameters and inform modification of the treatment system.		Revision: The stormwater design basis identifies the assumptions, logic, and uncertainties with the system design. A decision tree was added to the plan to identify the monitoring and adaptive management that will be required. Location: Final Design Report, Section 3; Appendix F (PMP), Table 5.
	Section 2.2 Sampling Frequency - Monitoring reports should include flow data.	**Flow data will be included with the monthly discharge monitoring reports. Section 4 of the plan will be modified to reflect this change.**	Response is approved.		Revision: Stormwater flow rate data will be included in the monthly discharge monitoring reports. Location: Appendix F (Performance Monitoring Plan), Section 4.
	Section 2.6 Quality Assurance /Quality Control - Consistent with DEQ Cleanup	**Collection and analysis of field quality assurance/quality control samples for**	Response is disapproved. For each sampling event, LSS is directed to collect	LSS agrees that the Laboratory QA/QC programs will include the collection of	Revision: The plan was modified to include the collection of one set of

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	Program Quality Assurance Policy, field quality assurance/quality control samples need to be collected and analyzed for each sampling event with equipment rinse blanks collected daily.	**each sampling event would require the collection of one set of QA/QC samples with every two samples collected (i.e., a sampling event may only consist of one influent sample and one effluent sample). LSS believes that this requirement is unnecessary to meet QA/QC objectives. LSS proposes to modify the Performance Monitoring Plan to include collection of QA/QC samples for every five samples collected after the first three sampling events to replace quarterly collection of QA/QC samples.**	and analyze: • One equipment rinse blank each day of sampling activities. • Field duplicate at a minimum rate of five (5) percent. If fewer than 20 samples are collected for a particular sampling episode, than at least one duplicated will be collected.	one set of QA/QC samples for each stormwater sampling event for the first four events. Following the first four stormwater sampling events, if field QA/QC samples have established good quality control, the frequency of field QA/QC samples may be reduced to one set of QA/QC samples per quarter until a maximum of one year of sampling is completed. The schedule for stormwater monitoring after the first year will be based on the analysis of data from the first year of stormwater sampling.	QA/QC samples for each stormwater sampling event for the first four events. Following the first four stormwater sampling events, if field QA/QC samples have established good quality control, the frequency of field QA/QC samples may be reduced to one set of QA/QC samples per quarter until a maximum of one year of sampling is completed. The schedule for stormwater monitoring after the first year will be based on the analysis of data from the first year of stormwater sampling. Location: Appendix F (Performance Monitoring Plan), Section 2.7.
	Draft Quality Assurance Project Plan				
	Section A7.1 Data Quality indicators, Page A-10 (last paragraph) – How does the reference to sediment studied relate to the subject stormwater monitoring program?	**LSS will amend the sentence to read: "Comparability will be addressed through the use of field and laboratory methods that are consistent with methods and procedures recommended by EPA and commonly used for stormwater studies."**	Response is approved.		Revision: The sentence in the plan was revised read: "Comparability will be addressed through the use of field and laboratory methods that are consistent with methods and procedures recommended by EPA and commonly used for stormwater studies." Location: Appendix G (Quality Assurance Project Plan), Section A7.
	Section B4.1 Field Quality Control Samples, Page B-7 - Consistent with DEQ Cleanup Program Quality Assurance Policy, field quality assurance/quality control samples need to be collected and analyzed for each sampling event with equipment rinse blanks collected daily.	**Please refer to LSS' response to DEQ's comment on Section 2.6 of the Performance Monitoring Plan, above.**	Response is disapproved. LSS is directed to collect and analyze: • One equipment rinse blank each day of sampling activities. • Field duplicate at a minimum rate of five (5) percent. If fewer than 20 samples are collected for a particular sampling episode, than at least one duplicated will be collected.	Please see discussion of DEQ Specific Comment on Section 2.6 Quality Assurance /Quality Control.	Revision: Please see revisions associated with DEQ's comment on Section 2.6 (Quality Assurance/Quality Control) of the Performance Monitoring Plan.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	Table A6-1 Footnote 1 – See above previous comment on required frequency of field quality assurance/quality control samples.	**Please refer to LSS' response to DEQ's comment on Section 2.6 of the Performance Monitoring Plan, above.**	Response is disapproved. LSS is directed to collect and analyze: • One equipment rinse blank each day of sampling activities. • Field duplicate at a minimum rate of five (5) percent. If fewer than 20 samples are collected for a particular sampling episode, than at least one duplicated will be collected.	Please see discussion of DEQ Specific Comment on Section 2.6 Quality Assurance /Quality Control.	Revision: Please see revisions associated with DEQ's comment on Section 2.6 (Quality Assurance/Quality Control) of the Performance Monitoring Plan.
	Table A6-2: The protocol cited for Hexavalent Chromium (EPA 7195) does not appear to be listed in the approved CFR methods (CFR 136). The listed method is EPA 218.6 (SM3500).	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is approved.		Revision: The protocol for Hexavalent Chromium was changed from EPA Method 7195 to EPA Method 218.6. Location: Appendix G (Quality Assurance Project Plan), Table A6-2.
	Table A6-3: The ACGs listed in this table (and also listed in Table 1-1) appear to be from Table 2 of the 6/16/09 DEQ memo from Rob Burkhart to Matt McClincy. These ACGs are the daily maximum values from Table 2. It should be noted that Table 2 also contained average monthly values.	**Comment noted. Average monthly values will be incorporated into Table A6-3, Table 1-1, and Table 3-1, as applicable, in the Final Design Report submittal.**	Comment 1 – Response is approved.		Revision: Tables A6-3, 1-1, and 3 were updated with average monthly levels as an additional ACG column. Location: Appendix G (QAPP), Table A6-3; Final Design Report, Table1-1 Appendix F (PMP), Table 3.
	Table A6-3: The ACG values for pH are listed in Table A6-3 as 5.5 – 9.0. The value range given in Table 2 of the DEQ memo is 6.5-8.5.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Comment 2 - Response is approved.		Revision: The analytical concentration goal (ACG) value for pH was changed to 6.5–8.5. Location: Appendix G (Quality Assurance Project Plan), Table A6-3.
	An ACG has been included for Arsenic, but no limit was included in Table 2 of the DEQ memo (this is just a point of clarification). DEQ has been working on an updated human health criteria for arsenic which is expected to be lower than the Arkema proposed drinking water MCL.	**Comment noted. LSS recommends an assessment of the technical practicability of known stormwater treatment technologies to achieve proposed revisions of the Federal MCL for arsenic.**	Comment 3 – The first half of the response is approved.		Revision: None required. Comment noted.
	The listed DDX ACG (0.05) is appropriate if method 625 is determined to be the appropriate analytic method. If method 608 is used, the ACG should be 0.01.	**Comment noted. LSS will analyze all samples for DDx components utilizing method 625.**	Comment 4 – Response is approved.		Revision: None required. Comment noted. LSS will analyze all stormwater samples for DDx components using EPA Method 625.
	The MRLs for some of the listed parameters are higher than the PQLs listed in the DEQ	**Comment noted. An updated table will**	Comment 5 – Response is approved.		Revision: The QAPP has been modified to include project specific

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	water quality program's November 2007 memo on the subject: • The MRL for PAHs is listed as 10, it should be 1 • The MRL for Pentachlorophenol is listed as 25, it should be 2 Please provide an updated table that identified the method detection limits and method reporting limits for those compounds for which Columbia Analytical has not completed the method detection limit study.	**be provided.**			MRLs consistent with DEQ's November 2007 memorandum and agreed upon analytical methods. Location: Appendix G (QAPP), Table A6-3
	Draft Health and Safety Plan				
1	Section 1.6 Definitions, Page 1-5 – Footnote 2 in this section notes: "In general, the site does not have areas with exposed hazardous substances. However, when field activities are conducted, there is potential that hazardous substances may be brought to the ground surface and potential contact with hazardous substances could occur." As previously noted, DEQ considers all site surface and near surface soils to be potentially contaminated with DDX and dioxin/furans. Other site contaminants of concern may be present as well.	**Comment noted. LSS does not agree that the entire site has exposed hazardous substances.**	Comment 1 – Response is approved.		Revision: None required. Comment noted.
2	DEQ will want to review and approve the proposed layouts work zones (i.e., exclusion zone, contaminate reduction zone and support zone).	**Comment noted. As per the specifications, the contractor will be required to submit a Construction Work Plan prior to starting work. This Construction Work Plan will include the proposed layout of the work zones.**	Comment 2 - Response is approved.		Revision: None required. Comment noted.
3.	Contractor staging areas or support zones not located on paved surfaces, may need to be prepped with clean cover.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Comment 3 - Response is approved.		Revision: None required. Comment noted.
	Technical Specifications Draft Design Report Stormwater Source Control Measures				
	Table 01450-1 Required Chemical Analytes, Acceptance Criteria, methods and Reporting Limits for Import Materials – The referenced table is for marine sediments and not applicable for a freshwater upland site or terrestrial receptors. The attached December	**Comment noted. All fill material will be sourced from a commercially available fill source. Therefore, LSS will not be testing any commercially sourced borrow material.**	The commercial borrow source and any known history of site activities need to be identified to DEQ. Based on the source and site history, DEQ will determine what characterization of the fill is necessary and if a DEQ solid waste letter of		Revision: The following text was added to the Specifications: "Contractor shall identify and submit to Owner's Agent for approval sources of all imported fill materials to the site with the Construction Work Plan as

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	2010 Oregon Soil/Sediment Clean Fill Screening Table for Terrestrial/Upland Uses should be referenced.		authorization, (OAR) 340-93-0050(5), is required prior to placement on the Arkema site.		indicated in Section 01400 – Coordination and Construction Work Plan. Information will include information of any known site activities conducted at the source of imported fill materials. If the Contractor changes sources, the Construction Work Plan shall be amended to include this information on the proposed sources and Contractor shall not import any materials to the site until the new source is approved by the Owner's Agent." Location: Specifications, Section 01450.
	Section 02222 – Decommissioning of Storm Drain System - This work requires a City of Portland plumbing permit or Arkema to work with the City to identify the substantive requirements of the permit either of which may result in changes to the decommissioning specifications.	**Comment noted. LSS will coordinate with the City of Portland as necessary, to identify the substantive requirements for all City permits applicable to the project.**	Response is approved.		Revision: None required at this time. A land use review at the City of Portland is scheduled for the stormwater SCM in conjunction with the groundwater SCM.
	Section 3.03 Pipeline Decommissioning - What precautions will be taken to prevent potential releases to the Willamette River during decommissioning of the storm drain pipelines on the river side of the groundwater barrier wall?	**The contract documents will be modified in the Final Design Report submittal to indicate the schedule for decommissioning, which will include initially plugging the most downstream portion of the existing sewer system prior to any other construction.**	Response is approved.		Revision: The contract documents were modified to initially plug the most downstream portion of the existing stormwater system. Location: Specifications; drawings.
	Section 3.06 Disposal of Materials The Contaminated Materials Management Plan does not include test requirements and standards for off-site recycling of concrete debris. DEQ notes that no concrete was taken off-site for recycling during plant demolition.	**LSS will remove the option of off-site recycling of concrete debris from the specifications.**	Response is approved.		Revision: The option of offsite recycling of concrete debris was removed from the plan. Location: Appendix B (CMMP), Section 5.2. Specifications, Section 0222.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	EPA Comments				
	Overall Stormwater Source Control Measures (SCM) Draft Design Report Comments				
	General Comments				
1	Section 1.2 Selected Source Control Measure. The stated design objective of the SCM is simply reduction of the constituents of potential concern (COPCs) (e.g. DDx) in stormwater runoff from the site. This design objective is vague and qualitative. While stormwater treatment target levels are presented in Table 1.1, the Draft Design Report makes clear that these levels are not considered enforceable effluent limits, rather they will be used to measure the progress/removal efficiency of the stormwater system during performance monitoring. The definition of "progress" and the targeted removal efficiencies should be better defined. There should be clear, numeric effluent limits that the system must be designed to achieve based on risk-based or water quality based limits, whichever is more protective that this upland source control action on stormwater must attain.	**Please refer to LSS' response to DEQ's general comment 1 on the MAO objectives. LSS also disagrees with the use of numeric effluent limits as stated above.**	Refer to EPA's comment on the LSS response to DEQ's general comment 1. (Attachment A.)	Refer to discussion on Attachment A (below).	Revision: The stormwater system was further refined and additional information was provided on the basis of the design, including the removal efficiency and the presentation of the values in Table 1-1 as goals. Precise estimates of removal efficiencies cannot be provided until after the system is installed in accordance with the MAO. Location: Final Design Report, Sections 3 and 8; Appendix F (performance monitoring plan).
2	Section 1.2 Selected Source Control Measure. The draft design report states that it will use "an adaptive management approach in order to optimize the stormwater treatment implementation at the site." The reliance on performance monitoring to post-facto demonstrate the efficacy of the treatment necessitates a well thought out performance monitoring program and consideration of potential options necessary to "optimize" the treatment system. Per general comment 4 below, the design of the performance monitoring plan is minimal and will generate inadequate data for assessing performance. In	**LSS proposes to modify the sampling program to target 12 sampling events within the first year of operation of the stormwater conveyance and treatment system. Each sampling event will include 24-hour (or total rainfall duration, whichever is less) composite sampling of the influent to and effluent from the treatment system with locations and analytes as specified in the Draft Performance Monitoring Plan. In addition, LSS proposes to target 1 stormwater grab sample of influent to the treatment system during 3 separate "first**	The proposed monitoring plan is an improvement over the earlier plan and begins to address system performance data that can be used to inform adaptive management actions. The monitoring frequency (monthly or twice monthly, depending on season) should be a reasonable frequency to identify system performance and provide a reasonable time frame for making minor performance improvements. However, the overall program approach should address the potential need to trigger an immediate action, instead of a year-long program that	LSS will comply with EPA comments to the extent that the EPA comments do not contradict DEQ comments and do not conflict with the terms of the MAO. For example, the MAO clearly defines how system modifications should be employed, including: o Gathering one-year of data. o Develop recommendations & timeline for DEQ review & approval (report). Also, LSS will provide an implementation	Revision: The sampling program was modified to target 12 sampling events within the first year of operation of the stormwater conveyance and treatment system. The performance monitoring plan was expanded and a decision tree was incorporated into the plan. Location: Final Design Report, Section 8; Appendix F (PMP).

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	addition, the absence of a clear target and predicted performance means that there is nothing against which to compare monitoring results and identify the need for adaptive changes.	**flush" stormwater events (i.e., within the first 30 minutes of stormwater runoff)4. Further, the sampling program will be modified to schedule sampling events when it is predicted that the following storm event criteria will be met:** **Antecedent dry period of at least 24 hours (as defined by <0.1" rainfall over the previous 24 hours;** **Minimum predicted rainfall of volume of 0.2" per event; and** **Expected duration of at least 3 hours.** **The above target storm conditions will be considered goals. Each event sampled will be evaluated relative to these goals but circumstances may arise where all of these goals cannot be met. To target 12 sampling events spread over the first year of operation, the following number of samples will be targeted for each month:** **November, December, January, February, and March: Minimum of 9 composite samples over this period (target 2 samples each month).** **Minimum of 2 grab samples over this period.** **September, October, April, and May: Minimum of 2 composite samples over this period (target 1 sample each month).** **Minimum of 1 grab sample over this period.** **June, July, and August: Minimum of 1 composite sample over this period (target 1 sample each month).** **If, by the last week of the given month and/or the last month of a given period, the minimum number of samples has not been collected, one or more of the criteria may be ignored in order to obtain a sample(s). Note that ignoring these criteria does not necessarily mean that 12 samples can be collected over the year, or that the minimum number of samples**	would serve to characterize the „typical" stormwater over the course of a year. Consequently, one recommendation is to have monitoring triggers that are effluent-triggered rather than storm event-based. In addition to influent and/or effluent sampling, the monitoring program should include inspections and reporting of physical aspects of the system, as listed in item o. in EPA's comment on the LSS response to DEQ general comment 1. These aspects should be monitored monthly and after significant storms exceeding a predetermined amount (e.g. 0.5 inches). LSS' proposed revisions to the monitoring program should specifically identify how water quality monitoring data will be evaluated. The revisions should identify appropriate actions that will be required if treatment performance is inadequate. In addition, the monitoring plan should identify an appropriate schedule for timely data interpretation, response and reporting. The monitoring plan should add physical inspections of the system during operations and appropriate responses to deficiencies. See also EPA's supplemental comment on proposed monitoring plan regarding considerations for a tiered monitoring response plan.	schedule in the performance monitoring report as per the MAO.	

[4] Given the long detention time within the detention basin and the sand filter system, first flush sampling of the effluent from the treatment system will provide no additional insight beyond composite sampling data.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
		will be collected for a given period, as adequate rainfall to produce runoff is required to collect samples. Further, given the size of the detention and filtration systems, low volume storm events will result in a long lag-time before discharge and, therefore, flow rates may be difficult to measure. **In addition, LSS proposes to target one sampling event of a storm greater than the 2-year, 24-hour storm (i.e., storm event predicted to be greater than 2.4 inches over a 24-hour period). Note that this event may or may not occur within the preliminary monitoring period.** **Please refer to LSS' response to DEQ's general comment 1 on the MAO objectives for a discussion of target levels and predicted performance with which to compare data.**			
3	Section 3. Temporary Capping. The temporary capping approach for the existing asphalt surfaces relies on subjective application of crack sealer on "substantial" cracks. A complete asphalt overlay should be considered for these areas to encapsulate the area to mitigate recontamination from DDx-contaminated soil underlying the pavement and embedded in the existing pavement surfaces.	**Please refer to LSS' response to DEQ's specific comment on "Section 3.0 Temporary Capping, Page 3-3". Further, and if necessary, LSS would propose alternative capping methods to an asphalt overlay because an asphalt overlay has the potential to contribute PAHs to stormwater discharges to the Willamette River. PAHs are currently considered a COPC for the Portland Harbor Superfund Site.**	Response is acceptable.		<u>Revision:</u> None required. Please refer to the response to DEQ Specific Comment 1 on Section 3.0, Temporary Capping, page 3-3.
4	Section 7 Performance Monitoring. Given the absence of any quantitative treatment design objectives and reliance on an adaptive management approach to "optimize" stormwater treatment, the design of the performance monitoring is critical. The Draft Design Report devotes just over one page to the performance monitoring program and proposes collection of three (3) monthly composite paired influent/effluent samples that can be used to assess removal effectiveness of the SCMs. A performance	**Please refer to LSS' response to EPA general comment 2 for a discussion of proposed changes to the Performance Monitoring Plan. Please refer to LSS' response to DEQ's general comment 1 on the MAO objectives for a discussion of the appropriateness of numeric performance standards.**	See EPA's supplemental comment on the proposed monitoring plan [*Attachment A*] and the response to general comment 2 to the Draft Design Report.		<u>Revision:</u> Please refer to the response to DEQ General Comment 1 regarding modifications to the performance monitoring plan.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	target and method to evaluate performance should be established to inform future adaptive management strategies. EPA does not support the lack of numeric performance standards nor the inadequate performance monitoring proposed.				
5	Section 7 Performance Monitoring. The Draft Design Report notes that: "It is anticipated that COPC concentrations during the first few months will show an increase over previously observed levels due to the disturbance of soil during the construction process." (p. 7-1). This implies that Construction Quality Assurance Plan (CQAP) is presumed to be inadequate. Additional water quality monitoring should be conducted during construction. Additional erosion and sediment controls should be deployed during construction to prevent increases in total suspended solids (TSS) and confirm that the site is stabilized post-construction.	**While LSS will include a more thorough Erosion and Sediment Control Plan (ESCP) in the Final Design Report submittal, it disagrees that it is realistic to believe that all site surface soils can be controlled to the extent that an initial spike in COPC influent concentrations and in site stormwater discharges will not occur post-construction. However, given the extent of the reconfiguration of the site (i.e., decommissioning of the existing stormwater collection system in favor of surface collection and extensive temporary capping) the nature and degree of any initial "spike" is unknown at this point. The ESCP and Specification 01566 will be modified to include the following minimum elements:** **Construction of a silt fence on the river side of all disturbed areas.** **A construction schedule to indicate, at a minimum, that construction will begin with the installation of the silt fence and equipment decontamination pad/tire wash followed immediately by construction of berms along the perimeter of property. The construction schedule will also include the schedule for decommissioning the existing stormwater collection system (i.e., from the river inland).** **Weekly and post-storm event inspections of all onsite controls. (Note: These inspections will also be included within the CQAP).** **Daily cover requirements for any temporary or permanent soil stockpiling.** **Bi-weekly sampling of construction water**	See Attachment B.		<u>Revision:</u> Additional elements were added to the performance monitoring plan. In addition, LSS has agreed to initiate construction with the installation of the sand filter and settling basin such that stormwater on the site can be treated by the settling basin and sand filter prior to discharge. The sediment basin and sand filter will be inspected, and if deemed necessary based on this inspection, will be cleaned prior to implementation of the full-scale system. Additional requirements were also incorporated into the ESCP. <u>Location:</u> Final Design Report, Section 8; Appendix A (Construction Quality Assurance Plan), Attachment A (Erosion, Sediment, and Pollution Control Plan); Drawings; Specifications.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
		(including all stormwater and water developed from pumping out the existing stormwater system as defined in Section 01510 of the contract specifications) for analytes specified in the site's current NPDES permit. **Maximum ponding allowances during construction for sensitive areas as specified on the contract drawings. Criteria will be specified as an acceptable duration and depth of inundation for different areas within the site.**			
6	Appendix A Construction Quality Assurance Plan. Monitoring activities and frequencies are not provided. At a minimum the CQAP should specify inspections pre- and post-storm events of temporary erosion and sediment controls during construction.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	See response to EPA general comment 5 to Draft Design Report.	In the June 16, 2011 letter, EPA general comment 5 refers to Attachment B. Therefore, refer to discussions related to Attachment B (below).	Revision: Inspections and frequency of erosion and sediment control measures were included in the plan. Location: Appendix A (Construction Quality Assurance Plan), Section 3.
7	Appendix A Construction Quality Assurance Plan, Attachment A - Erosion and Sediment Control Plan. The Erosion and Sediment Control Plan (ESCP) simply requires the contractor to prepare an ESCP as per Specification 01566. Per General Comment 2 to the draft design plans and specifications, Specification 01566 is vague and non-specific, provides no design criteria, and relies on "field design and implementation" of erosion and sediment controls.	**Please refer to LSS' response to EPA general comment 5 for proposed modifications to the ESCP.**	See response to EPA general comment 5 to Draft Design Report.	In the June 16, 2011 letter, EPA general comment 5 refers to Attachment B. Therefore, refer to discussions related to Attachment B (below).	Revision: Additional requirements were added to the Erosion and Sediment Control Plan. Location: Appendix A (Construction Quality Assurance Program Plan), Attachment A (Erosion and Sediment Control Plan).
8	Appendix B Contaminated Material Management Plan. Equipment decontamination and offsite tracking of contaminated soil during excavation and site grading work is not adequately addressed in the plan. Details, including proposed location(s), of truck and equipment decontamination pad design and procedures need to be provided.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: A proposed pad location was added to sheet 4. Contractor will be responsible for pad design and construction; however, pad design and construction will be coordinated with the groundwater SCM (see groundwater barrier wall construction drawings). Location: Drawings, sheet 4.
9	Appendix B Contaminated Material Management Plan. Soils handling (Section 2.3) indicates that soils "suspected" or identified to contain elevated concentrations will be staged separately. "Suspected" is not an adequate criteria to identify the presence of	**Section 2.3 of the Contaminated Materials Management Plan will be modified to reflect that soil that exhibits field evidence of contamination will be staged separately from other soil and debris. Field observations will include**	Response is acceptable. DEQ notes that it disapproved the LSS response and provided directed changes.	See DEQ Specific Comment 1 to Section 2.3 Soil Handling, Page 2-2.	Revision: The word "suspected" was removed from the criteria to identify the presence of DDT. Location: Appendix B (CMMP), Section 2.3.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	DDT. The plan should be amended to read – soil that exhibits field evidence of contamination will be staged separately from other soil and debris.	**visual, olfactory and vapor monitoring in the breathing zone as well as within open excavations. Also, please refer to LSS' response to DEQ specific comment on the Contaminated Materials Management Plan, Section 2.3 Soil Handling, Page 2-2, comments 1 and 2 on the modification to the handling of soils that are located within the former Acid Plant and the Old Caustic Tank Farm.**			
10	Appendix E Operation and Maintenance Plan. The criteria stated for maintenance of clogged inlets or outlets is to "maintain 50% of conveyance capacity at all times" (Table 4-1). This criteria was developed by the City of Portland for municipal storm water systems which typically do not have the potential to recontaminate river sediments. Additional operation and maintenance activities should be included requiring inspections and necessary maintenance after major storm events to keep the system fully functional.	**LSS disagrees that municipal stormwater systems "typically do not have the potential to recontaminate river sediments." Specifically, two municipalities, the cities of Portland and Milwaukie, Oregon[5], have submitted stormwater NPDES permit renewals that address DDT loading to stormwater in regards to the Johnson Creek TMDL. Further, a public health assessment conducted by the Oregon Department of Human Services[6] indicated that the primary risk to the health of recreational users of the Portland Harbor was bacteria-related illness resulting from swallowing Willamette River water around municipal combined sewer overflows following a rain storm. Regardless, the Operation and Maintenance Plan will be updated, including Tables 4-1 and 4-2, to include inspections and maintenance activities necessary to maintain complete system functionality after a significant or major storm event. These inspections will be in addition to the yearly inspections currently specified within the plan. A significant or major storm event for this purpose will be defined as any storm equivalent or greater than the 2-year, 24-hour storm event (i.e., greater than 2.4 inches of precipitation over any 24-hour**	Response is acceptable.		Revision: Tables 1 and 2 in the Operation and Maintenance plan were updated to include the removal of blockages if standing water is observed more than 48 hours following a storm event. Location: Appendix E (Operation and Maintenance Plan), Tables 1 and 2.

[5] The City of Portland's MS4 permit renewal submittal was reviewed at http://www.portlandonline.com/BES/index.cfm?a=246007&c-c7485 and the City of Milwaukie's permit renewal was reviewed at http://www.cityofmilwaukie.org/new/2008/NPDES.html.
[6] Public Health Assessment. Public Comment Release. Portland Harbor: Recreational Use. Portland, Oregon. EPA Facility ID: ORSFNd1002155. Prepared by Oregon Department of Human Services. May 20, 2010.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
		period). The modified Operation and Maintenance Plan will be submitted as part of the final design.			
11	Appendix F Performance Monitoring Plan Attachment C. It is incorrect to state that sampling will be performed on a monthly basis. What is proposed is collection of one (1) influent and one (1) effluent storm event sample per month over a three-month period. Subsequent to that period, the plan only commits to monthly effluent samples pending review of the influent monitoring results.	**Please refer to LSS' response to EPA general comment 2 for proposed modifications to the Performance Monitoring Plan.**	See EPA's supplemental comment [*Attachment A]* on the proposed monitoring plan and the response to general comment 2 to the Draft Design Report.	Refer to discussions on Attachment A (below) & discussions on EPA General Comment 2 (above).	Revision: The performance monitoring plan was modified to include monthly influent and effluent sampling to the extent technically practicable during the first year of operation. Location: Final Design Report, Section 8; Appendix F (PMP), Section 2.
12	Appendix F Performance Monitoring Plan. Flow measurements are critical to obtaining data for compositing water samples and for ultimately calculating pollutant loads from the site. The brief description of flow monitoring provided in Section 2.4 and reference to the vendor's user manual are inadequate for assessing the efficacy of the flow measurements. Operation of area-velocity meters in pipes exhibiting shallow flows (<1") can be very problematic. Flow measurements should be continuous so that monitored event loads can be extrapolated to events that are not monitored.	**The Performance Monitoring Plan will be modified to include additional detail of flow monitoring and the installation of temporary weirs for flow monitoring during anticipated smaller storm events at proposed monitoring locations.** **LSS disagrees that flow measurements need to be continuous so that monitored events can be extrapolated to events that are not monitored. LSS proposes to modify the Performance Monitoring Plan to include a comparison of precipitation data (obtained from City of Portland precipitation data sources) from monitored events to events that are not monitored to extrapolate data.**	EPA reasserts that there should be continuous flow monitoring as stated in this comment. Estimation of runoff data from off-site precipitation data introduces error that can be avoided with direct measurement. DEQ understands that current proposal requires flow meters to be powered by batteries as electricity is not available at this location. LSS should either make arrangements to power the meters continuously or provide a sensitivity analysis, for DEQ consideration, of the flow data on the sediment recontamination evaluation.	LSS agrees to provide DEQ with information on why continuous flow monitoring will not be required.	Revision: None required. The following provides an explanation on why continuous flow monitoring should not be required. Continuous flow measurements will not be recorded during storm events that are not being monitored because continuous chemical of potential concern (COPC) concentration measurements will not be available to associate with the flows. COPC concentrations will likely vary between storm events based on the intensity of the storm, duration of the storm, and antecedent conditions (i.e., conditions present since the previous storm). Therefore, attempting to estimate COPC loading in stormwater discharges from continuous flow measurements (but using only single event concentration data) is an unnecessary refinement beyond what can be estimated using local rainfall records, recorded flow for monitored storm events, and associated concentration data from monitored storm events.
13	Appendix F Performance Monitoring Plan Attachment C, Sampling Equipment User Manuals. This appendix presents copies of the sampling equipment manufacturer's user	**The attachment was not provided in hard copy form; it was provided only in electronic format (attached CD).**	Response is acceptable.		Revision: None necessary.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	manuals verbatim. These manuals were not included in this technical review and add unnecessary bulk to the Draft Design Report (approximately 300 pages). In general, user manuals obtained directly from vendors can be incorporated by reference only.				
14	Appendix G Quality Assurance Project Plan. Section A7 (p. A-7) states: "Project specific data quality objectives were not developed for the PMP. Because the stormwater treatment system is being implemented in accordance with the MAO and in conjunction with the facility's existing NPDES permit, new or revised numerical discharge limits are not part of the design basis for the SCM." Data quality objectives (DQOs) should be developed for the SCMs according the U.S. EPA QA/G-47 1 to ensure that monitoring data is of sufficient quality and quantity to support the goals of the SCM. Of particular concern is the very limited quantity of data (e.g., 3 composite samples collected over a 3-month period) that is being proposed to provide the basis for assessing the performance of the SCMs and for deciding to curtail the ongoing performance monitoring program. DQOs should also consider applicable thresholds to curtail the performance monitoring program (e.g., discontinue influent monitoring).	**Comment noted. Please refer to LSS' response to EPA general comment 2 in regards to modifications of the sampling frequency in the Performance Monitoring Plan. Note that even though DQOs in the U.S. EPA QA/G-4 format are not provided, applicable effluent levels and analytical methodologies were considered in establishing the sampling program. LSS' intent is to conduct the sampling of the stormwater discharge as it would be done under a typical NPDES discharge permit with a focus on the effluent quality objects. The DQOs of that program are essentially set by the agency and reflected in the permit conditions. For this effort we have included influent sampling to assess the overall influence of the influent loading conditions to the stormwater treatment processes during the performance monitoring period.**	See EPA's comment on the LSS response to DEQ general comment 1 (Attachment A), EPA's supplemental comment on the proposed monitoring plan and the response to General Comment 2 to the Draft Design Report. Note that while runoff from this site is evaluated for effluent quality, it is not typical urban stormwater runoff and the monitoring measurements and results response would not be the same.	LSS agrees to provide the following DQO's: • The DQO's are geared toward effluent water quality and to test the efficiency of available technologies. • DQOs o Determine system efficiency through influent & effluent monitoring. o Compare effluent concentrations to Table 1-1 values.	Revision: Data quality objectives (DQOs) were added to the quality assurance program plan (QAPP). Location: Appendix G (QAPP), Table 7-1.
15	15. Appendix I WinTR-55 Modeling Results (pdf.902-914). A brief summary description of the modeling and summary results in tabular form should be provided.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: A brief summary of the TR-55 model and modeling results were added to Appendix I. Location: Appendix I (WinTR-55 Modeling Reports)
16	Appendix J HydroCAD Modeling Results. The listing of raw HydroCAD modeling results should include a summary and description of the input and output information provided for each rainfall return period storm event simulated. Tabular listings	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: A brief summary of the HydroCAD model and the modeling results were added to Appendix J. Location: Appendix J (HydroCAD Modeling Reports).

[7] USEPA. 2006. *Data Quality Assessment: Statistical Methods for Practitioners, EPA QA/G-9S*, Office of Environmental Information, EPA/240/B-06/003, February 2006.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	of hydrographs and stage-discharge relationships are not conducive for review purposes and are only needed in graphical format.				
	Specific Comments Pertaining to the Draft Design Report Stormwater Source Control Measures				
1	Section 1 page 1-1, 2nd paragraph. The Draft Design report considers multiple Source Control Measures ("SCMs"). The reference to SCM (singular) should be changed to SCMs (plural) throughout the report.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The reference to source control measures as SCM (singular) was changed to SCMs (plural) throughout the report. Location: Final Design Report and appendices.
2	Section 1.2 page 1-2, 2nd paragraph. Add ")"after BMPs and remove ")" later in sentence or revise awkward wording.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The ")" was moved to after BMPs in the sentence. Location: Final Design Report, Section 1.2.
3	Section 1.2 page 1-3, 1st paragraph. Change "target levels" to "target effluent concentrations." The report should provide information on how these target effluent levels/concentrations will be used to measure the progress/removal efficiency of the stormwater system.	**Please refer to DEQ general comment 1, MAO objectives, for the proposed modifications on how the target levels will be used to measure progress/removal efficiency of the stormwater system.**	See EPA's supplemental comment [*Attachment A*] on the proposed monitoring plan and the responses to general comments 2 and 5 to the Draft Design Report.	Refer to discussion on Attachment A (below) and EPA General Comments 2 and 5.	Revision: The report text was modified by changing "target level" to "goal" with respect to the comparison to Table 1-1. Additional details were added to the report on how target effluent levels/concentrations will be used. Location: Final Design Report, Section 8; Appendix F (PMP).
4	Section 2.1.4 page 2-4, 2nd paragraph. The Draft Design Report contends that .057 pounds (lbs) per year DDx is discharged from the site in comparison with 13.4 lb/year from the average annual Willamette River base load. This equates to .0012 lb/square mile (sq mi) per year from the watershed (11,100 sq mi) and 0.678 lbs/ from the site, which means on a "per square mile" basis the site contributes 565 times the load in comparison with the upper watershed. Even if just 10 percent of the watershed was contributing DDx, the site would be contributing over 50 times the average site. Arkema is clearly a high priority site as a source of DDx in the watershed. While the high river flow of 169,000 cubic feet per second (cfs) appears to be an exclusion of a lot of water, it equates to an average of 463 cfs per day, which is 0.7	**The average annual Willamette River base load was not measured at the discharge point (as measurements of loads from the Arkema site currently are taken). The majority of sites contributing to this base load are located significantly upstream of the point measured and will have substantially higher concentrations at the source; thus, the comparison made above is not valid. Also, EPA's assumption is fatally flawed as it is highly unlikely that the entire 11,100 sq mi contributes equally to the 13.4 lb/year load, and only a small portion of this area contributes to this loading; therefore, to say the entire basin only equates to 0.0012 lb/sq mi is extremely misleading. This information would be available if a TMDL study, as**	EPA disagrees that decreasing DDx discharges from the site will have little effect on the Willamette River. The discussion in the response suggesting that additional SCMs would not be productive is actually proposing a stormwater control approach that transfers the risk, contingencies, and unknowns about the discharge to the river. This is not an acceptable approach to evaluating and designing source control and is inconsistent with the presumptive approach to controlling stormwater. When assessing the feasibility of selecting and applying presumptive SCMs to the site, feasibility is measured by factors such as availability of technology, proven performance, cost-benefit evaluations (e.g. knee of the curve), and application of	LSS will comply with EPA comments to the extent they do not contradict DEQ comments or conflict with the terms of the MAO. • LSS would refer EPA to the MAO (dated 08/04/2010) regarding the selection of the "presumptive remedy". • LSS is implementing, at the request of DEQ, the system as a type of "full-scale field pilot test" (2009 IRM Work Plan).	Revision: None required. The MAO (dated 08/04/2010) is clear regarding the selection of the "presumptive remedy." LSS is implementing, at the request of DEQ, the system as a type of "full-scale field pilot test" (2009 IRM Work Plan). Regarding the loading estimates, please note that a screening level analysis was performed to evaluate the potential for recontamination of the Willamette River nearshore sediments by site stormwater discharges following the implementation of the new stormwater SCMs (see Section 2.1.5 of the Final Design Report and Appendix L).

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	percent of the average annual flow (63,600 cfs) of the Willamette, which would not be characterized as a "substantial" flow exclusion.	**required under the 303(d) listing, was completed for the Willamette River basin. Finally, the single point of 169,000 cfs does represent over 3.5 times the average annual flow of 63,600 cfs. Excluding this measurement from the calculations excludes all flows at or above this range and, thus, represents significantly more than 0.7 percent of the average annual flow.** **LSS is not contending that the Arkema site is not a priority site to control DDx loading to the Willamette River. But regardless of how much mass any individual site upstream contributes compared to the Arkema site or whether exclusion of the 169,000 cfs data point is discounting a substantial upstream contribution to the annual load, the data indicate that, by comparison, the mass of DDx within the Willamette River coming from upstream of the site is at least two orders of magnitude greater than that contributed by stormwater discharges from the Arkema site. The information shows that decreasing DDx discharges from the site will have little effect on the improvement of water quality and/or sediment quality within the Willamette River and therefore, implementation of measures, beyond what has already been proposed, would not be productive.**	known technology to the extent practicable. These are all examples of how presumptive stormwater measures for the site should be considered. Refer also to EPA's comment on the LSS response to DEQ's general comment 1 (Attachment A).		
5	Section 2.1.5, 1st paragraph. This paragraph describes the ability of the existing stormwater system to "carry very large volumes (i.e., millions of gallons per day)" of water. The calculated 2-year storm peak runoff rate of approximately 14 cfs equates to a rate of over 9 million gallons per day. The capacity of the existing systems to discharge the peak design flows through outfall 4 should be determined.	**Comment noted. The "as designed" maximum flow rate for Outfall 004 was 35.54 cfs[8]. Also, please note that with detention and sand filtration, the peak runoff rate for all storms will be significantly decreased as a result of the inherent equalization through the system. The estimated peak runoff for the 25-year, 24-hour is approximately 5.5 cfs. This information will be incorporated**	Response is acceptable.		<u>Revision:</u> The "as designed" maximum flow rate for Outfall 004 (7.74 cfs) was added to the text. Please note that the 35.54 cfs flow rate reference in the response to this comment is for the entire existing stormwater system (i.e., Outfalls 001, 002, 003, and 004). Also note that the estimated peak runoff from the 25 year storm is less than 3 cfs from the sand filter.

[8] As per Pennwalt Corporation design drawings as received from Arkema, Inc.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
		into the Final Design Report submittal.			Location: Final Design Report, Section 6.4.2.
6	Section 3.1 page 3-1, 2nd paragraph. The locations of the historic operations and current site features are not clearly presented in Figure 3-1.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: Figure 4-1 was updated to include the locations of historic operations and current site features. Location: Final Design Report, Figure 4-1.
7	Section 3.1 page 3-2, 2nd paragraph. This section references Figure 3-2 which shows "Area of Previous Temporary Capping" within which is shown "Historic Operational Areas." The northwestern extension of the "Former DDT Pond and Trench" should be included in the Historic Operational Areas. In general Figure 3-2 adds very little to Figure 3-1.	**Comment noted. Figure 3-2 will be removed, and the required additional information will be included on Figure 3-1 in the Final Design Report submittal.**	Response is acceptable.		Revision: Figure 3-2 was removed from the report. Location: Final Design Report, Figures.
8	Section 3.2 page 3-2, 2nd paragraph. The Draft Design Report includes a design criteria "*Cap must be relatively impermeable*." The target permeability of the cap should be stated and tested during construction.	**Capping at the site is considered temporary until completion of the final site remedy. Capping specifications will be identical to those incorporated in other temporary capping areas implemented previously at the site.**	Response is acceptable.		Revision: None required.
9	Section 3.2 page 3-2, 2nd paragraph. The Draft Design Report includes a design criteria "*Cap surface must be sufficiently competent to support equipment that will place capping materials*." The target load rating should be stated and tested during construction.	**Capping at the site is considered temporary until completion of the final site remedy. Capping specifications will be identical to those incorporated in other temporary capping areas implemented previously at the site.**	Response is acceptable.		Revision: None required.
10	Section 3.3 page 3-2, 1st paragraph. This section references Figure 3-4 which shows the very limited areas where a temporary cover will be placed as shown in yellow and purple. Figure 3-4 includes the yellow(ish) legend label as "*Foundation/Railroad –Fill and Cap*" and the purple(ish) legend label as *"Erodible (Exposed) Soil – Cap."* The distinction between capping treatment of these areas is not clear.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: Clarification between filling and capping the foundation/railroad areas and capping erodible soil areas was made to Figure 4-3. Location: Final Design Report, Figure 4-3.
11	Section 3.3.2 page 3-3, 1st paragraph. The Draft Design Report states that "*Asphalt cracks that are substantial enough to expose surficial soil to stormwater flows will be*	**Please refer to LSS' response to DEQ's specific comment on Section 3.0 Temporary Capping, Page 3-3.**	Response is acceptable.		Revision: A field survey was conducted on August 25, 2011 to assess the condition of the asphalt paving in the Acid Plant area. Design drawings were

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	sealed." This criteria is vague and relies on potentially inconsistent field judgment by untrained construction workers. Better defined criteria to identify cracks should be developed. Having an engineer mark all of the cracks with spray paint that will be filled may be preferable.				updated with the results of the survey. Location: Drawings, sheet 11. Specifications, Exhibit 3.
12	Section 3.3.4 page 3-4, 1st paragraph. The structures to be demolished should be identified on a figure or photograph, and the specifics of how the debris will be managed and disposed of should be described.	**Please refer to LSS' response to DEQ's specific comments on the Draft Contaminated Material Management Plan, Section 4 Material Segregation and Stockpiling, comment 4 in regards to management of construction debris from the former DDT manufacturing building. The drawings submitted as part of the Final Design Report will include photographs of the structures to be demolished.**	Response is acceptable.		Revision: The following sentence was added to the plan: "Demolition debris from the former DDT manufacturing building will be assumed to contain U061 hazardous waste and will be transported to an appropriate offsite disposal facility." Additional information on structures was also added to the drawings. Location: Appendix B (CMMP), Section 4; Drawings.
13	Section 4.3 page 4-2, 1st bullet. A design detail on how pipes >24" diameter will be decommissioned should be provided. This should include the anticipated length of fill and materials to be used. Design details should also be provided for installation of grout seal at manholes.	**Design details on how pipes >24" diameter will be decommissioned are provided in the project technical specifications, including materials to be used and installation of grout seal at manholes. The anticipated length of fill will be provided in the Final Design Report submittal.**	Response is acceptable.		Revision: Additional information on the anticipated length of fill for decommissioning stormwater pipes was added to sheet 10. Location: Drawings, sheet 10.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
14	Section 5.2 page 5-2, 4th bullet. The Draft Design Report includes design criteria to "*convey and treat the 25-year design storm*." Provision of significant water quality treatment of the 25-year storm event is very unlikely. Typical basin design targets the 1- or 2-year event and the sand filter design is for the 2-year, 24-hour event. This should be clarified to distinguish the water quality design storm from the conveyance and peak detention storage treatment.	**As stated in Section 5.4.2, the detention basin was designed to allow sufficient detention of the 25-year, 24-hour storm flows for discrete particle setting of clayey silt to silty sand size particles (typical of those surficial soil types present at the site). Actual treatment efficiency of this basin cannot be determined at this time because it will be dependent on the particle size distribution mobilized by a range of precipitation events at the site, as well as how site COPCs partition to the differing particle sizes within the distribution. Given the complete reconfiguration of the stormwater collection system at the site (i.e., decommissioning of the existing stormwater collection system and replacement with an overland flow collection system as well as the extensive temporary capping that will occur over the site), the future particle size distribution, as well as how the COPCs will be partitioned to the different particle sizes that will occur at the influent of the detention basin, cannot be predicted at this time.**	The LSS response did not address the comment. EPA requested clarification and consistency in the descriptions on what the proposed design storms for different aspects and performance of the system – conveyance, detention, sand filter, temporary construction measures, etc. Refer to EPA's comment on the LSS response to DEQ's general comment 1 and Draft Design Report specific comment 4.		Revision: The system design was changed to provide treatment of a 25-year, 24-hour storm. Clarification of the design storms for the components of the stormwater system was provided in the text. Location: Final Design Report, Section 6.4.
15	Section 5.2 page 5-2, 6th bullet. The Draft Design Report includes a design criteria to "prevent long-term ponding of stormwater." This criteria should be specified as an acceptable duration of inundation (e.g., 72 hour) and this should be evaluated under the hydrologic analysis.	**Given that this is a temporary stormwater control until the final site remedy is implemented and the site has been inactive since 2001, a minimal long-term ponding analysis was conducted and presented in Section 5.4.4 and Figure 5-17. This analysis (indicating ponding during the 100-year storm and no discharge) indicates that the majority of the site will not pond water, and that sensitive areas, including the area of the future Groundwater Extraction Treatment System building and current site office will remain "dry." Given the limited relief at the site, it has been previously presented that ponding is currently occurring and will continue to**	The term of "temporary" has not been provided and is important in the assessment of potential risk from different events. Please define a proposed time frame that corresponds to "temporary".	LSS will define temporary as the system only being in place until a final site remedy is in place.	Revision: The Operation and Maintenance Plan was updated to include provisions to inspect the site for "attractive nuisance" to wildlife, report such nuisances to DEQ, and implement measures to mitigate such nuisances. The term "long-term" was changed to "permanent" in the Final Design Report. The term "temporary" was defined in the text and means the stormwater system will only be in place until a final site remedy is in place. Location: Final Design Report, Sections 1 and 6.2; Appendix E (Operation and Maintenance Plan), Sections 4.2 and 4.4.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
		occur over a longer term period (i.e., >72 hours). The Operation and Maintenance Plan will include provisions to inspect the site for "attractive nuisance" to wildlife, report such nuisances to DEQ, and implement measures to mitigate such nuisances.			
16	Section 5.3.2 page 5-5, 3rd paragraph. Complete modeling results for peak flow and total volume are presented in Appendix J not Appendix I. As noted in the general comments, the presentation of modeling results is very cursory in the Draft Design Report and is not supported by additional descriptive text in the appendices which are simply listings of raw model input/outputs.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: Descriptive text was added to the HydroCAD appendix. Location: Appendix J (HydroCAD Modeling Reports), technical memorandum.
17	Section 5.4.1 page 5-5. The downstream detention pond and sand filter is likely to create backwater in the channel under certain conditions. A backwater analysis should be completed to demonstrate conditions under which water would be backed into the channels (i.e. during river floods, design storms, etc) and evaluate if conditions exist where the channels would overflow under normal operation.	**The Arkema site has very little relief within the former plant operations areas (Lots 3 & 4). Because of this lack of relief, backwater effect on the stormwater channels is likely to occur under a variety of storm conditions. This condition has been understood and discussed with DEQ during meetings that occurred as part of the development of the MAO. Figure 5-17 shows the extent of channel "over-topping" if the 100-year storm event were to occur AND no water could be discharged at that time due to elevated river levels. As indicated in Figure 5-17, no current (the Plant Office) or future (the Groundwater Extraction Treatment System) sensitive areas would be threatened by flooding.**	A backwater analysis should be performed to show the extent of flooding during system performance as described in item n. in EPA's comment on the LSS response to DEQ general comment 1 (Attachment A). The purpose is in part to understand the frequency and duration of inundation outside of the lined area and the potential for stormwater bypassing the treatment system. See DEQ review of the response to DEQ general comment 2.	Refer to discussion on backwater analysis in Attachment A and discussion related to DEQ general comment 2.	Revision: Please see the response to DEQ General Comment 2. A standard step backwater analysis was conducted for the site. Location: Appendix K (Standard Step Backwater Analysis).
18	Section 5.4.2 page 5, 1st paragraph. The hydrology and hydraulics (H&H) analysis should address the frequency, extent up the channel, depth of water, and estimated duration of precipitation events that would back-up water into the channel and infiltrate. The current analysis shows the 2-year event would back up water in the detention pond to the design flow level in the channel and create a backwater effect on the water stage in the	**Please refer to LSS' response to the previous comment (EPA specific comment 17). Note that the majority of the stormwater channel system is located behind the proposed groundwater barrier wall and will be captured by the proposed groundwater extraction and treatment system to be installed as part of the Groundwater SCMs.**	See item m. in EPA's comment on the LSS response to DEQ general comment 1 (Attachment A) and response above to specific comment 17 to the Draft Design Report. Modifications are recommended if the proposed system fails the listed design performance standards.	Refer to response to EPA Specific Comment 17.	Revision: Please see the response to EPA Specific Comment 17 on the Draft Design Report.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	channels. Smaller storms than the 2-year would back up into the channel at a frequency and depth that has not been determined. An acceptable return frequency for storms backing into the unlined channel and infiltrating should be established and H&H calculations provided to show this allowance is met. The analysis should consider constraints in the proposed system that could cause backwater effects through the system and influence ponding outside of the lined system.				
19	5.4.2 page 5-9, 2nd paragraph and footnote 5. The draft report states that there will be 4:1 side slopes on the detention facility unless final design indicates steeper slopes are feasible. The purpose is to reduce excavation volumes. If the side slopes are changed, the storage volume would need to remain constant and the site would need to be remodeled to confirm the change in the stage-storage curves on detention performance would remain unchanged. This design and calculation should be completed now for this stage of design and review.	**Comment noted. Modifications (as required to address DEQ and EPA comments) to the design between now and the Final Design Report will also include appropriate modifications to the previously conducted modeling. All modifications would be included in the Final Design Report submittal.**	Response is acceptable.		Revision: The 4H:1V side slopes on the detention pond was retained in the Final Design Report. Maintenance access to the detention pond and sand filter was added to the drawings. Location: Drawings, Sheet 9.
20	Section 5.4.3 page 5, 1st paragraph. The discussion in the report applies a presumptive approach to estimate the proposed BMP to remove TSS and the associated DDx. That is, the design storm will account for treatment of 90 percent of the average annual runoff, and the removal percentage is the basis for the configuration, depth and expected settling velocity, etc of the detention/settling pond. This is a presumptive approach to compliance which is in contrast to a performance approach that would rely on detailed engineering design and calculations. Arkema should use a performance-based approach that requires a target numerical effluent limit - not a mix and match of both approaches. With each effluent limit listed in Table 1.1 of the Draft Design Report, there should be clear instructions on monitoring, what constitutes	**Please refer to LSS' response to DEQ's general comment 1 on the MAO objectives. The performance approach (i.e. conducting treatability testing and additional data collection) was proposed as part of the Stormwater SCMs Design & Implementation Work Plan. However, this approach was rejected in favor of an expedited approach which will consist of implementation of the proposed system as a full-scale pilot, post-implementation testing and improvement as necessary (i.e. adaptive management). Without conducting the necessary pre-design studies, including both additional data collection and substantial treatability testing, an engineering report or evaluation of the treatability of the effluent to achieve a numeric limit cannot**	Refer to EPA"s comment on the LSS response to DEQ's general comment 1 (Attachment A), EPA's supplemental comment on the proposed monitoring plan and the responses to general comment 2 and specific comment 4 to the Draft Design Report.		Revision: The stormwater system was further refined and additional information was provided on the basis of the design, including the removal efficiency and the presentation of the values in Table 1-1 as goals. Precise estimates of removal efficiencies cannot be provided until after the system is installed in accordance with the MAO. Because influent concentrations will change considerably from the existing system and because LSS was directed to install the system without conducting pilot studies, the evaluation of the treatability of the effluent will be conducted in accordance with the Performance Monitoring Plan. Location: Final Design Report,

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	compliance under what storm and flood conditions, and required actions when the limit is exceeded. Arkema should provide an engineering report or evaluation of the treatability of the effluent to achieve the limit.	**be provided.**			Sections 3 and 8; Appendix F (Performance Monitoring Plan).
21	Section 5.4.3 page 5-10, 3rd paragraph. The Draft Design Report states that "*the results of the modeling demonstrate that 67 percent of the total storm flow for the 25 year storm will receive polishing treatment by the sand filter.*" The basis for this statement cannot be discerned from the information provided in the text, or the Section 5 figures. As noted in General Comment 16 above, the raw model input/output listings provided in Appendix J are superfluous and require additional descriptive summary and graphics. The use of the word "polishing" is misleading when describing the performance of the sand filter during the 25-year storm. The sand filter provides secondary treatment of effluent from the primary detention and settling system for the *2-year water quality design storm*. When flows exceed the 2-year flow, the sand filter passes less of the water through the filter (reduced to just 67 percent of the volume during the 25-year storm, bypassing 33 percent with no sand filter treatment) and does not provide a commensurate level of treatment for storms in excess of the 2-year storm. The sand filter design should include provisions to protect the system from damage and remobilization of collected DDx for events that exceed the design storm, while providing full treatment performance for the design storm volume. The system design should identify the design storm frequency that requires full storage and treatment of all runoff and compliance with the discharge effluent limit.	**Comment noted. Additional information will be provided to demonstrate the portion of the >2 year storms that will be treated by the sand filter.** **The Final Design Report submittal will be modified to include language that addresses the secondary nature of the sand filter.** **Please note that the sand filter is a downward flowing filter, and larger storms will bypass over the outlet weir on the downline portion of the sand filter. The >2 year storms will cause increased head on the sand filter as water passes over this weir; however, it is highly unlikely that this small increase in head is sufficient enough to cause system damage and remobilization of collected DDx within the sand filter.** **Please refer to LSS' response to DEQ's general comment 1 on the MAO objectives in regards to discharge effluent levels.**	Response is acceptable pending review of additional information to be provided in the final design.		<u>Revision:</u> Additional information was provided in the Final Design Report regarding the basis of the stormwater SCM design. <u>Location:</u> Final Design Report, Sections 6.3.3 and 6.4.3; Appendix J (HydroCAD Modeling Reports).
22	Section 5.4.3 page 5-11, paragraph 1, 1st bullet. The design criteria are not consistent with the plan there are concerns with what is shown: The clear wells described are not	**Comment noted. Drawings and figures will be labeled for clarification and stormwater flow paths indicated. Plan elements within the Design Report will**	Response is acceptable.		<u>Revision:</u> Revisions were made to the Final Design Report and associated drawings for consistency and clarification. Stormwater flow paths

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	indentified or dimensioned on the plans; the influent weir is not shown or labeled; the side slopes should be in final design, as commented above and the stage-storage should remain the same; the "*bottom elevation*" of 27 is shown as 27.5 in the plan detail and should be the "sand filter elevation", not bottom elevation; the pipe described in the final bullet does not match any pipe on the plans and it is not clear if it is the inlet or outlet pipe; and if it is the sand filter discharge pipe, it will not drain the sand filter as the invert is too high.	**also be indicated on all figures and drawings. Modifications will be included in the Final Design Report submittal.**			were also added to the drawings. Location: Final Design Report, Section 6.4.3; Drawings, sheets 17 and 18.
23	Section 5.4.4 page 5-11. The coincidence of storms during river floods (in excess of the 10-year flood and higher) would have a relatively high probability of occurring during a river flood and even low volume, routine storms could overwhelm the proposed system when there is no discharge. The approximate 25-year flood, for example, is higher than the sand filter and would prevent any flow-through treatment, thereby bypassing the sand filter. Consequently, any runoff would need to be stored on site while there is no discharge or treatment possible from the system. It is recommended that system performance during floods (above the 10-year river flood) be defined (i.e. what is the stage of water from a multiple–day storm having a 50 percent chance of occurring) and that Arkema demonstrate that storage is available with no sand filter bypass during river floods over the 10-year flood.	**Comment noted. As pointed out in LSS' response to other comments, ponding currently occurs at the site and will continue to occur during extreme weather events. Further, while by pass may occur during high river stages, this is also when the Willamette River currently carries the largest load of DDx from upstream. The co-occurrence of these events with large storm events at the site rarely occurs and thus represents an insignificant amount of the annual average load from the site. Performance of the system during flood events will be considered in the Final Design Report submittal.**	See items m., n. and o. in EPA's comment on the LSS response to DEQ general comment 1 (Attachment A) for recommended hydraulic evaluation during floods. Transferring risk, unknowns, and contingency to discharges to the river is not an acceptable approach to source control from the site.	Refer to discussion on Attachment A.	Revision: The invert elevation at the outlet of the sand filter was raised to be above the approximate level of the 25-year flood stage of the Willamette River. Location: Final Design Report, Section 6.4.3; Drawings, sheets 17 and 18.
24	Section 5.4.5.1 page 5-12, 2nd paragraph, 2nd bullet. A one-foot berm top is unlikely to be maintainable and stable. The report and plans conflict as the report lists 2:1 side slopes while the plans show 1:1. Guidance from a stormwater drainage manual for minimum berm width and side slopes should be referenced or the levee should be designed by a geotechnical engineer with expertise in levee design.	**Comment noted. Please note that the berms are not levees, but are small (most <2 ft in height) berms designed not to contain water, but to reroute runoff during storm events. The recommendation will be considered in the Final Design Report submittal.**	Response is acceptable pending review of additional information to be provided in the final design.		Revision: The berm side slopes were made consistent between the text and the drawings. Location: Final Design Report, Section 6.4.5; Drawings, sheet 19.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
25	Section 7. page 7-1, paragraph 3. The criteria or analysis that will be performed by LSS to determine whether to discontinue influent sampling after three months should be presented. Provide clarification on the meaning of "as needed" sampling. At this point only three (3) composite event samples will have been collected which will preclude any statistical significance testing.	**Please refer to LSS' response to EPA general comment 2 for proposed modifications to the Performance Monitoring Plan.**	See EPA's comment on the LSS response to DEQ general comment 1 (Attachment A), EPA's supplemental comment on the proposed monitoring plan and the response to general comment 2 to the Draft Design Report.		Revision: Please refer to the response to EPA General Comment 2 for proposed modifications to the Performance Monitoring Plan.
26	Section 7. page 7-1, 2 paragraph 6. The Draft Design Report notes that *"If modifications to the stormwater SCM are deemed necessary, an adaptive management approach will be used to optimize the stormwater treatment system."* The criteria to be used to determine whether modifications to the SCM are necessary should be presented.	**Please refer to LSS' response to DEQ's general comment 1 on the MAO objectives.**	See EPA's comment on the LSS response to DEQ general comment 1 (Attachment A), EPA's supplemental comment on the proposed monitoring plan and the responses to general comment 2 and specific comment 4 to the Draft Design Report.		Revision: Please refer to the response to EPA General Comment 2 for proposed modifications to the Performance Monitoring Plan.
27	Section 7. page 7-2, paragraph 1. The Draft Design report states that "a reduction in effluent stormwater DDx concentrations will be considered a marker of success of the stormwater SCM." SCM success should be based on quantitative data demonstrating the level of achievement meeting the Table 1-1 values.	**Please refer to LSS' response to DEQ's general comment 1 on the MAO objectives. The purpose of the MAO, which was a transparent process among all parties, was specifically to not use the Table 1-1 values as numeric discharge limits because of the requirement for substantial treatability testing as well as further data collection as stated in the response to DEQ's comment 1. If the agency has knowledge of a stormwater treatment technology that has been demonstrated capable of meeting the Table 1-1 values for a stormwater system with inputs commensurate with the Arkema site, LSS will evaluate, and pending an evaluation, implement the agency-recommended stormwater system.**	Refer to EPA's comment on the LSS response to DEQ's general comment 1 (Attachment A).There appear to be remaining questions on if and how the COPCs are partitioned within sediment size distributions and whether or not any exist in a dissolved form. It is also unclear whether the intended treatment mechanism in the filter is a physical screening process or an adsorptive process, or a combination. Adsorptive filtration removes colloidal and dissolved materials through electrical interactions. Activated carbon and other adsorptive media, such as metal oxides, should be evaluated for the capture of the colloidal sized particulates and dissolved fractions.	Refer to discussion on Attachment A and discussion on DEQ Specific Comment to Section 1.2 Selected Source Control Measure Page 1-2.	Revision: The ultimate goal of the stormwater SCM is to achieve, to the extent technically practicable, the effluent goals in Table 1-1 of the design report. Location: Final Design Report, Section 1.
	Stormwater Source Control Measures Draft Design Plans and Specifications Comments				
	General Comments				
1	The specifications for this level of design are normally standard boiler plate and do not include site-specific considerations. Consequently, EPA performed only a cursory	**Comment noted.**	Response is acceptable pending review of additional information to be provided in the final design.		Revision: None required.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	review. A more detailed review will be completed when the plans are at a final design level.				
2	No construction stormwater or Erosion and Sediment Control Plan (ESCP) was included or reviewed. Attachment A to Appendix A is entitled "Erosion and Sediment Control Plan" but in actuality is only a very brief and general summary of requirements for the contractor to submit an ESCP according to Specification #01566. Specification #01566 itself is very general and puts all of the responsibility for erosion and sedimentation controls on the contractor and is likely to result in inadequate on site controls because it only requires review of the City of Portland Erosion and Sediment Control Manual9. There are no requirements for inspections pre- and post- storm event to ensure that on site controls are properly designed and installed or to identify necessary maintenance or improvements. For example, Specification #01566 Section 1.01 (C) requires the contractor to "field design and implement" storm water runoff controls. An erosion and sediment control plan should be provided for review to indicate standard or minimum approaches and address the concern regarding mobilizing sediments immediately after construction.	**Please refer to LSS' response to EPA general comment 5 for proposed modifications to the Erosion and Sediment Control Plan.**	See EPA's response to Draft Design Report general comment 5 for Construction and Sequencing response (Attachment B). In addition, a plan and measures to control/treat/dispose of stormwater from the site while the future control measures are under construction has not been described. A plan for handling and discharge of all collected stormwater must be developed.	LSS agrees to complete construction such that site stormwater can be treated via the stormwater treatment system. First, LSS will construct the detention basin, then the sand filter. LSS will do inspections during construction as per the O&M plan. If necessary, LSS will "clean" the system after all construction is completed If necessary, LSS will provide bag filter/sand filter/carbon while building the detention basin and sand filter.	Revision: The construction schedule was modified to allow the use of the detention basin and sand filter during construction. The detention basin sand filter will be inspected following all site construction activities, and if deemed necessary, cleaned prior to implementation of the full-scale system. Location: Specifications; Drawings, sheet 4.
3	Section 5.4.4 of the draft design report discussed the need for flap gates to prevent backwater into the system during river floods. The location of the flap gates as well as a design could not be located in the submittal information.	**The flap gate will be installed within the existing manhole at the location where the new conveyance and treatment system will connect with the existing collection system for Outfall 004. The Final Design Report submittal will include design details for the installation of the flap gate.**	Response is acceptable.		Revision: The flap gate was removed from the plan because the invert elevation of discharge point on the sand filter was moved up to the approximate 25-year flood stage level of the Willamette River. Location: Final Design Report, Section 6.4.
4	Site drainage maps with catchment areas (existing and proposed with the new channel) would be useful for this review.	**Proposed catchment areas are provided in Figure 5-2. Existing catchment areas have been presented previously in the Stormwater Interim Remedial Measures**	EPA recommends that existing catchment area figures be included side-by-side with proposed. DEQ concurs.	LSS will provide the figures.	Revision: Figures with the existing and proposed site drainage maps were provided in the Final Design Report.

[9] City of Portland. 2008. *Stormwater Management Manual. City of Portland, Oregon.* Bureau of Environmental Services. August 1, 2008.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
		Focused Feasibility Study (Integral 2008).			Location: Final Design Report, Figures 2-10 and 6-2.
	Specific Comments				
1	Sheet 1. The titles in the List of Drawings do not match the sheet titles on sheets 5, 8, 10, 12, 14, and 16. Sheets 10 and 12 could be considered typographical errors; however, the other sheets reflect different information between the sheet list and sheet titles.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The titles in the list of drawings and the sheet titles were revised for consistency. Location: Drawings.
2	Sheet 2. The "limits of capture of existing stormwater system/project area" line does not extend to the limits of the berm shown on Sheet 3. The berm and any other construction or disturbance area should be included in the project area line.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The limits of the project area were expanded to include the entire site. Location: Drawings, sheet 2.
3	Sheet 3. There is a label on the West Channel calling out the southeast end as the "West Channel Trench Drain." More information about the design and details of this feature should be provided.	**Comment noted. LSS will include design details of the trench drain that is to extend across the main access gate to Front Avenue in the Final Design Report submittal.**	Response is acceptable.		Revision: Additional details were added regarding the west channel trench drain. Location: Drawings, sheet 4.
4	Sheet 3. Minimum berm height is a key factor and information is available to set the elevation now. This should be included at this design level, notably the small segment in the southwest portion of the site.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response accepted pending hydraulic analysis for peak stages. See item n. in EPA's comment on the LSS response to DEQ general comment 1 (Attachment A) and response to specific comment 17 to the Draft Design Report.		Revision: The berm height was added to sheet 4. Location: Drawings, sheet 4.
5	Sheet 3. This sheet should show the locations of all actions including: detention pond and sand filter; storm channels; storm sewer decommissioning plan; capping plan; and berms.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The locations of all stormwater SCM actions were added to sheet 4. Location: Drawings, sheet 4.
6	Sheet 4. Note 1 states that "*Extents of storm channel indicate extent of decommissioning of existing structures…*" It is unclear how this linear feature can indicate which drainage catchments are served by the proposed channel and can be decommissioned. The decommissioning area limits should be shown on the site plan, in addition to the catchment areas of the proposed channel and the decommissioned storm sewer area. Sheet 9 appears to be more representative of the	**Additional existing structures, beyond what is specified within the decommissioning plan, will be decommissioned to support the installation of the stormwater channels. This note will be modified for clarity in the Final Design Report submittal.**	Response is acceptable.		Revision: A note was added to sheet 5 regarding the decommissioning of utilities along the East Channel. Location: Drawings, sheet 5.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	decommissioning plan.				
7	Sheet 4, Note 2. It appears by this note that manhole decommissioning is limited to the channel corridor whereas manholes throughout the decommissioned storm sewer area will be decommissioned. If there is no difference between these two this note should be deleted.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The note regarding the decommissioning of all manholes within the extents of the storm channel was deleted from sheet 5. Location: Drawings, sheet 5.
8	Sheet 4, Note 3. Delete the words "…on sheet 6" from this note.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The reference in this note was changed to sheet 7. Location: Drawings, sheet 5.
9	Sheet 4. There is no starting or reference location for Station 0+00.00.	**Survey control points, including starting location for Station 0+00.00, will be included in the Final Design Report submittal.**	Response is acceptable.		Revision: Survey control points were added to sheet 5. Location: Drawings, sheet 5.
10	Sheet 4. A horizontal and vertical scale should be included for the channel profile.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: A horizontal and vertical scale was added for the channel profile. Location: Drawings, sheet 5.
11	Sheet 5. Note 1 states that "*Extents of storm channel indicate extent of decommissioning of existing structures…*" It is unclear how this linear feature can indicate which drainage catchments are served by the proposed channel and can be decommissioned. The decommissioning area limits should be shown on the site plan, in addition to the catchment areas of the proposed channel and the decommissioned storm sewer area. Sheet 9 appears to be more representative of the decommissioning plan.	**Additional existing structures, beyond what is specified within the decommissioning plan, will be decommissioned to support the installation of the stormwater channels. This note will be modified for clarity in the Final Design Report submittal.**	Response is acceptable.		Revision: A note was added to sheet 6 regarding the decommissioning of additional structures to support the installation of the stormwater channel. Location: Drawings, sheet 6.
12	Sheet 5, Note 2. It appears by this note that manhole decommissioning is limited to the channel corridor whereas manholes throughout the decommissioned storm sewer area will be decommissioned. If there is no difference between these two this note should be deleted.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The note regarding the decommissioning of all manholes within the extents of the storm channel was deleted from sheet 6. Location: Drawings, sheet 6.
13	Sheet 5. A horizontal and vertical scale should be included for the channel profile.	**Comment noted. The recommendation will be incorporated into the Final Design**	Response is acceptable.		Revision: A horizontal and vertical scale was added for the channel profile. Location: Drawings, sheet 6.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
		Report submittal.			
14	Sheet 5. This appears to be the lead plan sheet for the detention pond and sand filter location and design. There is no information provided indicating a reference location, dimensions, or pipe and outlet locations or dimensions. Dimensions should be given for finished pond bottom to confirm the design volume is provided. A call-out for where details of key design features can be found should also be provided.	**Sheet 8, not Sheet 5, is the lead plan sheet for the detention pond and sand filter location and design. A note will be added to clarify this to the contractor. In addition, the missing information, including reference coordinates, dimensions (including finished pond bottom dimensions), pipe and locations, and references to key design features will be included in the Final Design Report submittal.**	Response is acceptable.		Revision: A note was added to sheet 6 referring to sheet 9 for sand basin and detention basin construction details. Location: Drawings, sheet 6.
15	Sheet 5. The plans are not clear whether the sand filter discharge pipeline is new or existing and if it connects to an existing manhole. It appears to connect to Outfall 4. The decommissioning plan on Sheet 9 seems to point out this manhole in the decommissioning plan but does not explicitly state it should not be plugged.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The 48 in. precast, concrete manhole was added to sheet 6. Location: Drawings, sheet 6.
16	Sheet 5. It is not clear what the note at the downstream end of the sand filter discharge pipeline is instructing.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The note was clarified in sheet 6. Location: Drawings, sheet 6.
17	Sheet 5. The sand filter elevation of 27 feet is not consistent with other details and the actual pond bottom below the sand filter is 26 feet (or possibly 25.5). This sheet could show two elevations – one for the pond bottom elevation below the sand filter and the top of sand filter elevation 18 inches above the bottom.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The elevation of the sand filter was changed in sheet 6. Location: Drawings, sheet 6.
18	Sheet 5. Equipment access into the detention pond for maintenance is not shown but is must be included. This should be configured now to calculate how much pond storage volume should be deducted from the calculated volume.	**Side slopes of 4:1 and 1 ft of rock cover will be adequate to allow access of necessary maintenance equipment. If side slopes are modified, equipment access ramps will be included within both the detention pond and sand filter. This modification, if necessary, will be included within the Final Design Report submittal.**	EPA notes that the crushed rock surface proposed would not be suitable for maintenance equipment.		Revision: Maintenance access ramps were added to the detention pond and sand filter. Location: Drawings, sheet 6.
19	Sheet 6. There is a label on the West Channel	**Comment noted. LSS will include design**	Response is acceptable.		Revision: Additional details on the

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	calling out the southeast end as the "West Channel Trench Drain." More information about the design and details of this feature should be provided at this design stage.	**details of the trench drain that is to extend across the main access gate to Front Avenue in the Final Design Report submittal.**			trench drain were added to sheet 7. Location: Drawings, sheet 7.
20	Sheet 6. Note 1 states that "*Extents of storm channel indicate extent of decommissioning of existing structures…*" It is unclear how this linear feature can indicate which drainage catchments are served by the proposed channel and can be decommissioned. The decommissioning area limits should be shown on the site plan, in addition to the catchment areas of the proposed channel and the decommissioned storm sewer area. Sheet 9 appears to be more representative of the decommissioning plan.	**Additional existing structures, beyond what is specified within the decommissioning plan, will be decommissioned to support the installation of the stormwater channels. This note will be modified for clarity in the Final Design Report submittal.**	Response is acceptable.		Revision: A note was added to sheet 7 regarding the decommissioning of additional structures to support the installation of the stormwater channel. Location: Drawings, sheet 7.
21	Sheet 6. There is no starting or reference location for Station 0+00.00.	**Survey control points, including starting location for Station 0+00.00, will be included in the Final Design Report submittal.**	Response is acceptable.		Revision: Survey control points were added to sheet 7. Location: Drawings, sheet 7.
22	Sheet 6. A horizontal and vertical scale should be included for the channel profile.	**Comment noted. A horizontal and vertical scale will be included in the Final Design Report submittal.**	Response is acceptable.		Revision: A horizontal and vertical scale was added for the channel profile. Location: Drawings, sheet 7.
23	Sheet 6. No channel slope is shown.	**Channel slope can be determined from the elevation and station location. Specific channel slopes will be noted in the Final Design Report submittal.**	Response is acceptable.		Revision: Channel slope call outs were added to sheet 7. Location: Drawings, sheet 7.
24	Sheet 7. Note 1 states that "*Extents of storm channel indicate extent of decommissioning of existing structures…*" It is unclear how this linear feature can indicate which drainage catchments are served by the proposed channel and can be decommissioned. The decommissioning area limits should be shown on the site plan, in addition to the catchment areas of the proposed channel and the decommissioned storm sewer area. Sheet 9 appears to be more representative of the decommissioning plan.	**Additional existing structures, beyond what is specified within the decommissioning plan, will be decommissioned to support the installation of the stormwater channels. This note will be modified for clarity in the Final Design Report submittal.**	Response is acceptable.		Revision: A note was added to sheet 8 regarding the decommissioning of additional structures to support the installation of the stormwater channel. Location: Drawings, sheet 8.
25	Sheet 7. A horizontal and vertical scale	**Comment noted. The recommendation**	Response is acceptable.		Revision: A horizontal and vertical

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	should be included for the channel profile.	**will be incorporated into the Final Design Report submittal.**			scale was added for the channel profile. Location: Drawings, sheet 8.
26	Sheet 8. This sheet and Sheet 5 show the same plan view of the two ponds. LSS should consider including the plan view information and detail call-outs on this sheet on Sheet 5 and eliminate Sheet 8 as redundant. The pipe profiles can be called out on Sheet 5 and shown on a detail sheet or with Sheet 5. Comments provided here for Sheet 8 would apply to Sheet 5.	**Sheet 5 includes details for the construction of the stormwater channel. Please refer to LSS' response to comments on Sheet 5.**	Response is acceptable.		Revision: None required.
27	Sheet 8. There is no reference point for where the ponds will be constructed.	**Survey control points, including reference locations for structure construction, will be included in the Final Design Report submittal.**	Response is acceptable.		Revision: Survey control points were added to sheet 9. Location: Drawings, sheet 9.
28	Sheet 8. The sand filter elevation is 27 feet on this sheet and Sheet 5 but 27.5 feet on Sheet 14.	**Comment noted. Drawing sheets will indicate consistent sand filter elevations based upon the final design in the Final Design Report submittal.**	Response is acceptable.		Revision: The elevation of the sand filter was changed in sheet 9. Location: Drawings, sheet 9.
29	Sheet 8. The detention basin elevation should be labeled as the detention basin bottom elevation.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The term "detention basin elevation" was changed to "detention basin finish grade elevation" on sheet 9. Location: Drawings, sheet 9.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
30	Sheet 8. The detention basin appears to double as a primary settling basin. If this is the case, the length:width ratio should be modified and a baffle is recommended. The City of Portland Stormwater Manual10 recommends a 3:1 ratio and a minimum of two cells, one of which is a forebay with 10 percent of the pond design volume. The concrete block wall with gaps would not create an effective forebay. A second divider berm should be considered to enhance settling.	**Site constraints (e.g., lack of relief, allowing access to all parts of the site, etc.) did not allow for a 3:1 ratio (length:width). In lieu of this requirement, LSS opted for a discharge structure that would allow for continuous discharge along the entire width of the basin (instead of a single point discharge as allowed under the City of Portland Stormwater Manual, which would increase velocities to this point and negate the settling capacity of a large portion of the basin). Further, the "gapped" influent spreader was chosen to minimize the creation of a permanent pond in the forebay. DEQ has stated on multiple occasions the need to minimize these as an attractive nuisance to wildlife. If agreed to by DEQ, the concrete block wall will be modified to create a forebay as a solid, overflow type weir. Also, a second divider berm could then be considered to enhance settling. Pending concurrence by DEQ, these recommendations will be considered in the Final Design Report submittal.**	This issue should be resolved by DEQ. DEQ's position is that the primary focus of the engineering of the detention basin is to achieve the effluent objectives. Engineering modifications for wildlife management are secondary. DEQ is aware that many facilities (e.g., airports) use plastic balls (bird balls) as a wildlife management tool for surface water impoundments.	LSS agrees to build the detention basin (as well as the sand filter) to maximize treatment to the extent practicable.	Revision: A sediment forebay with overflow weir was added to the design of the detention basin. Baffles were added to increase the effective length to width ratio. Location: Drawings, sheet 9.
31	Sheet 8. The concrete block configuration and details should be included at this stage of design. Note 2 and the drawing seem to indicate that there will be gaps in the wall for flow spreading. Flow spreaders are normally flat and continuous with no gaps to concentrate and accelerate flow. If flow distribution across the facility bottom is desired, a flow spreader design detail should be provided and flow dividers in the pond bottom should be considered.	**Please refer to LSS' response to EPA's specific comment 30 on the Stormwater SCM draft design plans and specifications.**	This issue should be resolved by DEQ. DEQ – see above comment.	LSS will incorporate sediment forebay (10%) with overflow weir.	Revision: Please refer to the response to EPA Specific Comment 30 on the Draft Design Plans and Specifications.
32	Sheet 8. The gravel bed holding the transfer pipeline should be indicated on the plan view.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The crushed rock cover for the transfer pipeline was added to sheet 9. Location: Drawings, sheet 9.
33	Sheet 9. Spell out "CLSM" on first use.	**Comment noted. The recommendation**	Response is acceptable.		Revision: The acronym CLSM was

[10] City of Portland. 2008. *Stormwater Management Manual. City of Portland, Oregon.* Bureau of Environmental Services. August 1, 2008.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
		will be incorporated into the Final Design Report submittal.			spelled out on the first use. Location: Drawings, sheet 10.
34	Sheet 9, Note 3. The intent of this note and the overall design appears to be decommissioning of the storm sewer system shown on the plan as well as other pipes found in a zone up to 310 feet away from the groundwater barrier wall alignment. A 310-foot dimension line is shown on the plan. If the 310-foot limit is shown along the entire length of the groundwater barrier wall, a large portion of the storm sewers shown near the center of the sheet would be outside of the 310-foot limit. Rather than giving a distance, it is recommended that the limits of the decommissioning be shown on the plan (and on Sheet 3). The limits should include all of the storm sewers shown on the plan.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The 310-ft dimension was removed from the drawing notes. All pipelines requiring filling with CLSM are indicated on the drawings. Location: Drawings, sheet 10.
35	Sheet 9, Note 4. The 310-foot limit for decommissioning does not extend the length of the storm sewer shown. Rather than give a distance, it is recommend that the limits of the decommissioning be shown on the plan. The limits should include all of the storm sewers shown on the plan.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: Please see revisions to EPA Specific Comment 34 above.
36	Sheet 9, Note 5. The limits of the site-wide manhole and catch basin decommissioning should be shown on Sheet 9 and on Sheet 3 Site Plan.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: All manholes and catch basins requiring decommissioning are shown on sheet 10. Location: Drawings, sheet 10.
37	Sheet 9, Note 5. It appears the manholes and storm sewer segments will be partially demolished to construct the storm channel. Please clarify how stormwater using that system will be handled during construction of the channel and prior to decommissioning.	**Comment noted. The contract specifications, including the modified ESCP (please refer to LSS' response to EPA general comment 5 for modifications to the ESCP) provide details on handling of stormwater during the construction process.**	See response to EPA general comment 5 to Draft Design Report (Attachment B).		Revision: Please refer to the response to EPA General Comment 5.
38	Sheet 9. The direction in which the stormwater system will be decommissioned should be indicated on the plan sheet (e.g., upstream to downstream). Also clarify how water in the system or entering the system during construction will be handled prior to	**Comment noted. Please refer to LSS' response to the previous comment. The direction in which the stormwater system will be decommissioned will be incorporated into the Final Design**	See response to EPA general comment 5 to Draft Design Report (Attachment B).		Revision: The decommissioning work sequence was added as note 6 on sheet 10. Please refer to the response to EPA General Comment 5 for additional information.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	decommissioning.	**Report submittal.**			Location: Drawings, sheet 10.
39	Sheet 9. The Storm Channel Centerline does not show clearly on this sheet.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The drawing was zoomed out so that both storm channel centerlines are visible. Location: Drawings, sheet 10.
40	Sheet 10. The limits of the capping area, which appears to be shown, should be labeled as such. The Site Plan (Sheet 3) should include this boundary.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The capped areas were labeled as such on sheet 11. The capped area boundaries were added to sheet 4. Location: Drawings, sheets 4 and 11.
41	Sheet 10. Several drawing labels block the capping area hatching.	**Comment noted.**	Response is acceptable.		Revision: The drawing labels were moved off the capping area hatching on sheet 11. Location: Drawings, sheet 11.
42	Sheet 10. The limits of the storm channel footprint should be shown and then omitted from the capping area or hatched as not in the capping plan.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The limits of the storm channel footprint were added and the cap hatching was removed from the footprint on sheet 11. Location: Drawings, sheet 11.
43	Sheet 11. The bottom elevation is labeled differently on the two sections (29.0 feet and 29.5 feet)	**Comment noted. Drawing sheets will indicate consistent detention basin elevations based upon the final design in the Final Design Report submittal.**	Response is acceptable.		Revision: The detention basin elevations were made consistent on sheet 13. Location: Drawings, sheet 13.
44	Sheet 11. The block wall, outlet pipe, and fill gravel over the pipe should be shown on Section A, as well as other features that may be added as recommended by other comments (i.e. maintenance access, divider berm, etc.)	**Comment noted. Please refer to LSS' response to comments on maintenance access, divider berms, etc. The block wall, outlet pipe, and fill gravel will be shown on Section A in the Final Design Report submittal.**	See Response to specific comment 30 to the Draft Design Plans and Specifications.		Revision: None required. The intent of this sheet was changed to be an excavation plan rather than a finish grade plan. Location: Drawings, sheet 13.
45	Sheet 11. The Liner Anchor Trench detail call out is shown on the top of bank on three sides and down the slope on the forth. The forth side should be shown on the top as well.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The fourth side of the liner anchor trench detail was added to cross sections A-A and B-B. Location: Drawings, sheet 13.
46	Sheet 11. The Liner System and Anchor Trench should be shown in the section for clarity.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The liner system and anchor trench were added to cross sections A-A and B-B. Location: Drawings, sheet 13.
47	Sheet 11, Note 1. This sheet has no call-outs for the inlets or outlets. Note 1 should be	**Comment noted. The recommendation will be incorporated into the Final Design**	Response is acceptable.		Revision: Note 1 was deleted from

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	deleted or call-outs should be added if they are needed on this sheet.	**Report submittal.**			sheet 13. Location: Drawings, sheet 13.
48	Sheet 11, Note 2. The side slopes should be determined now, using conventions from the City of Portland Stormwater Manual[11] or a site-specific analysis of soil stability. It appears the pond storage was calculated based on the 4:1 slopes and steeper slopes would reduce storage volume, requiring that the pond be enlarged and the modeling redone.	**Please refer to LSS' response to EPA specific comment 19 on the Stormwater SCMs draft design plans and specifications.**	Response is acceptable.		Revision: Please refer to the response to EPA Specific Comment 19 on the Stormwater SCMs Draft Design Plans and Specifications.
49	Sheet 12. The facility is called the Sand Filtration Basin and the Sand Filter System on different sheets. The title should be consistent.	**Commented noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The facility call-out was changed to sand filter on cross sections A-A and B-B. Location: Drawings, sheet 14.
50	Sheet 12. The sand filter elevation is labeled differently on most sheets (27.5 feet) from the detail on Sheet 14.	**Comment noted.**	Response is acceptable.		Revision: The sand filter elevation was changed on sheet 14 for consistency between the drawings. Location: Drawings, sheet 14.
51	Sheet 12. The concrete block walls and sand filter bed with underdrain pipes should be shown on the sections.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: None required. The intent of this sheet was changed to be an excavation plan rather than a finish grade plan. Location: Drawings, sheet 14.
52	Sheet 12. The Liner System, Anchor Trench, and Sand Filter should be shown in the section for clarity.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The anchor trench and sand filter were added to sheet 14. The liner system was added to sheet 15. Location: Drawings, sheet 14 and 15.
53	Sheet 12. Note 1. This note should be deleted or alternatively call-outs should be added if they are needed on this sheet. Design features on Sheet 8 should be added to this section.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: Note 1 was deleted from sheet 14. Location: Drawings, sheet 14.
54	Sheet 12. Note 2. The side slopes should be determined now, using conventions from the City of Portland Stormwater Manual5 or a site-specific analysis of soil stability. It appears the pond storage was calculated based on the 4:1 slopes and steeper slopes would reduce storage volume, requiring that the pond be enlarged and the modeling redone.	**Please refer to LSS' response to EPA specific comment 19 on the Stormwater SCMs draft design plans and specifications.**	Response is acceptable.		Revision: Please refer to the response to EPA Specific Comment 19 on the Stormwater SCMs Draft Design Plans and Specifications.
55	Sheet 12. The liner anchor call out convention	**Comment noted. The recommendation**	Response is acceptable.		Revision: The call-outs have been

[11] City of Portland. 2008. *Stormwater Management Manual. City of Portland, Oregon*. Bureau of Environmental Services. August 1, 2008.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	is inconsistent. The detail is referenced to Sheets 11 and 12 on Section B-B, and Sheet 12 on Section A-A.	**will be incorporated into the Final Design Report submittal.**			changed for consistency. Location: Drawings, sheet 14.
56	Sheet 13. The concrete block configuration and details should be included at this level of design. Note 1 and the drawing seem to indicate that there will be gaps in the wall for flow spreading. Flow spreaders normally are flat and continuous with no gaps to concentrate and accelerate flow. If flow distribution across the facility bottom is desired, a flow spreader design detail should be provided and flow dividers in the pond bottom should be considered.	**Please refer to LSS' response to EPA's specific comment 30 on the Stormwater SCM draft design plans and specifications.**	This issue should be resolved by DEQ. DEQ – see response to comment 30	LSS will incorporate sediment forebay (10%) with overflow weir.	Revision: The detention basin design was modified to include a sediment forebay with overflow weir. Please see the response to EPA Specific Comment 30 on the Stormwater SCMs Draft Design Plans and Specifications for additional information. Location: Drawings, sheet 15.
57	Sheet 13. The inlet scour protection area should be shown and dimensioned in the plan view. The cross section should include dimensions and minimum thicknesses.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The inlet scour protection area was shown in plan view (sheet 9) and cross section (sheet 16). Location: Drawings, sheets 9 and 16.
58	Sheet 13. The wall cross section detail has no dimension for crushed rock thickness. It is not clear if the 12-inch thickness shown for the liner system is intended.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: Dimensions for the thicknesses of crushed rock and leveling sand were added to the block installation diagram on sheet 15. Location: Drawings, sheet 15.
59	Sheet 13. The detention basin inlet detail is called out on Sheet 5 as well as 7 and 8 as indicated.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: All detail call-outs were corrected. Location: Drawings.
60	Sheet 14. The location where Section A was cut is not referenced	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The location of cross section A was provided on sheet 17. Location: Drawings, sheet 17.
61	Sheet 14. The sand filter elevation of 27.5 feet is not consistent with other sheets. The crushed rock elevations are not shown on other sheets as different from the sand filter elevation.	**Comment noted.**	Response is acceptable.		Revision: The sand and crushed rock elevations in the sand filter were made consistent with the other sheets. Location: Drawings, sheet 17.
62	Sheet 14. The underdrain pipes in the sand filter should be depicted on this section. Passage for the underdrain pipes get through the concrete blocks should be shown. Also clarify what the underdrain pipes are connected to at the downstream end.	**Comment noted. The underdrain pipes pass under the effluent concrete weir and are open to the effluent clear well at the downstream end of the sand filter. The recommended change will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The underdrain pipes were added to the cross sections on sheet 17. Location: Drawings, sheet 17.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
63	Sheet 14. The elevation and profile of the underdrain pipes should be shown. It appears that the inverts shown in the section detail would be lower than elevation 26 feet by as much as 6 inches, which would be 6 inches lower than the sand filter pond outlet. This means that the underdrains would not drain and would likely be saturated all of the time. If the sand filter performance relies on the underdrains, the facility as designed would not meet the design flow capacity. There appears to be no way for water to leave the sand filter other than over the block wall.	**Comment noted. Underdrain design, under this condition, will take into consideration full pipe flow to meet design flow capacity. The recommendation will be incorporated into the Final Design Report submittal.**	Response pending hydraulic analysis. See items m. and n. in EPA's comment on the LSS response to DEQ general comment 1 (Attachment A).		Revision: The underdrain system was modified and the invert to the outlet of the sand filter is now at or slightly below the invert of the underdrain pipe. Location: Drawings, sheet 17.
64	Sheet 14. The block wall, which appears continuous in the sand filter, has a downstream elevation of 31 feet, which means that the water level could rise to this elevation without discharging. The bottom elevation of the detention pond is 29.5 feet, which means there could be a backwater effect from the sand filter up through the system into the storm channels. This backwater effect should be calculated, the storage adjusted if needed, and the elevations of the entire system and storm channel adjusted to prevent standing water in the channels during the design storm.	**Please refer to LSS' response to EPA specific comment 17 on the overall draft design report.**	See items m. and n. in EPA's comment on the LSS response to DEQ general comment 1 (Attachment A) and response to specific comment 17 to the Draft Design Report.		Revision: The backwater effects were calculated and are addressed in the HydroCAD modeling report. DEQ's requirement for the stormwater design is to backup water onto the site. Please see DEQ Specific Comment 30 for additional information. Location: Appendix J (HydroCAD Modeling Reports).
65	Sheet 14. Please clarify why the entrance block wall elevation is higher than the sand filter bed. The block wall should act as an energy dissipater and flow spreader, but it should not store water.	**The entrance block wall elevation is higher than the sand filter bed to allow for modifications to the filtration media in the future under the adaptive management approach. Regardless of whether the block wall is above or at the elevation of the sand filter bed, water will be stored behind the wall; it only changes the volume of water stored.**	Response is acceptable.		Revision: None required.
66	Sheet 14. It appears from the sections and details that the liner system would extend to the walls of the sand filter. This will create a preferential pathway for the water (gravel versus sand), thereby avoiding the filtering benefits of the sand filter. It is recommended that the liner system not be used as shown in	**Please clarify. The liner system will be sealed, as per manufacturer recommendations, against both the influent and effluent block wall. No preferential pathway for water will be created.**	The section shows a crushed rock layer on top of the liner in the sand filter, which would allow stormwater to follow the gravel layer instead of the sand filter. The detail needs revision showing that there is no crushed rock on top of the liner in the sand filter area.		Revision: Sand filter material has been extended to the geomembrane liner to remove any preferential flow pathways. Location: Drawings, sheet 17.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	the filtering area and it be modified to optimize sand filter performance.				
67	Sheet 14. It is recommended that the sand filter bed have a slight slope toward the center of the bed. EPA believes that bypasses or poor filtering can occur along the contact of the sand bed with the wall of the facility, and a slight slope will focus most of the stormwater in flows smaller storms to the center of the filter.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: A slope of 0.2 percent toward the center of the sand filter was added to sheet 17. Location: Drawings, sheet 17.
68	Sheet 14. Please clarify the purpose of the crushed rock downstream of the block wall. Also clarify if there will be an energy dissipater or splash pad should the downstream block wall overflow.	**The crushed rock downstream of the block wall is in place as a protective covering to the geomembrane liner. It is not anticipated that an energy dissipater or splash pad is required downstream of the block wall overflow.**	Response is acceptable.		Revision: None required.
69	Sheet 15, Detail 1501, 1502, and 1503. The details appear to show the water depth (indicated by dashed line) varying based on slope. The slope does not vary on any section at any location (s= -0.001) so this water depth can be shown. The section should have a minimum design freeboard indicated.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The water height was removed from channel sections 1901 through 1905 on sheet 19. Location: Drawings, sheet 19.
70	Sheet 15, Detail 1503, 1504, and 1505. The typical berm sections shown with a 1:1 side slope and 1 foot wide top, capped by ¾ minus crushed rock, appear to be unbuildable and unstable. A standard design from an approved drainage or stormwater manual or a design by a geotechnical engineer should be provided.	**Please refer to LSS' response to EPA specific comment 24 on the overall draft design report.**	Response is acceptable pending review of additional information to be provided in the final design.		Revision: The typical berm side slopes in sections 1905, 1907, and 1908 were changed to a 2H:1V. Location: Drawings, sheet 19.
71	Sheet 15, Note 1. Minimum berm height is a key factor and information is available to set the elevation now. This should be included at this design level.	**Comment noted.**	Response is acceptable.		Revision: The minimum berm height was provided in note 1 on sheet 19. Location: Drawings, sheet 19.
72	Sheet 16, Detail 1601. The detention basin bottom is shown at 28.5 feet on this sheet. It is 29.5 feet elsewhere.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The detention basin bottom elevation was changed to 30 ft on sheet 16 and is consistent with the other drawing sheets. Location: Drawings, sheet 16.
73	Sheet 16, Detail 1601. The call-out for upstream end of pipe invert shows 4" PVC pipe. This should be 24" PVC pipe.	**Comment noted. The recommendation will be incorporated into the Final Design Report submittal.**	Response is acceptable.		Revision: The detail was modified on sheet 16. Location: Drawings, sheet 16.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
	EPA Comments				
	Additional Comments				
	Attachment A				
			EPA provided the following review comments on the LSS responses to DEQ general comment 1. DEQ is forwarding this set (DEQ general comment 1) of EPA's review comments for LSS's reference and consideration in revisions to the system design. In general the EPA comments include detailed recommendations that address the substance of DEQ's issues regarding the lack of supporting documentation for the system design and for the goals of the updated performance monitoring plan (e.g., decision tree). EPA Comment on LSS Response to DEQ general comment 1 a) The response provided to the DEQ general comments clearly represents the position of LSS. The fundamental issue is to determine the most appropriate way to achieve a responsible level of protection and reduction of COPCs in stormwater at the site. The first consideration is establishing the acceptable and responsible loading rate. Then, the following uncertainties must be addressed: the unknowns such as loading and potential removal rates; and inherent variability of the hydrology (precipitation and site runoff response) and hydraulics (conveyance, pond stages, and river stages); the reasonably expected SCM performance; and the monitoring and	LSS agrees to provide supporting documentation for the system design and for the goals of the updated Performance Monitoring Plan. The remainder of this comment, for the most part, contradicts agreements within the MAO between LSS and DEQ. To the extent they do not conflict with the terms of the MAO or contradict DEQ comments, LSS will address the comments.	Revision. a). No Revision Necessary. b). Performance Monitoring considers the components in the Performance Monitoring Plan and associated Decision Tree Analysis as indicated to address previous comments. • Target concentrations and loading rates leaving the site will be evaluated during performance monitoring. • Treatment technologies proposed were as agreed to in the MAO. • Expected COPC removal performance of the technologies are presented in Section 3.0 of the Design Report and will be used as a baseline for assessing performance. • Design storm that should be fully treated without bypass as presented in Section 3.0 of the Design Report. • Allowable or desirable stages, system recovery rates, overflows, bypasses, flooding, and hydraulic performance, are considered in Section 3.0 and in Performance Monitoring (Section 8.0 and the Performance Monitoring Plan) to the extent possible given DEQ's request to back up stormwater onsite as necessary to fully filter the 25-year, 24-hour storm. • Monitoring of treatment performance and physical

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
			response system. b) The performance measures should consider: • Target concentrations/loading rates leaving the site, • Treatment technologies proposed, • Expected pollutant removal performance of the technologies, • Design storm that should be fully treated without bypass, • Allowable/desirable stages, system recovery rates, overflows, bypasses, flooding, and hydraulic performance, • Monitoring of treatment performance and physical components, • Performance triggers, actions, and schedules for response. c) The basis for selecting the design standards, the monitoring, and treatment system upgrades is to provide an appropriate system with a starting point that considers the unknowns and uncertainty, considers risks of failure, evaluates the range of potential system response and performance, builds in contingency, and is designed to be upgraded with minimal disturbance or down time. Uncertainty leads to the need to provide more initial protection, more effective control measures, and faster responses to monitoring. It is not appropriate to leave all uncertainty and contingency to adaptive management – there needs to be a reasonable balance. d) LSS states that "because treatability testing was not conducted, the levels presented in Table 1-1 are not a basis for design of the SCMs." They go on to say that "pending a determination of technical infeasibility, it is DEQ's intent that the SCMs		components are provided in the Performance Monitoring Plan. • Performance triggers, actions, and schedules for response are included in Tables 8-2 and 8-3 of Section 8 of the Final Design Report. c). Uncertainty has been addressed by determining anticipated SCM performance in meeting the Table 1-1 goals (Section 3.0 of the Final Design Report) as well as providing a decision tree for incorporating adaptive management approaches (Section 8.0 of the Final Design Report). d) Technologies employed are as agreed to in the MAO. e) Table 1-1 values will be used as the goals of the stormwater system to the extent achievement of these goals is technically practicable as agreed to in the MAO. Stormwater effluent concentrations will be compared to these goals as outlined in Section 8.0 to employ the adaptive management process if necessary. f) Technologies employed are as agreed to in the MAO. g) Technologies employed are as agreed to in the MAO. Feasibility analysis of additional technologies which may be contemplated will be made during the adaptive management process. Technologies given are those that may be potentially applicable to

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
			achieve the levels set forth in Table 1-1." In other words, they are proposing a presumptive stormwater treatment design based on "normal" constituents found in stormwater (the basis for design) rather than for actual constituents expected in the runoff. Further, LSS has proposed that the selected presumptive stormwater management SCMs are technically feasible and by exclusion that other known applicable SCMs are technically infeasible. An analysis of known, site-applicable, and technically feasible SCMs (an available and applicable technology evaluation) should be made to understand the suite of options available for implementation now and/or to be implemented in response to the adaptive management plan. e) The treatment target levels presented in Table 1.1 are reasonable for selecting technology, evaluating performance levels, and measuring progress. They provide a basis for selecting technology that would have a "reasonable potential" for achieving the targets. An analysis of this reasonable potential should be conducted to evaluate the expected effluent performance of the proposed system. The expected range of influent concentration, treatment rates, effluent concentration and loading should be evaluated. If the system as designed, using SCMs from the available and applicable technology evaluation, is not expected to meet the targets as proposed, additional measures should be proposed now and not left to adaptive management. EPA has concerns with a system that has limited potential of meeting the targets under		the site. i) SCM performance analysis has been provided in Section 3.0 of the Design Report. j & k) SCM performance analysis utilizing removal efficiencies from other sites has been provided in Section 3.0 of the Design Report. l) The SCMs are expected to have the ability to meet the goals as per Section 3.0 of the Design Report. Technologies employed are as agreed to in the MAO. m) A hydraulic analysis has been conducted and included as indicated in Appendices I, J, and K. n) Hydraulic performance parameters have been included within the design to the extent they agree with DEQ's request to back up stormwater onsite to the extent feasible to allow for the maximum extent practicable treatment via filtration. o) performance monitoring elements have been included in Section 8.0 and Tables 8-2 and 8-3 of the Final Design Report.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
			most circumstances when available and applicable technology could improve the potential of meeting those targets. f) The risk management strategy must be based on installing treatment measures to minimize reasonable potential of exceeding concentration and loading targets using available technology. Because of the reliance on presumptive stormwater treatment, the site should apply all available reasonable technology regardless of expected performance determined in the reasonable potential analysis (RPA). If there is too much uncertainty in SCM performance, additional consideration of source controls should be made in advance of installing the proposed treatment system. g) The selected technologies, settling and sand filtration, are "passive" technologies that primarily rely on physical settling or filtration through means that do not require an operator, power, or frequent and on-going maintenance, cleaning, or replacement. The reliance on passive technology is reasonable, provided the reasonable potential analysis demonstrates it is likely that targets will be met under most circumstances. However, in place of a treatability study an analysis of known, site-applicable, and technically feasible technology that relies on all passive techniques, such as enhanced filtration or settling, should be made and evaluated prior to implementation of the proposed SCM. h) LSS lists four technologies to be considered after performance monitoring. This apparently		

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
			represents the outcome of a feasibility evaluation made by LSS, which has not been provided. The feasibility evaluation should describe other technologies considered and what evaluation criteria were used to eliminate technologies not included. Two of the technologies, addition of carbon and addition of silt curtains, are passive concepts that should be applied regardless of the outcome of the RPA as feasible, presumptive SCMs. If the RPA does not find that the proposed SCMs are likely to meet the targets, then the other proposed technologies or perhaps technology rejected in the feasibility evaluation must be considered. i) The expected performance of the selected SCM should first consider an influent concentration based on the 90th percentile of measured effluent. While future discharges are expected to vary based on site disturbance for construction and future source controls from capping, it is a reasonably expected concentration. The influent volume should be based on the maximum runoff from the sampled events up to the water quality design, if applicable. j) Detention settling performance should be based on calculated removal rates in the facility or from SCM performance data bases using known influent characteristics. In addition, SCM performance evaluations have found that a small range of effluent concentrations can be expected and that influent and removal rates are more highly variable and a less reliable measure of		

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
			expected performance (e.g. ASCE BMP database http://www.bmpdatabase.org/). Estimated effluent rates from similar facilities should be reviewed to determine if targets from Table 1-1 could be reasonably expected to be met. k) The process should be repeated for the sand filter. The treated and untreated influent (effluent from the detention settling) should be evaluated. l) If the proposed facilities have a low potential to perform and meet targets, additional feasible SCMs determined from the technology evaluation described above should be considered. If all proposed facilities are not expected to achieve targets, the feasibility review should be reconsidered and the potential risk of discharges reevaluated. m) The design storm selected for detention settling and sand filter are appropriate for the potential occurrence and the subsequent discharges. However, a hydraulic analysis should be performed to evaluate whether the system will actually perform during those storm events under reasonably expected conditions. n) The following system hydraulic performance requirements are recommended: • No bypass and full treatment of the design storm with no backwater effects in the sand filter with the river level at the 10-year flood stage.		

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
			• With river at 100 year stage, full containment of all runoff on the site. • With sand filter at peak stage for design storm, the detention settling at full performance with no sand filter peak stage backwater effect. • The peak design storm stage in the settling pond is at or lower than the invert of the conveyance channel. • The detention settling and sand filter capacity 75 percent restored 72 hours after the start of the storm event. • All runoff from the site passes through the treatment system with no untreated flow bypass o) Performance monitoring should include the additional effluent monitoring as described in the Performance Monitoring Plan and address certain physical elements of the system, which include but are not limited to: • Peak stages exceeding design stages • Drawdown and recovery times • Bypasses • Accumulated sediment and visual blockage • Preferential pathways and water escaping the sand filter without full treatment for the design storm (e.g. around the filter fabric via gravel layer, at fabric/sand interface • Blockages of any structures • Preferential flow paths through the detention settling or sand filter • Erosion on side slopes, facility bottom, collection channel, and around inlets, outlets and		

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
			overflows • Build up of fines in detention basin, reducing capacity and detention time. Re-suspension during high flows. • Buildup of fines on surface of filter bed and filter occlusion • Decreases, or increases, in filtration rates Supplemental Comment on Proposed Monitoring Plan EPA also has the following supplemental comment on the proposed monitoring plan presented in LSS" response to DEQ general comment 1: The monitoring program does not include a data evaluation and interpretation or a response schedule. In lieu of a robust evaluation of technologies and predicted effluent, there must be an action/response plan that corresponds to on-going effluent water quality monitoring results. It is not acceptable to delay water quality treatment decisions until a year of monitoring are available, additional months of interpretation and reporting, design and approval of SCM modifications, and construction time, a process that could easily stretch into two years, to refine the system so that it has a reasonable potential to meet the targets. An acceptable monitoring and response plan should include at least two ""triggers" for action: an observed, physical problem, such a blockage, erosion, or structural failure, and an effluent concentration trigger that requires a predefined response within certain time frames.		

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
			Physical problems could include reduced filtering or screening as particles block the pore spaces within the media. Without backwashing, occlusion of the filter by the build-up of fines is a primary concern. This typically occurs close to the surface but some materials may also migrate into the bed for a distance. The uneven build up of fines on the filter surface can also promote the formation of preferential flow paths and filter bypass. Inspection and maintenance scenarios should be evaluated and procedures for restoring hydraulic capacity and maintaining even loading should be developed. Since the partitioning of COPCs remains in question the filter should target the removal of particulates over the entire size distribution. The gradation of the filter sand should be evaluated along with potential use of multiple layers at different gradations. Rather than failing hydraulically, as in the physical screening, filter breakthrough becomes the concern when the media reaches its capacity. Performance monitoring should include water quality samples of the filter effluent. If breakthrough is detected, a plan for replacing, or restoring, the media should be available for immediate implementation. The effluent concentration trigger could be, for example, based on the limits established on Table 1-1; exceeding a predicted performance concentration for the selected technology; or a cumulative loading result. Each exceedence should trigger an action or series of actions. For example, the first exceedence can result in		

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
			a review of the system, search for causes, and report of controls and actions that can be taken to improve the performance of the proposed system. A second exceedence should result in a pre-determined upgrade to the next feasible technology (within a predetermined time-frame), at which time the clock would restart. This process would repeat until or unless effluent was completely eliminated or the source was completed controlled (via capping). As described in EPA's comment on the LSS response to DEQ's general comment 1, the level of response and adaptive management approach should be balanced with the level of SCMs applied. The lower the risk and greater the certainty of the proposed system, the less rigorous the monitoring and response. The following are EPA's review of LSS responses to their comments on the draft design. DEQ has added clarifications as necessary.		
			Attachment B DEQ agrees with EPA that additional detail regarding stormwater management during construction is needed in the revised design. We understand that the interpreted project sequencing identified in the EPA table below is not reflective of current LSS plans. DEQ is particularly interested in how stormwater from work areas will be managed to prevent fouling of the sand filter and want to avoid using the performance monitoring plan to resolve the whether it has to be replaced. EPA Review Comment The response provided with additional detail includes acceptable measures for deployment of runoff control during	As per previous comments, LSS agrees to modify the construction schedule to allow use of the detention basin and sand filter during construction. After construction is complete, these components will be "cleaned", if necessary.	Revision: Stormwater will be managed in accordance with DEQ's agreement with LSS. The construction schedule was modified to allow use of the detention basin and sand filter during construction. The detention basin and sand filter will be inspected following all site construction activities, and if necessary, cleaned prior to implementation of the full-scale system.

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
			construction. However, additional details on the sequencing of events and related stormwater controls are lacking. In general, the sequencing of the project appears to be as shown in the following table. EPA has added the expected stormwater control measures that correspond to each project sequence. In general, no stormwater from work areas can be discharged to surface waters without advanced treatment or discharge to an approved facility that can accept this water.		

Project phase	Actions	Stormwater handling
Mobilization	Install TESC measures; minimize disturbance; no discharges to drainage system from disturbed areas	Stormwater from disturbed areas collected and discharged to approved location that accepts this water
Decommission storm sewer	Isolate decommissioning area from drainage; provide bypass of “clean” stormwater to existing discharge	Stormwater in work area collected and discharged to approved location that accepts this water

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)			Agreements (Week of June 27, 2011)	Revision Summary and Location
				points; collect active area stormwater			
			Construct groundwater wall	Isolate construction area from drainage; provide bypass of "clean" stormwater to existing discharge points; collect active area stormwater	Stormwater and groundwater in work area collected and discharged to approved location that accepts this water		
			Capping	Isolate capping area from drainage; provide bypass of "clean" stormwater to existing discharge points; collect active area stormwater	Stormwater in work area collected and discharged to approved location that accepts this water		
			Construct stormwater collection system	Isolate construction area from drainage;	Install temporary stormwater control		

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)			Agreements (Week of June 27, 2011)	Revision Summary and Location
				provide bypass of "clean" stormwater to existing discharge points; collect active area stormwater	system. Discharge only if standards are met or provide active treatment (e.g. coagulation) or offsite discharge.		
			Construct stormwater control system	Isolate construction area from drainage; provide bypass of "clean" stormwater to existing discharge points; collect active area stormwater. Do not discharge construction stormwater to control system	Install temporary stormwater control system. Discharge only if standards are met or provide active treatment (e.g. coagulation) or offsite discharge.		
			Stabilize site	Stabilize and cap or revegetate	When site is stable, discharge to		

No.	Agency Comment (February 15, 2011)	LSS Response (March 17, 2011)	Agency Response (June 16, 2011)	Agreements (Week of June 27, 2011)	Revision Summary and Location
			site stormwater control system and begin monitoring In addition, a plan and measures to control/treat/dispose of stormwater from the site while the future control measures are under construction has not been described. A plan for handling and discharge of all collected stormwater must be developed. Care must be taken that the provisions for maximum allowable flooding do not result in site dewatering and pumping of water to the surface water system or existing discharge points.		

STORMWATER SOURCE CONTROL MEASURES
FOR
FORMER ARKEMA, INC. FACILITY
PORTLAND, OREGON

SEPTEMBER 2011

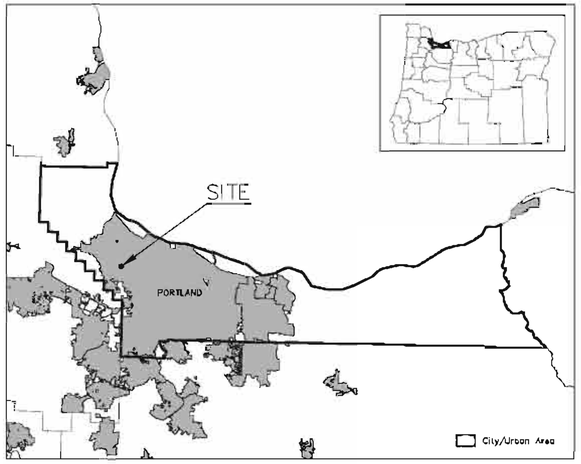
PREPARED FOR:

LEGACY SITE SERVICES, LLC
468 THOMAS JONES WAY
EXTON, PENNSYLVANIA 19341-2528

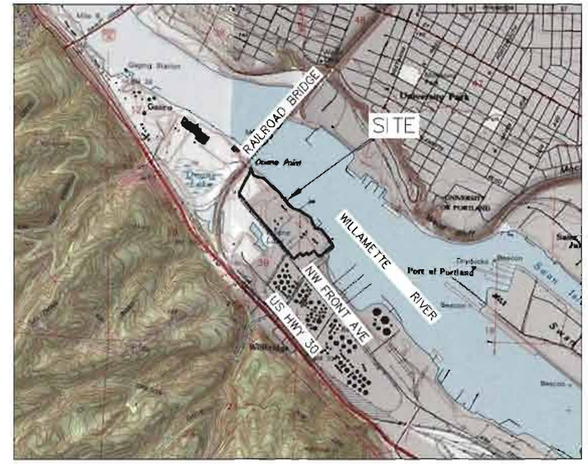
MICHAEL J. MARTIN P.E.
Oregon Professional Engineer License No. 81288PE

PREPARED BY:

INTEGRAL CONSULTING INC.
319 SW WASHINGTON ST., SUITE 1150
PORTLAND, OR 97214



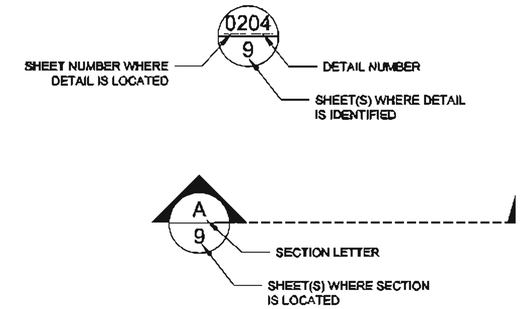
MULTNOMAH COUNTY, OREGON



SITE VICINITY MAP

USGS 7.5' QUADRANGLE PORTLAND
SECTIONS 13 AND 18
T1N, R1E/R1W

DETAIL AND SECTION REFERENCING



LIST OF DRAWINGS

SHEET NO.	TITLE
	COVER SHEET
1	LOCATION MAPS AND GENERAL NOTES
2	EXISTING CONDITIONS AND SITE LAYOUT
3	EXISTING CONDITIONS - UTILITIES
4	SITE PLAN
5	EAST CHANNEL PLAN AND PROFILE
6	EAST CHANNEL PLAN AND PROFILE, DETENTION BASIN AN SAND FILTER
7	WEST CHANNEL PLAN AND PROFILE
8	WEST CHANNEL PLAN AND PROFILE
9	DETENTION BASIN, SAND FILTER, AND PIPING PLAN AND PROFILE
10	DECOMMISSIONING PLAN
11	TEMPORARY CAPPING
12	SALT PITS
13	DETENTION BASIN EXCAVATION CROSS SECTIONS
14	SAND FILTER EXCAVATION CROSS SECTIONS
15	DETENTION BASIN DETAILS (1 OF 2)
18	DETENTION BASIN DETAILS (2 OF 2)
17	SAND FILTER DETAILS (1 OF 2)
18	SAND FILTER DETAILS (2 OF 2)
19	STORM CHANNEL AND BERM DETAILS
20	TRENCH DRAIN AND CURB DETAILS

GENERAL NOTES

1. SCALES ARE NOTED ON EACH DRAWING.
2. THE GENERAL NOTES AND LEGEND ON THIS SHEET APPLY TO ALL DRAWINGS, EXCEPT OTHERWISE NOTED.
3. GROUND SURFACE ELEVATIONS SHOWN ARE BASED ON A LIDAR SURVEY PERFORMED BY THE US ARMY CORPS OF ENGINEERS IN 2010 AND A TOPOGRAPHIC SURVEY PERFORMED BY DAVID EVANS AND ASSOCIATES IN 2007. ELEVATIONS SHOWN IN FEET ABOVE SEAL LEVEL (AMSL), NAVD 88. HORIZONTAL CONTROL IS BASED ON OREGON STATE PLANE COORDINATE SYSTEM (NORTH), NAD 83.
4. EXISTING CONTOUR LINES ARE SHOWN AT 2-FOOT INTERVALS, UNLESS OTHERWISE NOTED
5. CONTRACTOR SHALL ENSURE THAT CONSTRUCTION ACTIVITIES DO NOT INTERFERE WITH SITE ACTIVITIES AT ANY TIME.
6. CONTRACTOR SHALL COMPLY WITH ALL REQUIREMENTS OF SITE HEALTH AND SAFETY THROUGHOUT CONSTRUCTION.
7. IN THE EVENT THAT THE DRAWINGS AND TECHNICAL SPECIFICATIONS CONFLICT, THE DRAWINGS SHALL TAKE PRECEDENCE OVER THE SPECIFICATIONS.
8. BENCHMARKS, MONUMENTS, AND PROPERTY MARKERS SHALL BE PROTECTED AT ALL TIMES AND SHALL NOT BE DISTURBED BY CONSTRUCTION ACTIVITIES.
9. CONTRACTOR SHALL BE RESPONSIBLE FOR NOTIFYING THE OREGON UTILITY NOTIFICATION CENTER AT 1-800-332-2344 THREE DAYS PRIOR TO THE START OF ANY EXCAVATION WORK.
10. CONSTRACTOR SHALL CONTRACT AN APPROVED PRIVATE UTILITY LOCATOR FOR MARKOUT OF OWNER UTILITIES.

LEGEND

- FOUND MONUMENT
- D.E.A. CONTROL
- CATCH BASIN
- FIRE HYDRANT
- FIRE DEPARTMENT CONNECTION
- POWER POLE
- MANHOLE
- UTILITY VALVE
- UTILITY RISER
- BORE HOLE
- MONITOR WELL
- BOLLARD
- CHAIN LINK FENCE
- EASEMENT
- EDGE OF CONCRETE/FOUNDATION
- EDGE OF PAVEMENT
- EDGE OF WILLAMETTE RIVER 15.93' ELEV ON 5/03/06
- PROPERTY LINE
- RAILROAD TRACKS
- TOP OF BANK
- SD — INDUSTRIAL STORMWATER DRAIN
- DS — DOMESTIC SEWER
- W — CITY WATER LINE
- RW — RIVER WATER LINE
- S — STEAM LINE
- DW — DOMESTIC WATER LINE
- E — OVERHEAD ELECTRIC/UTILITY LINE
- B — BRINE LINE

ABBREVIATIONS

AC	ASPHALT/CONCRETE
CB	CATCH BASIN
CONC	CONCRETE
CLSM	CONTROLLED LOW-STRENGTH MATERIAL
G	GAS
GWBW	GROUNDWATER BARRIER WALL
MH	MANHOLE
OHP	OVERHEAD POWER
P	POWER
PP	POWER POLE
PVC	POLYVINYL CHLORIDE
RR	RAILROAD
SAN	SANITARY SEWER
STM	STORM SEWER
T	TELEPHONE
UNK	UNKNOWN
W	WATER
W/	WITH

ISSUE FOR REVIEW AND COMMENT PURPOSE NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	APP
0			
1			
2			
3			
4			
5			
6			

DRW EB	DATE 9-30-11	
DSN MJM	DATE 9-30-11	
CHK	DATE	
DWG SCALE		
DWG No.		C250
PROJ No.		

REGISTERED PROFESSIONAL ENGINEER 81268PE OREGON MAY 13, 2008 MICHAEL J. MARTIN
EXPIRES 12/31/2012

integral consulting inc.

LEGACY SITE SERVICES, LLC
STORMWATER SOURCE CONTROL MEASURES
FORMER ARKEMA, INC. FACILITY PORTLAND, OREGON
LOCATION MAPS AND GENERAL NOTES

SHEET **1** OF 20 REV 1

LEGEND

- LIMITS OF PROJECT AREA
- LIMITS OF CAPTURED EXISTING STORMWATER COLLECTION SYSTEM
- PAVED AREAS
- CONCRETE/FOUNDATION
- EXISTING CONTOUR

NOTES

1. ELEVATIONS ARE BASED ON NORTH AMERICAN VERTICAL DATUM (N.A.V.D.) OF 1988. THE NGS BENCHMARK USED IS LOCATED AT THE SOUTHWEST CORNER OF THE RAILROAD BRIDGE WING WALL, IDENTIFIED AS "D 718". THE NGS POINT WAS COMPARED TO THE CITY OF PORTLAND BENCHMARK LOCATED AT THE NORTHEAST CORNER OF N.W. FRONT AVE. AND N.W. 61ST AVE., IDENTIFIED AS "2529". THE N.A.V.D. DATUM WAS FOUND TO BE 1.98 FEET HIGHER THEN THE CITY OF PORTLAND DATUM.
2. THE BASIS OF BEARINGS FOR THIS SURVEY IS THE OREGON COORDINATE SYSTEM, NORTH ZONE, ESTABLISHED THROUGH GLOBAL POSITIONING SYSTEM (GPS) AND BEING NORTH AMERICAN DATUM OF 1983, 1998 ADJUSTMENT.
3. IT IS THE CONTRACTOR'S RESPONSIBILITY TO FIELD VERIFY ACTUAL SITE CONDITIONS PRIOR TO THE START OF ANY WORK. THERE IS NO GUARANTEE ON THE COMPLETENESS OF THE EXISTING CONDITION INFORMATION. ANY DISCREPANCY SHALL BE BROUGHT TO THE IMMEDIATE ATTENTION OF THE OWNER PRIOR TO THE START OF WORK.
4. FILL MATERIALS COMPRISE THE UPPER 15 TO 25 FEET OF THE SUBSURFACE AT THE SITE. PLEASE REFER TO THE TECHNICAL EXHIBIT FOR ADDITIONAL SUBSURFACE CONDITION INFORMATION.
5. AERIAL SOURCE: METRO, JUNE, JULY 2009

N

0 100 200FEET

ISSUE FOR REVIEW AND COMMENT PURPOSE
NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	APP
0			
1			
2			
3			
4			
5			
6			

DRW EB	DATE 9-30-11	
DES MJM	DATE 9-30-11	
CHK	DATE	
DWG SCALE	1"=100'	
DWG No.	3	
PROJ No.	C250	

REGISTERED PROFESSIONAL ENGINEER 81288PE OREGON MAY 13, 2008 MICHAEL J. MARTIN

EXPIRES 12/31/2012

integral consulting inc.

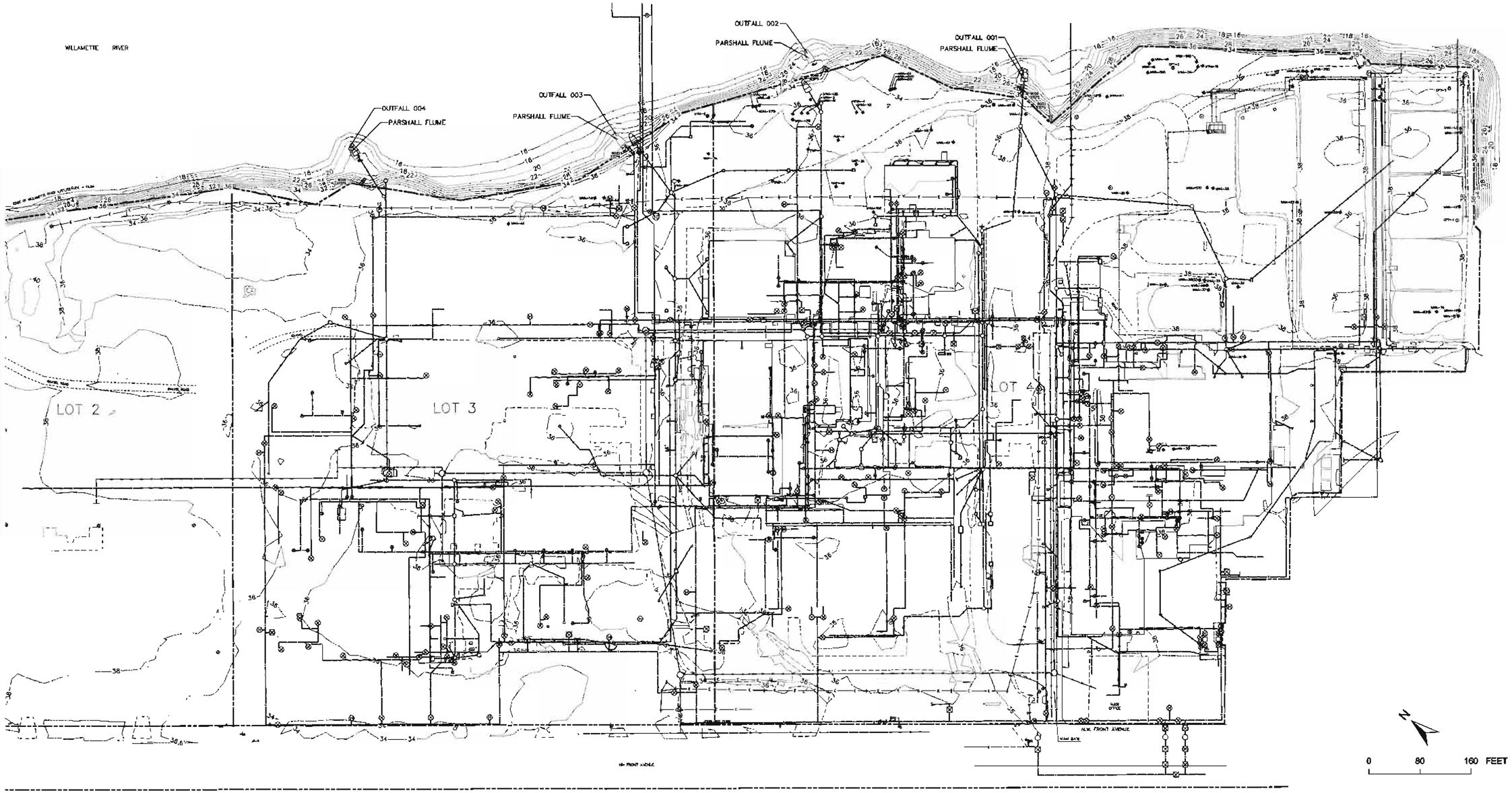
LEGACY SITE SERVICES, LLC

STORMWATER SOURCE CONTROL MEASURES

FORMER ARKEMA, INC. FACILITY PORTLAND, OREGON

EXISTING CONDITIONS AND SITE LAYOUT

SHEET **2** OF 20 REV 1



LEGEND

- MONITORING WELL LOCATION
- HYDRANT
- INDUSTRIAL STORMWATER DRAIN
- DOMESTIC SEWER
- CITY WATER LINE
- RIVER WATER LINE
- STEAM LINE
- DOMESTIC WATER LINE
- OVERHEAD ELECTRIC/UTILITY LINE
- BRINE LINE
- GAS LINE

NOTES

1. THE LOCATION OF EXISTING UTILITIES IS APPROXIMATE. THE CONTRACTOR SHALL VERIFY THE EXACT LOCATION OF ALL EXISTING UTILITIES PRIOR TO THE START OF WORK
2. IT IS THE CONTRACTOR'S RESPONSIBILITY TO FIELD VERIFY ACTUAL SITE CONDITIONS PRIOR TO THE START OF ANY WORK. THERE IS NO WARRANTY OR GUARANTEE ON THE COMPLETENESS OR CORRECTNESS OF THE EXSITING CONDITION INFORMATION. ANY DISCREPANCY FOUND SHALL BE BROUGHT TO THE IMMEDIATE ATTENTION OF THE OWNER'S AGENT PRIOR TO THE START OF WORK
3. AS OF THE DATE THESE DRAWINGS WERE PREPARED, THE ONLY UTILITIES THAT ARE REPORTEDLY ACTIVE ON SITE ARE THE SITE-WIDE OVERHEAD ELECTRIC, SITE-WIDE DESIGNATED STORMDRAINS, AND THE SANITARY SEWER SERVICING THE MAIN SITE OFFICE.

ISSUE FOR REVIEW AND COMMENT PURPOSE
NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	APP
0			
1			
2			
3			
4			
5			
6			

DRW	DATE	CHK	DATE	DWG SCALE	DWG No	PROJ No
EB	9-30-11	MJM	9-30-11	1"=80'		C250

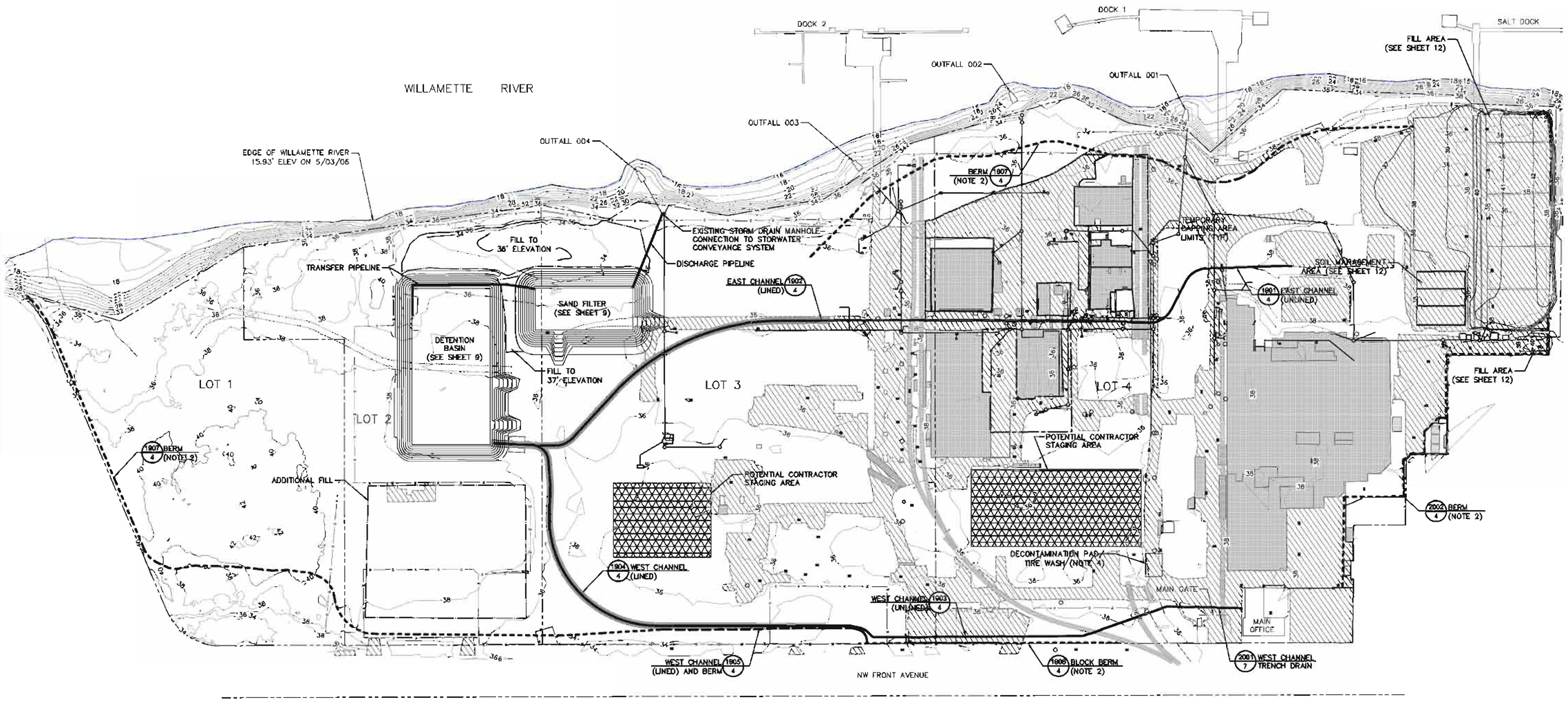
REGISTERED PROFESSIONAL ENGINEER 81288PE OREGON JULY 13, 2012 MICHAEL J. MARTIN
EXPIRES 12/31/2012

integral consulting inc.

LEGACY SITE SERVICES, LLC
STORMWATER SOURCE CONTROL MEASURES
FORMER ARKEMA, INC. FACILITY PORTLAND, OREGON

EXISTING CONDITIONS - UTILITIES

SHEET **3** OF 20 REV 1



LEGEND

- UNLINED STORM CHANNEL CENTERLINE
- LINED STORM CHANNEL CENTERLINE
- BERM CENTERLINE
- TEMPORARY CAPPING AREA LIMITS
- AREAS TO BE FILLED
- PAVED AREAS
- CONCRETE/FOUNDATION
- POTENTIAL CONTRACTOR STAGING AREA
- STORM DRAIN TO BE DECOMMISSIONED
- STORMWATER MANHOLE TO BE DECOMMISSIONED
- CATCH BASIN TO BE DECOMMISSIONED

NOTES

1. DETENTION BASIN AND SAND FILTER CONTOURS SHOWN AT 1' INTERVALS
2. STORMWATER CONVEYANCE BERMS TOP WIDTH SHALL BE AT 37.0 FT NAVD88 OR A MINIMUM BERM HEIGHT OF 1.0 FEET, WHICHEVER IS GREATER.
3. WORK SHALL COMMENCE IN THE FOLLOWING ORDER:
   A. INSTALLATION OF DECONTAMINATION FACILITIES AND EROSION AND SEDIMENT CONTROL MEASURES AS PER THE CONTRACTOR'S APPROVED WITH SPECIFICATION SECTION 01566 AND ATTACHMENT A TO APPENDIX A OF TECHNICAL EXHIBIT 2, FINAL DESIGN REPORT.
   B. COMPLETE INSTALLATION OF THE DETENTION BASIN DETENTION BASIN SHALL BE USED TO STORE SITE STORMWATER UNTIL INSTALLATION OF THE SAND FILTER AND ASSOCIATED DISCHARGE PIPING ARE COMPLETE.
   C. COMPLETE INSTALLATION OF THE SAND FILTER. DURING THE REMAINDER OF THE CONSTRUCTION ACTIVITIES, DETENTION BASIN AND SAND FILTER SHALL BE USED TO CONTAIN AND TREAT SITE STORMWATER PRIOR TO DISCHARGE.
   D. DECOMMISSIONING OF THE EXISTING STORMWATER COLLECTION SYSTEM. REFER TO SHEET 10 FOR DECOMMISSIONING SEQUENCING.
   E. INSTALLATION OF STORMWATER CONVEYANCE CHANNELS.
   F. TEMPORARY CAPPING TEMPORARY CAPPING SHALL NOT BE COMPLETED UNTIL ALL OTHER WORK THAT HAS THE POTENTIAL TO DAMAGE THE CAP HAS BEEN COMPLETE.
   G. SITE RESTORATION AND CLEANUP.
4. CONTRACTOR SHALL PROVIDE A DECONTAMINATION PAD/TIRE WASH IN ACCORDANCE WITH SECTION 01355 – ENVIRONMENTAL POLLUTION CONTROL PROTECTION CONTROL OF THE SPECIFICATIONS.
5. CONTRACTOR SHALL CONTAIN AND MAINTAIN EXCAVATION MATERIALS DURING CONSTRUCTION SUCH THAT MATERIALS ARE PREVENTED FROM ENTERING THE WILLAMETTE RIVER OR CROSS CONTAMINATE SITE SOILS.
6. CONTRACTOR SHALL COLLECT AND STORE SITE STORMWATER SUCH THAT NO DISCHARGE WILL OCCUR WITHOUT TREATMENT VIA THE CONSTRUCTED SAND FILTER OR EQUIVALENT FILTERING MECHANISM PRIOR TO DISCHARGE AND SHALL MEET ALL REQUIREMENTS AS SPECIFIED IN SECTION 01510 – TEMPORARY FACILITIES AND CONTROL IN THE SPECIFICATIONS AND THE CONTRACTOR OBTAINED NPDES 1200-C CONSTRUCTION STORMWATER PERMIT.

N

0 100 200 FEET

ISSUE FOR REVIEW AND COMMENT PURPOSE
NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	APP
0			
1			
2			
3			
4			
5			
6			

DATE	9-30-11	DATE	9-30-11
DRW	EB	CHK	MJM
DWG SCALE	1"=100'	DWG NO.	C250

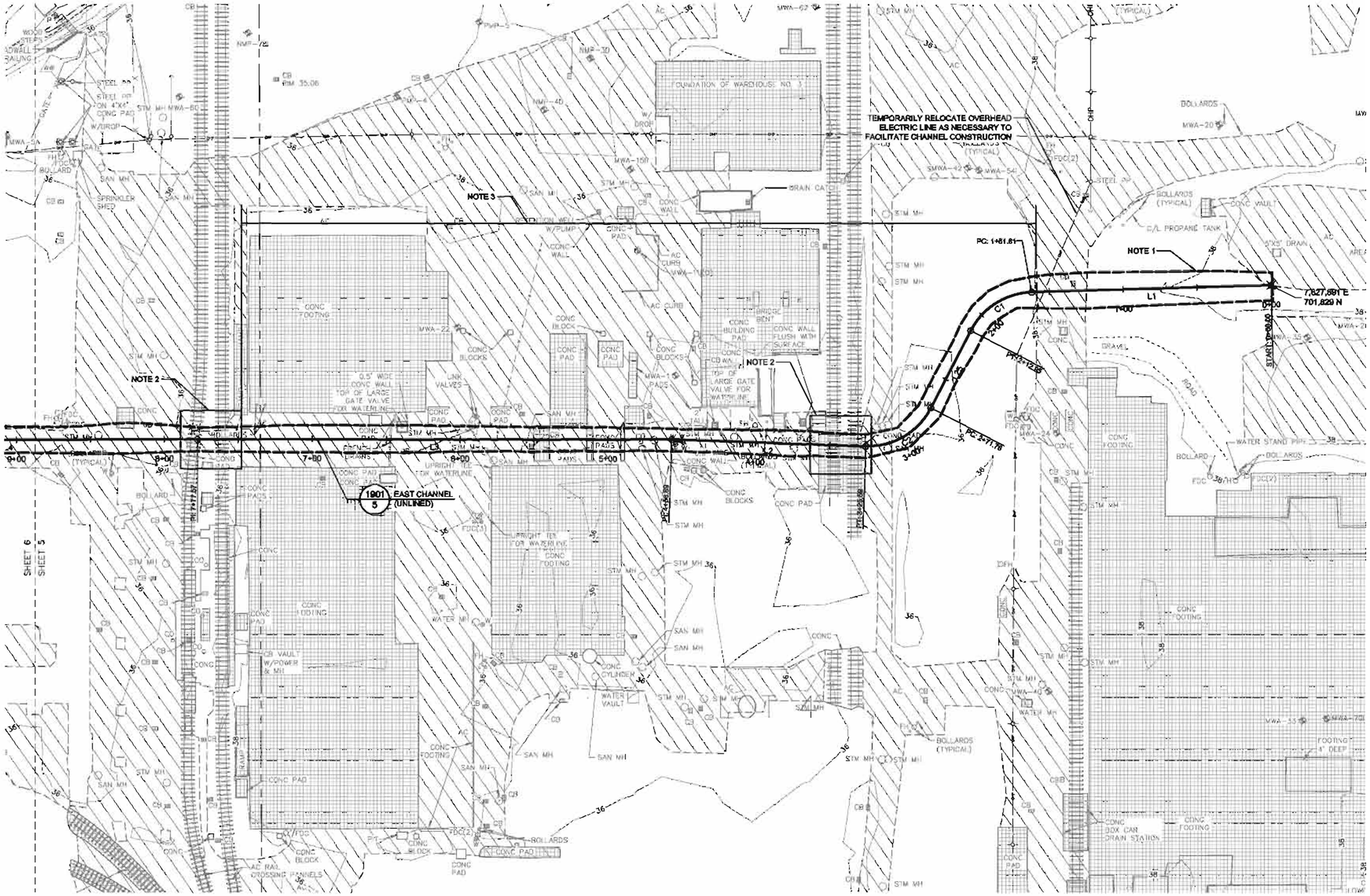
REGISTERED PROFESSIONAL ENGINEER 81268PE OREGON MAY 13, 2010 MICHAEL J. MARTIN
EXPIRES 12/31/2012

integral consulting inc.

LEGACY SITE SERVICES, LLC
STORMWATER SOURCE CONTROL MEASURES
FORMER ARKEMA, INC. FACILITY PORTLAND, OREGON

SITE PLAN

SHEET **4** OF 20 REV 1



LEGEND

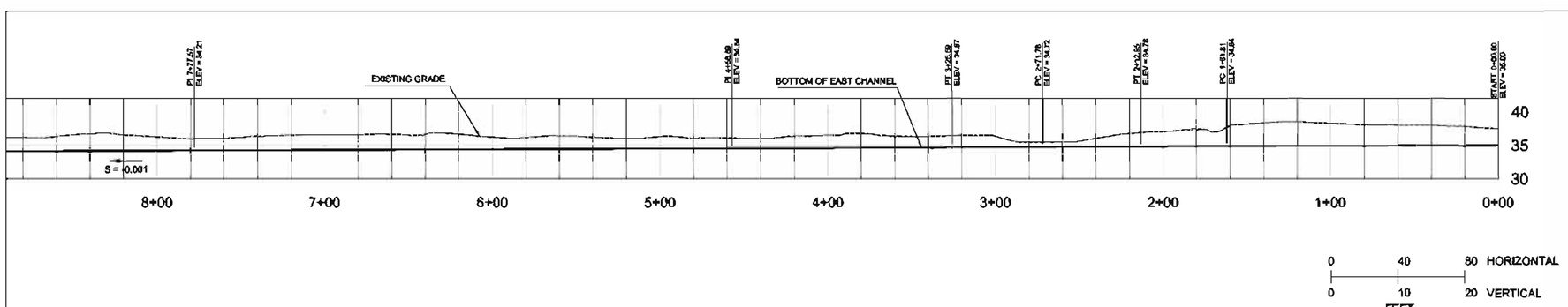
- STORM CHANNEL EXTENTS
- UNLINED STORM CHANNEL CENTERLINE
- PAVED AREAS
- CONCRETE/FOUNDATION

NOTES

1. EXTENTS OF STORM CHANNEL INDICATE EXTENT OF DEMOLITION OF EXISTING ABOVE AND BELOW GROUND STRUCTURES AS NECESSARY TO FACILITATE THE CONSTRUCTION OF THE CHANNEL.
2. REMOVE ALL RAIL STRUCTURES, INCLUDING BUT NOT LIMITED TO RAIL AND TIES, AND STOCKPILE IN AREA INDICATED ON SHEET 7.
3. INDICATES EXTENT OF DEMOLITION AND EXCAVATION THAT IS REQUIRED TO BE MANAGED AS A STATE-ONLY PESTICIDE RESIDUE IN ACCORDANCE WITH SECTION 01575 – WASTE MATERIAL HANDLING AND DISPOSAL AND THE CONTAMINATED MATERIAL MANAGEMENT PLAN (APPENDIX B OF EXHIBIT 2). ALL MATERIAL REMOVED FROM THIS AREA SHALL BE STOCKPILED IN THE STOCKPILE AREA 1 AS INDICATED ON SHEET 12. MATERIAL SHALL BE PLACED ON A HEAVY DUTY (MINIMUM 20 MIL) TEAR RESISTANT (FIBER REINFORCED) PLASTIC LINER AND SHALL BE COVERED WITH 6 MIL PLASTIC SHEETING DAILY OR DURING ADVERSE WEATHER CONDITIONS (E.G. HEAVY WIND AND/OR PRECIPITATION EVENTS).
4. MANAGE ALL OTHER EXCAVATED AND DEMOLITION MATERIALS IN ACCORDANCE WITH SECTION 01575 – WASTE MATERIAL HANDLING OF THE SPECIFICATIONS AND THE CONTAMINATED MATERIAL MANAGEMENT PLAN (APPENDIX B OF EXHIBIT 2), INCLUDING FIELD SCREENING FOR EVIDENCE OF CONTAMINATION (FIELD SCREENING TO BE DONE BY OWNER'S AGENT).
5. UTILITIES INTERSECTING THE STORMWATER CHANNELS SHALL BE IDENTIFIED, CUT, AND CAPPED OR CONCRETE PLUGGED PRIOR TO CONSTRUCTION OF THE STORMWATER CHANNELS TO PREVENT UNWANTED CONVEYANCE OF CONSTRUCTION MATERIALS. THE DEPICTED LOCATION OF THE UTILITIES IS APPROXIMATE AND THE CONTRACTOR SHALL BE RESPONSIBLE FOR VERIFYING. IT IS POSSIBLE THAT ADDITIONAL, UNIDENTIFIED UTILITIES INTERSECT THE STORMWATER CHANNEL AND THE CONTRACTOR SHALL BE PREPARED TO ADDRESS THESE UTILITIES IF ENCOUNTERED.

N

0 40 80 FEET



0 40 80 HORIZONTAL

0 10 20 VERTICAL

FEET

ALIGNMENT TABLE EAST CHANNEL					
NUMBER	RADIUS	LENGTH	LINE/CHORD DIRECTION	EASTING	NORTHING
L1		161.8	N41° 39' 11.45"W	7627891.3	701828.9
C1	48.0	51.1	N72° 11' 41.37"W	7627783.8	701949.8
L25		58.8	S77° 15' 48.71"W	7627737.3	701964.8
C2	47.7	53.8	N70° 24' 09.10"W	7627680.0	701961.8
L2		131.3	N38° 04' 08.91"W	7627631.9	701968.9
L3		320.7	N39° 57' 12.64"W	7627551.0	702072.3
L4		265.7	N40° 14' 55.65"W	7627345.0	702318.1
C3	437.1	358.4	N63° 44' 38.39"W	7627179.8	702513.2
L5		113.3	N87° 14' 17.14"W	7626867.3	702667.4
C4	49.9	41.2	N63° 33' 47.61"W	7626754.1	702672.9
L6		35.1	N39° 53' 18.08"W	7626718.2	702690.7

ISSUE FOR REVIEW AND COMMENT PURPOSE
NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	APP
0			
1			
2			
3			
4			
5			
6			

DATE	9-30-11	DATE	9-30-11
DRN	EB	CHK	MJM
DWG SCALE	1"=40'	DWG No.	C250
PROJ No.			

REGISTERED PROFESSIONAL ENGINEER 81288PE

OREGON MAY 13, 2010 MICHAEL J. MILLER

EXPIRES 12/31/2012

integral engineering inc.

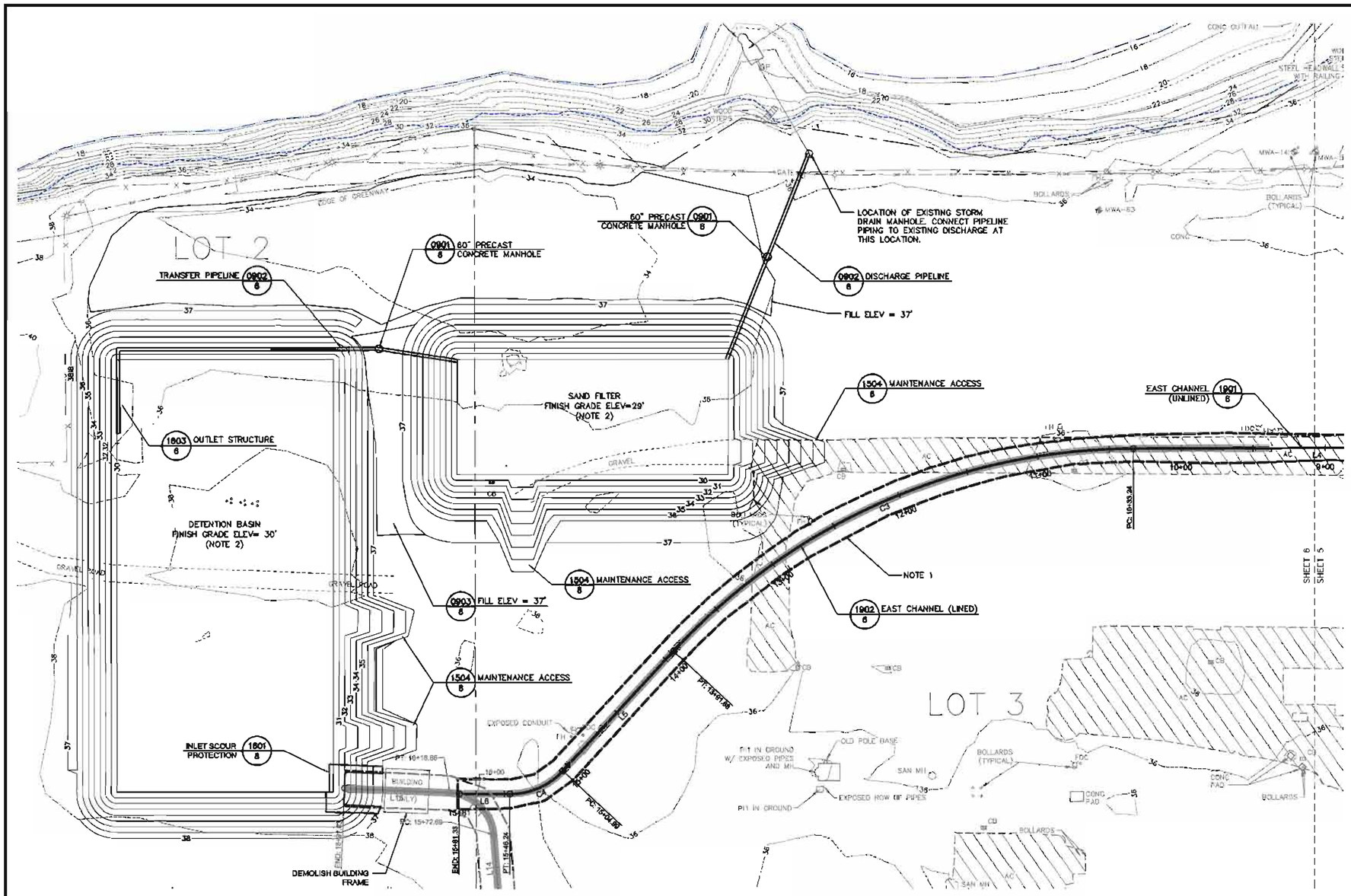
LEGACY SITE SERVICES, LLC

STORMWATER SOURCE CONTROL MEASURES

FORMER ARKEMA, INC. FACILITY PORTLAND, OREGON

EAST CHANNEL
PLAN AND PROFILE

SHEET **5** OF 20 REV 1



LEGEND

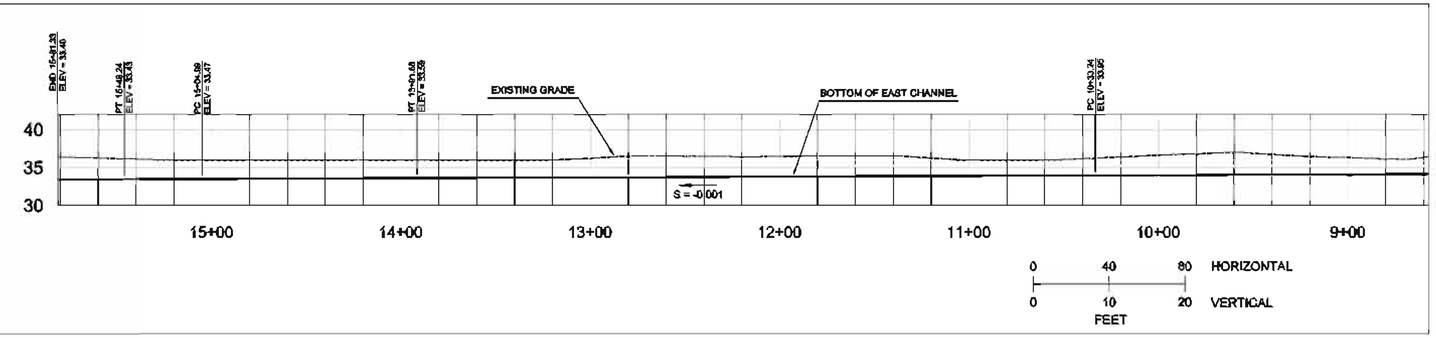
- STORM CHANNEL EXTENTS
- UNLINED STORM CHANNEL CENTERLINE
- LINED STORM CHANNEL CENTERLINE
- PAVED AREAS

NOTES

1. EXTENTS OF STORM CHANNEL INDICATE EXTENT OF DEMOLITION OF EXISTING ABOVE AND BELOW GROUND STRUCTURES AS NECESSARY TO FACILITATE THE CONSTRUCTION OF THE CHANNEL.
2. REFER TO SHEET 9 FOR SAND FILTER AND DETENTION BASIN CONSTRUCTION DETAILS.
3. MANAGE ALL EXCAVATED AND DEMOLITION MATERIALS IN ACCORDANCE WITH SECTION 01575 – WASTE MATERIAL HANDLING OF THE SPECIFICATIONS AND THE CONTAMINATED MATERIAL MANAGEMENT PLAN (APPENDIX B OF EXHIBIT 2), INCLUDING FIELD SCREENING FOR EVIDENCE OF CONTAMINATION (FIELD SCREENING TO BE DONE BY OWNER'S AGENT)
4. UTILITIES INTERSECTING THE STORMWATER CHANNELS SHALL BE IDENTIFIED, CUT, AND CAPPED OR CONCRETE PLUGGED PRIOR TO CONSTRUCTION OF THE STORMWATER CHANNELS TO PREVENT UNWANTED CONVEYANCE OF CONSTRUCTION MATERIALS. THE DEPICTED LOCATION OF THE UTILITIES IS APPROXIMATE AND THE CONTRACTOR SHALL BE RESPONSIBLE FOR VERIFYING. IT IS POSSIBLE THAT ADDITIONAL, UNIDENTIFIED UTILITIES INTERSECT THE STORMWATER CHANNEL AND THE CONTRACTOR SHALL BE PREPARED TO ADDRESS THESE UTILITIES IF ENCOUNTERED.

ALIGNMENT TABLE EAST CHANNEL

NUMBER	RADIUS	LENGTH	LINE/CHORD DIRECTION	EASTING	NORTHING
L1		161.8	N41° 39' 11.45"W	7627891.3	701828.9
C1	48.0	51.1	N72° 11' 41.37"W	7627783.8	701949.8
L25		58.8	S77° 16' 48.71"W	7627737.3	701984.8
C2	47.7	53.8	N70° 24' 09.10"W	7627680.0	701951.8
L2		131.3	N38° 04' 06.91"W	7627631.9	701968.9
L3		320.7	N39° 57' 12.64"W	7627551.0	702072.3
L4		255.7	N40° 14' 55.65"W	7627345.0	702318.1
C3	437.1	358.4	N63° 44' 36.39"W	7627179.8	702513.2
L5		113.3	N87° 14' 17.14"W	7626867.3	702667.4
C4	49.9	41.2	N63° 33' 47.61"W	7626754.1	702672.9
L6		35.1	N39° 53' 18.08"W	7626716.2	702690.7



ISSUE FOR REVIEW AND COMMENT PURPOSE
NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	APP
0			
1			
2			
3			
4			
5			
6			

DRW EB	DSN EB	DATE 9-30-11	
CHK MJM	DWG REVIEW	DATE 9-30-11	
DWG No.	SCALE 1"=40'		
PROJ No.	C250		

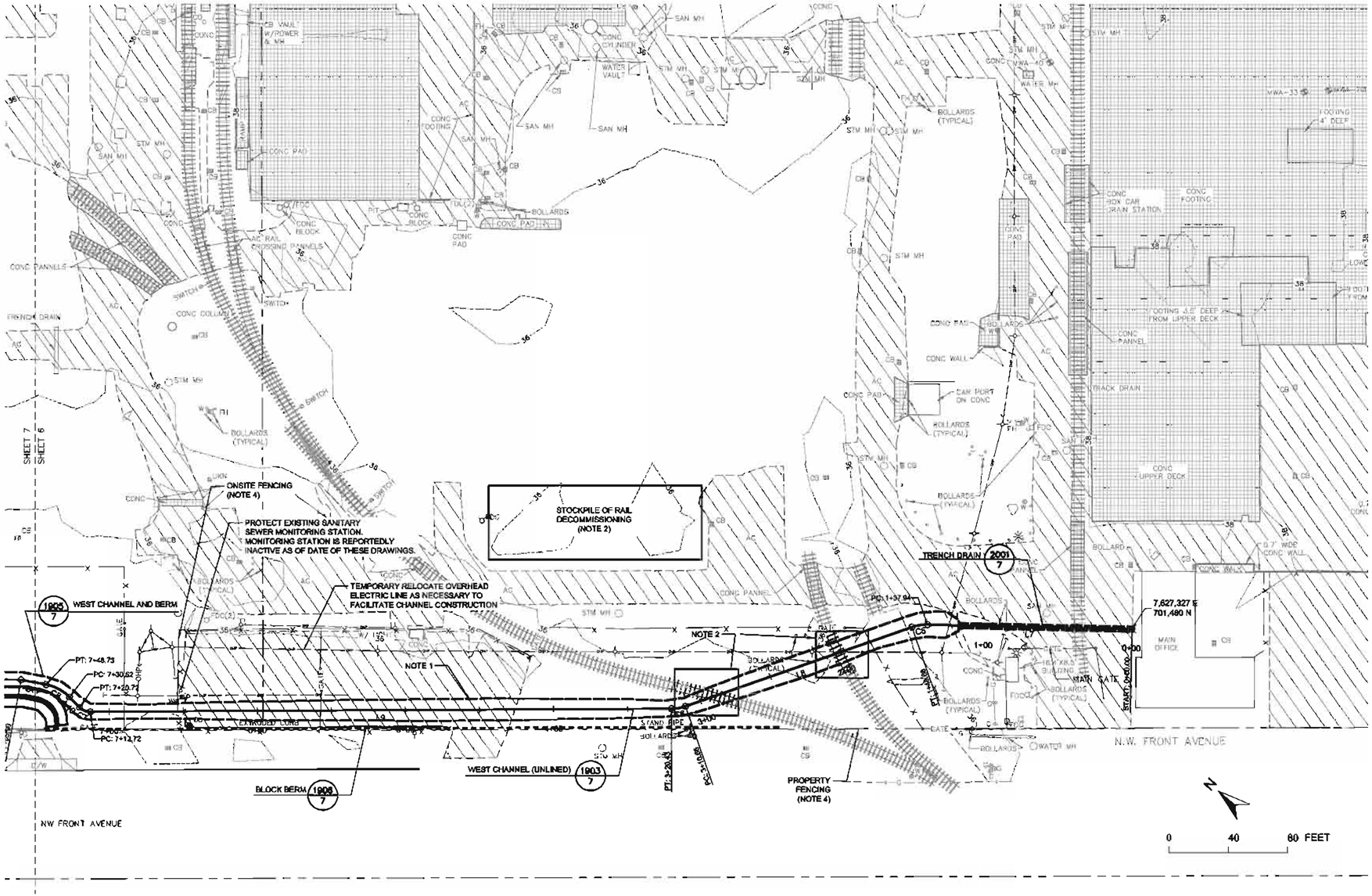
REGISTERED PROFESSIONAL ENGINEER 81288PE OREGON MAY 13, 2009 MICHAEL J. MARTIN EXPIRES 12/31/2012

integral consulting inc.

LEGACY SITE SERVICES, LLC
STORMWATER SOURCE CONTROL MEASURES
FORMER ARKEMA, INC. FACILITY PORTLAND, OREGON

EAST CHANNEL PLAN AND PROFILE
DETENTION BASIN AND SAND FILTER

SHEET **6** OF 20 REV 1

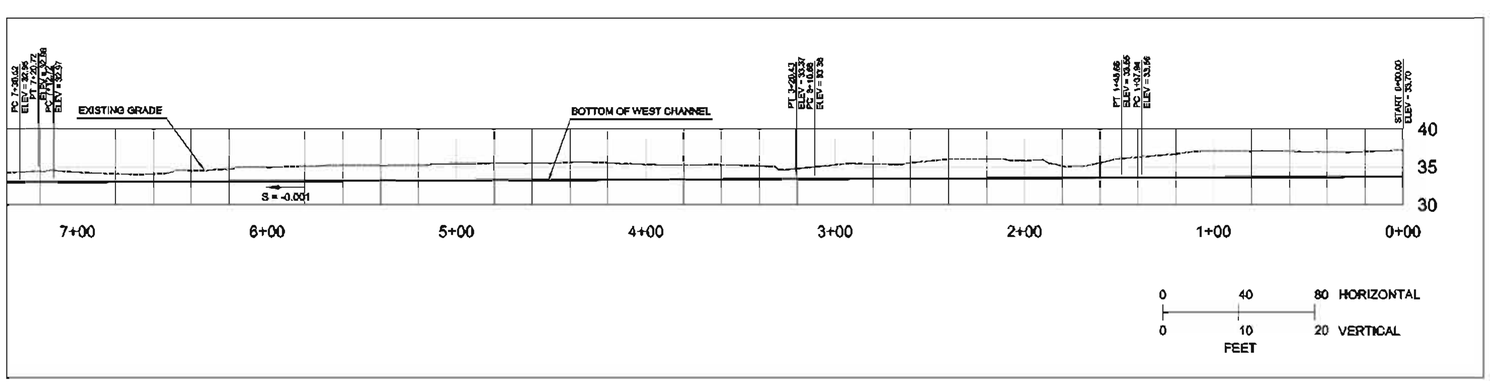


LEGEND

- STORM CHANNEL EXTENTS
- UNLINED STORM CHANNEL CENTERLINE
- BLOCK BERM CENTERLINE
- EARTHEN BERM – TOP EXTENTS
- EARTHEN BERM – TOTAL EXTENTS
- PAVED AREAS
- CONCRETE/FOUNDATION

NOTES

1. EXTENTS OF STORM CHANNEL INDICATE EXTENT OF DEMOLITION OF EXISTING ABOVE AND BELOW GROUND STRUCTURES AS NECESSARY TO FACILITATE THE CONSTRUCTION OF THE CHANNEL.
2. REMOVE ALL RAIL STRUCTURES, INCLUDING BUT NOT LIMITED TO RAIL AND TIES, AND STOCKPILE IN AREA INDICATED.
3. MANAGE ALL EXCAVATED AND DEMOLITION MATERIALS IN ACCORDANCE WITH SECTION 01575 – WASTE MATERIAL HANDLING OF THE SPECIFICATIONS AND THE CONTAMINATED MATERIAL MANAGEMENT PLAN (APPENDIX B OF EXHIBIT 2), INCLUDING FIELD SCREENING FOR EVIDENCE OF CONTAMINATION (FIELD SCREENING TO BE DONE BY OWNER'S AGENT).
4. REMOVE ALL ONSITE FENCING AS NECESSARY TO FACILITATE CONSTRUCTION OF THE CHANNEL AND STORMWATER CONTAINMENT BERM. PROPERTY FENCING SHALL BE PROTECTED AND/OR REPLACED UPON COMPLETION OF THE CONSTRUCTION.
5. UTILITIES INTERSECTING THE STORMWATER CHANNELS SHALL BE IDENTIFIED, CUT, AND CAPPED OR CONCRETE PLUGGED PRIOR TO CONSTRUCTION OF THE STORMWATER CHANNELS TO PREVENT UNWANTED CONVEYANCE OF CONSTRUCTION MATERIALS. THE DEPICTED LOCATION OF THE UTILITIES IS APPROXIMATE AND THE CONTRACTOR SHALL BE RESPONSIBLE FOR VERIFYING. IT IS POSSIBLE THAT ADDITIONAL, UNIDENTIFIED UTILITIES INTERSECT THE STORMWATER CHANNEL AND THE CONTRACTOR SHALL BE PREPARED TO ADDRESS THESE UTILITIES IF ENCOUNTERED



ALIGNMENT TABLE WEST CHANNEL					
NUMBER	RADIUS	LENGTH	LINE/CHORD DIRECTION	EASTING	NORTHING
L7		137.9	N36° 46' 05.12"W	7627327.2	701479.6
C5	30.0	10.7	N49° 02' 05.84"W	7627240.8	701587.3
L6		162.0	N59° 18' 06.65"W	7627232.7	701694.3
C6	29.5	9.8	N49° 47' 13.36"W	7627083.5	701677.1
L9		392.3	N40° 18' 20.18"W	7627086.0	701683.4
C7	10.0	8.0	N17° 24' 38.32"W	7626832.3	701982.5
L10		9.8	N5° 29' 03.52"E	7626829.9	701990.0
C8	30.0	18.2	N11° 54' 25.01"W	7626830.9	701999.7
L11		17.2	N29° 17' 63.53"W	7626827.2	702017.3
L12		371.6	N30° 52' 28.49"W	7626816.8	702032.2
C9	207.3	335.4	N6° 28' 16.03"E	7626580.8	702317.4
L13		38.2	N62° 49' 00.58"E	7626614.4	702815.5
C10	120.0	15.6	N49° 05' 47.58"E	7626644.8	702838.6
L14		46.0	N45° 22' 34.80"E	7626656.8	702848.8
C11	31.7	48.0	N3° 53' 03.42"E	7626689.3	702881.1
L15		73.2	N37° 35' 27.76"W	7626692.2	702723.1

ISSUE FOR REVIEW AND COMMENT PURPOSE NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	APP
0			
1			
2			
3			
4			
5			
6			

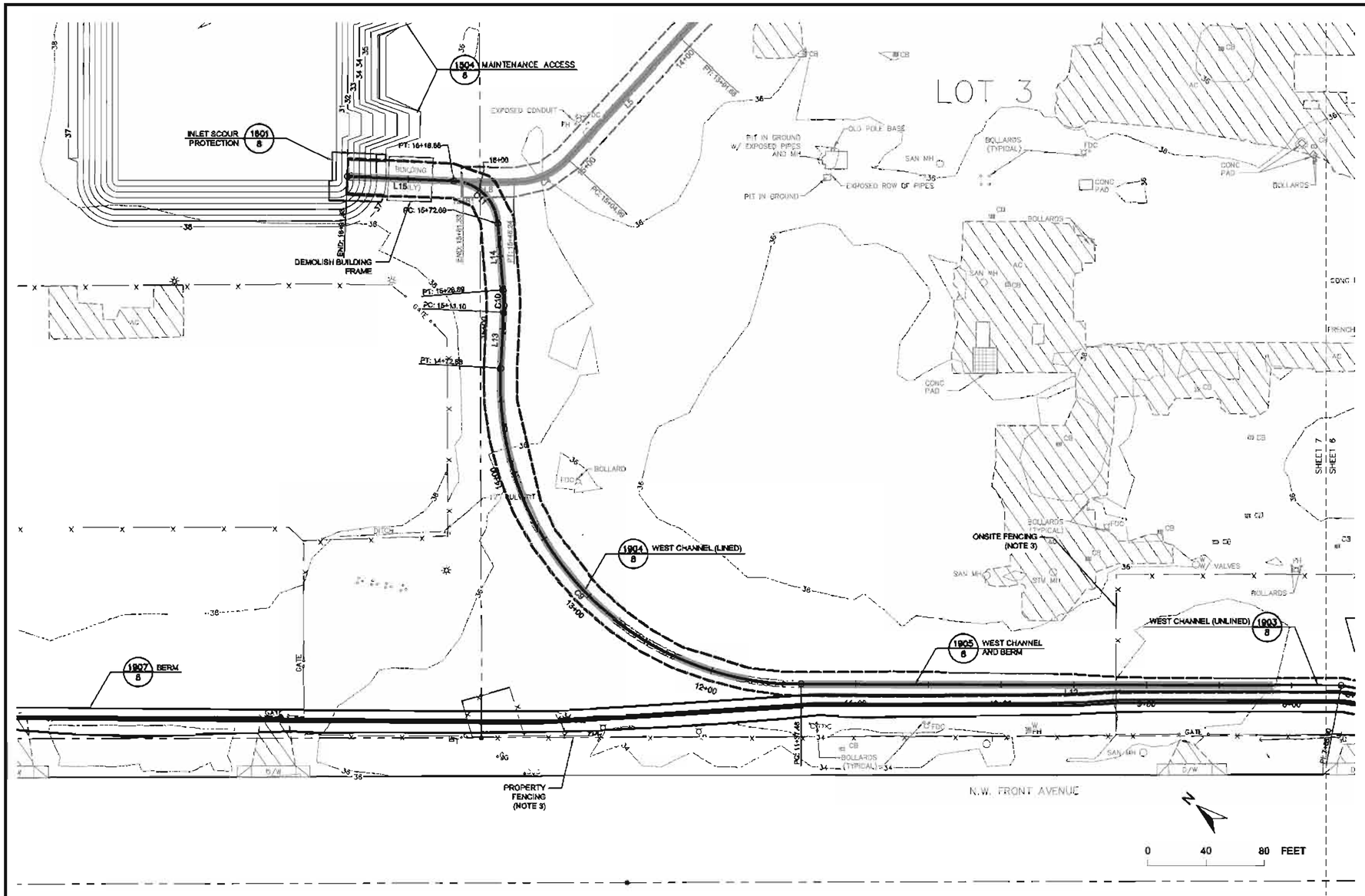
DATE	9-30-11	DATE	9-30-11
DRK	EB	CHK	MJM
DWG SCALE	1"=40'		
DWG NO.	C250		

REGISTERED PROFESSIONAL ENGINEER 81289PE OREGON MAY 13, 2008 MICHAEL J. MAWHIRT
EXPIRES 12/31/2012

integral consulting inc.

LEGACY SITE SERVICES, LLC
STORMWATER SOURCE CONTROL MEASURES
FORMER ARKEMA, INC. FACILITY PORTLAND, OREGON
WEST CHANNEL
PLAN AND PROFILE

SHEET **7** OF 20 REV 1



LEGEND

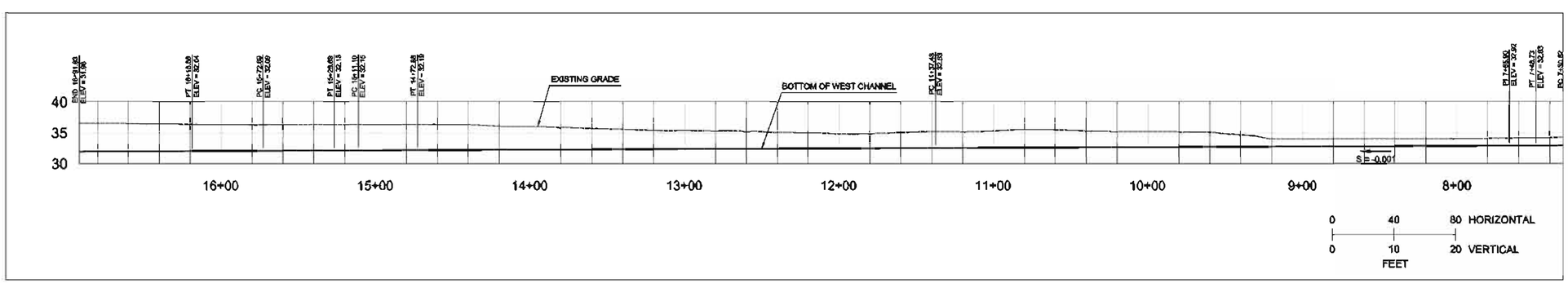
- STORM CHANNEL EXTENTS
- UNLINED STORM CHANNEL CENTERLINE
- LINED STORM CHANNEL CENTERLINE
- EARTHEN BERM – TOP EXTENTS
- EARTHEN BERM – TOTAL EXTENTS
- PAVED AREAS

NOTES

1. EXTENTS OF STORM CHANNEL INDICATE EXTENT OF DEMOLITION OF EXISTING ABOVE AND BELOW GROUND STRUCTURES AS NECESSARY TO FACILITATE THE CONSTRUCTION OF THE CHANNEL.
2. MANAGE ALL EXCAVATED AND DEMOLITION MATERIALS IN ACCORDANCE WITH SECTION 01575 – WASTE MATERIAL HANDLING OF THE SPECIFICATIONS AND THE CONTAMINATED MATERIAL MANAGEMENT PLAN (APPENDIX B OF EXHIBIT 2), INCLUDING FIELD SCREENING FOR EVIDENCE OF CONTAMINATION (FIELD SCREENING TO BE DONE BY OWNER'S AGENT).
3. REMOVE ALL ONSITE FENCING AS NECESSARY TO FACILITATE CONSTRUCTION OF THE CHANNEL AND STORMWATER CONTAINMENT BERM. PROPERTY FENCING SHALL BE PROTECTED AND/OR REPLACED UPON COMPLETION OF THE CONSTRUCTION.
4. UTILITIES INTERSECTING THE STORMWATER CHANNELS SHALL BE IDENTIFIED, CUT, AND CAPPED OR CONCRETE PLUGGED PRIOR TO CONSTRUCTION OF THE STORMWATER CHANNELS TO PREVENT UNWANTED CONVEYANCE OF CONSTRUCTION MATERIALS. THE DEPICTED LOCATION OF THE UTILITIES IS APPROXIMATE AND THE CONTRACTOR SHALL BE RESPONSIBLE FOR VERIFYING. IT IS POSSIBLE THAT ADDITIONAL, UNIDENTIFIED UTILITIES INTERSECT THE STORMWATER CHANNEL AND THE CONTRACTOR SHALL BE PREPARED TO ADDRESS THESE UTILITIES IF ENCOUNTERED.

ALIGNMENT TABLE WEST CHANNEL

NUMBER	RADIUS	LENGTH	LINE/CHORD DIRECTION	EASTING	NORTHING
L7		137.9	N38° 48' 05.12"W	7627327.2	701479.8
C5	30.0	10.7	N49° 02' 05.84"W	7627240.8	701587.3
L8		162.0	N59° 16' 06.55"W	7627232.7	701594.3
C6	29.5	9.8	N49° 47' 13.38"W	7627093.5	701677.1
L9		392.3	N40° 18' 20.18"W	7627088.0	701683.4
C7	10.0	8.0	N17° 24' 38.32"W	7626832.3	701982.5
L10		9.8	N5° 29' 03.52"E	7626829.9	701990.0
C8	30.0	16.2	N11° 54' 25.01"W	7626830.9	701999.7
L11		17.2	N29° 17' 53.53"W	7626827.2	702017.3
L12		371.6	N39° 52' 28.49"W	7626818.8	702032.2
C9	207.3	395.4	N6° 28' 16.03"E	7626580.6	702317.4
L13		38.2	N52° 48' 00.58"E	7626614.4	702615.5
C10	120.0	15.8	N49° 06' 47.58"E	7626644.8	702638.8
L14		46.0	N45° 22' 34.60"E	7626656.6	702646.8
C11	31.7	48.0	N3° 53' 03.42"E	7626689.3	702681.1
L15		73.2	N37° 36' 27.78"W	7626692.2	702723.1



ISSUE FOR REVIEW AND COMMENT PURPOSE
NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	APP
0			
1			
2			
3			
4			
5			
6			

9-30-11	9-30-11		
DATE	DATE	DATE	
EB	MJM		1"=40'
DRK	DES	CHK	DWG SCALE

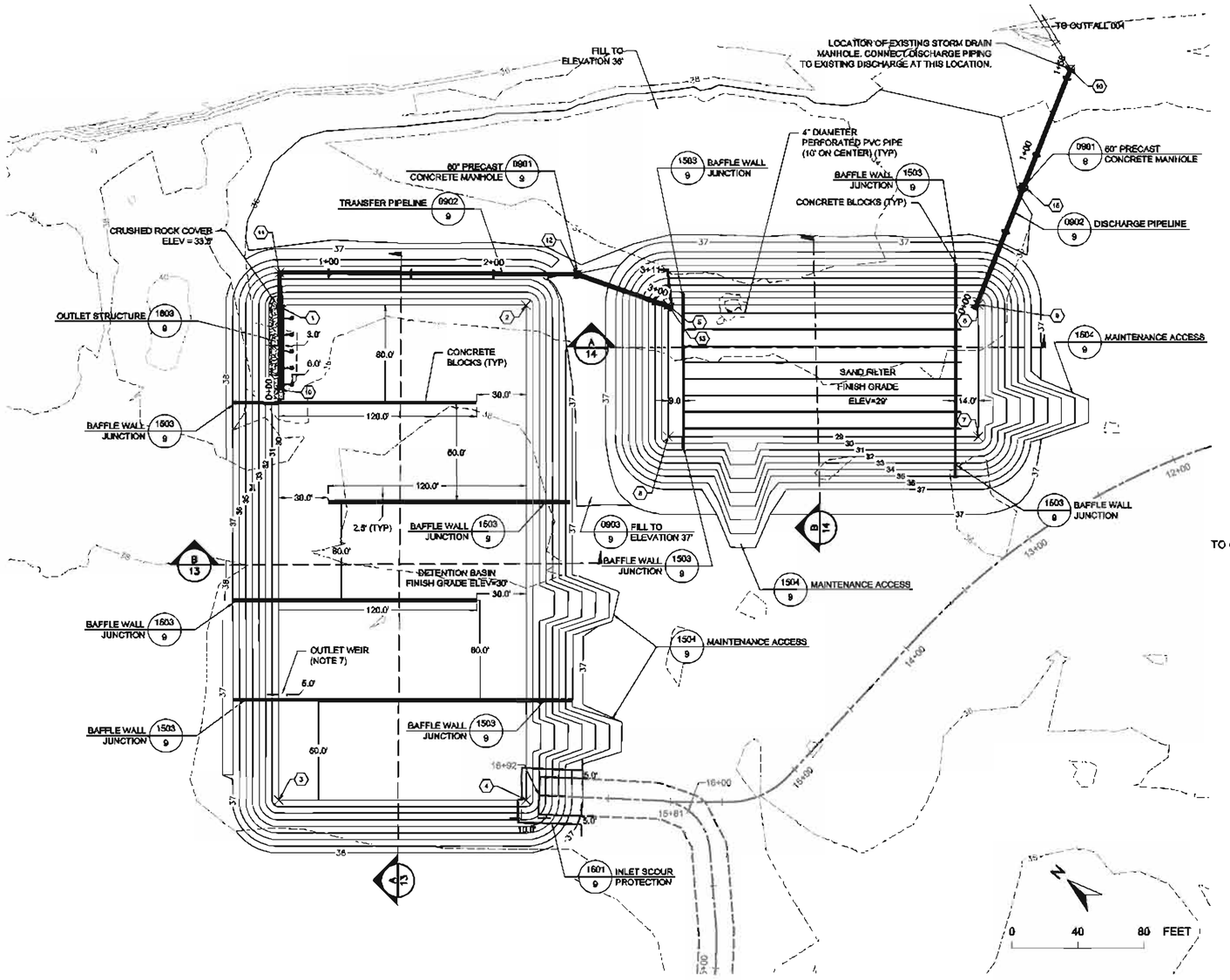
C250
DWG No. PROJ No.

REGISTERED PROFESSIONAL ENGINEER 81268PE OREGON MAY 13, 2010 MICHAEL J. KAWAYE
EXPIRES 12/31/2012

integral consulting inc.

LEGACY SITE SERVICES, LLC
STORMWATER SOURCE CONTROL MEASURES
FORMER ARKEMA, INC. FACILITY PORTLAND, OREGON
WEST CHANNEL
PLAN AND PROFILE

SHEET **8** OF 20 REV 1

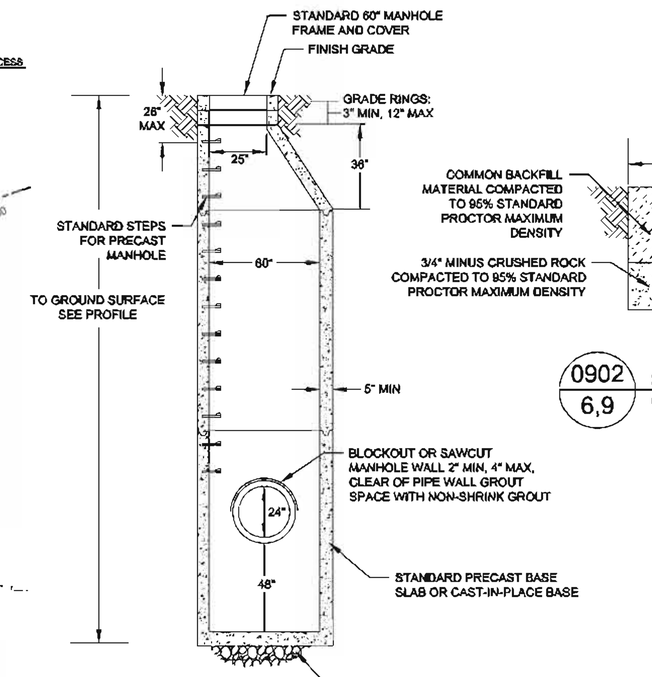


NOTES

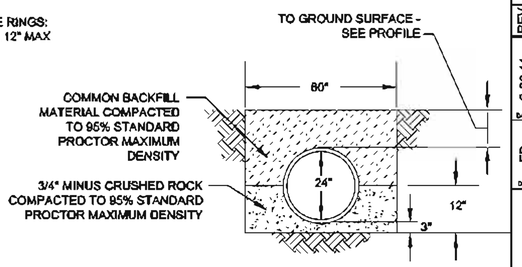
1. EXCAVATION SHALL PROCEED FROM THE TOP OF THE SLOPE DOWNWARD TO THE INDICATED LINES AND CONTROL POINTS. EXCAVATED SLOPES SHALL BE UNIFORM AND SHALL BE AT 4H:1V AND CONTROLLED BY THE CORNER POINTS AS INDICATED ON THIS DRAWING.
2. PRIOR TO PLACEMENT OF ANY LINER MATERIALS, PREPARE SUBGRADE IN ACCORDANCE WITH SPECIFICATION SECTION 02501 – STORM DRAINAGE AND TREATMENT SYSTEM.
3. COMPLETE POST–EXCAVATION SURVEY WITHIN 24 HOURS OF COMPLETION OF THE EXCAVATION.
4. EXCAVATION AND BACKFILL OVER–ALLOWANCE IS 0.1 FT.
5. PROTECT ALL EXISTING STRUCTURES TO REMAIN
6. UTILITIES INTERSECTING THE EXCAVATION AREAS SHALL BE IDENTIFIED, CUT AND CAPPED DURING EXCAVATION ACTIVITIES. THE DEPICTED LOCATION OF THE UTILITIES IS APPROXIMATE AND THE CONTRACTOR SHALL BE RESPONSIBLE FOR VERIFYING IT IS POSSIBLE THAT ADDITIONAL, UNIDENTIFIED UTILITIES INTERSECT THE EXCAVATION PRISMS AND THE CONTRACTOR SHALL BE PREPARED TO ADDRESS THE UTILITIES IF ENCOUNTERED.
7. OUTLET WEIR SHALL CONSIST OF A 5.0 FT GAP (ONE BLOCK WIDE) @ ELEVATION 31.75 FT NAVD88.

(X) Point Table

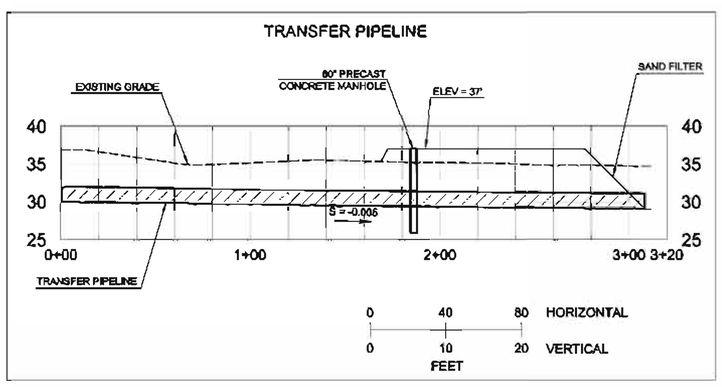
POINT #	DESCRIPTION	EXCAVATION ELEVATION (FT)	NORTHING	EASTING
1	DETENTION BASIN CORNER	28.0	703093.0	7626773.7
2	DETENTION BASIN CORNER	28.0	702978.1	7626870.2
3	DETENTION BASIN CORNER	28.0	702800.2	7626643.9
4	DETENTION BASIN CORNER	28.0	702785.3	7626640.3
5	SAND FILTER CORNER	26.5	702912.2	7626925.7
6	SAND FILTER CORNER	26.5	702768.2	7627046.5
7	SAND FILTER CORNER	26.5	702710.8	7626985.3
8	SAND FILTER CORNER	26.5	702860.8	7626864.4
9	DISCHARGE PIPE BEGINNING		702768.2	7627046.5
10	DISCHARGE PIPE - END		702617.3	7627191.9
11	TRANSFER PIPE - BEGINNING		703058.5	7626735.4
12	TRANSFER PIPE		703105.4	7626789.2
13	TRANSFER PIPE/MANHOLE		702958.2	7626904.5
14	TRANSFER PIPE - END		702912.2	7626925.7
15	DISCHARGE PIPE/MANHOLE		702793.2	7627118.8

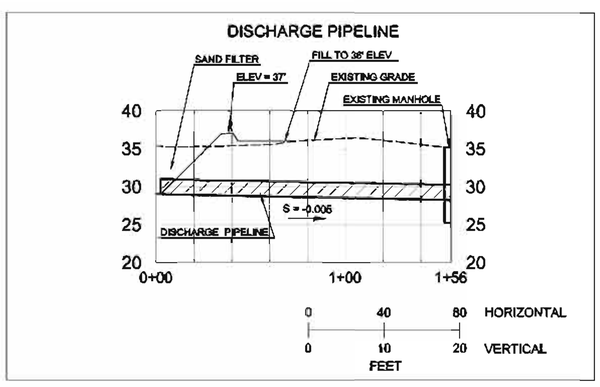


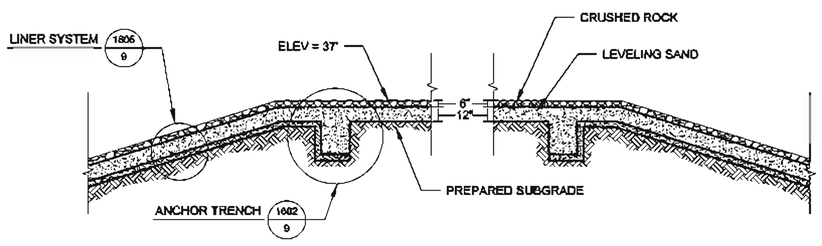
0901 / 6,9 MANHOLE N.T.S.



0902 / 6,9 PIPELINE BEDDING N.T.S.







0903 / 6,9 FILL BETWEEN DETENTION BASIN AND SAND FILTER NTS

ISSUE FOR REVIEW AND COMMENT PURPOSE NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	APP
0			
1			
2			
3			
4			
5			
6			

EB	9-30-11	MJM	9-30-11
DRK	EEB	CHK	DATE

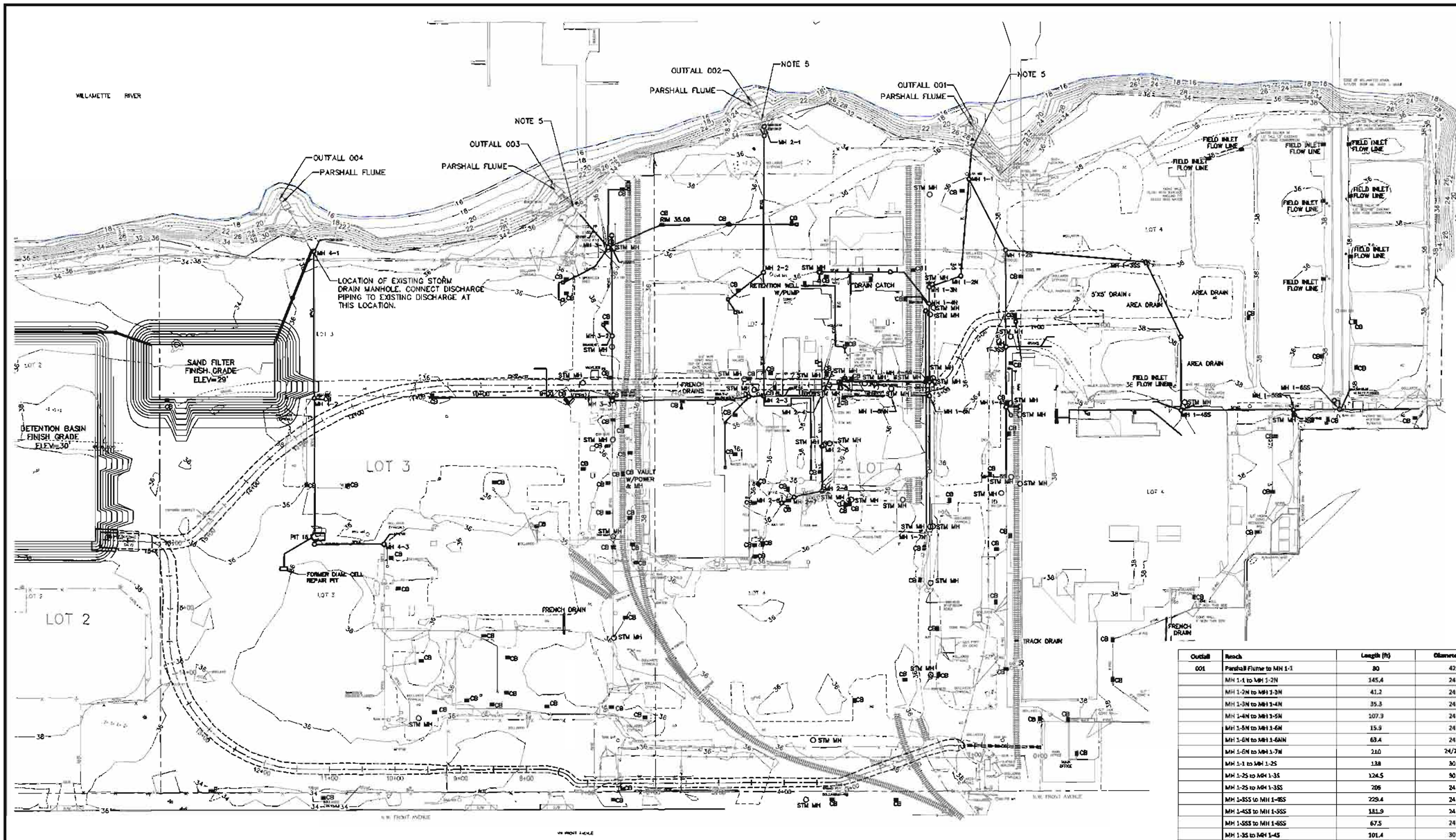
DWG SCALE | DWG No. | PROJ No. C250

REGISTERED PROFESSIONAL ENGINEER 81268PE OREGON MAY 13, 2010 MICHAEL J. MAYNARD EXPIRES 12/31/2012

integral consulting inc.

LEGACY SITE SERVICES, LLC
STORMWATER SOURCE CONTROL MEASURES
FORMER ARKEMA, INC. FACILITY PORTLAND, OREGON
DETENTION BASIN, SAND FILTER, AND PIPING PLAN AND PROFILE

SHEET **9** OF 20 REV 1



LEGEND

STORM CHANNEL CENTERLINE

STORM CHANNEL EXTENTS

NOTES

1. ALL DECOMMISSIONING WORK SHALL BE CONDUCTED IN ACCORDANCE WITH SECTION 02222 OF THE SPECIFICATIONS.
2. STORM DRAIN PIPELINES CONNECTED TO OUTFALLS 001, 002, 003 AND ON THE RIVER SIDE OF THE GROUNDWATER BARRIER WALL SHALL BE DECOMMISSIONED IN-PLACE WITH CONTROLLED LOW-STRENGTH MATERIAL (CLSM).
3. DECOMMISSION ALL PIPELINES AS INDICATED ON THESE DRAWINGS WITH CLSM. AT A MINIMUM, ALL PIPELINES 24-INCHES IN DIAMETER AND LARGER WILL BE DECOMMISSIONED WITH CLSM. DECOMMISSION ALL OTHER PIPELINES WITH GROUT PLUGS LOCATED AT CATCH BASINS AND MANHOLES. ADDITIONAL PIPELINES, NOT INDICATED ON THESE DRAWINGS, MAY EXIST AT THE SITE THAT REQUIRING DECOMMISSIONING
4. ALL POTENTIALLY ACTIVE MANHOLES, CATCH BASINS, AND SUMPS SITEWIDE SHALL BE DECOMMISSIONED IN-PLACE IN ACCORDANCE WITH SECTION 02222 OF THE SPECIFICATIONS. MANHOLES OR CATCH BASINS LOCATED WITHIN THE PROPOSED STORMWATER COLLECTION CHANNELS SHALL BE DEMOLISHED PRIOR TO CHANNEL INSTALLATION, IN ACCORDANCE WITH THE SPECIFICATIONS.
5. PLUG SYSTEM 25 LINEAR FEET UPGRADIENT OF THE PARSHALL PLUME TO MAINTAIN FUNCTIONALITY OF FLUME AND OUTFALL.
6. WORK SEQUENCE. THE STORM DRAIN PIPELINE SHALL BE DECOMMISSIONED STARTING WITH THE MOST DOWNGRADIENT LOCATION (I.E. CLOSEST TO THE DISCHARGE TO THE WILLAMETTE RIVER) TO ASSURE NO PLUGGING MATERIALS ARE DISCHARGED TO THE WILLAMETTE RIVER.
7. CARE SHALL BE TAKEN TO ASSURE THAT NO ACCIDENTAL DISCHARGE OF PLUGGING OR ASSOCIATED MATERIALS ARE DISCHARGED TO THE WILLAMETTE RIVER DURING DECOMMISSIONING.
8. A TOTAL OF 116 CATCH BASINS AND 41 STORMWATER MANHOLES ON THE SITE SHALL BE DECOMMISSIONED.

N

0 80 160 FEET

Outfall	Reach	Length (ft)	Diameter (in)	Material
001	Parshall Flume to MH 1-1	80	42	Fiberglass
	MH 1-1 to MH 1-2N	145.4	24	VC
	MH 1-2N to MH 1-3N	41.2	24	VC
	MH 1-3N to MH 1-4N	35.3	24	VC
	MH 1-4N to MH 1-5N	107.9	24	VC
	MH 1-5N to MH 1-6N	15.9	24	VC
	MH 1-6N to MH 1-6NN	63.4	24	VC
	MH 1-6N to MH 1-7N	210	24/21	VC
	MH 1-1 to MH 1-2S	138	30	C
	MH 1-2S to MH 1-3S	124.5	30	C
	MH 1-2S to MH 1-3SS	206	24	VC
	MH 1-3SS to MH 1-4SS	229.4	24	VC
	MH 1-4SS to MH 1-5SS	181.9	24	VC
	MH 1-5SS to MH 1-6SS	67.5	24	VC
	MH 1-3S to MH 1-4S	101.4	30	C
	MH 1-4S to MH 1-5S	117.4	30	C
002	Parshall Flume to MH 2-1	41.5	42	Fiberglass
	MH 2-1 to MH 2-2	230.1	30	VC
	MH 2-2 to MH 2-3	175.4	30	VC
	MH 2-3 to north	unknown	30	VC
	MH 2-3 to MH 2-4	79.4	30	VC
	MH 2-4 to MH 2-5	86.2	30	VC
	MH 2-5 to MH 2-6	61.3	30	VC
	MH 2-6 to MH 2-7	32.5	30	VC
	MH 2-7 to MH 2-8	23.3	30	VC
003	Parshall Flume to MH 3-1	116.5	36	Fiberglass
	MH 3-1 to 3-2	150	24	VC
	MH 3-2 to 3-3	77.7	24	VC
004	Parshall Flume to MH 4-1	80	36	Fiberglass
	MH 4-1 to MH 4-2	214.8	30	VC
	MH 4-2 to Pit 16	215.3	30	VC
	Pit 16 to MH 4-3	113.1	24	VC
	Pit 16 to Former Diam. Cell Repair Pit		24	VC

ISSUE FOR REVIEW AND COMMENT PURPOSE
NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	APP
0			
1			
2			
3			
4			
5			
6			

DRN EB	DATE 9-30-11	DATE	
DES MJM	DATE 9-30-11	CHK	
DWG SCALE	1"=80'	DWG No.	C250

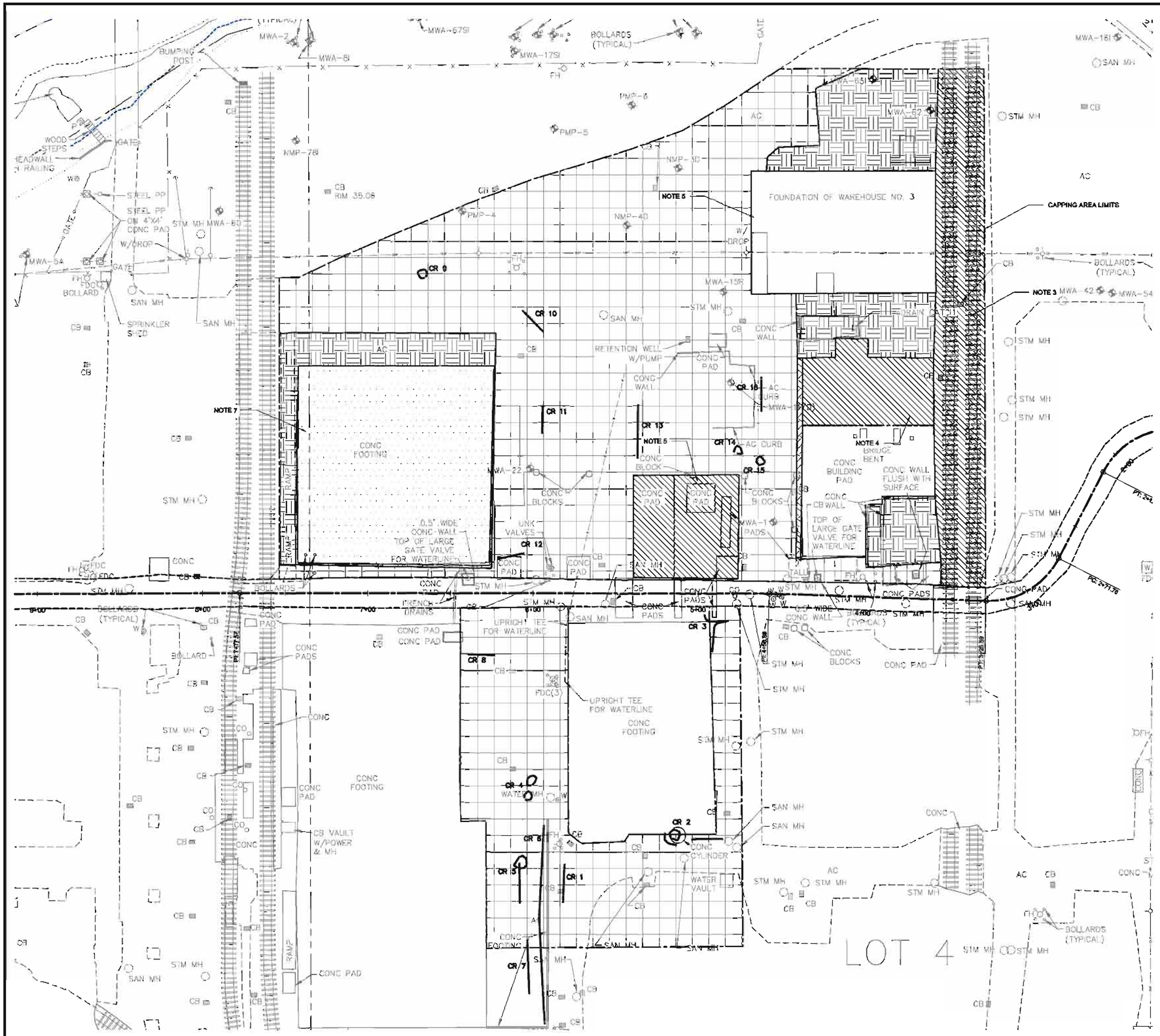
REGISTERED PROFESSIONAL ENGINEER 81288PE OREGON MAY 13, 2010 MICHAEL J. MARTIN
EXPIRES 12/31/2012

integral consulting inc.

LEGACY SITE SERVICES, LLC
STORMWATER SOURCE CONTROL MEASURES
FORMER ARKEMA, INC. FACILITY PORTLAND, OREGON

DECOMMISSIONING PLAN

SHEET **10** OF 20 REV 1



LEGEND

- FOUNDATION/RAILROAD – FILL AND CAP
- ERODIBLE (EXPOSED) SOIL – CAP
- PAVED AREA – REPAIR AS NEEDED
- FOUNDATION – RESEAL (NOTE 7)
- EXISTING ASHPALT CRACKS
- EAST CHANNEL CENTERLINE
- EAST CHANNEL EXTENTS

NOTES

1. SEAL ASPHALT CRACKS AS PER SPECIFICATION SECTION 02510 – TEMPORARY ENVIRONMENTAL CAP AS LOCATED ON THESE DRAWINGS AND LABELED CR-XX. ADDITIONAL INFORMATION ON ASPHALT IS PROVIDED IN TECHNICAL EXHIBIT 4. ADDITIONAL CRACKS MAY REQUIRE SEALING AS IDENTIFIED BY THE OWNER'S AGENT.
2. CLEAR ALL AREAS TO BE CAPPED BY REMOVING VEGETATION, GRUB ALL PROTRUDING ROOTS THAT WILL IMPACT THE INTEGRITY OF THE CAP. REMOVE ALL SURFACE DEBRIS AND SHARP STONES.
3. CAP CONSTRUCTED OVER RAILROAD TRACKS OR DEPRESSIONS WHERE TRACKS WERE PREVIOUSLY LOCATED. FILL AREAS WITH IMPORTED GRANULAR MATERIAL TO THE TOP OF RAILS AND TO PROVIDE A GRADUAL TRANSITION TO ADJACENT GRADES SO THAT NO GRADES ARE STEEPER THAN 2H:1V, DOWN OR UP TO SURROUNDING GRADES. THE FILL SHALL BE COMPACTED TO A FIRM AND NON-YIELDING CONDITION THAT IS SUITABLE FOR CONSTRUCTION OF THE CAP.
4. CAP WILL BE CONSTRUCTED OVER FORMER MANUFACTURING BUILDING FOUNDATIONS THAT, IN SOME CASES, CONTAIN SMALL ABOVE GRADE STRUCTURES, AND PITS AND CRACKS. THESE STRUCTURES SHALL BE DEMOLISHED TO THE EXTENT PRACTICABLE AND FILLED TO GRADE TO PROVIDE A LEVEL WORKING SURFACE FOR THE CAP AND COVER. ANY PITS, CRACKS, ETC. SHALL BE FILLED WITH IMPORTED GRANULAR MATERIAL TO THE PROPER GRADE. THE FILL SHALL BE PLACED SO THAT IT PROVIDES A GRADUAL TRANSITION UP OR DOWN TO ADJACENT GRADES WITH SLOPES NO STEEPER THAN 2H:1V. THE FILL SHALL BE COMPACTED TO A FIRM AND NON-YIELDING CONDITION THAT IS SUITABLE FOR THE CONSTRUCTION OF THE CAP. MANAGE ALL DEMOLITION FROM THESE AREAS AS A HAZARDOUS WASTE AS PER THE SECTION 01575 – WASTE MATERIAL DISPOSAL AND THE CONTAMINATED MATERIAL MANAGEMENT PLAN (APPENDIX B OF EXHIBIT 2).
5. CAP WILL BE CONSTRUCTED AROUND THE FORMER DDT MANUFACTURING AREA WHICH SHALL BE FILLED TO THE LEVEL OF THE TANK BASES TO PROVIDE A LEVEL SURFACE FOR THE PLACEMENT OF CAP MATERIALS. ANY PITS, TRENCHES, DEPRESSIONS ETC. SHALL BE FILLED WITH IMPORTED GRANULAR MATERIAL TO THE TOP OF TANK BASES. THE FILL SHALL BE PLACED SO THAT IT PROVIDES A GRADUAL TRANSITION UP OR DOWN TO ADJACENT GRADES WITH SLOPES NO STEEPER THAN 2H:1V. THE FILL SHALL BE COMPACTED TO A FIRM AND NON-YIELDING CONDITION THAT IS SUITABLE FOR CONSTRUCTION OF THE CAP.
6. ALL AREAS SHALL BE CAPPED WITH A GEOTEXTILE, PLASTIC LINER, GEOTEXTILE SYSTEM COVERED BY A MINIMUM OF 2 INCHES OF 3/4" MINUS CRUSHED ROCK AS PER SPECIFICATION SECTION 01510 – TEMPORARY ENVIRONMENTAL CAP.
7. SEAL CONCRETE FOUNDATION WITH CHEMTEC ONE EXTERIOR CONCRETE SEALER AS MANUFACTURED BY CHEMTEC INTERNATIONAL OR APPROVED EQUAL. FOLLOW ALL MANUFACTURER'S RECOMMENDATIONS FOR APPLICATION OF CONCRETE SEALER.

N

0 30 60 FEET

ISSUE FOR REVIEW AND COMMENT PURPOSE
NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	APP
0			
1			
2			
3			
4			
5			
6			

DATE 9-30-11	DATE 9-30-11	DATE	1"=30'
DRN EB	DES EB	CHK MJM	DWG SCALE / DWG NO. / PROJ NO. C250

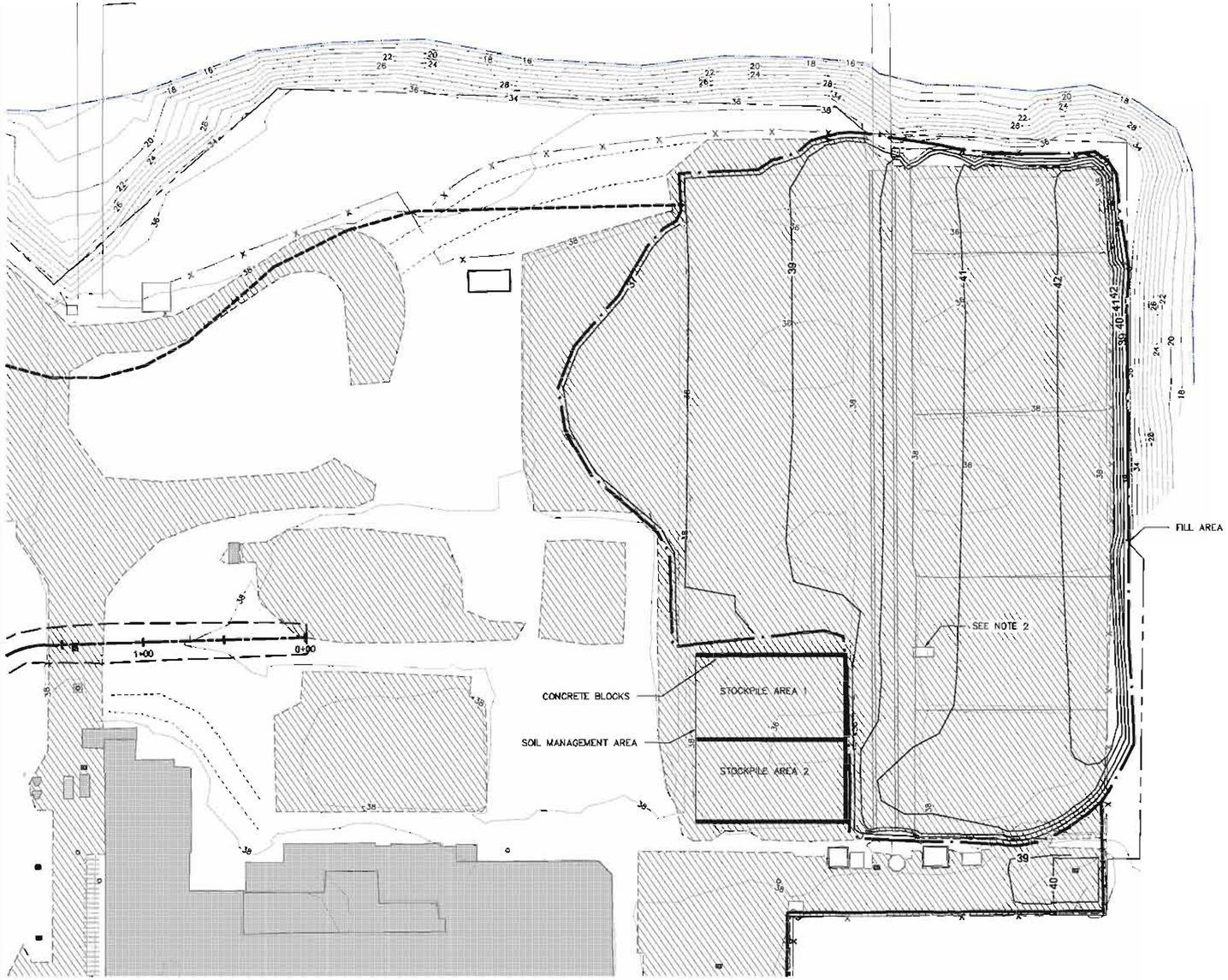
REGISTERED PROFESSIONAL ENGINEER 81288PE OREGON MAY 13, 2009 MICHAEL J. MARTIN
EXPIRES 12/31/2012

integral consulting inc.

LEGACY SITE SERVICES, LLC
STORMWATER SOURCE CONTROL MEASURES
FORMER ARKEMA, INC. FACILITY PORTLAND, OREGON

TEMPORARY CAPPING

SHEET **11** OF 20 REV 1



LEGEND

- EAST CHANNEL CENTERLINE
- EAST CHANNEL EXTENTS
- BERM CENTERLINE
- PAVED AREAS
- CONCRETE/FOUNDATION

NOTES

1. CONTRACTOR SHALL FILL AREA TO THE LINES AND GRADES AS INDICATED ON THIS DRAWING. FILL SHALL BE WITH MATERIAL PASSING FIELD SCREENING AS PER THE CONTAMINATED MATERIALS MANAGEMENT PLAN (APPENDIX B OF EXHIBIT 2).
2. CONTRACTOR SHALL DECOMMISSION ALL STORMWATER STRUCTURES AS PER SHEET 10 OF THESE DRAWINGS PRIOR TO PLACEMENT OF ANY FILL MATERIALS IN THIS AREA.
3. STOCK PILE AREAS SHALL BE CONSTRUCTED IN ACCORDANCE WITH THE CONTAMINATED MATERIAL MANAGEMENT PLAN (APPENDIX B OF EXHIBIT 2). AT A MINIMUM, STOCKPILE AREA SHALL BE BOUNDED ON THREE SIDES BY ULTRABLOCKS™ OR SIMILAR AND SHALL BE LINED WITH A HEAVY DUTY PLASTIC (MINIMUM 20 MIL) TEAR RESISTANT (FIBER REINFORCED) PLASTIC LINER. ALL MATERIALS MANAGED WITHIN THE STOCKPILE AREAS SHALL BE COVERED WITH A 6 MIL PLASTIC DURING ADVERSE WEATHER CONDITIONS (E.G. RAIN AND WIND) AND AT THE END OF THE WORK DAY.
4. UPON COMPLETION OF FILL, AREA SHALL BE CAPPED WITH A TEMPORARY CAP AS SPECIFIED IN SECTION 02510 – TEMPORARY CAP OF THE SPECIFICATIONS.

N

0 40 80 FEET

ISSUE FOR REVIEW AND COMMENT PURPOSE
NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	APP
0			
1			
2			
3			
4			
5			
6			

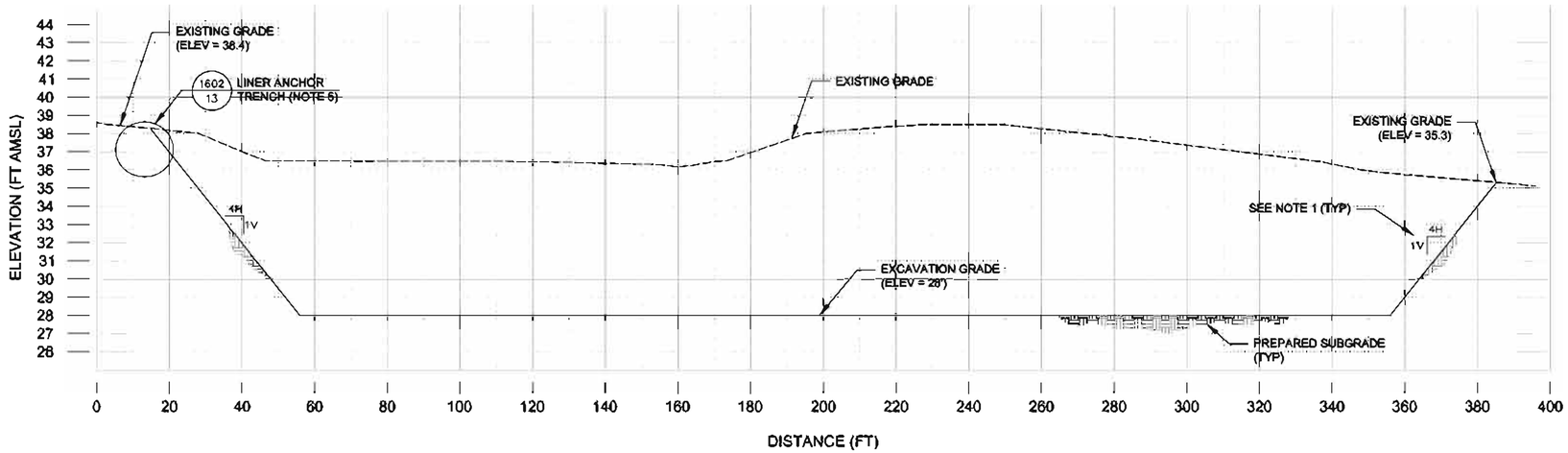
DRW EB	DATE 9-30-11	DWN	DATE
DSN EB	DATE 9-30-11	CHK	DWG SCALE 1"=40'
			DWG No. C250

REGISTERED PROFESSIONAL ENGINEER 81288PE OREGON MAY 13, 2003 MICHAEL J. MARTIN
EXPIRES 12/31/2012

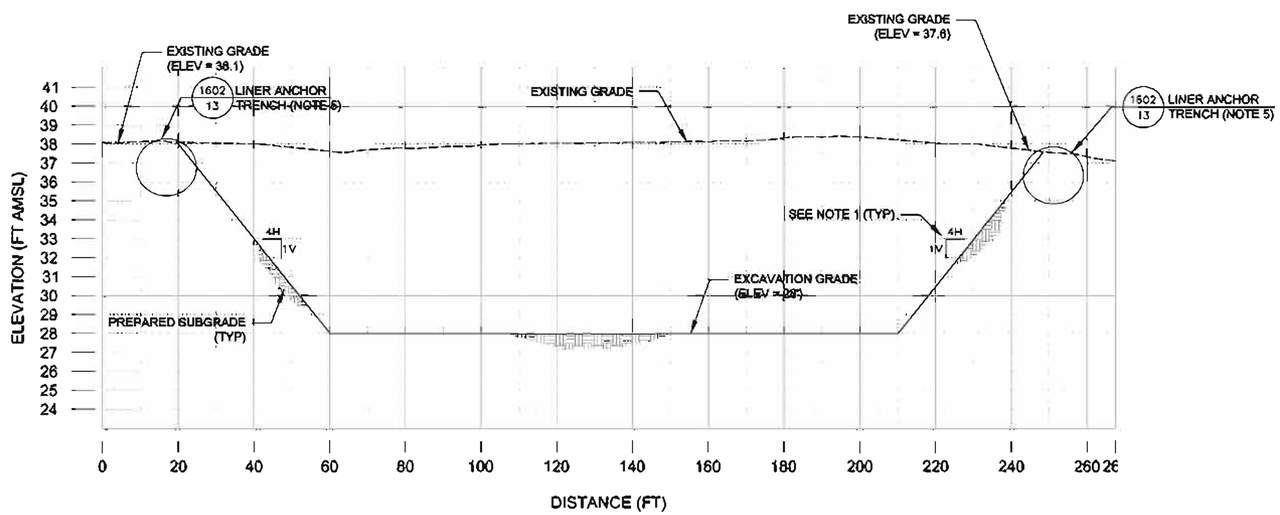
integral consulting inc.

LEGACY SITE SERVICES, LLC
STORMWATER SOURCE CONTROL MEASURES
FORMER ARKEMA, INC. FACILITY PORTLAND, OREGON
SALT PITS

SHEET **12** OF 20 REV 1



A/13 DETENTION BASIN EXCAVATION CROSS SECTION A-A



B/13 DETENTION BASIN EXCAVATION CROSS SECTION B-B

NOTES:

1. EXCAVATE DETENTION BASIN TO THE LINES AND GRADES SHOWN AND AS INDICATED ON SHEET 9.
2. EXCAVATION OVER-ALLOWANCE IS 0.1 FT.
3. REFER TO SHEET 9 FOR EXCAVATION NOTES.
4. REFER TO SHEET 15 FOR DETAILS ON BASIN COMPLETION.
5. EXCAVATE ANCHOR TRENCH AS REQUIRED FOR CONSTRUCTION.

0 20 40 HORIZONTAL
0 4 8 VERTICAL
FEET

ISSUE FOR REVIEW AND COMMENT PURPOSE
NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	APP
0			
1			
2			
3			
4			
5			
6			

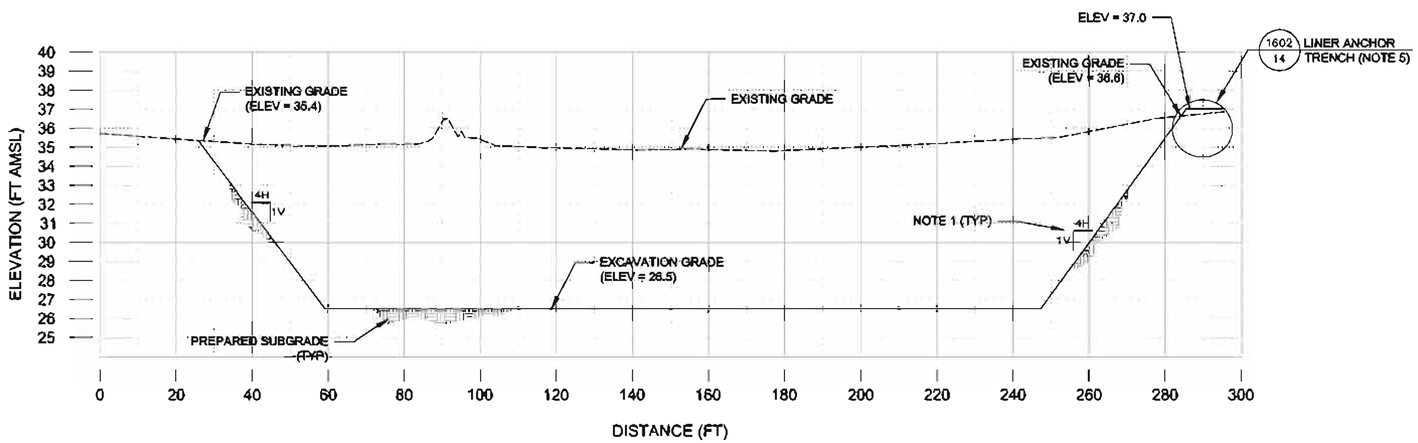
DRK EB DATE 9-30-11
DWN EB DATE 9-30-11
CHK MJM DATE
DWG SCALE
DWG No. C250
PROJ No.

REGISTERED PROFESSIONAL ENGINEER 81288PE OREGON MAY 13, 2008 MICHAEL J. MARTIN
EXPIRES 12/31/2012

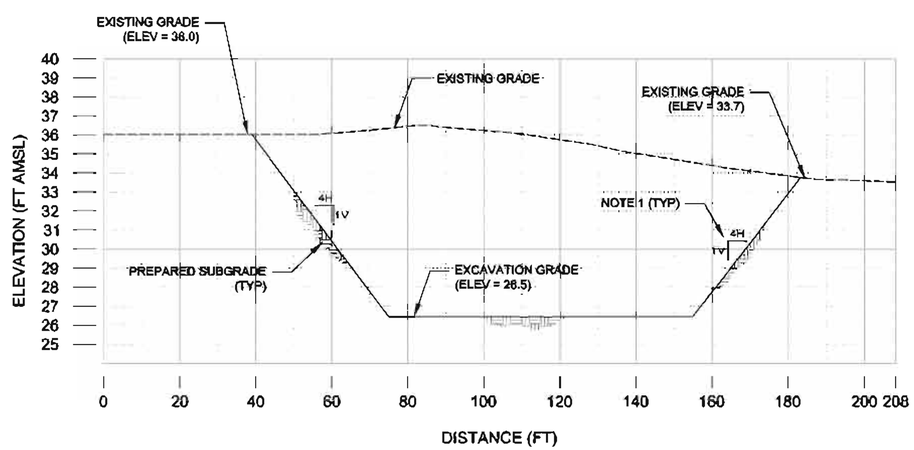
integral engineering inc.

LEGACY SITE SERVICES, LLC
STORMWATER SOURCE CONTROL MEASURES
FORMER ARKEMA, INC. FACILITY PORTLAND, OREGON
DETENTION BASIN
EXCAVATION CROSS SECTIONS

SHEET
13
OF 20 REV 1



A / 14 SAND FILTER EXCAVATION CROSS SECTION A-A



8 / 14 SAND FILTER EXCAVATION CROSS SECTION B-B

NOTES

1. EXCAVATE SAND FILTER TO THE LINES AND GRADES SHOWN AND AS INDICATED ON SHEET 9.
2. EXCAVATION OVER-ALLOWANCE IS 0.1 FT.
3. REFER TO SHEET 9 FOR EXCAVATION NOTES.
4. REFER TO SHEET 17 FOR DETAILS ON SAND FILTER COMPLETION.
5. EXCAVATE ANCHOR TRENCH AS REQUIRED FOR CONSTRUCTION.

0 20 40 HORIZONTAL
0 4 8 VERTICAL
FEET

ISSUE FOR REVIEW AND COMMENT PURPOSE
NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	APP
0			
1			
2			
3			
4			
5			
6			

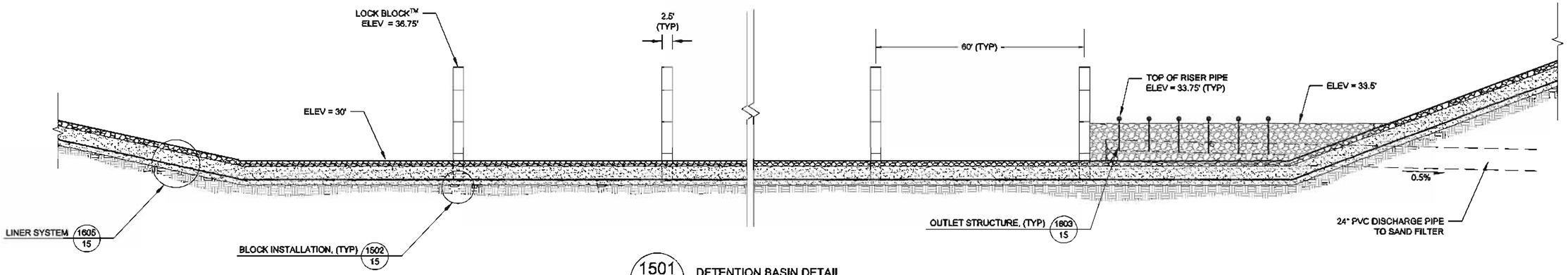
DRK EB DATE 9-30-11
DSN EB DATE 9-30-11
CHK DATE
DWG SCALE
DWG No. C250
PROJ No.

REGISTERED PROFESSIONAL ENGINEER 81288PE OREGON MAY 13, 2011 MICHAEL J. MARTIN
EXPIRES 12/31/2012

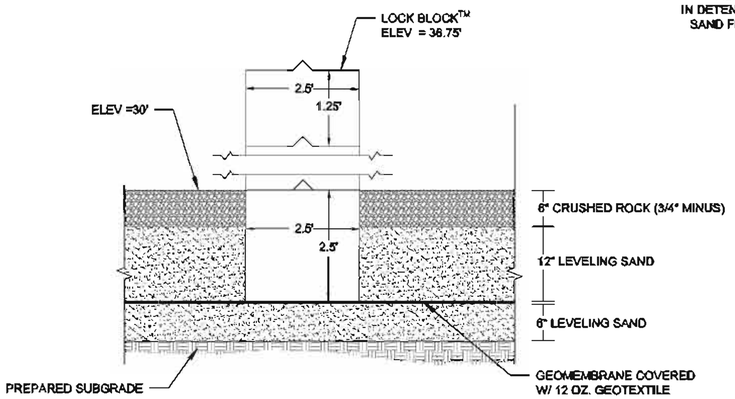
integral engineering inc.

LEGACY SITE SERVICES, LLC
STORMWATER SOURCE CONTROL MEASURES
FORMER ARKEMA, INC. FACILITY PORTLAND, OREGON
SAND FILTER
EXCAVATION CROSS SECTIONS

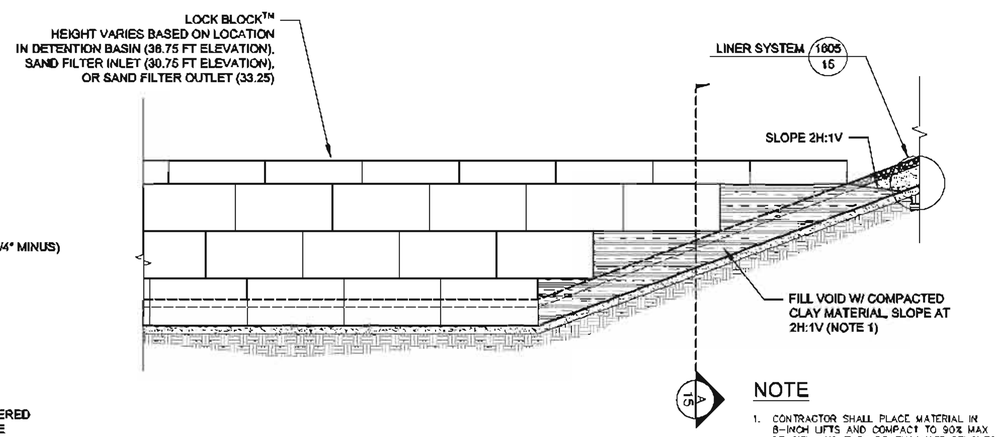
SHEET **14** OF 20 REV 1



1501/13 DETENTION BASIN DETAIL
N.T.S.



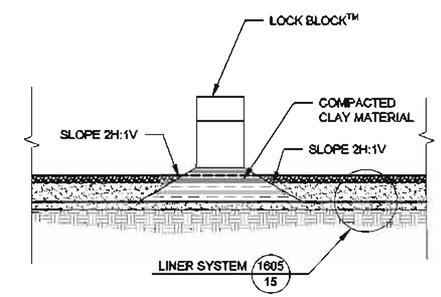
1502/15 BLOCK INSTALLATION
N.T.S.



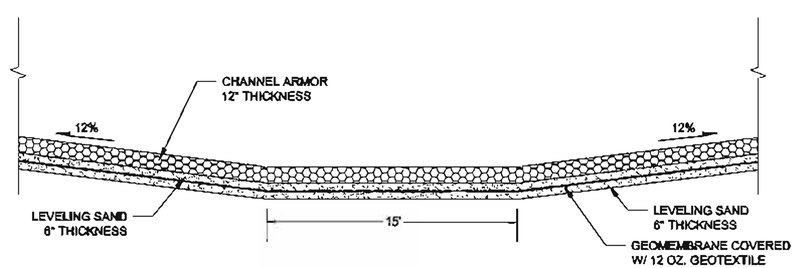
NOTE

1. CONTRACTOR SHALL PLACE MATERIAL IN 8-INCH LIFTS AND COMPACT TO 90% MAX DENSITY AND THEN RE-EXCAVATE BENCHES FOR PLACEMENT OF BLOCKS.

1503/9 TYPICAL BAFFLE WALL JUNCTION
N.T.S.



A/15 TYPICAL BAFFLE WALL JUNCTION CROSS SECTION
N.T.S.



1504/6,8,9 MAINTENANCE ACCESS ROAD DETAIL
N.T.S.

ISSUE FOR REVIEW AND COMMENT PURPOSE
NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	APP
0			
1			
2			
3			
4			
5			
6			

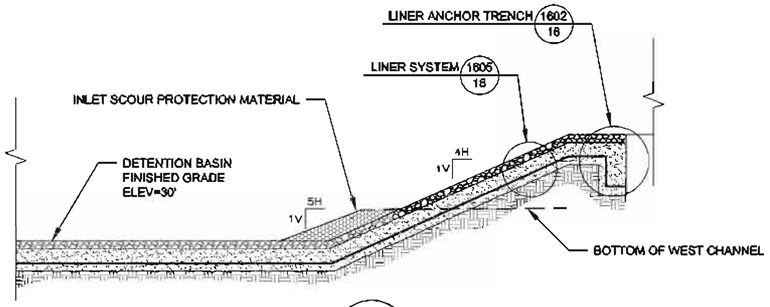
DRK EB DATE 9-30-11
DES MJM DATE 9-30-11
CHK DATE
DWG SCALE
DWG No.
PROJ No. C250

REGISTERED PROFESSIONAL ENGINEER 81288PE OREGON MAY 13, 2010 MICHAEL J. MAYNARD
EXPIRES 12/31/2012

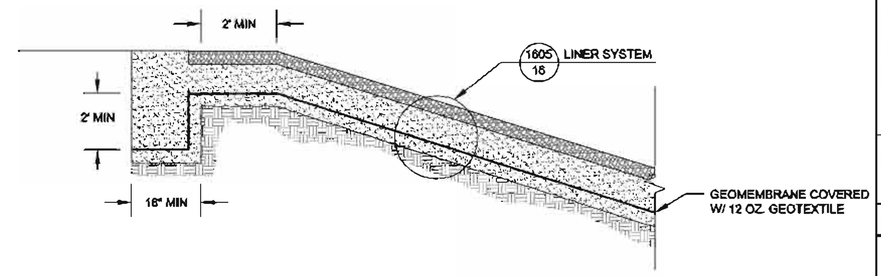
integral consulting inc.

LEGACY SITE SERVICES, LLC
STORMWATER SOURCE CONTROL MEASURES
FORMER ARKEMA, INC. FACILITY PORTLAND, OREGON
DETENTION BASIN DETAILS (1 OF 2)

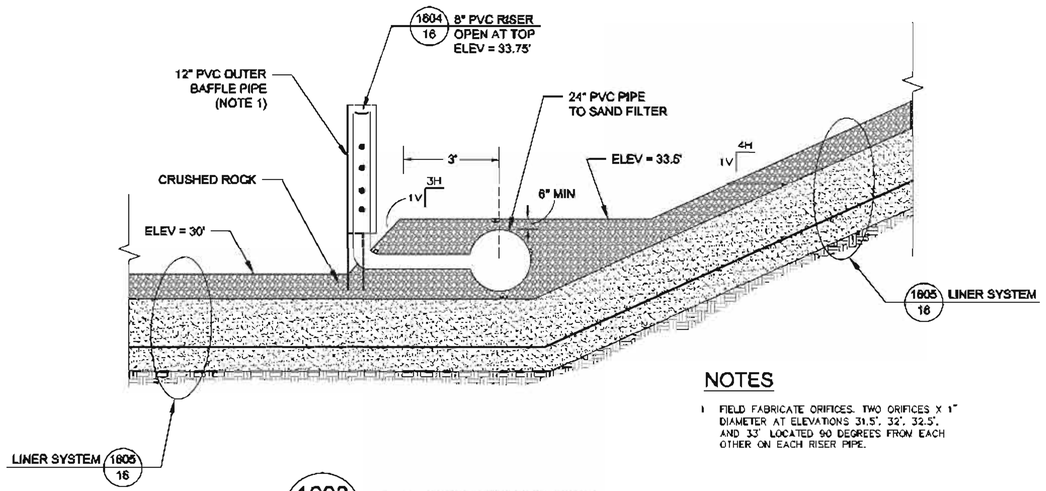
SHEET 15 OF 20 REV 1



1601 / 6,8,9 INLET SCOUR PROTECTION DETAIL
N.T.S.



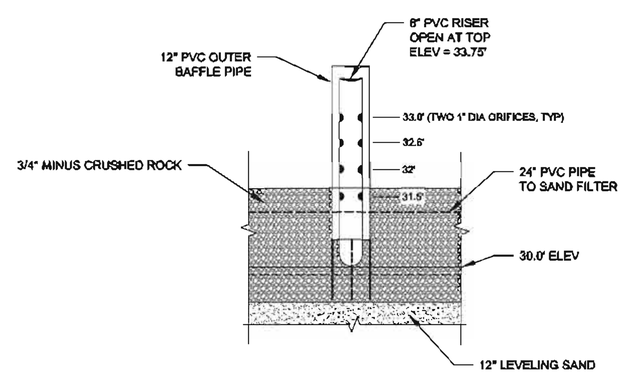
1602 / 9,13,14,16 LINER ANCHOR TRENCH
N.T.S.



NOTES

1. FIELD FABRICATE ORIFICES. TWO ORIFICES X 1" DIAMETER AT ELEVATIONS 31.5', 32', 32.5', AND 33' LOCATED 90 DEGREES FROM EACH OTHER ON EACH RISER PIPE.

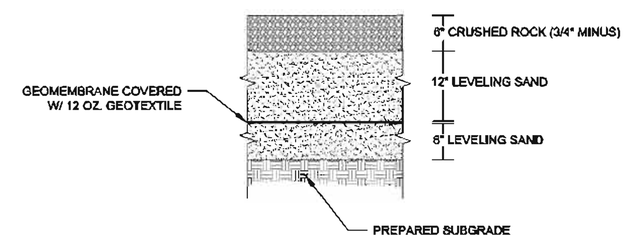
1603 / 6,9,15 OUTLET STRUCTURE DETAIL
N.T.S.



1604 / 16 RISER PIPE
N.T.S.

NOTES

1. FIELD FABRICATE ORIFICES. TWO ORIFICES X 1" DIAMETER AT ELEVATIONS 31.5', 32', 32.5', AND 33' LOCATED 90 DEGREES FROM EACH OTHER ON EACH RISER PIPE



1605 / MULTIPLE LINER SYSTEM DETAIL
N.T.S.

ISSUE FOR REVIEW AND COMMENT PURPOSE
NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	APP
0			
1			
2			
3			
4			
5			
6			

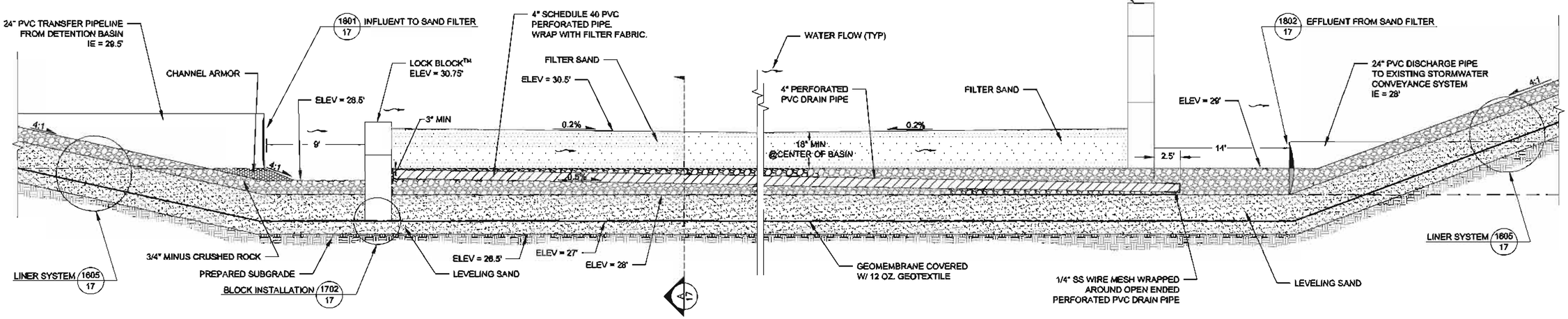
EB	9-30-11		
DRK	DATE		
MJM	9-30-11		
EBB	DATE		
CHK	DATE	DWG SCALE	DWG No.
			C250

REGISTERED PROFESSIONAL ENGINEER 81288PE OREGON MAY 13, 2010 MICHAEL J. MARTIN
EXPIRES 12/31/2012

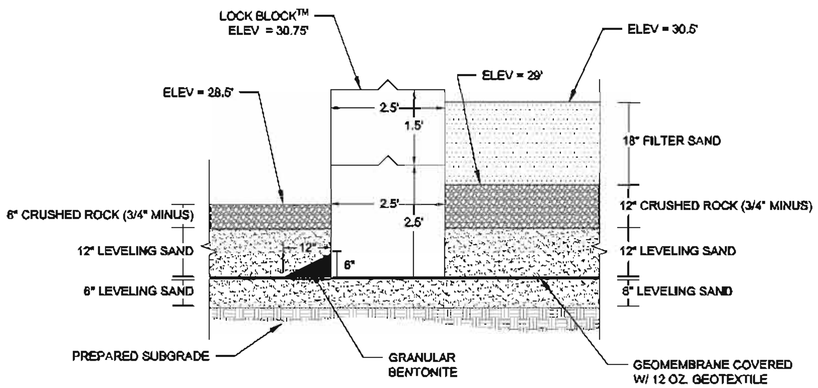
integral consulting inc.

LEGACY SITE SERVICES, LLC
STORMWATER SOURCE CONTROL MEASURES
FORMER ARKEMA, INC. FACILITY PORTLAND, OREGON
DETENTION BASIN DETAILS (2 OF 2)

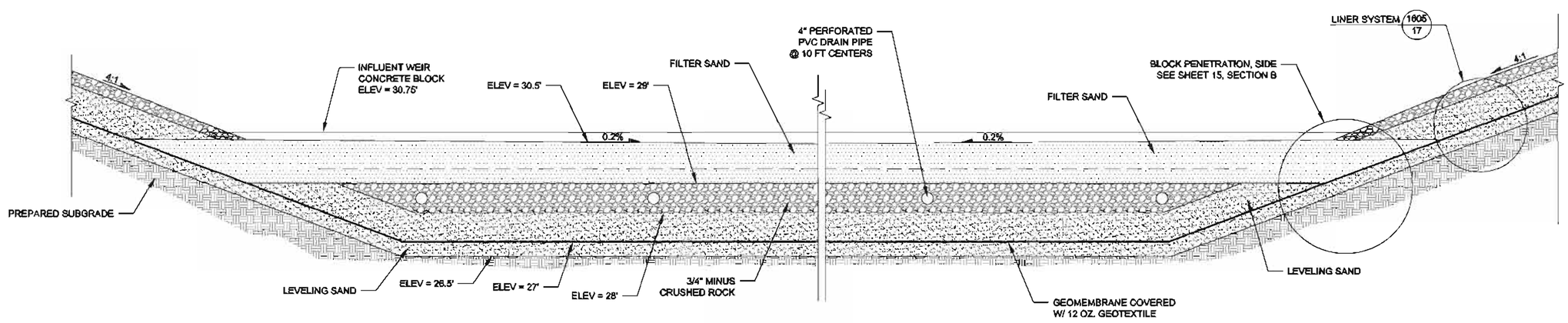
SHEET 16 OF 20 REV 1



1701 / 17 SAND FILTER DETAIL
N.T.S.



1702 / 17 BLOCK INSTALLATION
N.T.S.



A / 17 SAND FILTER CROSS SECTION
N.T.S.

ISSUE FOR REVIEW AND COMMENT PURPOSE
NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	APP
0			
1			
2			
3			
4			
5			
6			

DRK	DATE	CHK	DATE
EB	9-30-11	MJM	9-30-11

DWG SCALE | DWG No. C250 | PROJ No.

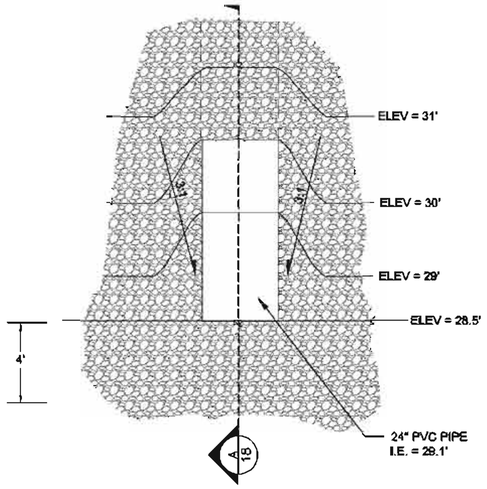
REGISTERED PROFESSIONAL ENGINEER 81268PE OREGON MICHAEL J. MARTIN MAY 11, 2012 EXPIRES 12/31/2012

integral

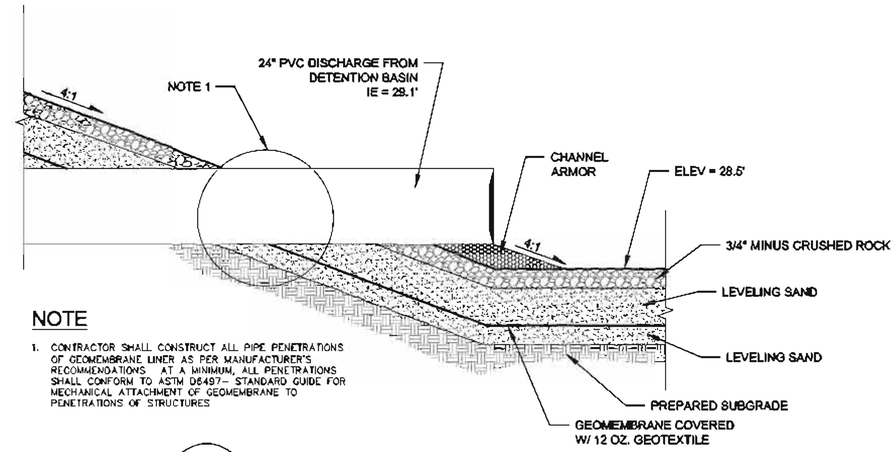
LEGACY SITE SERVICES, LLC
STORMWATER SOURCE CONTROL MEASURES
FORMER ARKEMA, INC. FACILITY PORTLAND, OREGON

SAND FILTER DETAILS (1 OF 2)

SHEET **17** OF **20** REV 1



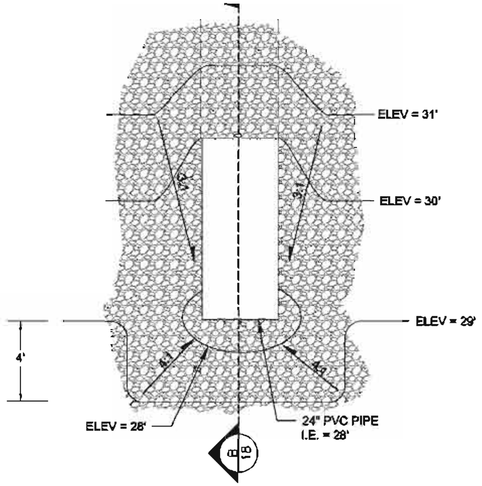
1801 / 17 INFLUENT TO SAND FILTER PIPE PENETRATION DETAIL - PLAN
N.T.S.



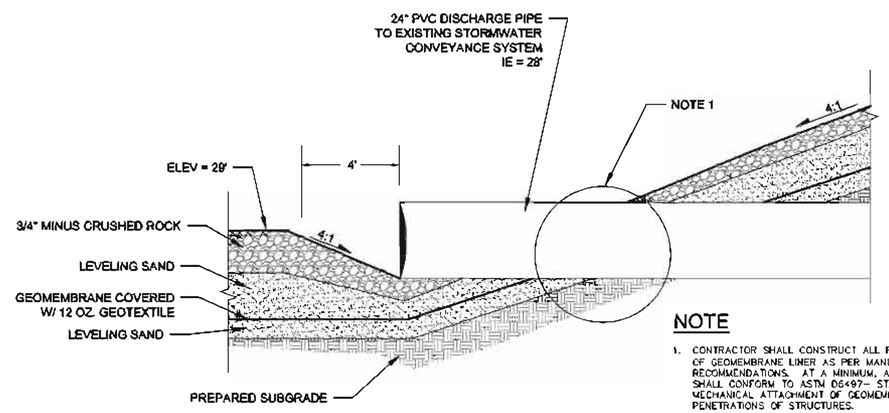
NOTE

1. CONTRACTOR SHALL CONSTRUCT ALL PIPE PENETRATIONS OF GEOMEMBRANE LINER AS PER MANUFACTURER'S RECOMMENDATIONS. AT A MINIMUM, ALL PENETRATIONS SHALL CONFORM TO ASTM D6497– STANDARD GUIDE FOR MECHANICAL ATTACHMENT OF GEOMEMBRANE TO PENETRATIONS OF STRUCTURES.

A / 18 INFLUENT TO SAND FILTER CROSS SECTION B
N.T.S.



1802 / 17 EFFLUENT FROM SAND FILTER PIPE PENETRATION DETAIL - PLAN
N.T.S.



NOTE

1. CONTRACTOR SHALL CONSTRUCT ALL PIPE PENETRATIONS OF GEOMEMBRANE LINER AS PER MANUFACTURER'S RECOMMENDATIONS. AT A MINIMUM, ALL PENETRATIONS SHALL CONFORM TO ASTM D6497– STANDARD GUIDE FOR MECHANICAL ATTACHMENT OF GEOMEMBRANE TO PENETRATIONS OF STRUCTURES.

B / 18 EFFLUENT TO SAND FILTER CROSS SECTION A
N.T.S.

ISSUE FOR REVIEW AND COMMENT PURPOSE
NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	APP
0			
1			
2			
3			
4			
5			
6			

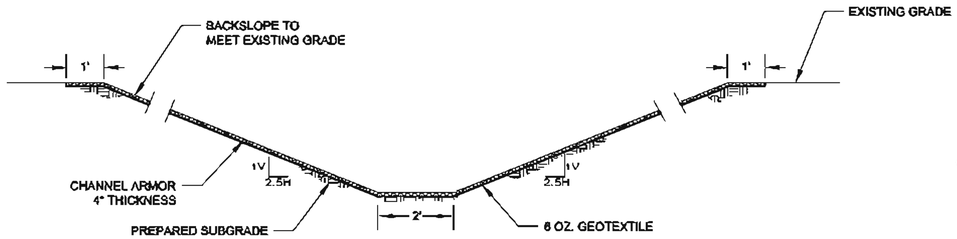
DRK EB	DWN MJM	DATE 9-30-11
EBD	CHK	DATE 9-30-11
DWG SCALE	DWG No.	PROJ No. C250

REGISTERED PROFESSIONAL ENGINEER 81288PE OREGON MAY 13, 2008 MICHAEL J. MARTIN
EXPIRES 12/31/2012

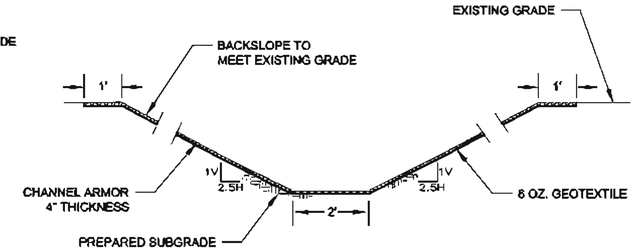
integral consulting inc.

LEGACY SITE SERVICES, LLC
STORMWATER SOURCE CONTROL MEASURES
FORMER ARKEMA, INC. FACILITY PORTLAND, OREGON
SAND FILTER DETAILS (2 OF 2)

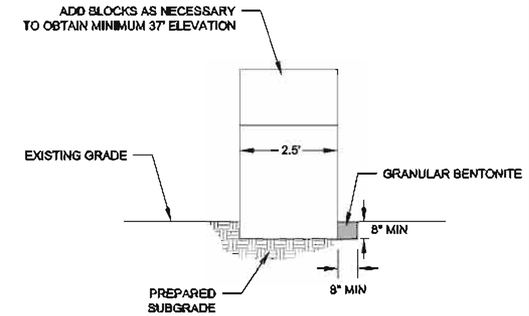
SHEET 18 OF 16 REV 1



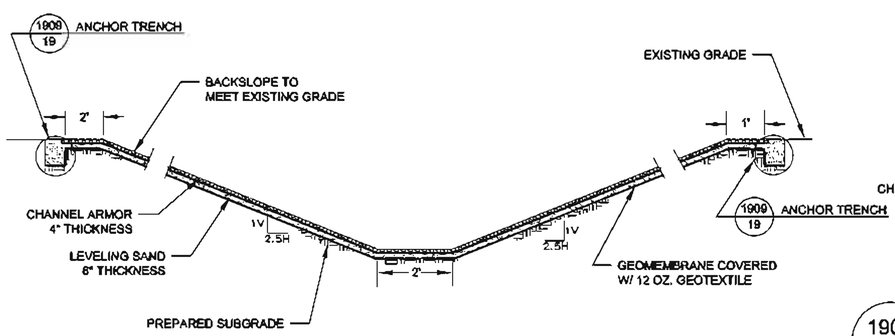
1901 / 4,5,6,12 EAST UNLINED CHANNEL TYPICAL SECTION
N.T.S.



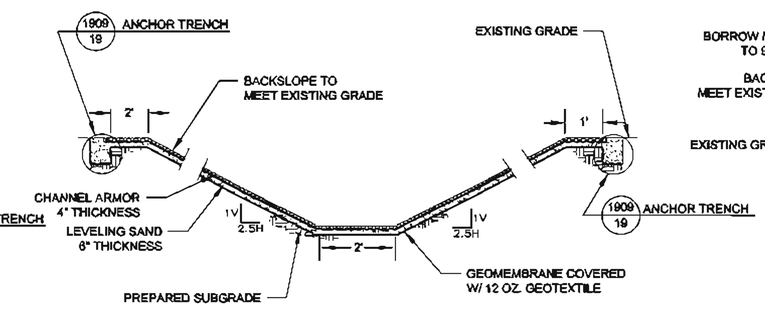
1903 / 4,7,8 WEST UNLINED CHANNEL TYPICAL SECTION
N.T.S.



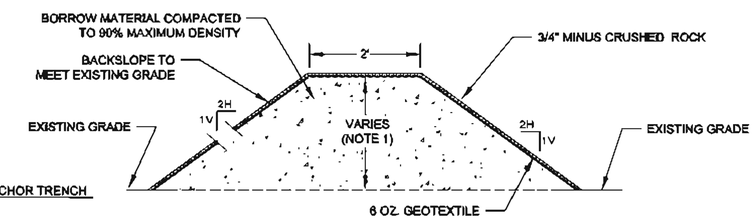
1906 / 4,7,19 BLOCK BERM
N.T.S.



1902 / 4,5,6,12 EAST LINED CHANNEL TYPICAL SECTION
N.T.S.



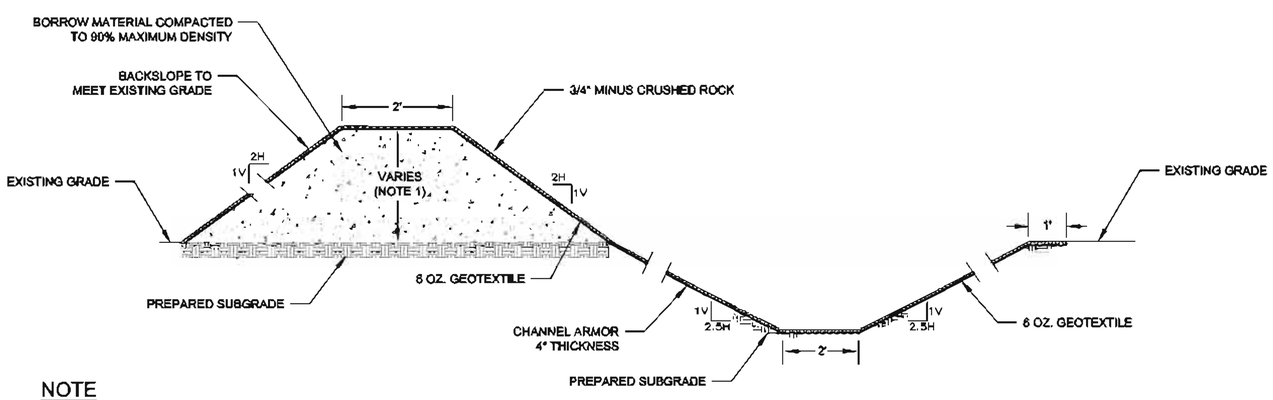
1904 / 4,7,8 WEST LINED CHANNEL TYPICAL SECTION
N.T.S.



1907 / 4,8,19 BERM TYPICAL SECTION
N.T.S.

NOTE

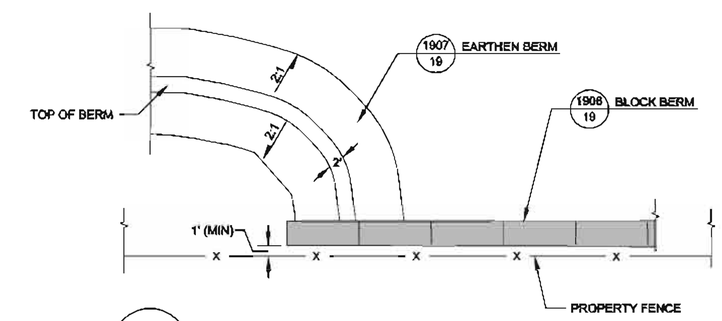
1. VARY HEIGHT TO MAINTAIN MINIMUM ELEVATION 37 FT OR MINIMUM 1 FT HEIGHT, WHICHEVER IS GREATER.



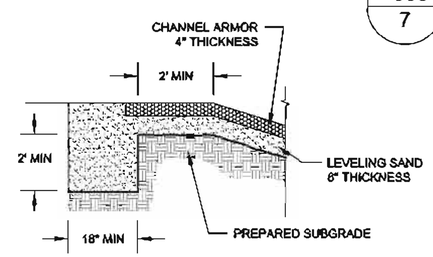
NOTE

1. VARY HEIGHT TO MAINTAIN MINIMUM ELEVATION 37 FT OR MINIMUM 1 FT HEIGHT, WHICHEVER IS GREATER.

1905 / 4,7,8 WEST CHANNEL AND BERM TYPICAL SECTION
N.T.S.



1908 / 7 END OF BLOCK WALL DETAIL
N.T.S.



1909 / 19 LINED CHANNEL ANCHOR TRENCH
N.T.S.

ISSUE FOR REVIEW AND COMMENT PURPOSE
NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	APP
0			
1			
2			
3			
4			
5			
6			

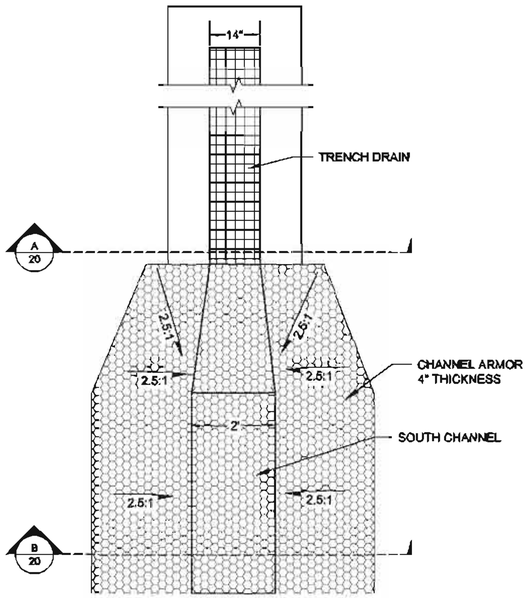
DRK EB DATE 9-30-11 | DSN EB DATE 9-30-11 | CHK MJM DATE | DWG NO. C250

REGISTERED PROFESSIONAL ENGINEER 81288PE OREGON MAY 13, 2008 MICHAEL J. MARTIN EXPIRES 12/31/2012

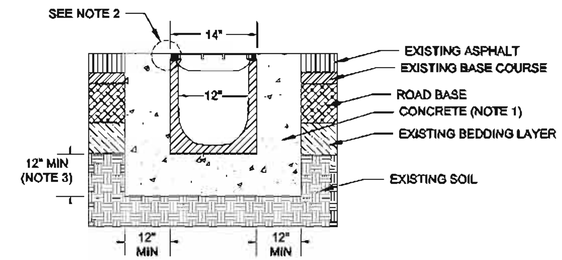
integral consulting inc.

LEGACY SITE SERVICES, LLC
STORMWATER SOURCE CONTROL MEASURES
FORMER ARKEMA, INC. FACILITY PORTLAND, OREGON
STORM CHANNEL AND BERM DETAILS

SHEET 19 OF 20 REV 1



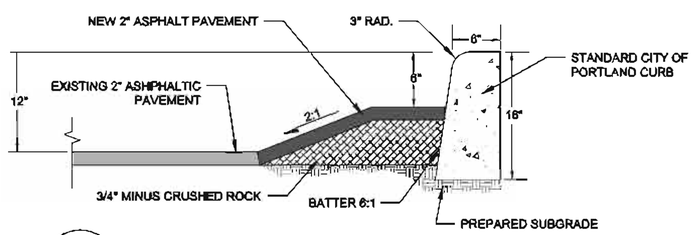
2001 / 4,7 TRENCH DRAIN PLAN DETAIL
N.T.S.



NOTES

1. A MINIMUM CONCRETE STRENGTH OF 3000 PSI IS RECOMMENDED. THE CONCRETE SHOULD BE VIBRATED TO ELIMINATE AIR POCKETS.
2. THE FINISHED LEVEL OF THE CONCRETE SURROUND MUST BE APPROX. 1/8" ABOVE THE TOP OF THE CHANNEL EDGE
3. CONCRETE BASE THICKNESS SHOULD MATCH ASPHALT THICKNESS OR 12", WHICHEVER IS GREATER.
4. TRENCH DRAIN SHALL BE ACO DRAIN S300K COMPLETED WITH LOAD CLASS F SLOTTED GRATINGS SECURED WITH 'POWERLOCK' LOCKING AS MANUFACTURED BY ACO POLYMER PRODUCTS, INC., OR EQUAL APPROVED.

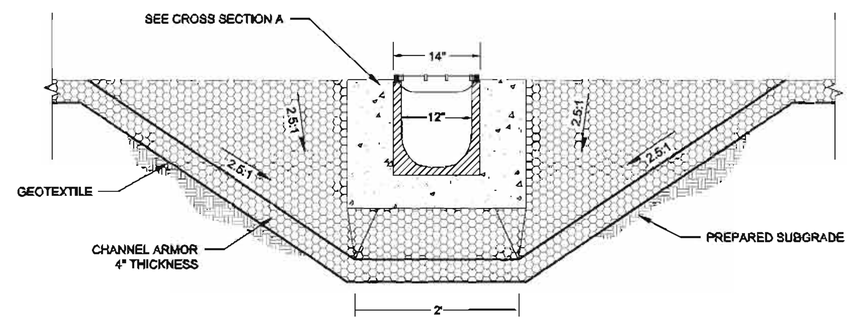
A / 20 TRENCH DRAIN CROSS SECTION A
N.T.S.



2002 / 4 CURB BERM DETAIL
N.T.S.

NOTE

1. EVALUATE EXISTING CURB. IF EXISTING CURB IS LESS THAN 12" ABOVE ADJACENT PROPERTY SURFACE, REPLACE WITH NEW CURB.



B / 20 TRENCH DRAIN CROSS SECTION B
N.T.S.

ISSUE FOR REVIEW AND COMMENT PURPOSE
NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	APP
0			
1			
2			
3			
4			
5			
6			

EB	MJM	
DRN	DSN	CHK
9-30-11	9-30-11	
DATE	DATE	DATE
DWG SCALE	DWG No.	PROJ No.
		C250

REGISTERED PROFESSIONAL ENGINEER 81288PE OREGON MAY 13, 2010 MICHAEL J. MARTIN
EXPIRES 12/31/2012

integral consulting inc.

LEGACY SITE SERVICES, LLC
STORMWATER SOURCE CONTROL MEASURES
FORMER ARKEMA, INC. FACILITY PORTLAND, OREGON
TRENCH DRAIN AND CURB DETAILS

SHEET 20 OF 20 REV 1

TECHNICAL SPECIFICATIONS

FINAL DESIGN REPORT

STORMWATER SOURCE CONTROL MEASURES

Former Arkema Inc. Facility

Portland, Oregon

Prepared for
Legacy Site Services LLC
468 Thomas Jones Way
Exton, PA 19341-2528

Prepared by

integral consulting inc.

319 SW Washington Street
Suite 1150
Portland, OR 97204

September 30, 2011

ISSUED FOR REVIEW AND COMMENT PURPOSES
NOT FOR CONSTRUCTION

TABLE OF CONTENTS

LIST OF EXHIBITS VIII
EXHIBIT 1. SUMMARY OF SITE SOIL QUALITY VIII
EXHIBIT 2. FINAL DESIGN REPORT (TO BE INCLUDED WITH CONTRACT) VIII
EXHIBIT 3. FORMER ARKEMA, INC. FACILITY NPDES PERMIT VIII
EXHIBIT 4. ASPHALT CRACK PHOTOGRAPHS VIII

INVITATION TO BID (TO BE INCLUDED IN CONTRACT) 1

INSTRUCTIONS TO BIDDERS (TO BE INCLUDED IN CONTRACT) 1

BID FORM (TO BE INCLUDED IN CONTRACT) 1

GENERAL CONDITIONS (TO BE INCLUDED IN CONTRACT) 1

SUPPLEMENTAL CONDTIONS (TO BE INCLUDED IN CONTRACT) 1

SECTION 01110 – SUMMARY OF WORK 1
PART 1 GENERAL 1
1.01 DEFINITIONS 1
1.02 DESCRIPTION 1
1.03 SUMMARY OF WORK 2
1.04 SITE CONSTRAINTS 3
1.05 CONTRACTOR USE OF SITE 3
1.06 COORDINATION OF WORK 4
1.07 SEQUENCE OF CONSTRUCTION 4
1.08 USE AND OCCUPANCY PRIOR TO COMPLETION OF CONTRACT 5
PART 2 PRODUCTS 5
PART 3 EXECUTION 5

SECTION 01270 – MEASUREMENT AND PAYMENT [TO BE FINALIZED WITH BID DOCUMENTS] 1
PART 1 GENERAL 1
1.01 DESCRIPTION 1
1.02 MEASUREMENT OF WORK 2
1.03 INCREASED OR DECREASED QUANTITIES 2
1.04 MEASUREMENT AND PAYMENT FOR THE BID ITEMS (TO BE COMPLETED WITH FINAL DESIGN) 3
1.05 CLEANUPS/REMOVALS OF SPILLS AND CONTAMINATION 11
PART 2 PRODUCTS 11
PART 3 EXECUTION 11

SECTION 01330 – SUBMITTALS 1
PART 1 GENERAL 1
1.01 DESCRIPTION 1
1.02 SUBMITTAL CONTROL DOCUMENTS 1
1.03 CONSTRUCTION WORK PLAN 2
1.04 SHOP DRAWINGS 2
1.05 OWNER'S AGENT REVIEW OF SUBMITTALS 5
1.06 PRODUCT DATA AND SAMPLES 6
1.07 TESTING RESULTS 7
PART 2 PRODUCTS 7

PART 3 EXECUTION 7

SECTION 01350 – HEALTH AND SAFETY REQUIREMENTS 1
PART 1 GENERAL 1
1.01 DESCRIPTION.....1
1.02 REFERENCE STANDARDS 1
1.03 SUBMITTALS 2
1.04 QUALIFICATIONS 3
1.05 PERSONAL DECONTAMINATION FACILITY 3
1.06 EQUIPMENT DECONTAMINATION 3
PART 2 PRODUCTS 4
2.01 HEALTH AND SAFETY PLAN 4
PART 3 EXECUTION 4
3.01 HEALTH AND SAFETY.....4
3.02 MATERIAL HANDLING.....5

SECTION 01355 – ENVIRONMENTAL POLLUTION PROTECTION CONTROL 1
PART 1 GENERAL 1
1.01 GENERAL.....1
1.02 SUBMITTALS 1
1.03 PRE-CONSTRUCTION SITE VISIT 1
1.04 PROTECTION OF LAND AREAS 1
1.05 PROTECTION OF TREES AND SHRUBS.....2
1.06 PROTECTION OF WATER RESOURCES.....2
1.07 WASTE DISPOSAL 2
1.08 BURNING 3
1.09 DUST CONTROL.....3
1.10 EROSION CONTROL 3
1.11 EMERGENCY REPONSE AND SPILL CONTINGENCY.....4
1.12 CORRECTIVE ACTION 4
1.13 POST-CONSTRUCTION CLEANUP OR OBLITERATION.....4
PART 2 PRODUCTS 5
2.01 DECONTAMINATION WORK PAD AND EQUIPMENT.....5
2.02 PORTABLE DECONTAMINATION 5
PART 3 EXECUTION 5
3.01 DECONTAMINATION WORK PAD CONSTRUCTION.....5
3.02 DECONTAMINATION OF EQUIPMENT 6
3.03 WASTE COLLECTION AND DISPOSAL 6
3.04 MAINTENANCE AND DEACTIVATION 6

SECTION 01400 – COORDINATION AND CONSTRUCTION WORK PLAN.....1
PART 1 GENERAL 1
1.01 GENERAL.....1
1.02 SUBMITTALS 1
1.03 COORDINATION 1
PART 2 PRODUCTS 2
2.01 DESIGNATION OF PROJECT MANAGEMENT PERSONNEL 2
2.02 SCHEDULES 2
2.03 CONSTRUCTION PLANS.....3
PART 3 EXECUTION 4
3.01 MANAGEMENT OF THE WORK 4
3.02 MANAGEMENT PERSONNEL.....5

3.03 COOPERATION WITH OWNER'S AGENT AND PROSECUTION OF THE WORK 5
3.04 MEETINGS 5

SECTION 01410 – REGULATORY REQUIREMENTS 1
PART 1 GENERAL 1
1.01 DESCRIPTION 1
1.02 PERMITS AND LICENSES 1
1.03 FEDERAL LAWS AND REGULATIONS 1
1.04 OREGON STATE LAWS AND REGULATIONS 1
1.05 REGISTRATION 2
PART 2 PRODUCTS 2
PART 3 EXECUTION 2
3.01 GENERAL 2

SECTION 01450 – QUALITY CONTROL 1
PART 1 GENERAL 1
1.01 DESCRIPTION 1
1.02 SUBMITTALS 1
1.03 TESTING 2
1.04 TEST CERTIFICATES 3
1.05 CONTRACTOR ASSISTANCE 3
1.06 OWNER'S AGENT'S QA PROGRAM 3
1.07 QUALITY CONTROL MANAGER QUALIFICATIONS AND RESPONSIBILITIES 3
PART 2 PRODUCTS 4
PART 3 EXECUTION 4
3.01 CONTRACTOR'S QC TESTS AND INSPECTIONS 4
3.02 CONTRACTOR'S OBLIGATION TO COMPLY WITH CONTRACT DOCUMENTS 5
3.03 FURNISHING OF SAMPLES 5
3.04 TEST REPORTS 5
3.05 CORRECTION OF DEFECTS 5
3.06 INSPECTION OF WORK AND MATERIALS 5
3.07 ACCEPTANCE 6

SECTION 01510 – TEMPORARY FACILITIES AND CONTROLS 1
PART 1 GENERAL 1
1.01 DESCRIPTION 1
PART 2 PRODUCTS 1
2.01 TEMPORARY SITE DEVELOPMENT 1
2.02 FIELD OFFICE FOR CONTRACTOR 1
2.03 MATERIAL STORAGE 2
2.04 DRINKING WATER 2
2.05 TEMPORARY TOILETS 2
2.06 ELECTRICAL LIGHT AND POWER 3
2.07 TEMPORARY HEATING AND COOLING 3
2.08 WATER FOR CONSTRUCTION PURPOSES, DECONTAMINATION, DUST CONTROL, AND FIRE PROTECTION 3
PART 3 EXECUTION 3
3.01 GENERAL 3
3.02 REMOVAL 4

3.03 WASTE DISPOSAL 4
3.04 HANDLING AND DISPOSAL OF SITE WATER 4

SECTION 01566 – EROSION AND SEDIMENT CONTROL 1
PART 1 GENERAL 1
1.01 DESCRIPTION 1
1.02 SUBMITTALS 2
PART 2 PRODUCTS 2
2.01 MATERIALS AND EQUIPMENT 2
2.02 QUALITY OF PERMANENT WORK 3
2.03 ACCEPTANCE 3
PART 3 EXECUTION 3
3.01 MINIMUM EROSION AND SEDIMENT CONTROL REQUIREMENTS 3
3.02 STORMWATER HANDLING AND DISPOSAL 4

SECTION 01575 – WASTE MATERIAL HANDLING AND DISPOSAL 1
PART 1 GENERAL 1
1.01 DESCRIPTION 1
1.02 SUBMITTALS 1
1.03 REQUIREMENTS FOR WASTE DISPOSAL AND RECYCLING SITES 2
PART 2 PRODUCTS 3
PART 3 EXECUTION 3
3.01 GENERAL 3
3.02 SITE MAINTENANCE 3
3.03 EXCAVATED MATERIAL HANDLING 4

SECTION 01724 – FIELD ENGINEERING AND SURVEYING 1
PART 1 GENERAL 1
1.01 DESCRIPTION 1
1.02 SUBMITTALS 1
1.03 INDEPENDENT SURVEYOR QUALIFICATIONS AND RESPONSIBILITIES 2
1.04 PROJECT RECORD DOCUMENTS 3
PART 2 PRODUCTS 3
PART 3 EXECUTION 3
3.01 GENERAL 3
3.02 SURVEY CONTROL AND REFERENCE POINTS 3
3.03 INSPECTION 4
3.04 SURVEY REQUIREMENTS 4
3.05 FINAL AS-BUILT SURVEY 5

SECTION 01781 – PROJECT RECORD DOCUMENTS 1
PART 1 GENERAL 1
1.01 DESCRIPTION 1
1.02 SUBMITTALS 1
1.03 SURVEYOR QUALIFICATIONS 1
PART 2 PRODUCTS 2
2.01 GENERAL 2
PART 3 EXECUTION 2
3.01 GENERAL 2
3.02 SURVEYOR'S FIELD BOOK 2
3.03 IMPROVEMENTS AND EXISTING UTILITIES 2

3.04 FREQUENCY OF UPDATING DRAWINGS 3
3.05 FINAL AS-BUILT SET 3
3.06 PAYMENT WITHHELD 3

SECTION 02222 – DECOMMISSIONING OF STORM DRAIN SYSTEM 1
PART 1 GENERAL 1
1.01 DESCRIPTION 1
1.02 DEFINITIONS 1
1.03 SUBMITTALS 1
1.04 REFERENCE STANDARDS 2
1.05 JOB CONDITIONS 3
PART 2 PRODUCTS 4
2.01 CLSM 4
2.02 BALLAST 4
2.03 PLUGS 5
2.04 FILTER FABRIC 6
PART 3 EXECUTION 6
3.01 GENERAL 6
3.02 PREPARATION 7
3.03 PIPELINE DECOMMISSIONING 7
3.04 CATCH BASIN AND MANHOLE DECOMMISSIONING 7
3.05 FIELD QUALITY CONTROL 8
3.06 DISPOSAL OF MATERIALS 8
3.07 MAINTENANCE AND CLEAN UP 8

SECTION 02325 – EXCAVATION AND BACKFILL 1
PART 1 GENERAL 1
1.01 DESCRIPTION 1
1.02 DEFINITIONS 1
1.03 REFERENCE STANDARDS 2
1.04 SUBMITTALS 2
1.05 PERMIT COMPLIANCE 2
1.06 PROJECT CONDITIONS 3
PART 2 PRODUCTS 3
PART 3 EXECUTION 3
3.01 GENERAL 3
3.02 PREPARATION 3
3.03 TRENCHING 4
3.04 EXCAVATION 4
3.05 DEBRIS REMOVAL AND DISPOSAL 5
3.06 ACCESS RAMPS AND HAUL ROADS 6
3.07 BACKFILL 6
3.08 SURVEYING 8
3.09 REPORTS AND RECORDS 8

SECTION 02501 – STORM DRAINAGE AND TREATMENT SYSTEM 1
PART 1 GENERAL 1
1.01 DESCRIPTION 1
1.02 REFERENCES 1
1.03 SUBMITTALS 3
1.04 DELIVERY AND STORAGE 4
1.05 SYSTEM DESCRIPTION 4

1.06 GRADATION TESTS 5
1.07 ACCEPTANCE CRITERIA FOR BACKFILL MATERIALS 5
PART 2 PRODUCTS 6
2.01 MATERIAL SOURCES....6
2.02 BORROW MATERIAL....6
2.03 PIPE BEDDING....7
2.04 FILTER SAND....7
2.05 LEVELING SAND....8
2.06 ¾" MINUS CRUSHED ROCK....8
2.07 CHANNEL ARMOR LAYER 9
2.08 INLET SCOUR PROTECTION....9
2.09 GRANULAR BENTONITE 10
2.10 CLAY 10
2.11 GEOTEXTILES 10
2.12 GEOMEMBRANE LINER 11
2.13 24" AND 8" POLYVINYL CHLORIDE (PVC) PIPE....14
2.14 4" POLYVINYL CHLORIDE (PVC) UNDERDRAIN PIPE....15
2.15 PRECAST CONCRETE MANHOLE....16
2.16 ULTRABLOCK™ SEGMENTAL UNIT 16
2.17 SOURCE QUALITY CONTROL 17
PART 3 EXECUTION 17
3.01 GENERAL....17
3.02 GEOMEMBRANE LINER 17
3.03 GEOTEXTILES 21
3.04 PIPING PLACEMENT 21
3.05 QUALITY CONTROL 22

SECTION 02510 – TEMPORARY ENVIRONMENTAL CAP 1
PART 1 GENERAL 1
1.01 DESCRIPTION....1
1.02 REFRENCES 1
1.03 SUBMITTALS 2
1.04 DELIVERY AND STORAGE....2
1.05 SYSTEM DESCRIPTION 2
PART 2 PRODUCTS 3
2.01 MATERIALS....3
2.02 EQUIPMENT FOR CRACK SEALING....4
PART 3 EXECUTION 5
3.01 GENERAL....5

LIST OF EXHIBITS

EXHIBIT 1. SUMMARY OF SITE SOIL QUALITY

EXHIBIT 2. FINAL DESIGN REPORT (TO BE INCLUDED WITH CONTRACT)

EXHIBIT 3. FORMER ARKEMA, INC. FACILITY NPDES PERMIT

EXHIBIT 4. ASPHALT CRACK PHOTOGRAPHS

INVITATION TO BID

(TO BE INCLUDED IN CONTRACT)

INSTRUCTIONS TO BIDDERS

(TO BE INCLUDED IN CONTRACT)

BID FORM

(TO BE INCLUDED IN CONTRACT)

GENERAL CONDITIONS

(TO BE INCLUDED IN CONTRACT)

SUPPLEMENTAL CONDTIONS

(TO BE INCLUDED IN CONTRACT)

SECTION 01110 – SUMMARY OF WORK

PART 1 GENERAL

1.01 DEFINITIONS

A. Whenever the following terms are used in these Specifications, it is understood that they represent the following:

1. OWNER
   Arkema, Inc.
   6400 Northwest Front Avenue
   Portland, Oregon 97210

2. OWNER'S AGENT
   Legacy Site Services, LLC
   468 Thomas Jones Way
   Suite 150
   Exton, Pennsylvania 19341

3. ENGINEER
   Integral Consulting Inc.
   319 SW Washington St., Suite 1150
   Portland, OR 97204

4. CONTRACTOR
   The individual, firm, partnership, or corporation which is determined to be the successful Bidder.

1.02 DESCRIPTION

A. This section provides a summary of the Work for informational purposes and for the convenience of the Contractor. In the event that information provided in this section conflicts in any way with the requirements of any other section of the Contract Documents, those other sections shall prevail.

B. This section provides a description of key features of the Work, site constraints, Contractor use of site, coordination of the Work, sequence of construction, and use and occupancy prior to completion of the project.

1.03 SUMMARY OF WORK

A. Project Description. This work is being performed pursuant to the Order on Consent requiring source control measures (SCMs) issued by the Oregon Department of Environmental Quality (DEQ) and signed October 31, 2008 (DEQ No. LQVC-NWR-08-04) (Consent Order), and the Mutual Agreement and Order, requiring stormwater treatment, No. WQ/I-NWR-10-175, executed by DEQ and LSS on August 4, 2010 (MAO). The goal of the stormwater SCMs is to reduce the potential for migration of site constituents of potential concern (COPCs) in stormwater to the Willamette River. The system generally consists of a series of surface stormwater collection channels and trenches, a stormwater detention basin, and a stormwater sand filter basin. Some of the site will be capped, and a majority of the existing site stormwater conveyance features will be decommissioned as part of this work. The stormwater SCMs are considered an interim action that is being applied in advance of the site-wide Feasibility Study and selection of a final site remedy that addresses COPCs in soil and groundwater (and ultimately stormwater) in the upland portions of the site.

B. This work includes labor, materials, tools, equipment, supplies, testing, transportation, services, and superintendence for the Contractor to perform decommissioning, excavation, transportation and disposal, backfill, and all related work at the Site.

C. The Base Items of this Contract are defined in Section 01270 – Measurement and Payment.

D. The Work includes, but is not limited to, the following activities:

1. Compliance with the General Conditions and Special Conditions of the Contract.
2. Submittal of a Construction Work Plan in accordance with Section 01400 – Coordination and Construction Work Plan.
3. Mobilization, site work, and temporary facilities, including mobilization of personnel and equipment; site preparation; meetings; temporary facilities such as trailers and decontamination facilities, temporary access, sanitary facilities, and traffic controls; dust, erosion, fugitive emissions, and surveying.
4. Construction of a stormwater settling/detention basin and a sand filtration basin, and construction of piping and other structures required to connect the outfall from the treatment basin to an existing site outfall as shown on the Contract Drawings and detailed in these specifications.
5. Decommissioning selected underground storm and sanitary sewer structures as defined on the Contract Drawings and detailed in these specifications.
6. Construction of surface stormwater conveyance features.
7. Construction of a temporary environmental cap in selected areas shown on the Contract Drawings as detailed in these specifications.
8. Installation and/or repair of the temporary environmental cap in selected areas shown on the Contract Drawings as detailed in these specifications.

9. Monitoring and verification of construction activities as specified in Section 01450 – Quality Control and Section 01724 – Field Engineering and Surveying.
10. Preparation of Record Drawings and other construction documentation as specified in Section 01450 – Quality Control and Section 01724 – Field Engineering and Surveying.
11. Demobilization of personnel, equipment, and materials at the completion of construction, including demobilization of temporary facilities, utilities, and close-out reporting.

E. Additional items of this Contract defined in Section 01270 – Measurement and Payment include:

1. Standby time approved by the Owner's Agent due to unforeseen delays not specified in Paragraph 1.03 of this section. This item includes, but is not limited to: standby time due to delays caused or requested by the regulatory oversight agency or other unforeseen issues identified by the Owner's Agent during the progress of the Work.

1.04 SITE CONSTRAINTS

A. The following special constraints shall be considered by the Contractor in the planning and execution of the Work. This is not intended to be a comprehensive list of constraints for the Work, but as an aid to the Contractor in development of schedules and in executing the Work. Additional constraints may exist or develop as the Work progresses. In any event, the Contractor is responsible for compliance with the requirements of the various specification sections and the work procedures and protection requirements contained therein, and identifying all constraints associated with the work execution and incorporating them into work schedules, proposed construction activities, and bid prices.

B. It is anticipated that the Stormwater SCMs defined in this contract will be completed during the same construction season and potentially at the same time as the Groundwater SCMs will be completed on the site by others. The details of the Groundwater SCMs are shown on the EPA web site at the following address http://www.epa.gov/region10/pdf/ph/arkema/gwbw_pre_final_design.pdf. Contractor shall review this document to understand the portions of the site that will be occupied by the Groundwater SCMs activities. The location of the groundwater barrier wall construction activities is provided on the Contract Drawings for reference.

1.05 CONTRACTOR USE OF SITE

A. The Contractor shall control use of the Site; comply with laws, regulations, standards, and requirements of the Contract; allow inspection and verification of the Work by the Owner's Agent; and control access to the staging areas and active work areas by the public. Health and safety is the responsibility of the Contractor.

B. The Contractor's use of upland staging and access areas shall be in accordance with applicable provisions of the Contract Specifications and Drawings in accordance with Section 01510 – Temporary Facilities and Controls.

1.06 COORDINATION OF WORK

A. The Groundwater SCMs contractor will be using the site at the same time as the work defined under this contract will occur. The Contractor shall cooperate and coordinate with the different parties as required to avoid conflicts.

B. Owner's Agent will require regular coordination meetings between the Groundwater SCMs contractor and the Stormwater SCMs Contractor in order to coordinate interaction between the two contractors and all others who may be performing activities at the site.

1.07 SEQUENCE OF CONSTRUCTION

A. The Work will be conducted in accordance with the construction schedule submitted by the Contractor and accepted by the Owner's Agent. The construction schedule shall be based on the requirements of these Contact Documents, including requirements in these Specifications and on the Contract Drawings, the required interaction between the Groundwater SCMs and the Work in this contract, and on the Contractor-prepared and Owner's Agent-accepted Construction Work Plan.

B. The Contractor shall conduct its operations understanding and controlling the effect that precipitation during construction will have on the new stormwater system as it is being constructed. Contractor shall mobilize and use a portable stormwater treatment system to store and treat the stormwater as needed.

C. In general, the contract administration sequence is as follows:

1. The Owner's Agent awards base bid items;
2. The Owner's Agent will issue phased Notices to Proceed (NTP), including:
   a. NTP for submittals (issued with executed Contract Documents).
   b. NTP for mobilization and site preparation.
   c. NTP for site work, contingent on acceptance of Contractor's Construction Work Plan and taking into consideration the site constraints identified in Paragraph 1.03 of this section and elsewhere in the Contract Documents.
3. The general required construction sequencing that will take place on the site as a whole includes the following activities:
   a. Install all erosion, sediment and pollution control devices, including install all stormwater containment berms as shown on the Contract Drawings.
   b. Complete construction of stormwater detention basin and sand filter basin so that the system is can treat and discharge stormwater as other aspects of the Work are completed.
   c. Locate and decommission stormwater piping and other features shown on the Contract Drawings in this Stormwater SCMs contract. Most of these utilities are in the working footprint for the Groundwater SCMs contract. This work is required to be complete, and Contractor shall be off the work area of the Groundwater SCMs by July 15, 2012. Contractor will be required to manage site stormwater, except as noted below, upon

completion of the decommissioning activities until the stormwater SCMs are in place.

i. Groundwater SCMs work to begin once all underground stormwater features have been decommissioned by the Stormwater SCMs Contractor.

ii. Groundwater SCMs contractor to be responsible for controlling all construction stormwater that impacts within their Limits of Disturbance shown on the Groundwater SCMs drawings.

d. Complete construction of the stormwater channels for conveyance site stormwater to the detention basin.

4. Stormwater SCMs Contractor shall complete new temporary environmental cap construction and existing temporary environmental cap repair after the Groundwater SCMs contract work is completed. Contractor shall have site to place cap after December 31, 2012.

5. The Contractor shall perform the Work in accordance with the Contract and applicable laws, regulations, and standards. The Contractor shall provide prompt written notice to the Owner's Agent of changes in the Work, contract amount, contract time, or contract terms due to Site conditions, quantities, or nature of the Work. Contractor shall not commence with changes in the Work without prior written approval from the Owner's Agent.

6. The Contractor shall perform the Work of any contract-required corrective measures in accordance with the Contract and applicable laws, regulations, and standards.

7. The Contractor shall prepare project documents, reports, and close-out submittals required by the Contract at the completion of Work for acceptance by the Owner's Agent.

8. The Owner's Agent will issue Final Acceptance to the Contractor when requirements of the Contract are completed.

1.08 USE AND OCCUPANCY PRIOR TO COMPLETION OF CONTRACT

A. The Owner's Agent will use and occupy any portion of the Work which has been sufficiently completed, but such use and occupancy shall not be construed as an acceptance of any portion of the work.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

Not used.

END OF SECTION 01110

SECTION 01270 – MEASUREMENT AND PAYMENT [TO BE FINALIZED WITH BID DOCUMENTS]

PART 1 GENERAL

1.01 DESCRIPTION

A. This Section includes measurement and payment description clauses for the Bid Items.

B. Measurement for payment will be at the lump sum or unit price stipulated in the schedule of bid prices presented in the Bid Form in the Contract Documents for the pay items listed below. Payment shall be considered full compensation for furnishing all labor, materials and equipment to complete the Work in accordance with the requirements and intent of the Contract Documents, including the Contract Specifications, Exhibits, and Contract Drawings.

C. Where unit price work is shown, quantities are those believed to be required to accomplish the Base Bid scope of work, as described in these Contract Documents; however, actual quantities will govern final payment. Any omission in the pay item descriptions listed in this section, but otherwise specified in the Contract Documents, is not a basis for Contractor change orders. The Contractor is responsible for providing a written declaration, submitted with its bid proposal, identifying any apparent omissions that it believes have not been properly addressed in this section, the Bid Form, or elsewhere in the Contract Documents.

D. Only the Base Bid Pay Items listed in Article 1.04 of this Section shall be considered for measurement and payment. The listed Base Bid Pay Items are designated with the same item numbers as, and correspond to, the pay items listed in schedule of bid prices presented in the Bid Form in the Contract Documents. Together these pay items constitute the entire Base Bid Scope of Work under this Contract. Unless otherwise stated, each pay item shall include all direct and indirect costs necessary to complete the subject Work of that item.

E. The pay item descriptions provided in Article 1.04 of this Section are abbreviated in form and rely on reference to the applicable sections of the Contract Specifications and Drawings for detailed requirements. The descriptive terms used in this section to describe the locations, materials, structures, and other elements of the pay items correspond to the terminology used in the Contract Specifications and Drawings. Contractor shall verify its understanding of these terms and their associated relationship to the respective pay items.

1.02 MEASUREMENT OF WORK

A. Lump Sum Pay Items

1. Items of work for which payment is made by a "lump sum" shall be measured as a complete unit. Labor, materials, or equipment used in lump-sum price pay items will not be measured or paid for separately. Partial payment, if made, shall be on the basis of the completed percentage of the lump sum unit, as agreed between Contractor and the Owner's Agent. Contractor shall, at the Owner's Agent's request, submit with its progress payment requests, an itemized accounting of the estimated costs incurred towards the respective elements of each lump sum pay item, which documents the basis for Contractor's estimate of the percent complete.
2. The lump sum pay items described in Article 1.04 shall not be adjusted as a result of change orders or extra work. The negotiated Contract price for change orders or extra work shall include additional provisions for any work that may be described as part of an existing lump sum pay item.
3. Estimated quantities that may be included in the description of certain lump sum or incidental pay items are approximate only and are provided for Contractor's use in determining bid prices. In the event that the actual quantity for such items exceeds the estimated quantity by more than 25 percent, Contractor may claim additional compensation in accordance with the General Conditions and Supplemental Conditions of the Contract.
4. For lump sum or incidental pay item descriptions that do not include estimated quantities, Contractor shall be responsible for estimating the pay quantities based on information provided in the Contract Documents, or other means as deemed appropriate by Contractor.

B. Unit Price Pay Items

1. Items of work for which payment is made by a "unit price" shall be measured according to the methods and units described in Article 1.04 of this Section and the applicable requirements of General Conditions and Supplemental Conditions of the Contract.

1.03 INCREASED OR DECREASED QUANTITIES

A. Payment to Contractor will only be made for the actual quantities of the work performed and accepted in conformance with the Contract. When the accepted quantities of work vary from the original bid quantities, payment will be at the unit contract prices for accepted work unless the total quantity of any pay item increases or decreases by more than 25 percent relative to the original bid quantity. In that case, that part of the increase or decrease exceeding 25 percent will be adjusted in accordance with the applicable requirements of the General Conditions and Supplemental Conditions of the Contract.

1.04 MEASUREMENT AND PAYMENT FOR THE BID ITEMS (TO BE COMPLETED WITH FINAL DESIGN)

A. Pay Item No. 1: Construction Management.

1. Construction Management shall include all labor, equipment, and materials required to complete the following elements of the Work:

   a. Project Coordination, Construction Work Plan and Meetings. All requirements of Section 01400.

   b. Submittals. All requirements of Section 01330, including preparation and processing of submittals specified under other sections of the Specifications.

   c. Contract Closeout. All requirements of Section 01781.

   d. Project management and related activities associated with all other Specifications Sections, except those activities, if any, specifically addressed under another pay item.

2. Payment for Construction Management shall be on the basis of the lump sum price stated in the schedule of bid prices for this pay item. Measurement for this pay item shall be estimated on the basis of percent complete, relative to the overall bid price and the actual progress toward completion, as specified in Article 1.02 of this Section.

B. Pay Item No. 2: Field Engineering and Surveying.

1. Field Engineering shall include all labor, equipment, and materials required to complete the following elements of the Work:

   a. Field Engineering and Surveying. All requirements of Section 01724.

   b. Quality Assurance/Quality Control. All requirements of Section 01450.

2. Payment for Field Engineering shall be on the basis of the lump sum price stated in the schedule of bid prices for this pay item. Measurement for this pay item shall be estimated on the basis of percent complete, relative to the overall bid price and the actual progress toward project completion, as specified in Article 1.02 of this Section.

3. Surveying requirements noted in other pay items are provided for informational purposes, but shall be paid under this pay item.

C. Pay Item No. 3: Mobilization.

1. Mobilization shall include all labor, equipment, and materials required to mobilize and prepare to accomplish the Work specified in the Contract Documents, including, but not limited to, the following elements of the Work:

a. Environmental Protection. All requirements of Section 01355.

b. Health and Safety. All requirements of Section 01350.

c. Regulatory Requirements. All requirements of Section 01410.

d. Temporary Facilities and Controls. All requirements of Section 01510.

e. Erosion and Sediment Control. All requirements of Section 01566.

f. Transport all labor and equipment to the site, as required to complete the Work.

g. Supply, transport, and install temporary facilities within the onsite offsite support zones, including field offices, access roads, parking areas, materials and equipment storage facilities, sanitary services, and power, water, and telephone utility services.

h. Supply, transport, and assemble construction aids and equipment at the site.

i. Procure permits and inspection necessary to hook up utilities.

j. Preparation of the site for initiating the Work.

k. Remove all equipment, unused materials, supplies, and incidentals from the job site at the completion of the Work.

l. Costs for bonds, insurance, local utility permits (as required), and similar charges.

m. Other costs of preparatory work and related operations performed by Contractor that are not defined as a part of other pay items.

2. Payment for Mobilization shall be on the basis of the lump sum price stated in the schedule of bid prices for this pay item. Measurement of this pay item shall be estimated on the basis of the percent complete, relative to the overall bid price and the actual progress toward project completion, as specified in Article 1.02 of this Section.

D. Pay Item No. 4: Decommissioning of Existing Stormwater Collection System.

1. Decommissioning of Existing Stormwater Collection System shall include all labor, equipment, and materials necessary to complete the following elements of the Work, as specified in Section 02222:

a. Plugging of all pipelines less than 24-inches in diameter as indicated on the Contract Drawings with a grout plug.

b. Filling of all pipelines greater than 24-inches in diameter as indicated on the Contract Drawings with CLSM.

c. Decommissioning of all catch basins and manholes as indicated on the contract drawings as per the following:

i. Fill with ballast material up to 2 ft bgs.

ii. Cover ballast material with a filter fabric.

iii. Fill the remainder of the structure, up to 3-inches below ground surface.

iv. Cap with a 3-inch lift of asphalt placed flush with the ground surface.

2. Payment for Decommissioning of Existing Stormwater Collection System shall be on the basis of the lump sum price stated in the schedule of bid prices for this pay item. Measurement for this pay item shall be estimated on the basis of the percent complete, relative to the overall bid price and the actual progress toward project completion, as specified in Article 1.02 of this Section.

3. As per the schedule of bid prices, contractor shall provide the following alternative bid prices in the case that additional decommissioning activities are required during the progress of the Work. These additional decommissioning activities may be required if additional structures are determined to require decommissioning by the Owner's Agent beyond those indicated on the Contract Drawings.

   a. Alternative Bid Item 4A. Pipeline Grout Plugging. Payment for this bid item shall be on the basis of cubic yards of additional grout material required to complete an additional plugging, as determined during the progression of the Work.

   b. Alternative Bid Item 4B. CLSM Material. Payment for this bid item shall be on the basis of cubic yards of additional CLSM material required to complete additional pipeline filling and/or manhole/catch basin decommissioning as determined during the progression of the Work.

   c. Alternative Bid Item 4C. Ballast Material. Payment for this bid item shall be on the basis of cubic yard of additional ballast material required to complete additional manhole and/or catch basin decommissioning as determined during the progression of the Work.

   d. Alternative Bid Item 4D. Geotextile Material. Payment for this bid item shall be on the basis of square yard of additional geotextile material required to complete additional manhole and/or catch basin decommissioning as determined during the progression of the Work.

   e. Alternative Bid Item 4E. Asphalt Paving. Payment for this bid item shall be on the basis of cubic yard of additional asphalt pavement required to complete additional manhole and/or catch basin decommissioning as determined during the progression of the Work.

E. Pay Item No. 5: Excavation and Disposal.

1. Excavation and disposal shall include all labor, equipment, and materials necessary to complete the following elements of the Work as specified in Section 02501:

   a. Complete all excavation, including excavation of the Stormwater Conveyance Channels, Detention Basin and Sand Filter, to the neatlines and grades shown on the Contract Drawings.

   b. Management of all excavated materials in accordance with Section 01575.

c. Debris Handling and Disposal. Segregate all concrete, asphalt, and/or other debris encountered during the excavation. Manage all debris in accordance with Section 01575.

2. Payment for excavation and disposal shall be on the basis of cubic yards of excavated material, at the unit price stated in the schedule of bid prices for this pay item. Measurement of this pay item shall be determined on the basis of the Owner's Agent (or Contractor's approved) pre-construction survey of the existing grades prior to excavation, and Contractor's post-construction survey upon completion of the excavation.

3. No payment will be made to Contractor for excavation beyond the lines and grades shown on the Drawings, except as otherwise directed by the Owner's Agent. All excavations shall be surveyed by Contractor and approved by the Owner prior to backfilling.

4. Contractor shall not be permitted to excavate soil beyond the allowable over-excavation limits, except as otherwise directed by the Owner's Agent. I the event that excavation depths exceed the allowable over-excavation limits as a result of Contractor's failure to control the Work, Contractor will be directed to cease excavation activities until construction methods are corrected as required to maintain compliance with the specified construction tolerances, at no additional cost to Owner.

5. Contractor shall be responsible for implementing shoring controls as required to complete the Work.

6. All work and associated costs for handling and disposal of any and all debris encountered during excavation shall be considered incidental to this pay item.

F. Pay Item No. 6: Stormwater Conveyance and Treatment 6 oz Geotextile.

1. Stormwater Conveyance and Treatment System 6 oz Geotextile shall include all labor, equipment, and materials required to satisfy the applicable requirements of the following Specification Sections and related elements of the Work, including, but not limited to:

a. Stormwater Containment Berms 6 oz Geotextile. Supply and install geotextile material over all stormwater containment berms as indicated on the Contract Drawings and in Section 02501.

b. Unlined Stormwater Channels 6 oz Geotextile. Supply and install geotextile material within all unlined stormwater conveyance channels as indicated on the Contract Drawings and in Section 02501.

2. Payment for Stormwater Conveyance and Treatment 6 oz Geotextile shall be on the basis of square yards, at the unit price stated in the schedule of bid prices for this pay item. Measurement for this pay item shall be determined on the basis of Contractor's survey of the area actually covered

3. No payment will be made to Contractor for specified geotextile overlaps, remaining extra material or waste for trimming.

G. Pay Item No. 7: Stormwater Conveyance and Treatment 12 oz Geotextile.

1. Stormwater Conveyance and Treatment System 12 oz Geotextile shall include all labor, equipment, and materials required to satisfy the applicable requirements of the following Specification Sections and related elements of the Work, including, but not limited to:

   a. Stormwater Liner Cover 12 oz Geotextile. Supply and install 12 oz geotextile material over the detention basin and sand filter liner as indicated on the Contract Drawings and in Section 02501.

   b. Lined Stormwater Channels 12 oz Geotextile. Supply and install 12 oz geotextile material over the stormwater channel liner as indicated on the Contract Drawings and in Section 02501.

2. Payment for Stormwater Conveyance and Treatment 12 oz Geotextile shall be on the basis of square yards, at the unit price stated in the schedule of bid prices for this pay item. Measurement for this pay item shall be determined on the basis of Contractor's survey of the area actually covered

3. No payment will be made to Contractor for specified geotextile overlaps, remaining extra material or waste for trimming.

H. Pay Item No. 8. Leveling Sand

1. Leveling Sand shall include all labor, equipment, and materials required to satisfy the applicable requirements of the following Specifications Sections and related elements of the Work, including, but not limited to:

   a. Liner leveling layer. Supply and place Leveling Sand fill material as required to achieve specified final grades for the placement of the geomembrane liner in the detention basin and sand filter as indicated on the Contract Drawings and in Section 02501.

   b. Liner cover. Supply and place Leveling Sand as cover material on the geomembrane liner in the detention basin and sand filter as indicated on the Contract Drawings and in Section 02501.

2. Payment for Leveling Sand shall be on the basis of tons of imported material actually placed, at the unit price stated in the schedule of bid prices for this pay item. Measurement for this pay item shall be based on certified truck weights for material delivered to the site and used in the Work.

3. No payment will be made to Contractor for material placed beyond the specified backfill limits shown on the Contract Drawings, except as directed by the Owner's Agent.

I. Payment No. 9. ¾-inch Minus Crushed Rock.

1. ¾-inch Minus Crushed Rock shall include all labor, equipment, and materials required to satisfy the applicable requirements of the following Specifications Sections and related elements of the Work, including, but not limited to:

   a. Liner cover crushed rock. Supply and place all ¾-inch minus crushed rock as required for cover material on the geomembrane liner in the detention basin and sand filter as indicated on the Contract Drawings and in Section 02501.

b. Stormwater containment berms crushed rock. Supply and place all ¾-inch minus crushed rock as required to cover the stormwater containment berms as required on the Contract Drawings and Section 02501.

c. Sand Filter underdrain system crushed rock. Supply and place all ¾-inch minus crushed rock as required for construction of the sand filter underdrain system as required on the Contract Drawings and Section 02501.

d. Manhole base course crushed rock. Supply and place all ¾-minus crushed rock as require for installation of manholes as required on the Contract Drawings and Section 02501.

2. Payment for ¾-inch Minus Crushed Rock shall be on the basis of tons of imported material actually placed, at the unit price stated in the schedule of bid prices for this pay item. Measurement for this pay item shall be based on certified truck weights for material delivered to the site and used in the Work.

3. No payment will be made to Contractor for material placed beyond the specified backfill limits shown on the Contract Drawings, except as directed by the Owner's Agent.

J. Payment Item No. 10. Channel Armor Material

1. Channel Armor Material shall include all labor, equipment, and materials required to satisfy the applicable requirements of the following Specifications Sections and related elements of the Work, including, but not limited to supplying placing all channel armor as required for in the stormwater conveyance channels on the Contract Drawings and in Section 02501.

2. Payment for Channel Armor material shall be on the basis of tons of imported material actually placed, at the unit price stated in the schedule of bid prices for this pay item. Measurement for this pay item shall be based on certified truck weights for material delivered to the site and used in the Work.

3. No payment will be made to Contractor for material placed beyond the specified backfill limits shown on the Contract Drawings, except as directed by the Owner's Agent.

K. Payment Item No. 11. Inlet Scour Protection

1. Inlet Scour Protection shall include all labor, equipment, and materials required to satisfy the applicable requirements of the following Specifications Sections and related elements of the Work, including, but not limited to supplying placing all inlet scour protection as required for in the detention basin on the Contract Drawings and in Section 02501.

2. Payment for Inlet Scour Protection material shall be on the basis of tons of imported material actually placed, at the unit price stated in the schedule of bid prices for this pay item. Measurement for this pay item shall be based on certified truck weights for material delivered to the site and used in the Work.

3. No payment will be made to Contractor for material placed beyond the specified backfill limits shown on the Contract Drawings, except as directed by the Owner's Agent.

L. Payment Item No. 12. Geomembrane Liner

1. Geomembrane Liner shall include all labor, equipment, and materials required to satisfy the applicable requirements of the following Specification Sections and related elements of the Work, including, but not limited to:

   a. Geomembrane liner. Supply and install LLDPE geomembrane liner material in the detention basin and sand filter to the lines and grades shown on the Contract Drawings. Supply and install boots and other approved methods to seal all penetrations through the geomembrane liner as specified. Supply and place all sand bags to secure geomembrane liner as specified (See Section 02501).

2. Payment for Geomembrane Liner shall be on the basis of square feet of geomembrane installed, at the unit price stated in the schedule of bid prices for this pay item. Measurement for this pay item shall be determined on the basis of Contractor's survey of the area actually covered.

3. No payment will be made to Contractor for specified geomembrane overlaps, remaining extra material, or waste from trimming.

M. Pay Item No 13. Stormwater Conveyance and Treatment System Piping.

1. Stormwater Conveyance and Treatment System Piping shall include all labor, equipment, and materials required to satisfy the applicable requirements of the following Specification Sections and related elements of the Work, including, but not limited to:

   a. Treatment System Structures. Supply and install the treatment system piping structures including but not limited to the outlet structure to the detention basin and the manhole located between the detention basin and sand filter and the treatment system piping as indicated on the Contract Drawings (See Specification 02501).

   b. Treatment System Piping. Supply and install all treatment system piping, including 24" PVC transfer pipeline from the detention basin to the sand filter and 24" PVC discharge pipeline from the sand filter, including connection to existing stormwater drainage system manhole as to the lines and grades indicated on the Contract Drawings (See Specification 02501).

   c. Sand Filter Underdrain Piping. Supply and install all 4" PVC for the sand filter underdrain to the lines and grades indicated on the Contract Drawings (See Specification 02501).

   d. Trenching and Site Restoration. Identify, located, and protect all potentially impacting existing utilities and vegetation. Complete all backfilling as specified. Reconstruct and restore to their original condition any existing surface features impacted by the installation of the treatment system piping.

2. Payment for the Stormwater Conveyance and Treatment System shall be on the basis of lump sum price state in the schedule of bid prices for this pay item. Measurement for this pay item shall be estimated on the basis of percent

complete, relative to the overall bid price and the actual progress toward project completion.

N. Pay Item No 14. ULTRABLOCK™ Concrete Blocks

1. ULTRABLOCK™ Concrete Blocks shall include all labor, equipment, and materials required to satisfy the applicable requirements of the following Specification Section 02501 and related elements of the Work, including, but not limited to:

   a. Installation of sediment forebay block wall an overflow weir as indicated on the Contract Drawings.

   b. Installation of baffles within the detention basin as indicated on the Contract Drawings.

   c. Installation of influent flow spreader in the sand filter as indicated on the Contract Drawings.

   d. Installation of effluent overflow weir in the sand filter as indicated on the Contract Drawings.

   e. Installation of Stormwater Containment Berm along Front Avenue as indicated on the Contract Drawings.

2. Payment for the ULTRABLOCK™ Concrete Blocks shall be on the number of blocks stated in the schedule of bid prices for this pay item. Measurement for this pay item shall be determined by the actual number of blocks required to complete the Work.

3. All excavation, demolition, waste material handling, and supply and placement of granular bentonite and clay materials required to install the concrete blocks will be considered incidental to this pay item.

O. Pay Item No 15. Temporary Environmental Cap.

1. Temporary Environmental Cap shall include all labor, equipment, and materials required to install the temporary environmental cap, including geotextiles, plastic sheeting, and crushed rock as indicated in the Contract Drawings and in Specification Section 02510.

2. Payment for the Temporary Environmental Cap shall be based on the square yards of the cap as installed. Measurement for this pay item shall be determined on the basis of Contractor's survey of the area actually covered, based on a horizontal projection of the covered area.

3. All demolition, waste material handling, and supply and placement of granular fill required to install the temporary environmental cap will be considered incidental to this pay item.

P. Pay Item No 16. Concrete Foundation Sealer

1. Concrete Foundation Sealer shall include all labor, equipment, and materials required to install the concrete foundation sealer as indicated in the Contract Drawings.

2. Payment for the Concrete Foundation Sealer shall be based on the square yards of the foundation sealed as installed. Measurement for this pay item shall be determined on the basis of Contractor's survey of the area actually covered, based on a horizontal projection of the covered area.
3. All demolition, waste material handling, and supply and surface preparation required to install the concrete foundation sealer will be considered incidental to this pay item.

Q. Payment Item No. 16. Borrow Material

1. Borrow Material shall include all labor, equipment, and materials required to satisfy the applicable requirements of the following Specifications Sections and related elements of the Work, including, but not limited to supplying and placing all borrow material as required for the construction of the stormwater containment berms as indicated on the Contract Drawings and in Section 02501.
2. Payment for Borrow Material shall be on the basis of tons of imported material actually placed, at the unit price stated in the schedule of bid prices for this pay item. Measurement for this pay item shall be based on certified truck weights for material delivered to the site and used in the Work.
3. No payment will be made to Contractor for material placed beyond the specified backfill limits shown on the Contract Drawings, except as directed by the Owner's Agent.

1.05 CLEANUPS/REMOVALS OF SPILLS AND CONTAMINATION

A. No payment will be made for materials, equipment, or labor for cleanups/removals of spills and contamination due to Contractor negligence or failure to follow proper work operations, Contractor equipment failures, or booms and containment equipment required as a general operating constraint for operations required under this Contract to maintain environmental pollution prevention control and spill prevention and pollution in accordance with Section 01355 – Environmental Pollution Protection Control.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION 01270

SECTION 01330 – SUBMITTALS

PART 1 GENERAL

1.01 DESCRIPTION

A. This Section establishes procedures for submittals by the Contractor and provides a list and schedule of submittals with reference to the Sections where the submittal contents are described in detail.

B. The Bid prices shall include costs for furnishing all submittals.

C. Each submittal shall be accompanied by a Submittal Transmittal and Review Form, with a distribution list to be determined by the Owner's Agent. Four (4) copies of each submittal shall be included with each submittal.

1.02 SUBMITTAL CONTROL DOCUMENTS

A. The Contractor shall prepare and submit to the Owner's Agent, within 7 calendar days after receipt of Notice to Proceed of Submittals, a Submittal Control Document in duplicate, listing all Bid items for which submittals are required.

B. The Submittal Control Document shall be organized by specification section number and shall include the following information for all listed items:

1. Bid item(s) that the submittal represents.
2. Contractor submittal identification number.
3. Identification of those items which are "or equal" substitutions.
4. Scheduled submittal date.
5. Date when the Bid Item is needed.

C. The Submittal Control Document shall be coordinated with the preliminary critical path schedule reviewed and accepted at the preconstruction conference.

1. The Contractor shall allow 7 calendar days for the Owner's Agent's review.
2. If rejected by the Owner's Agent, the Contractor shall resubmit the document, allowing an additional 7 calendar days for each review required until accepted by the Owner's Agent.
3. The data in the Submittal Control Document shall not relieve the Contractor of the obligation to comply with the Specification requirements regarding Contract Time.

4. The Contractor shall review the Submittal Control Document, update or correct the Submittal Control Document as necessary, and resubmit the updated or corrected document to the Owner's Agent along with any revised progress schedule for review and comment at the progress meetings as specified in Section 01400 – Coordination and Construction Work Plan.

D. The Submittal Control Document and the critical path schedule shall indicate when the various Shop Drawings, as defined in Article 1.04 of this Section, or other documents are to be submitted.

1.03 CONSTRUCTION WORK PLAN

A. Prepare and submit to the Owner's Agent, within 14 calendar days of the issuance of the Notice to Proceed for Submittals, a Construction Work Plan. Obtain Owner's Agent's acceptance of the plan prior to conducting the respective components of the Work. The Plan shall include at a minimum all of the components described in Section 01400 – Coordination and Construction Work Plan.

1.04 SHOP DRAWINGS

A. General.

1. If a Shop Drawing is required by the Specifications, Work on the specified item shall not be performed by the Contractor until the submittal is accepted by the Owner's Agent in writing.
2. In addition to Supplemental Drawings furnished by the Owner's Agent, the Contract may also require the Work to be supplemented by Shop Drawings prepared by the Contractor, a Subcontractor, Material Supplier, or manufacturer when necessary to detail and illustrate portions of the Work. The Bid item prices shall include all costs for furnishing Shop Drawings and submittals.

B. Size and Layout.

1. Shop Drawings may be on 22-inch x 34-inch sheets or, if adequate, on smaller sheets, size 8½ x 11, 8½ x 14, or 11 x 17 inches.
2. For Shop Drawings, size 8½ x 11, 8½ x 14, or 11 x 17 inches, the Contractor shall submit four (4) copies that are sufficiently legible to make photocopies.
3. For Shop Drawings that are 22 x 34 inches in size, the Contractor shall submit one (1) reproducible original and four (4) copies.
   a. The reproducible original shall be Mylar.
   b. Other types of reproducibles will be accepted provided they are on clear and permanent type material (e.g., reprographic Mylar base film).
4. Each Shop Drawing shall have a 4-inch x 4-inch clear space for the Owner's Agent's review stamp and comments (preferably in the lower, right-hand corner of the drawing).

5. Two (2) copies will be returned to the Contractor after review. If the Contractor requires more copies to be returned, then the four (4) copies required shall be increased accordingly.

C. Shop Drawing Submittal.

1. Before submittal of Shop Drawings, the Contractor shall have determined and verified all quantities, dimensions, specified performance criteria, installation requirements, materials, catalog numbers and similar data and reviewed or coordinated each Shop Drawing with other Shop Drawings and with the requirements of the Contract.
2. The Contractor shall timely submit Shop Drawings as indicated in Paragraph D of this Article; however, the Contractor shall take into consideration the actual need for additional time to permit the Owner's Agent, and other involved reviewing agencies if applicable, to review them and shall allow sufficient time for revisions and resubmittal.
3. Shop Drawings shall be submitted for:
   a. All items required by the Specifications.
   b. All substitutions.
   c. All items submitted as "or equal."
   d. Any item of work which does not conform to the Contract Documents.
4. The Contractor shall coordinate assembly of all Shop Drawings for submittal, including those prepared by Subcontractors, material suppliers and/or manufacturers, and professional engineers.
   a. Shop Drawings shall be numbered consecutively and shall show the following information:
      i. Contractor Identification number.
      ii. Project name.
      iii. Bid item or intended use.
      iv. Owner's Agent's Drawing number.
      v. Detail number.
      vi. Project location.
      vii. Material standard reference (if any).
      viii. Contractor's name and address.
      ix. Any other information needed for the Owner's Agent's review.
   b. The Contractor shall examine and approve all Shop Drawings for accuracy, completeness and compliance with Contract requirements before submittal to the Owner's Agent.
   c. The Contractor shall sign a "Shop Drawing Review Form" for each shop drawing package, thereby accepting responsibility for the correctness and completeness of the Shop Drawings.

5. Identification of Shop Drawings Submittals.
    a. Identify each submittal and resubmittal on copies of a Shop Drawing Review & Acceptance Request Form furnished by the Contractor for acceptance by the Owner's Agent.
    b. One Review Form shall be filled out by the Contractor for each Shop Drawing submittal package.
        i. A separate Review Form is not necessary for each Shop Drawing submitted.
6. Blanket review of catalogs or groups of Bid items which lack reference to specific Bid items will not be made.
7. Copies of the Drawings or Standard Plans will not be accepted in lieu of Contractor prepared Shop Drawings.
8. At the time of submittal, the Contractor shall give the Owner's Agent specific Written Notice of each variation that the Shop Drawings may have from the requirements of the Contract, and, in addition, shall highlight with a specific notation each such variation on each Shop Drawing submitted to the Owner's Agent for review.
    a. Shop Drawings submitted to the Owner's Agent for review which are determined by the Owner's Agent to be carelessly prepared, erroneous, incomplete, illegible, or lacking the Contractor's acceptance, will be returned to the Contractor for correction, re-checking, and resubmittal.

D. Shop Drawing Review.
1. The Owner's Agent's Shop Drawing review is only for conformance with the general design concept of the Project and for compliance with the information given in the Contract.
2. The review shall not extend to:
    a. Consideration of structural integrity.
    b. Detailed compliance with Contract requirements.
    c. Any other obligation of the Contractor including means, methods, techniques, sequences or procedures of construction (except where a specific means, method, techniques, sequence, or procedure of construction is indicated in or required by the Contract).
    d. Safety precautions or programs incident thereto.
3. The review of a separate item as such will not indicate acceptance of the assembly in which the item functions.
4. The Contractor is responsible for confirming and correlating all dimensions; fabricating and construction techniques; coordinating the Contractor's work with that of all other trades; and the satisfactory performance of the entire Work in strict accordance with Contract.
5. The review is undertaken solely to satisfy Owner's Agent's obligations and does not relieve the Contractor from the Contractor's obligation to perform all Contract

requirements, nor shall such review give rise to any right of action or suit in favor of Contractor or third persons against the Owner's Agent.

6. Where the Contractor intends to change, or deviate from, a previously reviewed Shop Drawing by the Owner's Agent, the Contractor shall resubmit the originally reviewed Shop Drawing to the Owner's Agent for additional review indicating the proposed changes or deviations from the originally reviewed Shop Drawing with reasons, additional calculations, additional details, and as necessary supporting the need for change or deviation. The Owner's Agent's review of these revisions or changes to originally reviewed Shop Drawings shall not in any way change the intent of the Owner's Agent's review as specified in "Shop Drawing Review" Paragraph D of this Article.

7. Owner's Agent's review of Shop Drawings shall not relieve Contractor from responsibility for any variation from the requirements of the Contract unless the Contractor has in writing called the Owner's Agent's attention to each such variation at the time of submission, and the Owner's Agent has given written review of each such variation by a specific written notation thereof incorporated in or accompanying the returned Shop Drawing; nor will any review by Owner's Agent relieve Contractor from responsibility for errors or omissions in the Shop Drawings or from responsibility for having complied with the provisions of this Specification Section.

1.05 OWNER'S AGENT REVIEW OF SUBMITTALS

A. Marking of Submittals.

1. Submittals will be marked to indicate the result of the Owner's Agent's review, as follows:

   a. "NO EXCEPTION TAKEN" - Revision of drawing or data will not be required.

   b. "MAKE CORRECTION NOTED" - Contractor shall revise the drawing or data as indicated. Resubmittal is not required.

   c. "REVISE AND RESUBMIT" - Contractor shall revise the drawing or data and shall resubmit the revised drawing or data to the Owner's Agent for review and acceptance.

   d. "SEE NOTES" - Contractor shall comply with notations as indicated on the reviewed submittal. Resubmittal is not required.

   e. "REJECTED" - Submittal does not conform to Contract Documents. Contractor shall resubmit in a form that conforms to Contract Documents to the Owner's Agent for review and acceptance.

2. Copies marked "NO EXCEPTION TAKEN" or "MAKE CORRECTION NOTED" authorize the Contractor to proceed with construction or fabrication covered by those drawings or data sheets with corrections, if any, incorporated.

3. No revision in any way shall be made after a drawing has been marked "NO EXCEPTION TAKEN" without resubmitting the drawing.

4. When prints of drawings have been marked "REVISE AND RESUBMIT," the Contractor shall make the necessary corrections and submit the number and size of originals and copies as specified in “Shop Drawings” Article of this Section.
   a. Every revision shall be shown by number, date and subject in a revision block.
   b. Each revised drawing shall have its latest revision clearly indicated by clouding around the revised areas on the drawing.
   c. Drawings submitted without these indications will be considered nonconforming.
5. The applicable parts of the requirements of the above paragraphs with reference to the drawings shall apply equally to design data, catalog cuts, illustrations, printed specifications, draft reports or any other submittal furnished for review.

B. Return of Submittals.
   1. The Contractor shall allow 7 calendar days, or other time frame where specified otherwise in the Contract (from receipt of Shop Drawings by the Owner’s Agent) for Owner’s Agent's review and return of comments. The Contractor shall make any corrections required by the Owner’s Agent, and shall resubmit the Shop Drawings for the Owner’s Agent's review.
   2. The number of resubmittal copies shall be as specified in “Size and Layout” Paragraph of this Article.
      a. The Contractor shall direct specific attention in writing to revisions other than the corrections called for by the Owner’s Agent on previous submittals. If marked "REVISE AND RESUBMIT" or "REJECTED" by the Owner’s Agent, the Contractor shall resubmit the Shop Drawing allowing an additional 7 calendar days for each review required until the submittal is marked "NO EXCEPTION TAKEN," "MAKE CORRECTION NOTED," or "SEE NOTES" by the Owner’s Agent.

1.06 PRODUCT DATA AND SAMPLES

A. Product data includes: catalog cuts and material samples (if necessary).

B. Product data shall be submitted in the same manner as shop drawings in the quantities specified in the applicable technical Sections.

C. Affected finish installation work shall not commence until the Owner’s Agent has given an acceptance of the item to be installed.

D. Mark each copy to show applicable choices and options, and indicate the applicable information on selection product. Include the following information:
   1. Manufacturer’s printed recommendations.
   2. Compliance with recognized trade association standards.

3. Compliance with recognized testing agency standards.
4. Application of testing agency labels and seals.
5. Notation of dimensions verified by field measurement.
6. Notation of coordination requirements.
7. Any deviation from Contract Drawings or Specifications.
8. Date when review has to be finalized to meet schedule. This shall be a minimum of 7 calendar days from the date of submittal.

1.07 TESTING RESULTS

A. Testing results shall be submitted in the same manner as shop drawings in the quantities specified in the applicable technical Sections.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION 01330

SECTION 01350 – HEALTH AND SAFETY REQUIREMENTS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section covers the minimum health and safety requirements at the Site.

B. This Contract requires excavating, grading, transport, backfill, sewer decommissioning and other construction activities involving handling of contaminated materials at the Site. Based on field investigations, the presence of elevated concentrations of 2,4' and 4,4'-isomers of DDT, DDD, and DDE has been confirmed in soil at the Site. Therefore, the Contractor shall comply with, at a minimum, the provisions of 29 CFR 1926 (OSHA Construction Standards). Additionally, Contractor shall exercise caution when excavating and handling soil, and construction-related water in any location on the Site to minimize the potential health hazard to all persons on adjacent properties, and the general public.

C. Information on materials and substances known to be present are provided as Exhibit 1, Summary of Site Soil Quality, to the Contract Documents.

D. Contractor shall at all times conduct its activities with appropriate precautions to avoid the bodily harm to persons or the risk of damage to any property or the environment. Contractor shall continuously inspect all Work, materials, and equipment, and shall be solely responsible for discovery, determination, and correction of any conditions that may involve such risks.

E. Contractor shall supply all equipment, materials, and personnel necessary to meet the requirements of this section and all applicable codes and regulations for safe handling and disposal of the waste.

F. The Owner's Agent and its representatives will be responsible for health and safety protection of its personnel. The Contractor shall allow use of its decontamination facilities by the Owner's Agent and its representatives, federal or state agencies, and authorized visitors.

1.02 REFERENCE STANDARDS

A. Regulatory requirements applicable to the Work include, but are not limited to, the following:

1. 29 CFR 1926, Safety and Health Regulations for Construction
2. ORS Chapter 654, Oregon Occupational Safety and Health
3. OAR Division 3, Oregon Safety and Health Regulations for Construction

1.03 SUBMITTALS

A. Submit under provisions of Section 01330 - Submittals.

B. Prepare and submit to the Owner's Agent, within 14 calendar days of the issuance of the Notice to Proceed of Submittals, a site-specific health and safety plan meeting applicable regulatory requirements. Obtain Owner's Agent's acceptance with the plan before conducting the Work. Contractor is responsible for independently evaluating the physical and chemical hazards associated with the Site and Work and developing a plan that adequately addresses these hazards in compliance with applicable local, state, and federal regulations. Acceptance of the plan by the Owner's Agent does not constituent Owner's Agent responsibility of the plan. As a minimum, the Contractor's health and safety plan shall include:

1. A description of the site activities to be performed.
2. A listing of wastes and associated Work known to be or suspected of being present at the site.
3. A description of the site chemical hazards (e.g., toxicity, flammability, stability, reactivity, etc.), including the nature of each chemical; its physical properties; OSHA, State OSHA, or ACGIH standards, where established; and physical hazards (e.g., noise, heavy equipment, heat stress).
4. A map of the site showing the proposed Work activity locations, evacuation routes, and assembly areas.
5. General health and safety directives regarding onsite conduct, including levels of protection and contingency plans.
6. Site-specific health and safety directives for activities associated with contaminated materials. These directives shall specify the equipment and safety procedures to be used by personnel engaged in the Work activities.
7. Establishment of the Work area definitions for an exclusion zone, a decontamination zone, and a support associated with contact with contaminated materials (e.g. sediments). Planned changes in boundaries during the Work shall be identified.
8. Requirements for personal protective equipment, including respiratory, eye, and skin protection. The plan shall include a listing of the health and safety equipment that will be available onsite and required for site activities during Work under this Contract.
9. Personal decontamination facilities and procedures. Provide decontamination facilities for personnel as necessary for conformance with health and safety plan.
10. Emergency procedures in case of waste spillage or exposure to personnel, personal injury, fire, explosion, etc. This section of the plan shall include emergency telephone numbers and specific procedures for immediate removal to a hospital or doctor's care of any person who may be injured on the job site.
11. Names and responsibilities of personnel assigned to implement, administer, and supervise the health and safety plan.

12. Names, firms, and staff positions of personnel authorized to Work at the site, including personnel handling any chemical sampling equipment and personnel performing any offsite material disposal.
13. An employee signature page on which each of the Contractor's employees whose activities involve contact with contaminated sediment, and each employee of each subcontractor of any tier whose activities involve contact with contaminated sediment, will acknowledge receipt of the plan, an understanding of the plan, and an agreement to comply with plan provisions.
14. Recordkeeping requirements and all necessary reporting to cover the implementation of this plan.

C. Submit to the Owner's Agent name and qualifications of Contractor's health and safety officer for the Work. This person shall not be replaced without prior written acceptance by the Owner's Agent

D. Submit proof of 40-hour and current 8-hour annual refresher training per OSHA 29 CFR 1910.120 for general site workers. Submit proof of 8-hr supervisory training per OSHA 29 CFR 1910.120 for all site supervisors. Site work and training shall comply with Oregon Revised Statutes (ORS) Chapter 654 and Oregon Administrative Rules (OAR) Chapter 437. Submit documentation of respiratory fit testing for laborers, operators, and supervisor (if required).

1.04 QUALIFICATIONS

A. Contractor's employees who engage in the Work shall at minimum meet training requirements as specified in the regulatory requirements listed in this section.

1.05 PERSONAL DECONTAMINATION FACILITY

A. Provide a personal decontamination facility that meets the requirements specified in the site specific health and safety plan or Section 01355 – Environmental Pollution Protection Control.

B. On completion of the Work, and with the Owner's Agent's acceptance, decontaminate and demobilize decontamination facilities.

1.06 EQUIPMENT DECONTAMINATION

A. Conform to the provisions of Section 01355 – Environmental Pollution Protection Control.

PART 2 PRODUCTS

2.01 HEALTH AND SAFETY PLAN

A. Prepare and maintain for the duration of this Contract a site-specific health and safety plan (HASP) to promote the health and protection of all onsite personnel and the environment. The plan shall be consistent with the requirements of Part 1 of this section. The plan shall be at least as protective as Owner's Agent's HASP (Appendix H of Exhibit 2).

B. Contractor shall submit the health and safety plan to the Owner's Agent for review and acceptance. The Owner's Agent's review and acceptance with the Contractor's health and safety plan will not in any way relieve Contractor of its responsibility for health and safety, nor shall the Owner's Agent's acceptance be construed as limiting in any manner the Contractor's obligation to undertake actions that may be necessary or required to establish and maintain safe Working conditions at the site, including conditions not related to hazardous materials, nor shall the Owner's Agent's acceptance be construed as establishing Owner's Agent or Owner's Agent's representatives in a position of responsibility for implementation or administration of Contractor's health and safety plan.

C. Contractor and subcontractors shall comply with the site-specific health and safety plan for the duration of this Contract. Contractor shall coordinate with the Owner's Agent and with all of the Contractor's subcontractors on health and safety matters. Contractor shall furnish all necessary first-aid, safety, personal protective and decontamination equipment and facilities, and enforce the use of such equipment and facilities by its employees and its subcontractors of any tier.

D. As conditions change or if new operations are to be performed, the Contractor's health and safety plan shall be modified or amended, or a new health and safety plan shall be developed.

PART 3 EXECUTION

3.01 HEALTH AND SAFETY

A. Site activities shall be conducted in accordance with the Contractor's site-specific health and safety plan.

B. Contractor shall designate a qualified representative as Health and Safety Officer whose responsibility will be health and safety oversight. The designated qualified health and safety representative shall be onsite at all times.

C. Contractor shall be responsible for providing safety training and shall require its subcontractors and all Contractor's authorized visitors to have this training, if appropriate, for the Work to be conducted by these personnel. Documentation of this training shall be available at the site. Provide appropriate personal protective equipment

for Contractor's employees, as specified in the health and safety plan, and require subcontractors to provide this equipment for subcontractor's employees.

D. Provide for decontamination of Contractor's and subcontractor's personnel and equipment that contacts contaminated or potentially contaminated materials.

E. Contractor shall provide for the proper disposal of disposable safety gear and equipment used by Contractor's employees. Such disposal shall conform to all applicable federal and local waste disposal regulations. Waste material from the Contractor's onsite decontamination facilities shall be properly containerized, labeled, and disposed of by the Contractor.

F. Contractor shall maintain accurate accident and injury reports and shall furnish to the Owner's Agent a copy of the reports within 24 hours of the reported incident.

G. Contractor shall provide proper illumination of construction activity, as necessary, to allow all Workers and oversight personnel to safely execute their responsibilities and tasks.

H. Contractor shall promptly comply with any specific instructions or directions given to Contractor by the Owner's Agent's representatives unless overriding health and safety concerns dictate another course of action.

I. Health and safety plans, emergency procedures, and first aid procedures shall be conspicuously posted at the site and Contractor shall hold regularly scheduled meetings, as necessary, to instruct its personnel and its subcontractors on health and safety practices and use of personal protective equipment.

3.02 MATERIAL HANDLING

A. Material handling shall be in accordance with Section 01575 – Waste Material Handling and Disposal.

END OF SECTION 01350

SECTION 01355 – ENVIRONMENTAL POLLUTION PROTECTION CONTROL

PART 1 GENERAL

1.01 GENERAL

A. This section covers the measures necessary to prevent environmental pollution and minimize environmental degradation during and as a result of construction operations. Other Sections of the specifications may also contain specific requirements for environmental protection. Those specific requirements are in addition to the requirements of this section. If a conflict arises between the various portions of the Specifications, the more stringent requirements shall apply. The control of environmental pollution requires consideration of noise levels, air, water, and land.

1.02 SUBMITTALS

A. Provide all submittals in accordance with Section 01330 – Submittals.

B. Within 14 calendar days after a Notice to Proceed of Submittals, submit Emergency Response and Spill Contingency Plan as defined in this Section.

C. Within 14 calendar days after a Notice to Proceed of Submittals, submit Dust Control Plan as defined in this Section.

D. Within 14 calendar days after a Notice to Proceed of Submittals, submit Contractors Equipment Decontamination Plan that documents the proposed methods, equipment, and operating sequences to be used in performance of the decontamination of equipment as Section 01400 – Coordination and Construction Work Plan.

1.03 PRE-CONSTRUCTION SITE VISIT

A. Prior to the start of any onsite construction activities, Contractor and the Owner's Agent shall make a joint condition survey of the Site, after which the Contractor shall prepare a brief report indicating on a layout plan the condition of trees, shrubs, grassed areas, and location of existing structures immediately adjacent to designated Work areas, assigned storage areas, and access route(s), as applicable. This report will be signed by both the Owner's Agent and Contractor upon mutual agreement of its accuracy and completeness.

1.04 PROTECTION OF LAND AREAS

A. Except for Work and storage areas, and access routes specifically assigned for the use by Contractor, land areas outside the limits of permanent Work shall be preserved in

their present condition. Contractor shall confine its construction activities to areas defined on the Contract Drawings, or specifically assigned by the Owner's Agent for its use.

1.05 PROTECTION OF TREES AND SHRUBS

A. Except for trees or shrubs marked on the Contract Drawings to be removed, the Contractor shall minimize the defacing, injury, or destruction of trees or shrubs. Contractor shall not remove or cut any trees or shrubs without the Owner's Agent's acceptance. No ropes, cables, or guys shall be fastened to or attached to nearby trees for anchorages.

B. Restoration of Damaged Trees. All trees that are damaged by Contractor beyond saving, in the opinion of the Owner's Agent, shall be immediately removed, if so directed, and replaced with a nursery-grown tree of the same species and size as part of the site restoration.

1.06 PROTECTION OF WATER RESOURCES

A. Contractor shall control the handling and disposal of fuels, oils, bitumens, acids or other harmful materials, both on and off the Owner's Agents premises, and shall comply with applicable federal, state, county, and municipal laws concerning pollution of rivers, streams, and other surface waters while performing Work under this Contract. Special measures shall be taken to prevent chemicals and other hazardous or deleterious substances, including but not limited to fuels, oil, greases, bituminous materials, herbicides, shotcrete (if necessary) and insecticides from entering public waters. Water used in onsite material processing and other waste waters shall not be allowed to enter natural surface water bodies.

1.07 WASTE DISPOSAL

A. If any waste material is dumped or spilled in unauthorized areas, the Contractor shall completely remove the material to Owner's Agent's satisfaction and restore the area to the condition of the adjacent undisturbed areas. Where directed, contaminated ground shall be excavated, disposed of as approved, and replaced with suitable fill material, all at the expense of the Contractor.

B. Soil that is developed as a result of grading activities on the site will be stockpiled on the site in accordance with the Contract Drawings and with the Contaminated Materials Management Plan (CMMP; Appendix B of Exhibit 2).

C. Waste materials generated during performance of the Work may include soil and water that is generated as a result of equipment and personnel decontamination. These environmental media and materials shall be managed, handled, stored, and disposed of by Contractor in accordance with all local and federal laws and regulations.

1.08 BURNING

A. No burning will be permitted.

1.09 DUST CONTROL

A. Contractor shall maintain all excavations, embankments, stockpiles, access roads, plant sites, waste areas, borrow areas, and all other work areas free from excess dust to such reasonable degree as to avoid causing a hazard or nuisance to others. Dust control shall be performed as the Work proceeds and whenever a dust nuisance or hazard occurs.

B. Dust Control Plan. The Contractor will be required to submit a Dust Control Plan that will accompany all construction activities The Contractor's dust control plan will be used to accomplish the following:

   1. Eliminate origins of dust from the site.
   2. Identify potential dust migration pathways.
   3. Visually monitor for dust produced by site activities.
   4. Implement corrective actions as the need arises.

C. At a minimum, the Contractor will employ dust control techniques in following locations:

   1. Areas of heavy equipment and vehicular traffic.
   2. Transport routes, which shall be clean of tracked soils or excavated fill materials.
   3. Soil and fill excavation sites.
   4. Exposed excavation faces or disturbed ground surfaces.
   5. Soil and fill stockpiles.
   6. Soil and fill loading and unloading operations.
   7. Soil backfill placement, grading, and compacting.

1.10 EROSION CONTROL

A. Erosion control/runoff protection measures will be in place for active construction areas, staging areas, soil staging areas, and the equipment decontamination area. Temporary erosion control measures shall be installed adjacent to and on the downgradient side of unpaved roadways or vehicle access routes to control the movement of erodible soil from these surfaces by surface water drainage. All drainage and erosion control measures shall be carried out in accordance with Section 01566 – Erosion and Sediment Control.

1.11 EMERGENCY REPONSE AND SPILL CONTINGENCY

A. Emergency Response and Spill Contingency Plan. The Contractor will be required to submit an emergency response and spill contingency plan that describes the response measures that will accompany all construction. The plan will ensure an effective, comprehensive response to prevent injury or damage to the construction personnel, public, and the environment during the project. The contractor shall comply with all elements of the plan and the contract documents. The City of Portland Bureau of Environmental Services provides guidance on the development of emergency response and spill cleanup plans (City of Portland. 2000. Environmentally Responsible Best Management Practices, prepared by City of Portland Bureau of Environmental Services, ISW 0007-4). This information has been summarized below and shall, at a minimum, be included in the Contractor's plan:

- Identify and protect areas where spilled material can impact stormwater runoff.
- Propose methods to prevent spills along with cleanup and notification procedures.
- Provide a site plan showing location of chemical storage areas (if any), location of storm drains, and direction of slope of site toward drains, water bodies or offsite. Indicate location of any structures or devices on site, such as control valves or lined sumps, to prevent spills leaving the site.
- Provide notification procedures to be used in the event of a spill for contacting key personnel.
- Provide notification instruction regarding cleanup procedures, including how to handle fires and explosions should they occur.
- Identify the person with overall spill response cleanup responsibility.
- Describe training program that will be implemented for key personnel. All employees should have basic knowledge of spill control procedures.
- Provide information on cleanup kits located on the site.

1.12 CORRECTIVE ACTION

A. Contractor shall, upon receipt of a notice in writing of any noncompliance with the foregoing provisions, take immediate corrective action. If the Contractor fails or refuses to comply promptly, the Owner's Agent may issue an order stopping all or part of the Work until satisfactory corrective action has been taken. No part of the time lost due to a stop work order shall be made the subject of a claim for extension of time or for excess costs of damages by the Contractor unless it was later determined that the Contractor was in compliance.

1.13 POST-CONSTRUCTION CLEANUP OR OBLITERATION

A. Contractor shall, unless otherwise instructed in writing by the Owner's Agent, obliterate all signs of temporary construction facilities such as haul roads, work areas, structures, foundations of temporary structures, stockpiles of excess or waste materials, and other

vestiges of construction and shall restore the site to its original condition prior to final acceptance of the Work.

B. All areas disturbed by the Work shall be revegetated to similar conditions.

PART 2 PRODUCTS

2.01 DECONTAMINATION WORK PAD AND EQUIPMENT

A. Contractor shall install such temporary decontamination facilities. Location of the decontamination facilities shall be indicated in the decontamination plan approved by the Owner's Agent. Temporary decontamination facilities shall be equipped as follows:

1. Decontamination pads shall be at least 20 feet wide and at least 30 feet long and shall be constructed of materials suitable for the containment and collection of decontamination fluids.
2. One pressure washer, capable of producing a minimum temperature of 180°F and a minimum pressure of 2,500 psi.
3. A sump pump, piping, valves, fittings, controls, and filters to transfer water from the pad to storage tanks. The sump pump shall be connected to the temporary storage tank(s) with a chemically-resistant flexible hose.
4. All other pumps, tanks, cleaning tools, and equipment, and other supplies and materials, required to effectively decontaminate equipment.
5. Detergents shall not be used for power washing.

2.02 PORTABLE DECONTAMINATION

A. Supply portable pressure washers, pumps, hoses, and water storage tanks, as required for decontamination of construction equipment during excavation and backfilling activities in accordance with Section 02325 – Excavation and Backfill.

PART 3 EXECUTION

3.01 DECONTAMINATION WORK PAD CONSTRUCTION

A. Contractor shall construct temporary decontamination work pads, as required, at locations accepted by the Owner's Agent and in conformance with the requirements of Article 2.01.

B. Prior to operating decontamination facilities, Contractor shall test all pipelines that may transfer contaminated water to demonstrate pipes are watertight.

3.02 DECONTAMINATION OF EQUIPMENT

A. All equipment such as hand tools and other hand-carried items that have been taken into the exclusion zone or have been in contact with contaminated or potentially contaminated sediment or water shall be washed at the decontamination work pad or decontaminated at supplemental equipment decontamination stations according to procedures set forth in the equipment decontamination plan.

B. Heavy equipment shall be pressure washed at decontamination work pads unless otherwise accepted by the Owner's Agent. Operators must remain in the cab when in the exclusion zone to prevent contamination of the cab areas. If this is not feasible, cab floor areas must be washed at the decontamination facilities. Contractor shall provide brushes, brooms, and scrapers at the decontamination work pad for equipment decontamination purposes. Personnel manning the decontamination work pad shall comply with all applicable provisions of the Contractor's health and safety plan. The exterior of all heavy equipment exiting the exclusion zone shall be completely pressure washed, including undercarriages.

C. Decontaminate all steel sheeting or other materials used for temporary haul roads after each use and prior to demobilizing same materials from the site.

D. Decontaminate all potentially contaminated construction debris from decommissioning activities prior to offsite disposal as per the CMMP (Appendix B of Exhibit 2).

3.03 WASTE COLLECTION AND DISPOSAL

A. Decontamination liquids shall be collected, contained and disposed of according to the requirements of Section 01575 – Waste Material Handling and Disposal.

B. Contractor shall remove debris and sediment clumps from the decontamination work pads and handle the material as directed in the CMMP.

3.04 MAINTENANCE AND DEACTIVATION

A. Contractor shall inspect the decontamination work pad and associated equipment on a periodic basis to ensure that there is no damage to the system and that leakage at fittings or along piping or hoses is not occurring. When damage is noted, repair of the component shall be completed immediately at no cost to the Owner's Agent. Contractor shall provide expendable supplies, as required, to maintain an effective and efficient decontamination system for the project.

B. At the conclusion of the project, Contractor shall remove sediment and debris from the pad and pressure wash the surface to clear the surface of contaminated sediment and drain lines. The existing decontamination work pad shall remain in place at the conclusion of the project. Contractor shall remove other equipment, materials, supplies, disposing of these components consistent with applicable federal and state laws.

END OF SECTION 01355

SECTION 01400 – COORDINATION AND CONSTRUCTION WORK PLAN

PART 1 GENERAL

1.01 GENERAL

A. This section covers Contractor's responsibilities and coordination requirements associated with project management, project planning and scheduling, the minimum requirements for meetings between the Owner's Agent and the Contractor, and certain other elements of the Work. Minimum requirements for the Contractor's Construction Work Plan submittal are also provided.

B. As an independent contractor with complete control over employees and subcontractors, Contractor shall be responsible for management of all Work, from Notice to Proceed through project closeout and final payment, in full compliance with the requirements of this Contract.

C. Site meetings shall be attended by Contractor and its subcontractors as requested by the Owner's Agent during the Work.

1.02 SUBMITTALS

A. Provide all submittals in accordance with Section 01330 – Submittals.

1.03 COORDINATION

A. Coordinate scheduling, submittals, and execution of the Work in a manner that ensures efficient and orderly installation of interdependent construction elements, with provisions for accommodating items installed later.

B. Coordinate space requirements and installation of material and equipment to use space efficiently and maximize accessibility for other installations, for maintenance, and for repairs. Review Section 01110 – Summary of Work for required interactions with Groundwater SCMs contractor.

C. Verify that construction utility requirements are compatible with available project utilities. Coordinate installation, testing, and placing into service such utilities. Major utility purveyors serving the work area shall be identified and contacted as required to carry out the Work. These utilities shall be notified immediately if conflicts or emergencies arise during the progress of the Work. The Contractor shall be responsible for obtaining utility location assistance, as required, during the course of the Work.

D. After Owner's Agent occupancy of premises, coordinate with Owner's Agent and others, as necessary, to correct any defective Work and to complete any unfinished tasks.

PART 2 PRODUCTS

2.01 DESIGNATION OF PROJECT MANAGEMENT PERSONNEL

A. Contractor shall submit within 14 calendar days after Notice to Proceed of Submittals, in writing, the name and qualifications of its project manager, project superintendent, construction quality control manager, and health and safety officer. Each shall have demonstrated experience completing stormwater construction projects of similar size and complexity, including experience on hazardous waste sites. The project manager shall have a minimum of 10 years of experience and the superintendent shall have 5 years of experience in construction of stormwater projects. Contractor's construction quality control manager shall meet the requirements set forth in Section 01450 – Quality Control. Contractor's health and safety officer shall meet the requirements set forth in Section 01350 – Health and Safety Requirements.

2.02 SCHEDULES

A. Initial Construction Schedule. Within 14 calendar days of Notice to Proceed of Submittals, Contractor shall submit a detailed initial construction schedule for review and acceptance by the Owner's Agent. The initial construction schedule shall clearly show each element of Work to be performed under this Contract, and all items involved in overall sequencing of Work, including equipment and material submittals and Owner's Agent review time. The schedule shall reflect that Contractor is familiar with site conditions and with all circumstances that may affect the performance and completion of the Work, and shall include appropriate provisions and contingencies to respond to such conditions and circumstances.

B. Weekly Progress Schedules. An updated schedule, to be known as a progress schedule, shall be kept current, taking into account the actual progress of the Work. The progress schedule shall record the actual time required to accomplish the various activities included therein and shall also include the Contractor's projections of the time it anticipates will be required to complete unfinished tasks. The progress schedule shall be revised and updated weekly and submitted to the Owner's Agent for review and comment at the progress meetings.

C. Contractor shall prepare all schedule submittals in accordance with standard methods for scheduling. The schedule shall be presented in a Gantt, or bar-type, format. The schedule shall be presented on an 11-inch by 17-inch format. Critical path tasks, milestone dates, and coordination with other work by the Owner's Agent shall be identified. Scheduling shall identify the earliest start date, latest completion date, the minimum and maximum estimated completion time for each work activity, and indicate the Contractor's work hours (e.g., 5 days on, 2 days off; 8:00 a.m. to 5:00 p.m., etc.) which are dependent on favorable tides. Scheduling documentation shall include records of actual start and completion dates for activity, providing a comparison of planned

versus actual progress of the Work. The time scale for the schedule shall be based on calendar days and weeks after Notice to Proceed.

2.03 CONSTRUCTION PLANS

A. Construction Work Plan. Following the Notice to Proceed, Contractor shall submit a detailed Construction Work Plan. The detailed plan shall address the minimum topical requirements described under the submittal requirements for the various sections of the Specifications. The Construction Work Plan submittals shall be issued for the Owner's Agent's review and acceptance in accordance with the specified submittal schedule requirements. The various plans included within the Construction Work Plan may be issued separately, or as a combined document, provided that the plans comply with the specified submittal schedule. A narrative format with appropriate graphical diagrams, tables, and sketches shall be used to demonstrate that the Work is thoroughly planned with adequate staffing, equipment, and management control, and that suitable construction methods and equipment are planned to meet the critical technical requirements of the Work. The Plan shall include the following elements:

1. Initial Construction Schedule as described in Paragraph 2.02A of this section.
2. Submittal control documentation as described in Section 01330 – Submittals.
3. Waste material handling, transportation and disposal documentation as described in Section 01575 – Waste Material Handling and Disposal.
4. Health and Safety Plan as described in Section 01350 – Health and Safety Requirements.
5. Erosion and Sediment Control Plan as described in Section 01566 – Erosion and Sediment Control.
6. Emergency Response and Spill Contingency Plan as described in Specification Section 01355 – Environmental Pollution Protection Control.
7. Dust Control Plan as described in Specification Section 01355 – Environmental Pollution Protection Control.
8. Quality Control Plan as described in Section 01450 – Quality Control.
9. Equipment Decontamination Plan as described in Section 01355 – Environmental Pollution Protection Control.
10. Decommissioning of Existing Storm Drain Plan as described in Section 02222 – Decommissioning of Storm Drain System.
11. Geomembrane Liner Installation plan as described in Section 02501 – Storm Drainage and Treatment System.
12. Excavation Plan as described in Section 02325 – Excavation and Backfill.

B. Contractor shall obtain the Owner's Agent's acceptance of the plan submittals prior to initiating the elements of Work covered in the plan. Owner's Agent's acceptance of the Construction Work Plan shall in no way eliminate Contractor's responsibility to carry out the Work in accordance with the Contract Documents; nor shall such acceptance, in any

way, cause the Owner's Agent to take responsibility for substandard or defective Work that may result from construction methods proposed by Contractor.

PART 3 EXECUTION

3.01 MANAGEMENT OF THE WORK

A. Contractor shall manage the Work in strict compliance with the technical, procedural, reporting, and scheduling requirements of this Contract. Contractor shall provide the necessary management, technical, and administrative personnel and sufficient project management systems and equipment to carry out the Work in compliance with these requirements.

B. Contractor's management personnel and systems shall be located at the site. Contractor may propose to utilize management and other personnel and systems at offsite locations within the Construction Work Plan for acceptance by the Owner's Agent for the purpose of more efficient and cost-effective management of the Work so long as the remoteness of such personnel and systems does not impair the progress of the Work or delay decisions affecting the Work. The project manager, together with other staff, shall be organized to meet the Contractor's various onsite management requirements during implementation of the Work under this Contract.

C. Contractor shall prepare and maintain the schedule for the Work in accordance with Article 2.02 of this section. When the initial construction schedule is accepted by the Owner's Agent, it shall become the "contract schedule." Contractor's execution of the Work shall be in accordance with the contract schedule until modified by a duly executed Change Order, or as otherwise accepted by the Owner's Agent.

D. Provide and maintain a listing of required and completed reviews and submittals. Manage the preparation, review, acceptance, and submittal of same to the Owner's Agent in a timely manner, keeping all individuals involved in the process advised of the schedules applicable thereto.

E. Manage quality control activities required by this Contract in conformance with the requirements of Section 01450 – Quality Control and the applicable QA/QC requirements of the respective sections of the Specifications. Provide specified QC documentation to the Owner's Agent and the Owner's Agent's QA representatives in a timely manner to ensure that the specified quality of Work is attained.

F. Contractor shall manage contract administration and cost accounting to maintain responsive, accurate, and thorough reporting, documentation, and invoicing of the Work in compliance with applicable provisions of the General and Special Conditions.

3.02 MANAGEMENT PERSONNEL

A. The project manager shall have responsible charge of the Work and have complete authority to direct the Work, including negotiation of all issues affecting Contract Price, Contract Time, personnel, and quality of workmanship. This person shall not be replaced without prior written acceptance by the Owner's Agent.

B. The QC manager shall be present at the site whenever any of Contractor's or its subcontractor's quality-related activities are in progress at the site. The QC manager shall be fully qualified by verifiable training and experience to perform its assigned duties, and shall have successfully performed similar QC-related duties.

C. Contractor's project manager, quality control manager, and health and safety officer may not be replaced without a minimum 10-calendar-day notice to, and written acceptance of, the Owner's Agent.

3.03 COOPERATION WITH OWNER'S AGENT AND PROSECUTION OF THE WORK

A. Contractor shall work cooperatively with the Owner's Agent and its representatives, making all reasonable efforts to provide labor, equipment, supplies, and related support to facilitate the collection of data required by the Owner's Agent and its representatives required to carry out environmental monitoring, quality assurance, and collection of other data required for construction documentation and reporting.

3.04 MEETINGS

A. Pre-Construction Meeting. Following Notice to Proceed for mobilization and site preparation, a pre-construction conference will be arranged by the Owner's Agent. This conference shall be attended by Contractor and its major subcontractors and shall be held at the site. The purpose of the meeting will be to:

1. Discuss implementation of the Contractor's initial construction schedule and construction plan.
2. Establish lines of authority and communication, and discuss periodic progress meetings.
3. Confirm the specific responsibility of each party.
4. Identify relevant documents and review the scope of work and critical design details of the project.
5. Establish methods for documenting and reporting construction monitoring and QA/QC data and for distributing/storing documents and reports.
6. Review and make any appropriate modifications or addenda to the various plans, Contract Drawings, specifications, and QA/QC documents so that site-specific considerations are incorporated.
7. Discuss any other items that may require clarification.

8. Review work area security and health and safety protocols, and identify remedial action areas, work zone locations, and other site features for representatives who were not present at the pre-bid conference.
9. Conduct a site reconnaissance to verify that the Contract Drawings and Specifications are understood and to review Contractor support facility, equipment and material storage locations.

B. Progress Meetings. Contractor shall attend weekly site progress meetings that may include representatives of the Owner's Agent and of regulatory agencies. Site meetings shall be held for the purpose of coordination of the project activities. The meetings may be held more or less frequently, as necessary, at the Owner's Agent's option, or as may be required by the progress of certain remedial construction activities. Contractor shall provide a briefing on the status of the Work and on scheduled activities. Contractor's project manager and representatives of major subcontractors shall attend onsite meetings when requested by Owner's Agent. Contractor's project manager shall keep onsite personnel fully informed and shall carry out responsibilities in a coordinated manner with the Owner's Agent. The site progress meeting agenda will include:

1. Discussion of site safety conditions, practices, any necessary modifications, and conformation with the Contractor's health and safety plan.
2. Review of work progress and schedule.
3. Identification of any potential construction problems or delays, and developing actions to resolve problems and maintain schedules.
4. Discussion of technical issues of construction methods and QC.
5. Establishing the project schedule for the succeeding 7-calendar-day period.
6. Coordination of work with the Contractor and representatives of the Owner's Agent.

C. Contractor shall attend special meetings that may be held at the Owner's Agent's request when a problem or deficiency is present or likely to occur. The purpose of these meetings shall be to define and discuss a problem or recurring work deficiency, review alternative solutions, and identify a plan to efficiently and effectively resolve the problem or deficiency.

D. The Contractor's project manager shall attend other meetings at the Owner's Agent's request to coordinate Contractor's activities with related work being conducted by Owner's Agent, Owner's Agent's representatives, or the Owner's Agent's tenants.

E. Contractor shall notify the Owner's Agent prior to any planned meeting(s) with the local governments that may be necessary for obtaining permits or carrying out the Work. The Owner's Agent may elect to attend these meetings with the Contractor at the discretion of the Owner's Agent.

F. At the Owner's Agent's request, Contractor shall attend, with the Owner's Agent, site meetings initiated by other regulatory agencies.

G. Health and Safety Meetings. Contractor shall conduct health and safety meetings for Contractor personnel as required by the Contractor's accepted health and safety plan. The Owner's Agent's onsite representatives may attend Contractor's health and safety meetings, as needed, to be aware of Work conditions or health and safety concerns that could affect the normal business activities of the Owner's Agent's employees or tenants, or the coordination or prosecution of work under other contracts.

END OF SECTION 01400

SECTION 01410 – REGULATORY REQUIREMENTS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies the Contractor's responsibilities for determining requirements and complying with local, state, and federal laws, regulations, and permits that govern the remedial action at this site.

B. Contractor shall comply with all federal, state, city, county, and other local laws, ordinances, statutes, rules, or regulations applicable to execution of the Work.

1.02 PERMITS AND LICENSES

A. Unless otherwise specified in the Contract, the Contractor shall obtain all required permits including, but not limited to, the NPDES 1200-C Construction Stormwater Permit and licenses for the performance of the Work, shall give any notices such permits and licenses require, shall comply with all requirements of permits and licenses, and shall furnish the Owner's Agent a copy of each permit or license as they are obtained. Permits and licenses obtained by the Owner's Agent will be referenced or included in the Contract. The costs of permits and licenses obtained by the Contractor shall be included in the Bid item prices for the Work.

1.03 FEDERAL LAWS AND REGULATIONS

A. Resource Conservation and Recovery Act (RCRA) regulations, including but not limited to:

1. 40 CFR 260 EPA General Regulations for Hazardous Waste Management.
2. 40 CFR 261 EPA Regulations for Identifying Hazardous Waste.

B. Federal Water Pollution Control Act Amendments of 1972, and implementing regulations.

C. 29 CFR 1926 (OSHA Construction Standards).

1.04 OREGON STATE LAWS AND REGULATIONS

A. Contractor shall comply with all Oregon Revised Statues (ORS) and implementing Oregon Administration Regulations (OAR), including, but not limited to:

1. ORS 467 Noise Control
2. ORS 468B Water Quality

3. ORS 654 Occupational Safety and Health (and OAR 437, Division 1 – General and Division 3 – Construction)
4. ORS 480 Explosives, Flammable Materials, and Pressure Vessels
5. ORS 757 Utility Regulation
6. ORS 652.010 Hours, Wage Claims, Records
7. ORS 653 Minimum Wages, Employment Conditions

1.05 REGISTRATION

A. Pursuant to ORS 701 and OAR 812, the Contractor shall be registered by the State of Oregon prior to execution of contract.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 GENERAL

A. Perform all activities associated with the Work in compliance with permit terms and conditions, and substantive requirements associated with state and local laws and regulations. Contractor is responsible for complying with all terms and conditions and substantive requirements identified in these Contract Documents and other referenced documents and regulations.

B. Contractor shall be solely responsible for compliance with all permit conditions, substantive permit requirements, and all relevant federal, state, and local laws and regulations. The provisions for the failure to comply with any permits, substantive requirements, laws and regulations shall be at the Contractor's sole expense, including, but not limited to, all costs to correct the deficiency, any associated fines or penalties, and any costs incurred by the Owner's Agent associated with noncompliance.

END OF SECTION 01410

SECTION 01450 – QUALITY CONTROL

PART 1 GENERAL

1.01 DESCRIPTION

A. This Section specifies general requirements for Contractor's quality assurance/quality control (QA/QC) programs and plans, including monitoring, tests, inspections, and documentation, required for the Work performed under this Contract.

B. The Specifications provide detailed requirements for QC monitoring, testing, inspection, and reporting to be conducted by Contractor during execution of the Work under this Contract.

C. The Specifications address the minimum QC requirements to be performed by Contractor. Contractor shall also perform all of its internal QA/QC activities and conduct such additional QA/QC observations, tests, and inspections as it deems necessary to perform the Work and ensure compliance with the requirements of the Contract Documents.

1.02 SUBMITTALS

A. Within 14 calendar days after Notice to Proceed of Submittals, submit Contractor's project QA/QC plan. Contractor's QA/QC plans shall include, or reference as appropriate:

1. Detailed descriptions of methods and procedures for inspection, surveillance, testing, and documentation of the Work, including the test name, applicable Specification references, the feature of the Work to be tested, the test frequency, and the person or entity responsible for performing the test.
2. A description of QC personnel, including names, qualifications, duties, responsibilities, and lines of authority; and the duties, responsibilities, and authority of Contractor's QC manager.
3. QC inspection criteria, including frequency and specific content of inspections.
4. QC testing procedures for each specific test, including documentation that personnel and laboratories performing the tests are qualified, and that equipment and procedures employed in testing comply with applicable industry standards.
5. Procedures for scheduling and managing inspections or reporting test results, including those of subcontractors, offsite fabricators, suppliers, and purchasing agents.
6. Reporting procedures, including frequency of reports and report formats, and tracking procedures that monitor the handling of inspection or test data from initial identification of nonconformance or noncompliance through acceptable corrective action.

7. A qualified testing laboratory, engineer, or engineering firm subject to acceptance by the Owner's Agent shall be provided by Contractor to perform the QA/QC work involving materials design and testing. The QC program for soil and materials testing shall be performed under the direction of a professional geotechnical engineer with registration in the State of Oregon.

B. Submit certified copies of all inspection or test reports or other documentation required by the Specifications or generated through implementation of Contractor's accepted QA/QC plans. Submittal of these reports and documentation to the Owner's Agent shall be substantially concurrent with the receipt of same by Contractor, and shall be no later than three calendar days after receipt by Contractor. No Work may proceed until submittals affecting the Work have received a favorable review by the Owner's Agent.

C. Contractor shall identify and submit to Owner's Agent for approval sources of all imported fill materials to the site with the Construction Work Plan as indicated in Section 01400 – Coordination and Construction Work Plan. Information on all sources of imported fill materials will include identification of the material source, location of the source, and information of all known historical site activities conducted at the source of imported fill materials. If the Contractor changes sources, the Construction Work Plan shall be amended to include this information on the proposed sources and Contractor shall not import any materials to the site until the new source is accepted by the Owner's Agent.

1.03 TESTING

A. Contractor shall not deliver any material to the site until the material has been accepted by the Owner's Agent.

B. The Contractor shall sample proposed import backfill materials for physical analysis as described in this Section.

C. The frequency of analyses for import materials and physical test requirements are described in Section 02222 – Decommissioning of Storm Drain System, 02501 – Storm Drainage and Treatment System, Section 02325 – Excavation and Backfill, and in Section 02510 – Temporary Environmental Cap.

D. The Contractor shall coordinate with disposal facility and determine if debris or other waste requires chemical analysis prior to disposal as described in Section 01575 – Waste Material Handling and Disposal.

E. The Contractor shall submit certified test reports guaranteeing that geotextile and geomembranes meet or exceed requirements set forth in this section and Section 02501 – Storm Drainage and Treatment System. All test certificates shall meet the requirements specified in Paragraph 1.05.

F. The Contractor shall sample stormwater for chemical analysis as required in this section and Section 01510 – Temporary Facilities and Controls.

1.04 TEST CERTIFICATES

A. The Contractor shall supply to the Owner's Agent copies of test certificates for materials or equipment from suppliers indicating that such material or equipment is in compliance with Contract requirements. When, in the opinion of the Owner's Agent, additional tests are required to confirm compliance with Contract requirements, such additional tests shall be carried out by the Contractor in a timely manner, and the cost thereof shall be borne by the Contractor.

1.05 CONTRACTOR ASSISTANCE

A. When requested by the Owner's Agent, the Contractor shall provide assistance as required to complete inspection and testing. Such assistance shall include provision of access, use of Contractor's equipment such as ladders, hoists, temporary lighting, temporary water supply and labor.

1.06 OWNER'S AGENT'S QA PROGRAM

A. The Owner's Agent or Owner's Agent's QA representatives will observe Contractor's construction operations and materials testing and measurement activities, and will review Contractor's QC data, as it becomes available, for consistency, accuracy, and conformance with the specified requirements. The Owner's Agent's QA representatives may intermittently make independent evaluations, observations, tests, and measurements to verify the precision of Contractor's QC data. These tests shall not in any way relieve Contractor of its responsibility to provide all QC testing and documentation required by its QA/QC plan or by other sections of these Specifications.

1.07 QUALITY CONTROL MANAGER QUALIFICATIONS AND RESPONSIBILITIES

A. Provide an experienced, qualified QC manager for onsite management of Contractor's QA/QC activities. The QC manager shall be present at the site whenever any of Contractor's or its subcontractor's quality-related activities are in progress at the site. The QC manager shall be fully qualified by verifiable training and experience to perform assigned duties, and shall have successfully performed similar QC-related duties. Contractor's QC manager shall have at least 5 years experience in performing similar QC-related duties.

B. The QC manager shall continuously coordinate its activities with the Owner's Agent or Owner's Agent's QA representatives, with such coordination to occur no less than on a daily basis. The QC manager shall be responsible for the development, implementation, and enforcement of Contractor's QA/QC plans, and shall verify that the quality of materials, workmanship, and construction complies with the specified requirements throughout the duration of the project.

C. The QC manager shall have the authority, and shall proactively perform its duty, to identify and report any QC problems; reject any nonconforming materials; initiate any necessary corrective actions; identify and implement solutions for any nonconforming

activities; control quality-related aspects of Contractor's material delivery, storage, handling, and installation activities; control quality-related aspects of Contractor's earthwork, special construction, and stormwater management activities; and stop work when necessary until appropriate corrective actions are identified and implemented. The QC manager's duties shall also include, but are not limited to:

1. Monitoring site activities for compliance with specified project quality requirements.
2. Performing and documenting inspection and testing activities, and preparing Contractor's as-built report and record drawings for the project.
3. Monitoring Contractor's QC sampling and measurement activities, laboratory testing, and reporting activities, including, but not limited to:
    a. Sampling and measurement methods, locations, and frequencies.
    b. Testing procedures.
    c. Test equipment calibrations and compliance.
    d. Documentation, reporting, and records preservation activities.
4. Verifying and documenting that Contractor and subcontractor QC staff are properly trained, qualified, and where required, certified to the appropriate level for the Work being performed.
5. Providing QC staff with a comprehensive project-specific indoctrination that includes a review of QA/QC and regulatory requirements, work plans, and all other project-specific documents necessary for the individual's role in the execution of the Work.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.01 CONTRACTOR'S QC TESTS AND INSPECTIONS

A. Contractor shall perform detailed examinations, tests, inspections, and quality surveillance of the Work, including but not limited to those summarized in these Specifications, which will ensure that the Work is progressing in accordance with accepted schedules and is being completed in strict accordance with the requirements of the Contract Documents and all applicable codes and regulations.

B. Contractor shall have sole responsibility for determining when it is necessary to perform tests that are required to verify its inspections and to ensure that the Work is being completed in accordance with the Contract Documents. Contractor shall give the Owner's Agent and its representatives, as well as appropriate code authorities, reasonable advance notice of all inspections and tests performed by Contractor.

3.02 CONTRACTOR'S OBLIGATION TO COMPLY WITH CONTRACT DOCUMENTS

A. No acceptance of Work by the Owner's Agent shall be construed to result from inspections, tests, or delays or failures to inspect or test by the Owner's Agent or its representatives. No inspection, test, delay or failure to inspect or test, or failure to discover any defect or noncompliance of the Work by the Owner's Agent or its representatives, shall relieve Contractor of its obligations under the Contract Documents or otherwise by law, notwithstanding the Owner's Agent's or its representatives' knowledge of the defect or noncompliance or of the substantiality or ease of its discovery of a defect or noncompliance.

3.03 FURNISHING OF SAMPLES

A. Contractor shall furnish samples to the Owner's Agent or its representatives as requested or required by the Specifications, and shall provide reasonable assistance and cooperation as may be necessary for them to conduct inspections or testing of materials or the Work, including stoppage of construction activity during the inspection or testing period.

B. Contractor shall coordinate all QA/QC activities with other contractors or utility services to facilitate the efficient completion of the Work by all concerned parties.

3.04 TEST REPORTS

A. Unless otherwise specified in the Contract Documents, Contractor shall submit to the Owner's Agent one (1) reproducible and three (3) copies of the certified results of all tests and inspections.

B. Copies of all material tests performed to verify physical or mechanical properties or to identify chemical composition shall be provided to the Owner's Agent, retained on file at the site by Contractor, and submitted to the Owner's Agent as part of final reporting and project closeout activities.

3.05 CORRECTION OF DEFECTS

A. Defects revealed as a result of observations, inspections, or tests shall be rectified by Contractor to the satisfaction of, and at no additional cost to, the Owner's Agent.

3.06 INSPECTION OF WORK AND MATERIALS

A. The Owner's Agent or its representatives may inspect all Work and materials for conformity with the Contract Documents. To ensure personnel safety and access during these inspections, provide any equipment needed, such as walkways, railings, and ladders.

B. At the Owner's Agent's request, provide (without additional charge) samples of materials used or to be used in the Work. The Owner's Agent may order Contractor to remove or replace any materials used without inspection or acceptance, at no additional cost to the Owner's Agent.

C. Any inspections, tests, measurements, or other quality-related actions by the Owner's Agent are intended to serve the purpose of assuring that the Work, materials, progress rate, and quantities comply with the requirements of the Contract Documents. Such activities conducted by the Owner's Agent shall not relieve Contractor from doing any contract-assigned Work or from determining whether Contract requirements are being met. Contractor shall correct any substandard work or materials. The Owner's Agent reserves the right to reject unsuitable Work or materials even though inspected or paid for in a progress payment.

D. If the Owner's Agent requests, Contractor shall remove or uncover any area of the completed Work. After the Owner's Agent inspects the Work, Contractor shall restore the area to the standard specified in the Contract Documents. Contractor shall bear the cost of uncovering, removing, and restoring the exposed Work if: (a) the Work proves unacceptable; or (b) the Work was placed without authority or without due notice to the Owner's Agent. The Owner's Agent will pay these costs by agreed price if the Work proves to be acceptable and Contractor had performed the original Work with the authority of and due notice to the Owner's Agent.

E. Contractor, if advised to do so by the Owner's Agent, shall permit representatives from other agencies or utilities to inspect the Work.

3.07 ACCEPTANCE

A. The Owner's Agent's final acceptance of the Contractor's QC-related work under this Contract will be an integral part of the final acceptance of the components of the Work requiring QA/QC. The Owner's Agent's acceptance or acceptance of Contractor's QA/QC plans shall not constitute acceptance of any Work.

END OF SECTION 01450

SECTION 01510 – TEMPORARY FACILITIES AND CONTROLS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies the minimum requirements for certain temporary facilities that shall be provided and maintained for the Work. Contractor shall assess the requirements and provide for all temporary facilities that are necessary to accomplish the Work and shall permit, design, fabricate, procure, lease, and install or otherwise supply the required facilities at no additional cost to the Owner's Agent. Temporary facilities are not shown on the Contract Drawings.

B. Temporary facilities include a field office for Contractor, temporary water, sanitary, power, and telephone utilities, parking areas, material and equipment storage areas, site safety and security structures and equipment, and other temporary site improvements determined by Contractor as necessary for execution of the Work.

C. Available areas for temporary facilities within and around the site are limited due to other construction activities that may be occurring at the Site. Potential areas are designated on the Contract Drawings. Contractor shall provide details of his construction staging and temporary facilities layout as required in Section 02325 – Excavation and Backfill.

PART 2 PRODUCTS

2.01 TEMPORARY SITE DEVELOPMENT

A. Provide and maintain temporary berms, granular pads, and ditches, as may be required, to prevent offsite movement of waste materials, spills, etc., resulting from Work under this Contract and to provide a suitable working surface in areas occupied by temporary facilities.

B. Maintain construction, staging, storage, and office areas in a neat, orderly condition throughout the duration of the Contract.

C. Provide barricades, temporary fencing, handrails, warning lights, and other devices required by law or regulation, or as necessary to safely operate temporary facilities and to protect people on the site.

2.02 FIELD OFFICE FOR CONTRACTOR

A. Provide secure mobile office building at the site for use of the Contractor and Owner's Agent during the entire period of work.

1. The field office shall be of a size (minimum 12 ft by 50 ft), construction and outfitted in a manner customary to such facilities at similar construction sites.
2. The field office shall be furnished with appropriate fire extinguishers, first aid supplies, furniture, photocopier, and office supplies. The field office shall have a fax machine, long meeting table, twelve fold-up chairs for project meetings, drinking water service, a minimum of three desks with lamps, cushioned desk chairs, phones, and a white board (minimum 10 ft long and 4 ft high) along one wall. Five sets of keys for the Owner's Agent's personnel shall be provided to the Engineer. The Contractor shall supply and pay for power through the contract period.

B. Mobilization shall include office site preparation, electrical inspection costs, power and telephone and internet monthly service costs, access road construction, and maintenance of the site access.

2.03 MATERIAL STORAGE

A. Provide trailers or shelters, as required, for material storage to protect goods and supplies against the elements, theft, vandalism, or other damage. The storage trailers shall be of sufficient size and so arranged or partitioned to provide security for their contents and provide ready access for inspection and inventory.

B. Construct temporary material and equipment storage yards, as required, to secure and protect same against damage, loss, theft, and vandalism.

2.04 DRINKING WATER

A. Provide drinking water in all appropriate facilities for all personnel connected with the Work. Water shall be piped or transported in sanitary conduits or containers to provide clean and fresh water.

B. Provide drinking water for consumption in the excavation and backfilling areas. Contractor shall devise a method for water consumption that does not pose a health and safety risk for site workers.

2.05 TEMPORARY TOILETS

A. Provide adequate chemical toilet facilities for all individuals connected with the Work, in numbers as required by federal and state safety and occupational standards.

B. Provide regular service of each chemical toilet facility to maintain sanitary conditions. Remove units at the completion of the Contract.

2.06 ELECTRICAL LIGHT AND POWER

A. Determine the locations and requirements for electrical power services at the work locations and provide the required poles, voltage regulation, distribution circuits, and other installations to provide required electrical service to Work under this Contract.

B. Provide power hookup and power to the site and support zones, as required.

C. Provide temporary light and power service as required for safe, efficient, and satisfactory performance of the Work and to inhibit vandalism.

D. Provide safety switches and wiring to trailers and required extension cords, lighting outlets, power outlets (grounded type), lamps, and other equipment and accessories necessary for adequate temporary lighting and power.

E. Remove temporary lighting and power and their connections at completion of the Work unless otherwise directed by the Owner's Agent.

2.07 TEMPORARY HEATING AND COOLING

A. Provide temporary heating and cooling, including fuel and power, as required, for personnel, materials, supplies, and the Work.

B. Protect all temporary facilities during cold periods by temporary measures, as necessary, to prevent damage by freezing of water.

2.08 WATER FOR CONSTRUCTION PURPOSES, DECONTAMINATION, DUST CONTROL, AND FIRE PROTECTION

A. The Contractor shall provide all wash water required for construction water purposes.

B. At the completion of the Contract, Contractor shall disconnect all temporary connections from the site unless otherwise directed by the Owner's Agent.

PART 3 EXECUTION

3.01 GENERAL

A. Install and maintain necessary facilities for the duration of the project, consistent with applicable codes and regulations and the requirements of these Specifications.

3.02 REMOVAL

A. Temporary facilities subject to contamination shall be decontaminated in accordance with the requirements of Section 01355 – Environmental Pollution Protection Control, before being removed from the site.

B. Upon removal of temporary facilities from the site, restore areas occupied by those facilities to a condition similar to those that existed prior to the Contract or to a condition acceptable to the Owner's Agent.

3.03 WASTE DISPOSAL

A. In accordance with the Contract, remove from temporary facilities rubbish, debris, and other accumulations that may result from Work under this Contract. Dispose of nonhazardous and nondangerous wastes, rubbish, debris, and construction waste materials at accepted offsite locations weekly.

3.04 HANDLING AND DISPOSAL OF SITE WATER

A. The Contractor shall furnish all labor, materials, and equipment necessary for the proper handling, collection, and off-site transport of water accumulated that is generated from stormwater, groundwater, dust control operations, decontamination operations, or otherwise.

B. Construction Water.

1. Any stormwater or other ponded water encountered within the areas of excavation or disturbance with potentially impacted material exposed during construction activities shall be properly collected, managed and transported by the Contractor to constructed detention basin and sand filter basins system for settling and filtration treatment prior to disposal or an approved disposal facility or in accordance with the Contractor obtained Oregon Department of Environmental Quality Construction 1200-C Construction Stormwater permit.
2. All waste fluids generated by the Contractor from decontamination activities, or otherwise, shall be properly contained, managed, and transported by the Contractor to an approved disposal facility.
3. The Contractor shall take the necessary measures; i.e., divert runoff from the work area, to minimize the quantity of water generated for disposal.

C. Site Stormwater.

1. Once decommissioning of the existing stormwater collection system has been initiated, any stormwater or other ponded water within the limits of collection of the existing stormwater collection system, as indicated on the Contract Drawings, or water developed from pumping out the existing stormwater system that will be

decommissioned, shall be contained and managed by the Contractor according to these Specifications.

2. Contractor will be responsible for maintaining control of stormwater on the site as necessary to maintain site access and limit flooding of site features.

3. Upon decommissioning of the existing stormwater collection system, Contractor shall collect and store stormwater on the site for offsite disposal or onsite treatment, and discharge through the existing site Outfall Number 004. Upon completion of the detention basin and sand filter basin and associated transfer and discharge piping in accordance with the Contract Drawings and Specifications, Contractor can transport site stormwater to the inlet of the detention basin to allow for treatment and discharge through the existing site Outfall Number 004.

4. Any discharge through existing site outfalls shall meet the existing NPDES discharge permit requirements. The existing NPDES discharge requirements are listed on the existing site NPDES permit attached to these specifications as Exhibit 3. Contractor is solely responsible for meeting the site discharge limits and is responsible for any fines that are incurred by the permitting agency as a result of out of compliance discharges during construction activities.

END OF SECTION 01510

SECTION 01566 – EROSION AND SEDIMENT CONTROL

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies requirements for control of erosion and surface water drainage during the Work for protection of the Contractor's Work area and adjacent properties and water bodies. These requirements are specified to protect environmental quality and to minimize the potential for surface movement of contaminants during the Work.

B. This section describes the minimum drainage and erosion control requirements for stormwater management in the Work area. Contractor shall prepare an Erosion, Sediment, and Pollution Control Plan (ESPCP) as part of the Construction Work Plan to address the planning, design, and implementation of erosion control and stormwater management activities prior to and during the construction phase of the Work, and shall obtain Owner's Agent acceptance of the ESPCP prior to initiating earthwork or other soil disturbing activities at the site.

C. Field design and implement surface water runoff control measures appropriate to activities associated with temporary earthwork and other construction requirements. Measures include those that are not defined on the Contract Documents but are required to meet the requirements of applicable regulatory programs.

D. If the Owner's Agent or any governmental agency determines that Contractor's erosion and drainage control measures are inadequate to meet the intent of the applicable regulatory programs, including the City of Portland's Erosion, Sediment and Pollution Control program or the Contract Documents with regard to the control of surface water runoff or erosion or the prevention of environmental degradation as a result surface water runoff or erosion, provide field design and implement additional surface water runoff or erosion control measures that address the deficiencies observed by the Owner's Agent or the governmental agency at no additional cost to the Owner's Agent. Submit these measures to the Owner's Agent for review and acceptance prior to implementation.

E. Protect the Work from damage caused by surface water, including damage due to ponding, erosion, or contamination as a result of the lack of adequate surface water control measures. Repair or replace damaged Work shall to the satisfaction of the Owner's Agent at no additional cost to the Owner's Agent. Protect adjacent properties, drainage ways, and watercourses from physical or environmental damage proximately caused by surface water runoff, erosion, soil instability, migration of contaminants, clearing, grading, filling, or similar activities associated with the Work.

F. The requirements of this section apply to all areas of the site subject to construction activity as described in the Specifications and Contract Drawings, including Contractor construction support facilities, Contractor personnel parking areas, equipment and

material storage/laydown areas, and other upland areas utilized by Contractor for completion of the Work under this Contract.

G. Handle construction water as described in Section 01510 - Temporary Facilities and Controls.

1.02 SUBMITTALS

A. Within 14 days after the Notice to Proceed of Submittals, submit the ESPCP and obtain the Owner's Agent's acceptance of the Plan prior to initiating earthwork or other soil disturbing activities at the site.

B. The ESPCP will cover potential environmental releases as a result of the construction operations, as well as monitoring and corrective actions necessary to control such releases. The plan will contain separate sections addressing contamination prevention, containment and cleanup, stormwater pollution prevention, stormwater control, and water quality.

C. The ESPCP will address elements related to the management of erosion and sediment controls to prevent releases during construction activities. Review the City of Portland Erosion and Sediment Control Manual (City of Portland. 2008. Erosion and Sediment Control Manual. Prepared by City of Portland, Oregon, Bureau of Development Services, Bureau of Environmental Services, Portland Office of Transportation, and the Portland Water Bureau) for the development of the plan and selection of BMPs for use during construction activities. Construction activities related to stormwater management will follow permit requirements. The ESPCP should at a minimum address the sequencing, BMP selection and submittal requirements of Attachment A to Appendix A of the Design Report, Stormwater Source Control Measures, Former Arkema Inc. Facility, Portland, Oregon. Prepared by Integral Consulting Inc. (Technical Exhibit 2).

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Provide pumps and hoses, temporary berms, temporary ecology block or straw bale walls, drainage ditches, polyethylene sheeting and sandbags, silt fencing, sediment retention measures, and all other materials and equipment necessary to control surface water, erosion, and sediment transport during the Contract period.

B. Provide suitable products to construct all necessary drainage, erosion, and sediment controls. Submit proposed material specifications and Contractor drawings to the Owner's Agent for acceptance prior to construction of the drainage, erosion, and sediment controls.

2.02 QUALITY OF PERMANENT WORK

A. Permanent Work shall be free of damage caused by surface water, including erosion, sediment, and contaminant transport, or excessive water content of materials.

2.03 ACCEPTANCE

A. Repair or replace Work determined by the Owner's Agent to be damaged or potentially contaminated due to lack of control or care and handling of surface water runoff at no additional cost to the Owner's Agent.

PART 3 EXECUTION

3.01 MINIMUM EROSION AND SEDIMENT CONTROL REQUIREMENTS

A. Ensure that provisions for the following minimum requirements for erosion and sediment controls are implemented and maintained throughout the duration of the Work.

1. Prior to the start of clearing activities, mark in the field the clearing limits or easements, setbacks, sensitive/critical areas, and their drainage courses.
2. Protect properties adjacent to the site from stormwater runoff and from sediment deposition.
3. Control/contain stormwater runoff and drainage from, at a minimum:
    a. The construction staging area for the temporary stockpiling of removed soil when trucks are not available;
    b. Construction support and storage areas as well as vehicle haul roads; and,
    c. Areas of exposed excavations.
    d. Areas currently discharging to the existing stormwater collection system upon decommissioning of this system (as indicated on the Contract Drawings).
4. Provide functional sediment traps, berms, and other BMPs intended to trap sediment on site as a first step in grading, prior to initiating other land disturbing activities.
5. Stabilize areas where grading has been completed, and areas disturbed by temporary, short-term activity by Contractor, and no longer occupied or used, with a final ground cover (soil, gravel, pavement, etc.) as soon as is reasonably practical in order to minimize the potential for erosion. Protect stormwater drain inlets within the area serviced by the current stormwater collection system as shown on the Contract Drawings so that stormwater runoff will not enter the conveyance system without first being filtered or otherwise treated to remove sediment. Place geotextile "socks" within catch basins and enclose grate with straw bales.

6. Do not allow stormwater from areas of exposed excavation, temporary stockpiling, or construction support and storage areas to enter the newly constructed components of these stormwater SCMs without first being filtered or otherwise treated to remove sediments. Construct silt fences or place straw bales as required to filter all site stormwater prior to entrance into the newly constructed components of these stormwater SCMs. Conduct stormwater handling in accordance with Contractor's ESPCP, as accepted by the Owner's Agent.
7. Wherever construction vehicle access routes intersect paved roads, provide BMPs to minimize the transport of sediment (dust, soil, or mud) onto the paved road. If sediment is transported onto a road surface, clean the road thoroughly at the end of each day (or more frequently, if necessary, to meet the requirements of these Specifications) and place the recovered sediment on the site in accordance with the Contaminated Material Management Plan for the site (Appendix B of Exhibit 2).
8. Remove temporary BMPs within 30 days after final site stabilization is achieved or after the BMPs are no longer needed. Remove and stabilize trapped sediment, as directed by the Owner's Agent. Permanently stabilize disturbed soil areas resulting from removal of BMPs.
9. Maintain and repair temporary and permanent BMPs, as needed, to assure continued performance consistent with their intended function. Conduct maintenance and repair in accordance with Contractor's ESPCP, as accepted by the Owner's Agent. Maintain BMPs during suspensions of work and during nonwork periods. Maintain an inspection record file describing the condition of BMPs at the time of inspection, recommended repairs, if needed, and the date of repair. Complete repairs within 24 hours of discovery.
10. Handle and store hazardous materials used for construction purposes in accordance with the Section 01355 – Environmental Pollution Protection Control.
11. Implement permanent erosion control and restore all areas disturbed by the Contractor once construction activities have been completed.

3.02 STORMWATER HANDLING AND DISPOSAL

A. Once the existing stormwater features on the site have been decommissioned in accordance with this Contract, stormwater that impacts the site will be allowed to accumulate on the site. The accumulated stormwater will either be allowed to stay on the site if it is determined not to be impacting activities or if it is determined to be impacting site activities or flooding site facilities, control stormwater as described in Section 01510 – Temporary Facilities and Controls.

B. Provide temporary periphery containment berms and drainage channels as needed to control stormwater runoff during execution of construction activities.

END OF SECTION 01566

SECTION 01575 – WASTE MATERIAL HANDLING AND DISPOSAL

PART 1 GENERAL

1.01 DESCRIPTION

A. This Section includes the procedures and requirements for the disposal or recycling of wastes generated by the construction activities. Anticipated waste streams include soil and fluids generated from decontamination of equipment and personnel on the site, debris developed from site clearing and utility decommissioning, and general site trash such as PPE and trash. Note that soil generated from excavation activities on the site will not be sent offsite for disposal and will be reused/consolidated on the site as described in Paragraph 3.03 of this section, the Contaminated Material Management Plan (Appendix B of Exhibit 2), and on the Contract Drawings.

B. Disposal work shall include furnishing all labor, tools, equipment and incidentals required for transport of excavated materials, wastewater (from decontamination activities) and any associated debris from their existing location to an off-site upland disposal or recycling facility. Disposal work also includes all transportation and disposal fees.

C. Disposal work shall include any required chemical sampling and analysis for disposal characterization.

D. All wastes generated during the course of the project shall be disposed of in accordance with all applicable local, state, and federal regulations.

1.02 SUBMITTALS

A. Contractor shall address the handling, storage, transportation, and disposal of non-hazardous waste generated at the Site in the Construction Work Plan detailed in Section 01400 – Coordination and Construction Work Plan. Comply with regulations administered by the U.S. Department of Transportation (DOT), the Oregon Department of Transportation, and any other state department of transportation as it applies to the transportation of any waste to another state, and the Oregon Department of Environmental Quality. The Construction Work Plan shall include the following:

1. A list of wastes that will be generated by the project. A disposal site shall be identified for each waste stream and submitted to the Owner's Agent for acceptance prior to removal from the site. The list shall identify estimated quantities and the type of material to be disposed of or removed from the site. Include copies of permits for waste sites and recycling operations. Include EPA ID numbers, names, locations, and telephone numbers of all proposed disposal and recycling facilities and transporters.
2. Materials shall be shipped using an Contractor's Solid Waste Tracking Sheet (bill of lading) provided by the Contractor in the Construction Work Plan and accepted

by the Owner's Agent. Bills of lading requiring shipper's certifications shall be signed by an authorized representative of the Owner's Agent.

3. Small aboveground structures on the former DDT manufacturing building foundation will be demolished as part of this Work (see Section 02510 – Temporary Environmental Cap). Demolition debris from this area will be assumed to contain U061 hazardous waste and will be immediately transported to an appropriate offsite disposal facility. In the Construction Work Plan, Contractor shall provide all necessary documentation for transportation and disposal of this material as a RCRA-listed hazardous waste.
4. On-site management practices for waste, including types and volumes of waste anticipated, inventory controls, and waste minimization methods. Including procedures for packaging, labeling, and manifesting of waste streams generated and managed by the Contractor and all "Cradle to grave" documentation of all wastes generated at the project Site.
5. A list of all subcontractors employed in transportation, types of trucks, containers, and liners to be used, and inspection procedures prior to transport, and best management practices to avoid any leakage or spillage.
6. A description of, and proposed sequencing of, all sampling and analysis of any waste materials that may be required by the landfill for disposal characterization.

B. Should additional or alternate disposal or recycling sites become necessary during the life of the Contract, the locations and information for each site shall be submitted to the Owner's Agent for acceptance at least 7 calendar days prior to their use.

C. All transportation-related shipping documents shall be submitted to the Owner's Agent, including draft manifests for waste; draft bills of lading; lists of proposed labels, packages, markings, and placards to be used for shipment; and any waste profiles and/or supporting waste analysis documents, for a review a minimum of 7 calendar days prior to anticipated shipment. Generator copies of manifests used for initiating shipments of waste, bill of ladings, and supporting waste analysis documents shall be furnished when shipments are originated. The Contractor shall not allow any waste to leave the project site until shipping documents have been accepted by the Owner's Agent.

D. Receipt copies of waste shipment records at the designated disposal facility shall be furnished no later than 30 calendar days after acceptance of the shipment. When required by law, waste shipping papers shall be returned to the Owner's Agent within the legally specified time.

1.03 REQUIREMENTS FOR WASTE DISPOSAL AND RECYCLING SITES

A. Waste disposal sites shall be identified by the Contractor and must be accepted by the Owner's Agent prior to their use.

B. Waste disposal sites shall meet the environmental, grading, safety and health requirements of the state, county, and local political subdivision where located.

1. All sites shall be legally licensed and permitted.
2. Sites, operations, or results of operations that create a definite nuisance problem, or that result in damage to public or private properties, will not be permitted.
3. Disposal facilities with significant RCRA violations or compliance problems (such as facilities known to be releasing hazardous constituents into ground water, surface water, soil, or air) shall not be used.

C. The selection of the waste disposal and recycling sites and their operation shall at all times be subject to the acceptance of the Owner's Agent.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 GENERAL

A. Use only accepted waste disposal sites.

B. Take the protective measures required for the type of waste being handled.

C. All wastes shall be transported in accordance with federal, state, and local transportation requirements, including driver training, placarding, and use of shipping papers or waste manifests.

D. Notify the Owner's Agent at least 7 calendar days in advance of any proposed changes to the operations outlined in the accepted Construction Work Plan for handling, transportation or disposal of any waste materials. Notify the Owner's Agent at least 7 calendar days in advance of any proposed changes to the disposal or recycling sites in the accepted Construction Work Plan.

3.02 SITE MAINTENANCE

A. Keep work area, site, and adjacent properties free from accumulations of waste materials, rubbish, and windblown debris resulting from Contractor's operations.

B. Provide on-site containers for collection of waste materials, debris, and rubbish. Periodically remove waste from the site.

C. Do not use the Owner's Agent's waste containers for construction waste.

D. Dispose of trash and debris in compliance with governing codes, ordinances, regulations, and anti-pollution laws.

E. Locate dumpster(s) or other waste containers or stockpiles inside the staging area or at a site designated by the Owner's Agent.

F. Control all operations in accordance with Section 01355 – Environmental Pollution Protection Control.

3.03 EXCAVATED MATERIAL HANDLING

A. Contractor shall handle excavated soils, excavation dewatering water (if generated), and other debris generated from excavation during prosecution of the Work consistent with these Specifications, the Contaminated Materials Management Plan (CMMP; Appendix B of Exhibit 2) and directives issued by the Owner's Agent or its representative. These materials shall be contained within designated areas as shown on the Contract Drawings and shall not, at any time, be placed in other areas, except as accepted, in writing, by the Owner's Agent.

B. Contractor shall transport contaminated soil and liquids from the point of removal to the point of temporary or permanent storage in such a manner that material is not placed on and does not spill or fall on other areas. Contractor shall clearly stake and mark temporary storage locations for excavated materials at all times.

C. Contractor shall assist Owner's Agent or its representatives whenever they elect to acquire samples of excavated materials. Contractor shall assist Owner's Agent or its representatives to the maximum extent practicable and shall facilitate the complete removal of soil within the limits specified by Owner's Agent, subject to contractual provisions related to changes in the scope of Work.

END OF SECTION 01575

SECTION 01724 – FIELD ENGINEERING AND SURVEYING

PART 1 GENERAL

1.01 DESCRIPTION

A. This section includes the procedures and requirements for field engineering and surveying to be conducted at the Site. The Contractor shall provide all materials, items, operations, or methods specified, listed, or scheduled on the Contract Drawings or in the Specifications including all materials, labor, equipment, and incidentals necessary to conduct proper surveys required to determine the location of installed stormwater features, decommissioned site stormwater features, and new and repaired cap areas.

B. The Contractor shall employ an independent, professional land surveyor licensed in the State of Oregon to perform all project-related surveys for layout of the Work, to document final "as-built" construction for acceptance of completed work as stipulated in this Part 3 of this section, and for measurement and payment as described in Section 01270 – Measurement and Payment.

1.02 SUBMITTALS

A. Submittals shall be submitted in accordance with Section 01330 – Submittals.

B. Within 14 calendar days of a Notice to Proceed, Contractor shall submit the qualifications of the project surveyor. Surveyor shall be licensed in the State of Oregon.

C. Contractor shall submit surveys to the Owner's Agent within 7 calendar days of completion. Include AutoCAD 2010 electronic file, plan view drawings with 1-ft contour intervals and spot elevations depicting high and low points plotted at 1" = 50 feet. The AutoCAD electronic file shall include the Digital Terrain Model (DTM) as 3D-polylines. ASCII-format processed survey data shall be provided in x, y, z (easting, northing, elevation) format. Each data file shall include a descriptive header including, but not limited to: software and equipment information, client, project, horizontal and vertical datum, units, survey type, alignment, and stations surveyed.

D. On the day the Contractor submits request for progress payment, the Contractor shall furnish to the Owner's Agent copies of all field notes, computations, any records relating to the quantity survey or to the layout of the work, and PC-compatible versions of any computer software required to interpret the finished data and records. The Contractor is responsible for converting data and drawing files to a standard software version accepted by the Owner's Agent. Standard ASCII format is pre-accepted for data files. Survey data shall be provided in x, y, z (easting, northing, elevation) format. Each data file shall include a descriptive header including, but not limited to: software and equipment information, client, project, horizontal and vertical datum, units, survey type, alignment, and stations surveyed.

E. The Contractor shall maintain on site a complete, accurate log of control of survey work as it progresses.

F. The Contractor shall keep updated survey field notes in a standard field book. These field notes shall include all survey work performed by the Contractor's surveyor in establishing line, grade, and slopes for the construction work. Copies of these field notes shall be provided to the Owner's Agent upon request and, upon Substantial Completion of the Contract Work, the field books shall be submitted to the Owner's Agent and become the property of the Owner's Agent.

1.03 INDEPENDENT SURVEYOR QUALIFICATIONS AND RESPONSIBILITIES

A. Contractor shall retain an independent surveying firm who will be responsible for conducting surveying, field engineering, and related reporting activities, as specified in this section. Contractor's independent surveyor shall satisfy the minimum qualification requirements:

1. All survey, layout, and related work for progress surveys shall be performed under the supervision of and sealed by a professional land surveyor or civil engineer registered in the State of Oregon. The surveyor or engineer shall have at least 5 years experience in computing earthwork quantities.
2. Surveying firm shall utilize, and be proficient in the use of, the survey equipment and methods specified in this section.
3. Contractor's proposed independent surveying firm will be subject to review and acceptance by the Owner's Agent.

B. The responsibilities of the Contractor's independent surveyor shall included, but not be limited, to the following:

1. Verification of existing monuments, benchmarks, and control points established for the Work.
2. Establishment of supplemental benchmarks, control points, etc. as need to conduct the Work.
3. Initial layout of all Work elements.
4. Daily calibration and verification of surveying system accuracy.
5. As-built surveys of all completed Work.
6. Calculation of construction quantities for Contractor's progress payment requests.
7. Maintenance of the "Project Record" Drawings.
8. Preparation of as-built construction record drawings.

C. Contractor shall assume full responsibility for the coordination, scheduling, accuracy, and quality of the independent surveyor's work. The independent surveyor shall coordinate with Contractor's QC manager as necessary to fulfill project QC requirements, in accordance with Section 01450 – Quality Control.

1.04 PROJECT RECORD DOCUMENTS

A. The Contractor shall maintain on site a complete, accurate log of control of survey work as it progresses. Upon completion of the Work, the Contractor shall submit Record Documents to the Owner's Agent under the provisions of Section 01781 – Project Record Documents

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 GENERAL

A. The Contractor shall exercise care during the execution of the Work to minimize any disturbance to existing property and to the landscape and waters in the areas surrounding the work Site. Survey crews shall comply with all provisions of the Contractor's Health and Safety Plan when traversing into controlled or contaminated areas.

1. If the survey work provided by the Contractor does not meet the standards of the Owner's Agent, the Contractor shall, upon the Owner's Agent's Written Notice, remove the individual or individuals doing the survey work. Thereafter, the survey work will be completed by the Owner's Agent at the Contractor's expense. Costs for completing the survey work required by the Owner's Agent will be deducted from moneys due or to become due the Contractor.
2. The Owner's Agent reserves the right to check all work laid out by the Contractor during the progress of the work, as deemed necessary to verify conformance with the Contract Drawings and Specifications. The Contractor shall allow a reasonable time to permit such checks before completing the work. These checks will be made during the regular working hours.

3.02 SURVEY CONTROL AND REFERENCE POINTS

A. All survey Work shall be based on the following datum:

1. Horizontal Datum. Basis of bearings are the Oregon Coordinate System, North Zone, Established Through GPS and being NAD83, 1988 adjustment.
2. Vertical Datum. North American Vertical Datum of 1988 (NAVD88).
3. Control Points. NGS benchmark used is located at the southwest corner of the railroad bridge wing wall identified as "D 718". The NGS point was compared to the City of Portland benchmark located at the northeast corner of N.W. Front Ave and N.W. 61st Ave, identified as "2529". The NAVD datum was found to be 1.98 ft higher than the city of Portland datum.

B. The Contractor shall protect all survey control points prior to starting site work and preserve permanent reference points during construction. The Contractor shall not relocate site reference points without prior written acceptance from the Owner's Agent.

C. The Contractor shall promptly report to the Owner's Agent the loss, damage, or destruction of any reference point or relocation required because of changes in grades or other reasons. The Contractor shall replace dislocated survey control points based on original survey control at no additional cost to the Owner's Agent. Replacement of dislocated survey control points shall be done by a land surveyor licensed in the State of Oregon.

3.03 INSPECTION

A. The Contractor shall verify locations of Site reference and survey control points prior to starting work. The Contractor shall promptly notify the Owner's Agent of any discrepancies discovered. The Contractor shall also verify layouts periodically during Construction.

3.04 SURVEY REQUIREMENTS

A. The Contractor shall reference survey and site reference points to the provided control monuments and record locations of survey control points, with horizontal and vertical data, on Project Record Documents.

B. Survey Requirements.

1. Contractor shall use the Owner's Agent's existing baseline site survey for the site as the base map for the purposes of work on this contract. Contractor shall perform sufficient checking of the Owner's Agent's survey to verify the accuracy of the existing survey in relation to the site grades. Contractor shall provide the results of this verification with a statement indicating their acceptance of the existing survey, or suggestions on how the existing survey should be modified.
2. Surveys shall be completed after all excavation and backfill activities. Surveys shall be done with sufficient detail to develop a 1-foot contour map in an electronic format. The surveys shall cover all work areas**.**
3. The Contractor shall, with its own forces, obtain working or construction lines or grades as needed.
4. The Contractor shall provide all materials as required to properly perform surveys, including but not limited to: instruments, tapes, rods, measures, mounts and tripods, stakes and hubs, nails, ribbons, other reference markers, and all else required. All material shall be of good professional quality and in first-class condition.
5. All lasers, transits, and other instruments shall be calibrated and maintained in accurate calibration throughout the execution of the work. Calibration certificates shall be submitted to the Owner's Agent prior to the use of any instrument.

C. Topographic Surveys. All surveying shall be performed to a minimum standard of accuracy conforming to Third-order, Class I as defined by the Federal Geodetic Control Committee. Horizontal control shall be measured and recorded to the nearest 0.1 ft. Vertical control shall be measured and recorded to the nearest 0.01 ft.

D. Project elements where surveying is required include:

1. Stormwater conveyance and treatment system – survey all features associated with the system including but not limited to:

   a. Channel location and elevations. Provide details a minimum of every 50 feet along the channel and more if required to adequately define the channel.

   b. Stormwater detention and treatment basins. Provide sufficient coverage of points on the basins to define the features in accordance with the standard of practice for surveying similar features. At a minimum, provide coverage of the basin subgrade, top of sand, location and top elevation of weirs, and all piping and structures.

   c. New temporary environmental cap. Provide limits of the cap and final elevation of the top of the cap with a sufficient density of points to fully define the cap surface elevation and location. At a minimum, the survey shall include a point every 2,500 square feet.

   d. Existing cap repairs. The approximate location of cap repairs shall be noted on a capping repair as-built drawing. The drawing shall contain the approximate location of the cracks that were repaired.

2. Utility decommissioning survey. Contractor shall field locate stormwater structures to be decommissioned and shall notify Owner's Agent within 2 calendar days of the survey if stormwater features shown to be decommissioned on the plans are materially different than depicted on the Contract Drawings. Survey information shall document exact number, location and conditions (size, material) of all structures that are to be decommissioned.

3. Final list of remaining work elements and minimum shot requirements will be determined in Final Design.

3.05 FINAL AS-BUILT SURVEY

A. Upon completion of the Work, Contractor shall compile a final as-built survey and plan drawings of the Work for inclusion in the construction records report to be prepared by the Owner's Agent. The final as-built survey shall be a compilation of the baseline survey, progress surveys, and final backfill acceptance survey.

B. The as-built survey shall include a topographic survey of all final grades within the project limits. Representative cross sections shall also be prepared showing the final excavation grades within the work area. The accuracy of the topographic surveys shall be consistent with the requirements of Article 3.04 for surveying. The as-built survey shall include the location of all existing structures within the project limits.

C. The results of the as-built survey shall be presented in the form of contour plan drawings with 1- ft contour intervals. Toe and catch points shall be indicated for all slopes. Spot elevations shall be indicated in areas of limited topographic relief, as appropriate.

END OF SECTION 01724

SECTION 01781 – PROJECT RECORD DOCUMENTS

PART 1 GENERAL

1.01 DESCRIPTION

A. This Section specifies requirements for project record documents including, but not limited to, the following:

1. Land survey work. Survey work shall follow requirements of Section 1724 – Field Engineering and Surveying.
2. Record drawings, as-built drawings and records.

B. The Contractor shall retain two (2) complete sets of Contract Drawings and specifications for the sole purpose of indicating by “red-lines” or by lettering, all changes or deviations from the original Contract Documents recorded thereon for work under the Contract.

C. The Contractor shall record all survey data for the project.

D. “Record Drawings” shall refer to a set of final Contract Specifications and Drawings that shall be maintained in the Contractor’s Field Office. These specifications and drawings shall be modified, in the field, as work progresses to note any modifications to the original Contract Specifications and Drawings.

E. "As-built records" may also be called "as-built drawings," "as-built documents," and refer to final surveyed drawings prepared by the Contractor.

1.02 SUBMITTALS

A. Submit and record survey data.

B. Submit 2 copies of final surveys and As-Built Drawings. Submit AutoCAD electronic As-Built Drawings.

C. Submit 2 sets of completed record drawings with all changes marked on all pertinent sheets in red color.

1.03 SURVEYOR QUALIFICATIONS

A. As required in Section 01724 – Field Engineering and Surveying.

PART 2 PRODUCTS

2.01 GENERAL

A. The hard-copy sets of as-built and Record drawings may be submitted on paper or Mylar.

PART 3 EXECUTION

3.01 GENERAL

A. Contractor shall keep at the Project Site a of set record drawings that consist of the Contract Drawings, accurately marked with all changes or deviations from the original Contract or from the Owner's Agent-reviewed Shop Drawings.

B. These record drawings shall be kept up-to-date on a daily basis as the work requiring updates records progresses.

C. Prior to the Substantial Completion Date, the Contractor shall forward to the Owner's Agent for acceptance, a set of record drawings and other Contract Documents showing all record information where required. These record documents shall be clean and easily readable.

D. Prior to the Substantial Completion Date, the Contractor shall forward to the Owner's Agent for acceptance, the final as-built drawings which shall become the official record set for the Work.

3.02 SURVEYOR'S FIELD BOOK

A. The Contractor shall maintain a surveyor's Field Book of control and other survey work as also described in Section 1724 – Field Engineering and Surveying.

B. The Field Book shall be available for reference.

C. The Contractor shall record deviations from locations and elevations.

1. Advise the Owner's Agent when deviations exceed tolerances.
2. On Project Record Drawings, record deviations that are accepted and not corrected.

3.03 IMPROVEMENTS AND EXISTING UTILITIES

A. Locate and lay out stormwater improvements, including pavements, stakes for grading, backfill placement, decommissioned utilities, and invert elevations.

1. Indicate field changes of dimension and detail.
2. “X-out” conditions not constructed and appropriately annotate "not constructed" to convey the actual "as constructed" condition.
3. Where shop drawings are used, record a cross-reference at the corresponding location on the Contract Drawings.

B. Accurately record and indicate on the record drawings the location of all newly installed, modified, and discovered underground and above ground utilities.
   1. All references shall use the same Datum as the Contract Documents.
   2. Include all pertinent utility control information on the record drawings, including but not limited to shut-off valves, pumps, and cleanouts.

C. Furnish information necessary to adjust, move, or relocate existing structures, utility poles, lines, services, or other appurtenances located in or affected by construction.

3.04 FREQUENCY OF UPDATING DRAWINGS

A. The Contractor shall update the record drawings on a daily basis for acceptance by the Owner’s Agent.

B. Failure to have the record set up-to-date shall, at the discretion of the Owner’s Agent, be reason to withhold payment until such information is recorded.

3.05 FINAL AS-BUILT SET

A. Prepare a final survey showing significant features for the Project, in accordance with Section 01724 – Field Engineering and Surveying.
   1. Include certification that meets, bounds, lines, and levels of the Project are accurately positioned as shown on the survey.

B. Submit the completed as-built set of drawings and specifications showing the as-built notations to the Owner’s Agent for his/her acceptance and use.
   1. As-built drawings shall be submitted in both AutoCAD electronic drawings and hard copies. The hard-copy record set shall be clean, easily readable, and shall become the record set for the project.

3.06 PAYMENT WITHHELD

A. If the Contractor fails to keep the record set of documents up-to-date during the progress of work, the Owner’s Agent may withhold payment.

END OF SECTION 01781

SECTION 02222 – DECOMMISSIONING OF STORM DRAIN SYSTEM

PART 1 GENERAL

1.01 DESCRIPTION

A. This section includes the in-place decommissioning of storm drain pipelines, catch basins and manholes described below, and as shown on the project Contract Drawings.

B. Contractor shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to complete the storm drain and catch basin decommissioning.

1.02 DEFINITIONS

A. Decommissioning. In-place storm drain decommissioning consists of plugging and/or filling of catch basins, manholes and storm drains with materials as specified in this Section.

B. Controlled Low-Strength Material (CSLM). A highly flowable lean concrete mix; a mixture of fly ash, cement, fine aggregates, water and admixtures, if necessary.

C. Ballast. Open-graded aggregate used for filling catch basins and manholes and meeting the requirements of this Section.

1.03 SUBMITTALS

A. Within 14 calendar days of the Notice to Proceed, Contractor shall submit as part of its Construction Work Plan the proposed methods, materials, equipment, and operating sequences to be used in performance of the decommissioning work. The Construction Work Plan shall include, but is not limited to, the following information:

1. CLSM mix design:

   a. Describe mix design including constituents, material proportions, production methods and compressive strength. Provide types and amounts of admixtures including air entrainment or air generating compounds.

   b. Describe if mix will be mixed to final proportions and consistency in the batch plant or if constituents will be added in transit mixer at placement location.

   c. Provide 28-day cylinder reports from a trial CLSM batch based on the specifications of this Section. Reports shall include certification compressive strength requirements are met, based on at least three acceptable strength tests for proposed mix design.

2. Technical information for equipment and operational procedures including projected proposed CLSM injection rate, pressure, method of controlling injection pressure, bulkhead and vent design, and number of stages of CLSM application.
3. Gradation reports for ballast material, certifying conformance to the specifications in this Section.

B. Schedule: Show coordination of operations with other activities including excavating, backfilling, and other applicable items.

1.04 REFERENCE STANDARDS

A. ASTM C 150 - Standard Specification for Portland Cement.

B. ASTM C260 – Standard Specification for Air-Entraining Admixtures for Concrete.

C. ASTM C 494 - Standard Specification for Chemical Admixture for Concrete.

D. ASTM C 618 - Standard Specification for Fly Ash and Raw or Calcinated Natural Pozzolan for use as Mineral Admixture in Portland Cement Concrete.

E. ASTM C 940 - Standard Test Method for Expansion and Bleeding of Freshly Mixed Grout for Replaced Aggregate Concrete in the Laboratory.

F. ASTM C 1107 - Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink).

G. ASTM D 3786 Standard Test for Bursting Strength of Textile Fabrics—Diaphragm Bursting Strength Tester Method.

H. ASTM D 4491 Standard Test Methods for Water Permeability of Geotextiles by Permittivity.

I. ASTM D 4632 Standard Test Method for Grab Breaking Load and Elongation of Geotextile.

J. ASTM D 4751Standard Test Method for Determining Apparent Opening Size of a Geotextile.

K. ASTM D 4833 Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products.

L. ODOT TM 208. Test Method for Degradation.

M. AASHTO M 295. Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

N. AASHTO T 96. Standard Method of Test for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

O. AASHTO TP 61. Determining the Percentage of Fracture in Coarse Aggregate.

1.05 JOB CONDITIONS

A. Condition of Structures: The information regarding the existing structures shown on the Contract Drawings is based on historic facility documents and walk-through surveys only. The Owner's Agent does not assume responsibility for the actual location and condition of structures to be decommissioned. The Contractor shall be responsible for verifying and field-locating structures to be decommissioned, in accordance with the information specified in this Section:

B. Protection:

1. Storm drain decommissioning work shall be performed by competent workmen experienced in the storm drain decommissioning work activities, and it shall be carried through to completion with the prevention of damage or injury to structures, work persons on the site, and so as not to interfere with the use of, and free and safe passage to and from, adjacent structures.
2. Contractor shall provide, erect, and maintain lights, barriers, weather protection, warning signs and other items as required for proper protection of the occupants of the facility, work persons engaged in decommissioning operations, and adjacent construction.
3. Contractor shall take necessary precautions to control dust as required by Section 01355 – Environmental Pollution Protection Control.
4. Contractor shall carry out all operations so as to avoid interference with work conducted under other contracts, in accordance with the provisions of Section 01110 – Summary of Work.
5. Contractor shall repair damage caused by its decommissioning operations to site features to remain intact, including asphalt pavement, or to any damaged property belonging to the Owner's Agent.

C. Scheduling: Storm drain decommissioning work shall be conducted as required to facilitate other elements of the Work, and work to be conducted by others, in accordance with the Section 01110 – Summary of Work. Storm drain decommissioning shall commence with the furthest downgradient portion of the storm drain (i.e. point closest to the discharge point of the Willamette River) and work inward to assure no accidental discharge of decommissioning materials to the Willamette River.

D. Notification: At least 48 hours prior to commencement of decommissioning work, Contractor shall notify the Owner's Agent in writing of its proposed schedule.

PART 2 PRODUCTS

2.01 CLSM

A. CLSM shall attain a 28-day compressive strength of 100-200 psi, as determined based on an average of at least three acceptable strength tests for proposed mix design.

B. Shrinkage characteristics: non-shrink.

C. Placement characteristics: self-leveling.

D. Water bleeding for fill to be placed by grouting methods: not to exceed 2 percent according to ASTM C 940.

E. Minimum wet density: 90 lb per cubic foot.

F. Cement content: CLSM shall have a minimum Portland cement content of 100-lb per cubic yard. Portland cement shall consist of ASTM C 150 Type I or II.

G. Chemical admixtures to be used, as needed, shall conform to the following standards:

1. Air Entraining: ASTM C 260
2. Water-Reducing: ASTM C 494
3. Retarding: ASTM C 494
4. Accelerating: ASTM C 494

H. Fly ash used in Portland cement concrete shall be ASTM C 618 Class C or F and conform to AASHTO M 295, except that:

1. Loss on ignition shall be 1.5% maximum.
2. Moisture content shall be 1% maximum.
3. Amount retained on the No. 325 sieve shall be 30% maximum.

I. CLSM fine aggregate shall consist of commercial quality concrete sand with following gradation:

1. 100% passing 3/8-inch sieve and not more than 10% passing No. 200 sieve.

2.02 BALLAST

A. Open-graded aggregate conforming to the following grading requirements:

Table 02222-1. Aggregate Gradation for Ballast Material

Sieve Size	Percent Passing by Weight
1”	100
3/4”	80-98
1/2”	60-85
3/8”	30-65
No. 10	5-20
No. 40	0-6
No. 100	0-3

B. Fracture of rounded rock: Fracture or rounded rock will be determined according to AASHTO TP 61. Ballast material shall conform to the following:

Table 02222-2. Percentage of Fracture by Weight

Material Retained on 3/4”, 1/2”, and 1/4” Sieves (2 fractured faces)	Material Retained on No. 10 Sieve (1 fractured face)
90	75

C. Durability: Ballast material shall meet the following durability requirements:

Table 02222-3. Ballast Material Durability

Test	Test Method	Requirements
Abrasion	AASHTO T 96	35% Maximum
Degradation		
Coarse Aggregate (Passing No. 20)	ODOT TM 208	30% Maximum
Sediment Height	ODOT TM 208	3” Maximum

2.03 PLUGS

A. Permanent grout plugs shall conform to the following requirements:

1. Cement-based dry-pack grout conforming to ASTM C 1107, Grade B or C.
2. Minimum length of grout plug shall be 12 inches.
3. All plugs shall be watertight and capable of withstanding internal and external pressures without leakage.
4. For 21-inch and larger pipe, the plug may be constructed of common brick or concrete block, embedded and sealed with grout.

2.04 FILTER FABRIC

A. Filter fabric shall consist of non-woven geotextile meeting the following requirements:

1. Be composed of long chain, synthetic polymeric filaments or yarns formed into a stable network that retains its relative structure during handling, placement and design service life. At least 95%, by weight, of the long chain polymers shall be a polyolefin or polyester

2. Meet or exceed the properties specified in Table 02222-4:

Table 02222-4. Minimum Geotextile Filter Fabric Properties

Geotextile Property	Test Method	Units	Value
Grab Tensile Strength			
Machine Direction	ASTM D 4632	lb	80
Cross Machine Direction			80
Grab Elongation	ASTM D 4632	%	15
Burst Strength	ASTM D 3786	psi	130
Puncture Strength	ASTM D 4833	lb	35
Apparent Opening Size	ASTM D 4751	U.S. Standard Sieve Size	No. 70
Permittivity	ASTM D 4491	s^{-1}	0.5

PART 3 EXECUTION

3.01 GENERAL

A. The work required shall be done with care, and shall include all necessary shoring, or support to prevent movement, detention, or collapse of existing structures. Contractor shall be responsible for any damage which may be caused by decommissioning and removal work to any part or parts of existing structures or items designated for reuse or to remain. Contractor shall perform patching, and restoration in accordance with applicable technical sections of the Specifications and in accordance with the details shown on the Contract Drawings.

B. Decommissioning sequence: Storm drain pipelines shall be decommissioned first. Following storm drain decommissioning, all potentially active manholes and catch basins shall be decommissioned.

C. Pollution Controls: Temporary enclosures and other suitable methods to limit the amount of dust and dirt rising and scattering in the air to the lowest practical level. Temporary enclosures and other suitable methods to eliminate the release of any solids/liquid to the Willamette River during the Work. Comply with Section 01355 – Environmental Pollution Protection Control and all governing regulations pertaining to environmental protection.

3.02 PREPARATION

A. Contractor shall have its Construction Work Plan, including CLSM mix design and all other submittals required by Paragraph 1.03 above, approved by the Owner's Agent at least 24 hours in advance of commencing decommissioning work.

B. Perform any required decommissioning work prior to beginning CLSM placement. Clean manholes or catch basins of debris or sludge that may hinder placement and performance of fill. Dispose of removed waste materials in accordance with the Contaminated Material Management Plan (Appendix B of Exhibit 2).

C. Remove free water from catch basins prior to placement of materials and managed/disposed of in accordance with Section 01510 – Temporary Facilities and Controls.

3.03 PIPELINE DECOMMISSIONING

A. Decommissioning of storm drain pipelines connected to Outfalls 001, 002, and 003:

1. On the river side of the groundwater barrier wall, between the groundwater barrier wall alignment and 10 LF upgradient of the respective in-line Parshall flumes, as per the Contract Drawings:

   a. All pipelines shall be decommissioned in-place by filling with CLSM.

2. On the upland side of the groundwater barrier wall:

   a. All storm drain pipelines 24-inches, or larger, in diameter shall be decommissioned in-place by filling with CLSM.

   b. Pipelines less than 24-inches in diameter shall be sealed with a grout plug.

B. Decommissioning of storm drain pipelines connected to Outfall 004:

1. On the upland side of the connection point to the stormwater treatment system, as per the Contract Drawings:

   a. All storm drain pipelines 24-inches, or larger, shall be decommissioned in-place by filling with CLSM.

   b. Pipelines less than 24-inches in diameter shall be sealed with a grout plug.

3.04 CATCH BASIN AND MANHOLE DECOMMISSIONING

A. Once storm drain pipelines have been decommissioned in accordance with the requirements of Paragraph 3.03 above, all potentially active manholes and catch basins located site-wide shall be decommissioned in-place by the following methods:

1. Potentially active utility manholes and catch basins shall be filled with ballast material up to 2 ft bgs. Ballast material shall be compacted to a firm and non-

yielding surface then covered with filter fabric and the remainder of the structure shall be filled with CLSM, allowing sufficient space for an approximately 3-inch lift of asphalt, to be placed flush with existing ground surface.

2. As indicated on the Contract Drawings, existing utility manholes or catch basins that fall within the proposed stormwater channel alignment shall be decommissioned to a minimum of 2 feet below design grades. Connected pipes shall be decommissioned according to the procedure described in Paragraph 3.03 of this Section. Following decommissioning of pipes, manhole or catch basins shall be decommissioned in accordance with methods specified above.

3.05 FIELD QUALITY CONTROL

A. Provide batch plant tickets for each truck delivery of flowable fill. Note on tickets addition of admixtures at site.

B. Check flow characteristics and workability of fill as placement proceeds.

C. Obtain at least three test cylinders for each placement area for determination of 28-day compressive strength and bleeding. Acceptance of placement will be based on average strength of three tests.

D. Record volume of ballast together with flowable fill.

3.06 DISPOSAL OF MATERIALS

A. All debris shall be managed in conformance with the Contaminated Materials Management Plan (Appendix B of Exhibit 2).

3.07 MAINTENANCE AND CLEAN UP

A. Contractor shall provide on-site dump containers for collection of waste materials, debris and rubbish, and shall wet down dry materials to prevent blowing dust.

B. During the progress of the debris removal work, Contractor shall maintain the site and properties in a clean condition, and dispose of waste materials, debris, and rubbish on a regular basis.

END OF SECTION 02222

SECTION 02325 – EXCAVATION AND BACKFILL

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies requirements for furnishing transportation, labor, materials, equipment, and incidentals necessary to perform excavation, backfilling, and associated handling of reusable soil/backfill material and potentially contaminated site soil and debris from the stormwater channels and stormwater holding and treatment basins.

B. This is an environmental site in which the important elements are: 1) the safe handling of soil/backfill material; 2) the safe handling of contaminated soil; and 3) minimizing recontamination potential. Soil developed from excavation of the channels and stormwater basins will be consolidated as shown the Contract Drawings and capped with a temporary environmental cap.

C. All soil generated during site activities shall be handled in as described in the Contaminated Materials Management Plan (CMMP; Appendix B of Exhibit 2)

D. Channel and basin excavations will be lined as shown on the Contract Drawings.

E. Construction equipment, methods, sequence, and execution of the Work shall be conducted so as to prevent the spread of contaminated soil to uncontaminated areas, or areas that have been previously excavated and backfilled. Environmental controls shall be implemented for all Work in accordance with Section 01355 – Environmental Pollution Protection Control.

1.02 DEFINITIONS

A. Backfill: Backfill is excavated material for construction of the basin and channels. Backfill to be managed on site as per the Contaminated Material Management Plan (Appendix B of Exhibit 2) in locations as indicated on the Contract Drawings.

B. Debris: Debris is any non-soil material that may be encountered during excavation. Material to be expected may include, but is not limited to, concrete blocks, concrete slabs, broken concrete, decommissioned concrete pipes, steel pipes, wood, trash, and other miscellaneous items.

C. Excavation: Excavation, as used within this section, means the removal of soil by mechanical means using land-based excavation equipment or hand tools.

D. Maximum Pay Depth: The required depth of the stormwater feature plus the over-excavation allowance for this project. The over-excavation allowance for this project is 0.1 foot. Excavation beyond the maximum pay depth will not be paid and backfill material required to bring over excavated areas to the maximum pay depth will also not be paid.

E. Neatline Excavation: Neatline excavation is the required removal material to the depths, grades, lines, and limits shown on the Contract Drawings that must be accomplished to meet project goals.

1.03 REFERENCE STANDARDS

A. ASTM D 1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort.

1.04 SUBMITTALS

A. The Contractor shall submit all test reports as specified in Section 01450 – Quality Control, and in accordance with their Owner's Agent-accepted Quality Control Plan. Include samples of proposed backfill materials, including the backfill filter material, and backfill armor layer material.

B. Excavation Plan: Within 14 days of Notice to Proceed of Submittals and prior to initiating and excavation activities, the Contractor shall submit to the Owner for review a detailed work plan addressing the following:

1. Equipment – List all equipment to be used for performing excavation, backfill and material disposal activities. Include dimensions, bucket sizes, weight, anticipated production rate, and any cautionary warnings. Provide manufacturer cut sheets for all excavation buckets to be used.
2. Staging Area Plan – Provide a layout of the proposed construction staging area. Potential contractor staging areas are shown on the Drawings. The Contractor is responsible for all costs associated with its workspaces and staging areas.
3. Excavation Plan – Describe the order, sequence, schedule, and methods of proposed excavation, including layout plan and coordination with the various work activities between excavation, backfilling, and associated work.

1.05 PERMIT COMPLIANCE

A. Comply with all conditions and requirements of the Oregon Department of Environmental Quality Construction 1200-C Construction Stormwater permit, City of Portland grading and Erosion Control requirements (see Section 01410 – Regulatory Requirements and Section 01566 – Erosion and Sediment Control).

1.06 PROJECT CONDITIONS

A. The material to be excavated generally consists of silt/sand/gravel mixtures with debris that is consistent with an industrial facility.

B. Large debris, concrete and piping shall be removed by the Contractor as described in Section 02222 – Decommissioning of Storm Drain System and Section 01575 – Waste Material Handling and Disposal. It is likely that additional debris, riprap, and other man-made and natural objects will be encountered during excavation activities. Dispose of all debris that may be encountered during the Work as described in the Contaminated Material Management Plan (Appendix B of Exhibit 2).

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 GENERAL

A. Excavation and backfill shall be completed to the alignments, grades, and cross sections shown on the Drawings, or as otherwise directed by the Owner's Agent to complete to Work under this Contract.

B. Protect materials transported to and stored at the site from the elements so as to preserve the integrity of the materials for their intended purposes. Take full responsibility for the safety and security of materials and equipment mobilized or delivered to the site.

C. Material handling during construction shall proceed in a manner that complies with applicable federal and state safety codes and industry practices. The transportation or movement of materials on the site shall proceed in a manner that protects existing site features and facilities, protects the Work from damage, and protects the materials from damage or adverse effects until incorporated into the Work. Damage or nonconforming materials shall be removed from storage areas occupied by conforming materials and transported offsite for recycling or disposal as soon as practicable at Contractor's expense, unless otherwise approved by the Owner's Agent.

3.02 PREPARATION

A. Establish and protect benchmarks, survey control points, existing structures, existing stormwater collection system, existing site utilities, and fences.

B. Furnish, set, and maintain, in good order, all markers necessary to define the Work and to facilitate inspection.

C. Prior to conducting excavating and backfilling, conduct all clearing and grubbing as necessary to complete the Work.

3.03 TRENCHING

A. Trench safety is the sole responsibility of the Contractor. Compliance with all federal and state OSHA regulations is mandatory. Provide for the design, inspection, installation, and maintenance of all temporary trench shoring and sheeting systems needed to perform the excavation and backfill in conformance with the requirements of this section.

B. To prevent damage to the existing riverbank, provide, install, and use trench shoring or sheeting systems in utility and below grade trench excavations located below an imaginary 2H:1V plane projected downward from the top of any existing, operative facility and riverbank. Contractor shall be liable for all expenses associated with the repair or replacement of existing, operative facilities or the riverbank damaged by the Contractor's excavation and backfill activities.

3.04 EXCAVATION

A. Detention basin and sand filter excavation.

1. Excavated material that is suitable for reuse as common onsite backfill shall be transported to and placed in designated fill areas or temporary stockpiles within the limits of the Work as indicated on the Contract Drawings or as approved by the Owner's Agent. Unsuitable material, including soil which is disturbed by Contractor's operations or softened due to exposure to the elements and water, shall be moisture conditioned and reworked as needed until it is suitable for use as common onsite backfill, unless such material is designated for other disposal by the Owner's Agent. Unless otherwise directed by Owner's Agent, excavations shall be performed in a manner and sequence that will utilize available material from required excavations prior to importing borrow material.

2. Surface water shall be directed away from the work areas, and excavations shall be kept free from water while construction therein is in progress. Perform dewatering operations, as specified or required to complete the Work.

3. Dispose of all excavated soils that exhibit field indications of the contamination, as determined by the Owner's Agent according to the Contaminated Material Management Plan (Appendix B of Exhibit 2), in the areas as designated on the Contract Drawings, unless otherwise directed by the Owner's Agent.

4. Excavate the detention basin and sand filter to the lines and grades indicated on the Contract Drawings. The over-excavation allowance for this project is 0.1 foot. Excavation beyond the maximum pay depth will not be paid and backfill material required to bring over excavated areas to the maximum pay depth will also not be paid.

5. Protect prepared subgrade from the operation of equipment, erosion, and sloughing of excavated material to maintain conditions necessary for geomembrane liner installation (see Section 02501 – Storm Drainage and Treatment System). Any rework of subgrade necessary of installation of the geomembrane liner to the requirements of the liner installation contractor or Owner's Agent shall be completed at the Contractor's expense.

B. Stormwater conveyance channels and other excavation required for pipeline installation.

1. Excavated material shall be transported to and placed in designated stockpile areas or temporary stockpiles within the limits of the Work as indicated on the Contract Drawings or as approved by the Owner's Agent. Unsuitable material, including soil which is disturbed by Contractor's operations or softened due to exposure to the elements and water, shall be moisture conditioned and reworked as needed until it is suitable for use as common onsite backfill, unless such material is designated for other disposal by the Owner's Agent.

2. Surface water shall be directed away from the work areas, and excavations shall be kept free from water while construction therein is in progress. Perform dewatering operations, as specified or required to complete the Work.

3. Dispose of all excavated soils from the Former Acid Plant Area and the Old Caustic Tank Farm, as indicated on the Contract Drawings, or that exhibit field indications of contamination, as determined by the Owner's Agent according to the Contaminated Material Management Plan (Appendix B of Exhibit 2), in the areas as designated on the Contract Drawings, unless otherwise directed by the Owner's Agent.

4. Excavate the stormwater channels and trenches as necessary to install piping to the lines and grades indicated on the Contract Drawings. The over-excavation allowance for this project is 0.1 foot. Excavation beyond the maximum pay depth will not be paid and backfill material required to bring over excavated areas to the maximum pay depth will also not be paid.

3.05 DEBRIS REMOVAL AND DISPOSAL

A. Remove existing debris including metal, wood, concrete and asphalt from the areas to be excavated as indicated on the Contract Drawings.

B. Segregate concrete chunks, slabs, or pieces and other miscellaneous equipment debris such as manhole covers, pipe segments, vaults, etc and stock pile separately from other excavated materials in the areas designated on the Contract Drawings and as per the Contaminated Material Management Plan (Appendix B of Exhibit 2).

C. Remove any surface vegetation from the areas to be excavated as indicated on the Contract Drawings. Dispose of any vegetation in accordance with Specification Section 01575 – Waste Material Handling and Disposal.

D. Dispose of other debris removed during the Work as directed by the Owner's Agent. No offsite disposal will be allowed unless approved by the Owner's Agent.

3.06 ACCESS RAMPS AND HAUL ROADS

A. Contractor shall determine the requirements for construction equipment access into the detention basin and sand filter and for internal haul roads needed for efficient placement of materials with these excavations to complete the Work and shall include appropriate drawings, details, and material and equipment requirements for these temporary facilities with the Construction Work Plan.

B. Temporary access ramps and internal haul roads to be used for placement of materials within the detention basin and sand filter shall be designed and constructed by the Contractor as part of the Work under this Contract.

C. Unless otherwise approved by the Owner's Agent, access ramps on the outside of the detention basin and sand filter shall be constructed with imported granular leveling layer material or crushed rock that is subsequently removed by the Contractor.

D. Unless otherwise approved by the Owner's Agent, interior haul roads and berms needed for material handling shall be constructed by imported granular leveling layer, borrow material, or crushed rock as necessary.

3.07 BACKFILL

A. Contractor shall test backfill material in accordance with Section 02501 – Storm Drainage and Treatment and Section 01450 – Quality Control prior to delivery to the site.

B. Subgrade preparation: Areas cut to final subgrade elevation or prepared to receive fill shall be moisture conditioned to near its optimum moisture content and compacted to a depth of at least 12 inches to at least 90 percent of its maximum dry density as determined by ASTM D1557. Material exhibiting instability, including significant pumping or rutting, during compaction shall be removed, reconditioned, and reworked as needed, regardless of the density results.

C. Pipe bedding: Preparation of subgrade soil and placement of bedding to the pipe invert shall precede the pipe installation as shown on the Contract Drawings and included in these Specifications. Bedding material shall provide uniform support along the entire pipe barrel, without load concentration at joint collars or bells. All adjustments to line and grade shall be made by scraping away or filling in with bedding material under the body of the pipe and not by blocking or wedging. Following pipe installation, further bedding material shall be placed uniformly under and around the pipe to the centerline inlayers not exceeding 6 inches loose depth; the bedding shall be worked carefully under the pipe haunches and then compacted. Bedding material shall be compacted to at least 95 percent of its maximum dry density as determined by ASTM D 1557. Bedding material shall be placed, at a minimum, from 6 inches below pipe to 12 inches above pipe. Bedding placement and compaction shall proceed uniformly to prevent

displacement of the pipe alignment or grade or damage due to overloading or eccentric loading upon or against pipes, conduits, or structures.

D. Common Onsite Backfill: Common onsite backfill shall be moisture conditioned to near its optimum moisture content, placed in layers not to exceed 10 inches loose depth, and compacted to at least 90 percent of its maximum dry density as determined by ASTM D 1557. Material exhibiting instability, include significant pumping or rutting, during placement and compaction shall be removed, reconditioned, and reworked as needed, regardless of the density test results.

E. Leveling Sand for detention basin and sand filter basin liner system: Imported leveling sand for detention basin, sand filter, and channel liner construction as indicated on the Contract Drawings, shall be moisture conditioned to near its optimum moisture content, placed in layers not to exceed 6 inches loose depth. Material exhibiting instability, include significant pumping or rutting, during placement shall be removed, reconditioned, and reworked as needed, regardless of the density test results.

F. Clay materials for placement of concrete blocks in the detention basin and sand filter basin: Imported clay materials for placement of the concrete blocks in the detention basin, sand filter, and channel liner construction as indicated on the Contract Drawings, shall be moisture conditioned to near its optimum moisture content, placed in layers not to exceed 10 inches loose depth, and compacted to at least 90 percent of its maximum dry density as determined by ASTM D 1557. Material exhibiting instability, include significant pumping or rutting, during placement and compaction shall be removed, reconditioned, and reworked as needed, regardless of the density test results.

G. Borrow Material Backfill for berms: Borrow material used for construction of stormwater containment berms, berms around the sand filter, and for other Owner designated clean fill purposes, shall be moisture conditioned to near its optimum moisture content, placed in layers not exceeding 6 inches loose depth, and compacted to at least 95 percent of its maximum dry density as determined by ASTM D 1557. Material exhibiting instability, include significant pumping or rutting, during placement and compaction shall be removed, reconditioned, and reworked as needed, regardless of the density test results.

H. ¾" Minus Crushed Rock Surfacing: Crushed rock surfacing material used for the surface of the detention basin and sand filter liner covers, and covering stormwater containment berms shall be moisture conditioned to near its optimum moisture content, placed in layers not exceeding 8 inches loose depth, and graded until the finished grade indicated on the Contract Drawings has been achieved.

I. Channel Armor and Inlet Scour Protection: Channel armor and Inlet Scour Protection material shall be carefully placed by mechanical methods which limit particle segregation. Placement of all channel armor shall proceed form the lower elevations to higher elevations. Dumping channel armor materials on upper portions of the slope for placement on the lower slope shall be prohibited. Allow no loose or unkeyed rocks on the face of the slope. All unkeyed rock shall be promptly removed. Hand placing or rearranging of individual rock by mechanical equipment shall be used, if required.

3.08 SURVEYING

A. Complete all surveys required for controlling the Work, as-built survey records, and measurement for payment in accordance with Sections 01270 – Measurement and Payment, 01724 – Field Engineering and Surveying, and 01781 – Project Record Documents.

3.09 REPORTS AND RECORDS

A. Prepare and have on file the following records and reports:

1. Daily progress reports.

2. Results of all construction monitoring, inspection, and quality control testing completed to meet the requirements of this section.

3. Records, reports, and backup documentation as required by this section.

4. A record of unusual conditions of materials and construction problems encountered and disposition made, as well as a construction log indicating delays encountered during excavation and backfill operations and stating the cause, location, and extent of the delay.

B. The excavation and backfill will be considered “complete” when Contractor has performed all Work specifically stated or manifestly implied in this Specification and shown on the Contract Drawings. The following illustrates the type of Work that shall have been satisfactorily accomplished before the Work will be considered complete:

1. Completion of all required measurements and tests.

2. Completion of all required daily and final inspections and reports.

3. Completion of cleanup and site restoration.

END OF SECTION 02325

SECTION 02501 – STORM DRAINAGE AND TREATMENT SYSTEM

PART 1 GENERAL

1.01 DESCRIPTION

A. This section includes the proposed storm drainage system surface channels, piping, detention basin, sand filter basin, basin inlet and outlet structures, and connection vaults and manholes.

B. Contractor shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to complete the storm drainage and treatment system.

1.02 REFERENCES

A. Comply with the requirements of Section 01410 – Regulatory Requirements and as listed herein. The following is a list of standards referenced in this section.

1. The publications listed below are a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only. The most recent version of the reference applies.
2. ODOT TM 206: Oregon Department of Transportation Test Method 206: Soundness (Sodium Sulfate Loss).
3. ODOT TM 208: Oregon Department of Transportation Test Method 208: Oregon Air Aggregate Degradation.
4. ASTM D 422: American Society of Testing and Materials: Test Method for Particle-Size Analysis of Soil.
5. ASTM D 5519: American Society of Testing and Materials: Particle-Size Analysis of Natural and Man-Made Riprap Materials.
6. AASHTO T 85: American Association of State Highway and Transportation Officials (AASHTO): Test Method for Apparent Specific Gravity. Standard Specifications for Transportation Materials and Methods of Sampling and Testing.
7. ASTM D 3786 - Standard Test for Bursting Strength of Textile Fabrics—Diaphragm Bursting Strength Tester Method.
8. ASTM D 4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
9. ASTM D 4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextile.
10. ASTM D 4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.
11. ASTM D 4833 - Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products.

12. ASTM D 5890 - Standard Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners
13. ASTM D5261 - Standard Test Method for Measuring Mass per Unit Area of Geotextiles
14. ASTM D 1593 - Standard Specification for Nonrigid Vinyl Chloride Plastic Film and Sheeting
15. ASTM D 5199 - Standard Test Method for Measuring the Nominal Thickness of Geosynthetics
16. ASTM D 792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
17. ASTM D 1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique
18. ASTM D 1603 - Standard Test Method for Carbon Black Content in Olefin Plastics
19. ASTM D 638 - Standard Test Method for Tensile Properties of Plastics
20. ASTM D 6693 - Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
21. ASTM D 5617 - Standard Test Method for Multi-Axial Tension Test for Geosynthetics
22. ASTM D 1004 - Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting
23. ASTM D 5397 - Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test
24. ASTM D 1204 - Standard Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature
25. ASTM D 6392 - Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
26. ASTM D 3034 - Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
27. ASTM D 3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
28. ASTM F 477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
29. ASTM D 2412 - Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
30. ASTM D 1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
31. ASTM F 679 - Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings
32. ASTM D 2321 - Standard Practice for Underground Installation of Thermoplastic

Pipe for Sewers and Other Gravity-Flow Applications

33. ASTM D 1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
34. ASTM D 2665 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
35. ASTM D 5641 - Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber
36. ASTM D 4437 - Standard Practice for Non-destructive Testing (NDT) for Determining the Integrity of Seams Used in Joining Flexible Polymeric Sheet Geomembranes
37. ASTM D 6497 - Standard Guide for Mechanical Attachment of Geomembrane to Penetrations or Structures
38. ASTM C 478 - Standard Specification for Precast Reinforced Concrete Manhole Sections
39. ASTM D 2672 - Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement
40. ASTM D 5885 – Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry

1.03 SUBMITTALS

A. See Section 01330 – Submittals for submittal procedures.

B. Liner Installation Plan: Within 14 days of Notice to Proceed of Submittals and prior to initiating and liner installation activities, the Contractor shall submit to the Owner's Agent detailed a liner installation plan consisting of the following:

1. Construction methods and sequences, including manpower and equipment, for installation and testing of the geomembrane materials. Include methods proposed for sealing the geomembrane around all penetrations and all other details required for a complete and sound installation.

2. A list of proposed suppliers and installers, referencing the materials or supplies to be provided and used in the Work. Submit geomembrane manufacturer's certification or written approval of the liner installation contractor, as well as written qualifications and work experience for the liner installation contractor's site supervisor, QA technician, master seamer, and welding technicians.

3. Submit manufacturer's or installer's shop drawings showing the proposed geomembrane panel layout plan, sequence, and installation details. Geomembrane placement shall not commence until shop drawings, details, and other required information has been reviewed and accepted by the Owner's Agent. Such acceptance will be for concept only and actual panel placement shall be determined by site-specific conditions.

4. Submit samples of geomembrane and manufacturer's literature and recommendations for storage, handling, installation, seaming, testing, and repair.

C. Submit all certifications of material compliance with these specifications, along with copies of all laboratory testing results from Contractor's QC and/or a commercial testing laboratory.

D. Contractor shall submit shop drawings to the Owner's Agent for review prior to casting all concrete vaults and manholes for this Project. Standard vendor cut sheets or shop drawings are to be submitted for all off the shelf items required for the stormwater system for approval prior to shipping to the site.

E. Product Data Sheets: Provide for each manufactured product installed under Work of this Section.

1. Include fittings, couplings, and joints.

F. Diagrams: Provide scale diagrams of assemblies, structures, or other items that are materially different from the conditions indicated in the Contract Drawings.

1. Include special fittings, including connections manufactured specially for the Project.

1.04 DELIVERY AND STORAGE

A. Contractor is to manage delivery, storage, and rigging for all liners, geotextiles, piping, vaults and manholes associated with the Work. All materials and equipment delivered and placed in storage shall be stored with protection from the weather, dirt, dust or other contaminants.

B. All pipes shall be clearly marked with type, class and thickness. Lettering shall be legible and permanent under normal conditions of handling and storage.

C. Store in original protective packaging until time of installation.

D. Handle precast concrete manholes and other structures according to manufacturer's written rigging instructions.

1.05 SYSTEM DESCRIPTION

A. Provide a storm drainage system as indicated on the Contract Drawings and necessary for a complete and functional system meeting the Project requirements.

B. Layout:

1. Furnish, set, mark, and adjust line location stakes in accordance with industry and professional standards.

a. A qualified person experienced in layout and engineering fieldwork must be provided by the Contractor and assigned to the Contractor's crew for the duration of the Work requiring control.

b. Necessary equipment, supplies, and instruments must be provided and unconditionally available to the layout engineer.

c. Provide the same person and equipment, supplies, and instruments at no further cost to the Project for purposes of obtaining the Owner's Representative confidence the layout activities are properly performed.

2. The Contractor is responsible for review of records pertaining to the existing underground utilities.

   a. The location of existing utilities as shown on the Contract Drawings is approximate. The Contractor is responsible for field verifying exact locations all existing utilities prior to the start of the Work.

   b. Notify the Owner's Agent immediately about utilities which are encountered in locations or conditions differing from the available information, including the Contract Drawings.

3. The Contractor is responsible to notify the Owner's Agent immediately about proposed utilities that may be in conflict from the Contract Drawings.

4. Notify Owner's Agent not less than two days in advance of proposed utility interruptions.

1.06 GRADATION TESTS

A. Prior to importing backfill materials to the site, the Contractor shall conduct, as directed, at least one gradation test from each material type and import material source. Gradation testing shall follow ASTM D 422 for Leveling and Filter Sand, Pipe Bedding, Granular Bentonite and Crushed Rock and ASTM D 5519 for Channel Armor and Inlet Scour Protection material. Minimum test sample size shall be 200 pounds. All costs of such tests shall be borne by the Contractor and shall be incidental to placing materials. Results of such tests shall be submitted for acceptance in accordance with Section 1450 – Quality Control and the Contractor's Owner's Agent-accepted Quality Control Plan.

B. Additional gradation test shall be required if a material source changes prior to delivery of the new material prior to the Site. Additional tests shall be conducted if furnished materials do not meet gradation requirements. Results of tests shall be furnished to the Owner's Agent within 24 hours following selection of sample. All costs of such tests shall be borne by the Contractor and shall be incidental to placing materials.

1.07 ACCEPTANCE CRITERIA FOR BACKFILL MATERIALS

A. Materials shall be inspected at the Site prior to placement. The Contractor shall be responsible for maintaining gradations as specified. Materials that do not meet gradation or quality as herein specified will be rejected, and no payment will be made regardless of any general or provisional acceptance of materials from a source.

B. The acceptance standard for the material is as follows:

1. Import material shall not be obtained from an commercially available source, nor suspected to have been modified by the addition of man-produced chemicals. Provide detailed information on the source of all imported materials in accordance with Section 01450 – Quality Control.
2. Import material shall meet the requirements as specified in Part 2 of this Section.
3. For the Channel Armor Layer and Inlet Scour Protection material, the Owner's Agent will designate a qualified engineer to visually inspect the materials at the quarry source. The material shall meet the requirements as specified in this section. The engineer will inspect the material for size distribution, hardness, durability, angularity, shape, porosity, and presence of deleterious material. Acceptance by the Owner's Agent's designee is required prior to its delivery to the Site.

PART 2 PRODUCTS

2.01 MATERIAL SOURCES

A. Material sources shall be those identified in the accepted Construction Work Plan. Suitable representative samples and test reports must be submitted and accepted by the Owner's Agent prior to delivery of materials to the jobsite. The Contractor shall ensure that there is an availability of adequate and acceptable materials source, based on quantity, quality, and gradation to complete the Work. All borrow sources and imported material used by the Contractor shall meet the specifications listed below. Backfill materials must be on-site at a minimum of 3 days prior to use.

B. In addition to the physical characterization requirements described in Section 01450 – Quality Control, the Contractor will visually inspect import material upon delivery to the site for the presence of foreign, recycled, or reprocessed materials. The presence of such materials will be cause for rejection and return to the supplier.

2.02 BORROW MATERIAL

A. This material is used for construction of the stormwater berms and general backfill

B. Borrow material shall come from a commercial source accepted by the Owner's Agent as indentified in the Construction Work Plan. Contractor shall not change the source of borrow material for the duration of the Work without prior written acceptance from the Owner's Agent.

C. Borrow material shall not contain excess organic matter, rocks larger than 1 inch, or chunks of consolidate earth that may damage buried features or hinder compaction operations.

2.03 PIPE BEDDING

A. This material is used for pipe bedding material for transfer pipe from the detention basin to the sand filter and for discharge pipe from the sand filter to the discharge point (existing manhole).

B. The Contractor shall select materials that meet the quality requirements listed below from an existing commercial source or sources. Material shall meet the following gradation requirements:

Sieve Size	Percent Passing (by weight %)
¾	100
½"	80 – 100
No. 4	45-65
No. 40	10-25
No. 200	25-60
% fracture	75 min
Sand equivalent	40 min
No. 200	0 – 6
The portion retained on the US No. 4 sieve shall not contain more than 0.15% wood waste.	

2.04 FILTER SAND

A. This material is used as the filter in the stormwater filtration basin.

B. The Contractor shall select materials that meet the quality requirements listed below from an existing commercial source or sources. Material shall meet the following gradation requirements:

Size	Percent Passing (by weight)
3/8 inch	100
No. 4	95-100
No. 8	80-100
No. 16	45-85
No. 30	15-60
No. 50	3-15
No. 100	<4

2.05 LEVELING SAND

A. This material is used as a leveling and protection layer above the basin liners.

B. The Contractor shall select materials that meet the quality requirements listed below from an existing commercial source or sources. Material shall meet the following gradation requirements:

Size	Percent Passing (by weight)
3/8 inch	100
No. 4	90-100
No. 8	70-100
No. 16	50-85
No. 30	25-60
No. 50	5-30
No. 100	0-10
No. 200	0 – 6

2.06 ¾" MINUS CRUSHED ROCK

A. ¾" minus crushed rock material shall consist of broken stone from an accepted source that is hard, sound, dense, and durable. Material shall be free from seams cracks, and other defects tending to destroy its resistance to weather and seawater. Dry unit weight shall not be less than 160 pounds per solid cubic foot. Crushed Rock material shall be angular; each piece shall have its greatest dimension not greater than three times its least dimension. Material shall meeting the following gradation requirements:

Sieve Size	Percent Passing (by weight %)
¾	100
½"	80 – 100
No. 4	45-65
No. 40	10-25
No. 200	25-60
% fracture	75 min
Sand equivalent	40 min
No. 200	0 - 6
The portion retained on the US No. 4 sieve shall not contain more than 0.15% wood waste.	

2.07 CHANNEL ARMOR LAYER

A. Channel Armor Layer material shall consist of broken stone from an accepted source that is hard, sound, dense, and durable. Channel Armor Layer material shall be free from seams cracks, and other defects tending to destroy its resistance to weather and seawater. Dry unit weight shall not be less than 160 pounds per solid cubic foot. Channel Armor Layer material shall be angular; each piece shall have its greatest dimension not greater than three times its least dimension.

B. All Channel Armor Layer material shall meet the following testing requirements:

Test	Requirement	Test Method
Soundness (maximum value by mass (weight))	16.0% Max	ODOT TM 206
Durability	35.0% Max	ODOT TM 208
Specific Gravity	2.5 min	AASHTO T 85

C. The Contractor shall select materials that meet the quality requirements listed below from an existing commercial source or sources. Material shall meet the following gradation requirements:

Size	Percent Passing (by weight)
4 inch	100
2 inch	40 max.
1-1/4 inch	5 max.

2.08 INLET SCOUR PROTECTION

A. Inlet scour protection material shall consist of broken stone from an accepted source that is hard, sound, dense, and durable. Inlet scour protection material shall be free from seams cracks, and other defects tending to destroy its resistance to weather and seawater. Dry unit weight shall not be less than 160 pounds per solid cubic foot. Channel Armor Layer material shall be angular; each piece shall have its greatest dimension not greater than three times its least dimension.

B. All inlet scour protection material shall meet the following testing requirements:

Test	Requirement	Test Method
Soundness (maximum value by mass (weight))	16.0% Max	ODOT TM 206
Durability	35.0% Max	ODOT TM 208
Specific Gravity	2.5 min	AASHTO T 85

C. The Contractor shall select materials that meet the quality requirements listed below from an existing commercial source or sources. Material shall meet the following gradation requirements:

Size	Percent Passing (by weight)
8 inch	100
4 inch	40 max.
2 inch	5 max.

2.09 GRANULAR BENTONITE

A. Granular bentonite shall be a free flowing, high swelling, granular sodium bentonite. Bentonite in fine powder shall not be used. The bentonite shall have a free well of at least 18 cubic centimeters/2 grams as measured by ASTM Standard Test method D 5890 and shall meet the following gradation requirements:

Sieve Size	Percent Passing (by weight)
10	98 – 100
20	60 – 100
200	0 – 20

2.10 CLAY

A. Clay shall be free of organic matter, debris, frozen material, and other deleterious materials. Clay shall be excavated from approved borrow areas and shall meet the following requirements:

1. Material shall be classified as CL, CI, CH, SC, or GC under the USCS.
2. Material shall have a liquid limit between 30% and 60% and a Plasticity Index of >10%.

2.11 GEOTEXTILES

A. Geotextiles shall consist of long-chain polymeric fibers composed of polypropylene, polyester, or polyethylene. The geotextiles shall be free from defects or tears and shall

be mildew, insect, and rodent resistant, inert to chemicals commonly found in soil, and resistant to ultraviolet exposure. The geotextiles shall also be free of any treatment or coating which might adversely alter its hydraulic or physical properties after installation. The geotextiles shall be non-woven, needle-punched fabric meeting the following minimum requirements:

Test	Requirement (6 oz/yd^2 typical)	Requirement (12 oz/yd^2 typical)	Test Method
Weight (oz/yd^2)	5.7	12.0	ASTM D 5261
Grab strength	160	300	ASTM D 4632
Puncture strength (lbs)	80	180	ASTM D 4833
Burst strength (psi)	280	600	ASTM D 3786
Apparent opening size (mm)	0.210 (max)	0.150 (max)	ASTM D 4751
Water flow rate (gpm/ft^2)	110	75	ASTM D 4491

2.12 GEOMEMBRANE LINER

A. LLDPE Geomembrane.

1. The geomembrane liner shall be an Enviro Liner 6040^{HD} or equal.
2. The geomembrane shall be the thickness specified and manufactured of new, first quality resin, compounded and manufactured specifically for producing geomembrane. The resin used shall be from the same manufacturer and no reclaimed polymer shall be added. The geomembrane shall be produced so as to be free of holes, pinholes, bubbles, blisters, undispersed raw materials; any sign of contamination by foreign matter, and nicks or cuts on roll edges. Any such defect shall be repaired in accordance with the manufacturer's recommendations and approved by the Owner's Agent.
3. Each geomembrane roll shall be identified with labels indicating manufacturer's name, product identification, material thickness, roll length and width, and lot and roll numbers. Provide 40-mil smooth LLDPE geomembrane material that meets or exceeds the following minimum physical properties:

Test	Test Method	Specified Value[a]
Gauge thickness (mils)	ASTM D 1593 or ASTM D 5199	40 (nominal) 36 (minimum)
Density (g/cc)	ASTM D 792 or ASTM D 1505	0.940 (max)
Carbon black content (%)	ASTM D 1603	2 – 3
Tensile Strength	ASTM D 638 or ASTM D 6693. Machine direction and perpendicular to machine direction average values on the basis of five (5) test specimens each direction.	
Stress at break (ppi)		≥ 191
Elongation at break (2.0 in. G.L.) (%)		≥ 1200

Test	Test Method	Specified Value[a]
Puncture resistance (lbs)	ASTM D 4833	≥ 70
Tear resistance (lbs)	ASTM D 1004	≥ 24
Multi-axial elongation @ break (%)	ASTM D 5617	≥ 50
Environmental stress cracking resistance – NCTL (hrs)	ASTM D 5397	≥ 1000
High Pressure Oxidative Induction Time (minutes)	ASTM D 5885	≥ 2000
Dimensional Stability	ASTM D 1204 100°C, 1 hr	+/- 2
Seam Strength		
Shop Seam, shear strength (lb/in)	ASTM D6693	≥ 50
Shop Seam, peel strength (lb/in)	ASTM D6693	≥ 45
Field Seam, shear strength (lb/in)	ASTM D6693	≥ 45
Field Seam, peel strength (lb/in)	ASTM D6693	≥ 40

[a] Values represent certifiable minimum average values unless otherwise noted or approved by the Owner's Agent.

B. Fabrication

1. Set up.
   a. Carefully transfer rolls of geomembrane from storage to unwinding rack.
   b. The floor or table must be clean, dry, and free of foreign objects that could damage the liner.
   c. Pull panels to specified length, after double-checking dimensions in work order.
   d. Ensure seaming equipment is in good repair and functioning properly. Ensure equipment is adjusted to the material.
   e. Follow documented welding procedures.
2. Qualification seam.
   a. A qualification seam will be run prior to any fabrication.
   b. The qualification seam must be run using the same material and equipment that will be used in fabrication.
   c. Machine conditions and operator used for fabrication must be the same as those used for the qualification weld.
   d. Qualification seam must be tested in shear and peel and meet the specified requirements for the material as stated in the materials section.

e. A qualification seam must be rerun whenever the operator is changed, the equipment adjusted, shift changed, or if the equipment is idle more than 2 hours.

3. Fabrication seams.

   a. Fabrication seams must meet the specified requirements in peel and shear for the material.

   b. Fabrication seams will be destructively tested in shear and peel according to ASTM D6392.

      i. Test one specimen each in peel and shear on the first and last welded panel.

      ii. Test one specimen in peel and shear for every 1,000 lineal feet of welding.

   c. A record of the seam test results shall be maintained on the Shop QC report.

   d. The seaming process must be constantly supervised by the equipment operator. 100% of the fabrication seams must be visually inspected during seaming.

4. Protect from damage.

   a. Protect completed panels form damage.

   b. Handle carefully to avoid damaging the liner.

5. Packaging.

   a. Each panel will be accordion folded in one direction, and rolled or folded in the other direction.

   b. Wrap completed panels in a weather resistant, opaque cover material.

   c. Hold wrapper securely in place using UV resistant tape or other secure method.

   d. Label the packaged liner to clearly show:

      i. Material type

      ii. Dimensions

      iii. Stock code

      iv. Sales order number

      v. QC number

      vi. Panel number

      vii. Unfolding and deployment directions.

6. Accessories.

   a. Welding rod will be manufactured from the same formulation as the geomembrane.

b. Preformed Pipe Boots will be vacuum formed from the thicker sheet material manufactured from the same formulation as the geomembrane.

2.13 24" and 8" POLYVINYL CHLORIDE (PVC) PIPE

A. All PVC pipe and fittings shall conform to ASTM D3034 SDR 35 standards. Unless otherwise approved, joints shall be bell and spigot with a rubber gasket conforming to ASTM D3212 and ASTM F477. Additives and fillers, including but not limited to stabilizers, antioxidants, lubricants, etc., shall not exceed 10 parts by weight per 100.

B. 24" PVC Transfer and Discharge Pipe:

1. All PVC pipe and fitting shall be integral wall and spigot, rubber gasket joint unplasticized PVC pipe. All PVC pipe shall have a minimum pipe stiffness of 46 psi at 5% deflection at 32°F when tested in accordance with ASTM D2412, external loading properties of plastic pipe. The pipe shall be made of PVC plastic having a minimum cell classification of 12364 or 12454 as defined in ASTM D 1784. Homopolymer PVC compounds must equal or exceed the requirements of above listed minimum cell classification number. Pipe shall have a minimum impact strength based on test methods of ASTM F679.

2. All PVC pipe and fittings manufactured and installation shall meet or exceed the ASTM recommended specification F679, unless otherwise specified, and all installation shall be in strict compliance with the manufacturer's directions. All pipe shall be clearly marked with date of manufacture. All pipe shall be provided with the reference mark for proper spigot insertion. Joint gaskets shall be fabricated from a compound of which the basic polymer shall be a synthetic rubber consisting of styrene, butadiene, polyisoprene or any combination thereof and shall meet the requirements of ASTM F477.

C. 8" PVC Pipe Risers:

1. All PVC pipe and fitting shall be integral wall and spigot, rubber gasket joint unplasticized PVC pipe. All PVC pipe shall have a minimum pipe stiffness of 46 psi at 5% deflection at 32°F when tested in accordance with ASTM D2412, external loading properties of plastic pipe. Pipe shall have a minimum impact strength based on test methods of ASTM D3034 with the exception that conditioning temperature for sample shall be 32°F plus or minus 2°F.

2. All PVC pipe and fittings manufactured and installation shall meet or exceed the ASTM recommended specification D3034, SDR 35 unless otherwise specified, and all installation shall be in strict compliance with ASTM D2321 and the manufacturer's instructions. All pipe shall be provided with the reference mark for proper spigot insertion. Joint gaskets shall be fabricated from a compound of which the basic polymer shall be a synthetic rubber consisting of styrene, butadiene, polyisoprene or any combination thereof and shall meet the requirements of ASTM F477.

3. All orifices in the 8" PVC riser pipe shall be field manufactured as shown on the Contract Drawings.

2.14 4" POLYVINYL CHLORIDE (PVC) UNDERDRAIN PIPE

A. PVC underdrain pipe shall be Schedule 40 iron pipe size (ips) pipe. PVC Schedule 40 pipe shall be manufactured in strict accordance to the requirements of ASTM D1785 for physical dimensions and tolerances. PVC Sch 40 pipe shall also meet the requirements of ASTM D2665 Standard Specification for PBC plastic drain, waste and vent (DWV) pipe and shall be dual marked as such. Each production run of pipe shall also meet or exceed the test requirements for materials, workmanship, burst pressure, flattening, and extrusion quality defined in ASTM D1785 and ASTM D2665 as applicable. All belled-end pipe shall have tapered sockets to create an interference-type fit, which meet or exceed the dimensional requirements and the minimum socket length for pressure-type sockets as defined in ASTM D2672.

B. The material used in the manufacture of the pipe shall be domestically produced rigid polyvinyl chloride (PVC) compound, Type I Grade I, with a Cell Classification of 12454 as defined in ASTM D1784, trade name designation H70 PVC. The compound shall be white or gray in color as specified, and shall be approved by NSF International for use with potable water (NSF Std 61).

C. Product shall meet the requirement of ASTM D1785 and ASTM D2665 as applicable and shall include: the manufacturer's name (or the manufacturer's trademark when privately labeled); the nominal pipe size; the material designation code; the pipe schedule and pressure rating in psi for water @ 73°F; the ASTM designation D1785; the ASTM designation D2665 (when dual marked); the independent laboratory's seal of approval for potable water usage; and the date and time of manufacture.

D. Perforation shall be either circular or slots. Circular perforations shall be ¼ +/- 1/16-inch diameter holes arranged in rows parallel to the axis of the pipe. Perforations shall be evenly spaced along each row such that the center-to-center distance between perforations is not less than eight times the perforation diameter. Perforations may appear at the ends of short and random lengths. The pipe shall have a minimum opening area of 0.22 in^2 per foot of pipe. Rows shall be arranged in two equal groups at equal distance from the bottom on each side of the vertical centerline of the pipe. The lower-most rows of perforations shall be separated by an arc of not less than 60 degrees or more than 125 degrees. The uppermost rows of perforations shall be separated by an arc not to exceed 166 degrees. The spacing of rows between these limits shall be uniform. The perforations shall have a minimum of 2 rows.

E. Slot perforations shall be symmetrically located in two rows, one on each side of the pipe centerline. Slot perforations shall be located within the lower quadrants of the pipe with slots no wider than 1/8 inch and spaced not to exceed 11 times the perforation width. The pipe shall have a minimum opening area of 0.22 in^2 per foot of pipe.

F. On both the inside and outside of the pipe, perforations shall be free of cuttings or frayed edges and of any material that would reduce the effective opening.

2.15 PRECAST CONCRETE MANHOLE

A. Furnish cones with the same wall thickness and reinforcement as riser sections.

B. All precast concrete manhole sections shall conform to the requirements of the current Manufacturing Standards for Precast Concrete Products (MSPCP) Manual published by the City of Portland's materials Testing Laboratory. Furnish only rubber-gasket sections conforming to ASTM C478. Use only preformed rubber gaskets or mastic sealer for jointing material. Tongue and groove manhole sections must be approved by the Owner's Agent prior to use.

C. Precast manhole sections shall consist of circular sections with a 60 inch standard nominal inside diameter. Heights of sections shall be multiples of 6 inches.

D. Precast base sections may be used provided all details of construction are approved by the Owner's Agent prior to shipment.

E. Manhole grade ring extensions are to be limited to a minimum height of 3 inches and a maximum height of 12 inches.

2.16 ULTRABLOCK™ SEGMENTAL UNIT

A. Manufacturer. Ultrablock, Inc., Inter-block, Inc., and United ULTRABLOCK Ltd are the sole manufacturers of ULTRABLOCK™ Segmental Concrete Facing Units.

B. The ULTRABLOCK™ units shall have a minimum 28-day compressive strength of 2,200 psi. Maximum absorption shall be 10 pcf (absorption by weight = 6%) for walls constructed in areas where there is a potential for spalling due to freeze-thaw.

C. All individual ULTRABLOCK™ units shall be free of cracks and other defects that would interfere with the placement and locking of units. Specifically, all shear keys shall be free of any damage.

D. ULTRABLOCK™ unit dimensions such as height, width, depth, and batter shall match the details shown on the Contract Drawings. A tolerance of +/- ½ inch for all dimensions except height may be used. A tolerance of +/- ¼ inch shall be used for height.

E. The chamfered corners of the ULTRABLOCK™ units shall provide approximately 8 in^2 of drainage area per unit. Clearance of roughly ½ inch around locking grooves/shear keys shall provide additional drainage.

2.17 SOURCE QUALITY CONTROL

A. Products, fabrications, and other items of this Section are to be designed, manufactured, installed and made functional consistent with proper and appropriate hydraulic design practices.

PART 3 EXECUTION

3.01 GENERAL

A. Packaging, marking, shipping, storage, and handling of all materials shall be in compliance with the manufacturer's specifications unless otherwise approved by the Owner's Agent.

B. The geomembrane liner shall be installed by the manufacturer or an experienced liner installation contractor approved by the geomembrane manufacturer and the Owner's Agent.

C. Employ all necessary measures to protect the Work from damage. Use only lightweight, low-ground-pressure vehicles as approved by the geomembrane manufacturer during the installation of the geomembrane liner. Use low groundwater pressure (<5 psi) construction equipment for placement of all materials overlying the geomembrane cover.

3.02 GEOMEMBRANE LINER

A. Delivery, storage and protection.

1. Shipping.

   a. Completed panels will be placed on clean, serviceable pallets, free from exposed nails or other obstructions.

   b. A layer of geomembrane, geotextile, or wood will be placed on all pallets to protect the panel from damage.

   c. Secure panels to the pallet using metal or plastic bands. Use a layer of geomembrane between the packaged liner and the band to prevent damage to the liner as the band is tightened.

   d. The packaged liner must not extend beyond the outer edges of the pallet. Use larger pallets or a layer of plywood to extend the pallet edges to match the liner.

   e. Carefully handle and place on the truck to avoid damage to the liner.

   f. Panels may be stacked not more than two high.

2. Delivery.

   a. All panels will be inspected for damage on delivery.

b. Use suitable unloading equipment to handle panels. Do not drag, slide, or drop panels during unloading.

c. Place panels in a prepared area away from soft ground, standing water, or other deleterious surfaces.

d. Replace any pallets that may become damaged ruing shipping or handling.

e. Store liner panels in a secure area protected from extremes of heat or cold.

f. Protect panels from damage prior to use.

B. Foundation Preparation.

1. Liner installation contractor shall, on a daily basis, approve the surface on which the exposed geomembrane liner will be installed. Provide written certification by the liner installer that the surface on which the geomembrane liner is to be installed is acceptable for this application. The surface on which the geomembrane is to be placed shall be maintained in a smooth and firm condition during geomembrane installation.

2. Excavate anchor trench to line, grade, and width indicated on the Drawings, prior to liner placement. Provide slightly rounded corners in the trench to avoid sharp bends in the geomembrane.

3. Prepare mechanical attachments according to ASTM D 6497 Standard Guide for Mechanical Attachment of Geomembrane to Penetrations or Structures.

4. Compaction at pipe penetrations and areas of mechanical attachment will be inspected carefully as these are areas where differential settlement can occur.

C. Deployment.

1. Assign each panel a simple and logical indentifying code. The coding system shall be determined at the site and shall be subject to approval by the Owner's Agent.

2. The geomembrane shall be installed in the manner and at the locations shown on the Drawings and on the approved panel layout plan. Record all geomembrane panel and seam numbers on the as-built record drawings.

3. Panel placement and installation sequencing shall take into account site drainage patterns, wind direction, access to the area being lined, and the sequence of construction of the foundation layer and the stormwater drainage facilities. Geomembrane panel deployment shall not proceed when adverse weather conditions (e.g. winds above 12 mph or during precipitation) exist which may jeopardize the integrity of the liner installation. Field panels shall be seamed as soon as possible after deployment and all deployed panels shall be marked with appropriate identification. Visually inspect the geomembrane during deployment for imperfections and mark faulty or suspect areas for repair as needed.

4. Unroll geomembrane panels using methods and equipment that will not damage the geomembrane and will protect the underlying foundation materials from damage. Only that amount of geomembrane which can be anchored and

seamed together that same day shall be placed in position unless otherwise approved by the Owner's Agent.

5. Anchor the geomembrane as necessary and place sandbags on the geomembrane as required to prevent wind uplift during installation.
6. Do not allow heavy vehicular traffic directly on the geomembrane; low-ground-pressure, rubber-tired vehicles may be acceptable if wheel contact pressure is less than 5 psi and proper care is taken to avoid damage and excessive traffic.
7. Personnel walking on the geomembrane shall not engage in activities or wear shoes that could damage the geomembrane.
8. Provide sufficient material (slack) to allow for expansion and contraction of the exposed geomembrane cover. The geomembrane shall be installed so as to be generally free of tension or stress to the maximum extent practicable.
9. Fabricate and install LLDPE boots and mechanical attachments for all pipe penetrations, concrete blocks, pipes and other structures located within the limits of the liner in accordance with the manufacturer's recommendations.

D. Qualification seams.

1. A qualification seam will be run prior to any field seams.
2. A qualification seam is made with separate pieces of geomembrane using the same material and equipment that will be used for production wielding.
3. Machine conditions, and operator used for wielding must be the same as those used for the qualification weld.
4. Qualification seam must be tested in shear and peel, and meet the specified requirements for the material as stated in the materials section.
5. A qualification seam must be rerun whenever the operator is changed, the equipment adjusted, or at least every 4 hours.

E. Field Seams.

1. Field seams will be sampling for testing in a way that does not compromise the installed liner
   a. One sample to be tested for every 500 ft of field seams.
   b. Test samples are to be removed from the ends of seams, from the anchor trench, or other location that does not introduce defect into the liner.
   c. Samples to be approximately 4 inches long to permit testing of one shear and two peel specimens (ASTM D6392).
   d. Test samples immediately after seaming.
   e. Record date, location and pass/fail description
2. Field seams must meet the specified requirements in peel and shear for the material.
3. A written record shall be maintained for all field seam tests. Documentation shall include the location, date, test unit number, name of tester, test conditions and

procedures, and the outcome of all testing. For failing seams, document the repair satisfactory resting of seams.

4. At locations where seams cannot be tested prior to final installation, the seam shall be cap-stripped with the same geomembrane unless otherwise approved by the Owner's Agent. At such locations, the seaming and cap-stripping operations shall be carefully observed by the installer and the Owner's Agent for uniformity and completeness.
5. All completed field seams will be 100% non-destructively tested using an air lance test (ASTM D4437 method 7.2).

F. Tolerances.

1. Follow the procedure in ASTM D6392 for all seam tests.
2. Seam test three specimens per sampling point, on in shear and two in peel. All specimens shall meet the seam strength requirements as specified in the materials section.
3. Procedures for destructive test failure.
   a. Cut out seam and re-weld; or,
   b. Retrace welding path to 10 feet from location of failed test. Take sample for additional test. If passed – cap strip or extrusion weld between failed location and original failed location.

G. Defects and Repairs.

1. The liner installer's QA/QC personnel shall inspect all seams and non-seam areas of the exposed geomembrane liner, mark, test, and repair any defect or defective areas, including potential defects or potentially defective areas, in accordance with approved procedures and the manufacturer's recommendations; and indicated on the Daily QC log and the as-built record drawings the location and description of each defect and the corrective action taken.
2. Defective seams: Cap strip or replace.
3. Small Holes: Repair by extrusion welding using a bead of extruded material over hole. Patch if hole is large than ¼ inch.
4. Tears: Patch and seal round sharp ends of tears on slope or stressed area prior to patching.
5. Repair blisters, large cuts and undispersed raw materials with patch.
6. Secure patches by Extrusion Welding.
   a. Clean area to be patched.
   b. Tack patch in place with hot are welding or with doubled sided tape.
   c. Prepare patch area by roughening with a wire brush.
   d. Extrude all the way around patch.

e. More than one extrusion bead can be laid side-by-side on Enviro Liner 6000 materials. A maximum of three extrusion beads can be laid side-by-side on Eviro Liner 6000.

7. Patches: round or oval, or same geomembrane. Extend minimum 3 inches beyond the edge of the defect.

8. Verification of repairs. All repairs to be non-destructively tested using:

   a. Air Lance Test, ASTM D4437 Method 7.2

   b. Vacuum Box Test ASTM D5641.

9. Each repair shall be properly numbered and logged. Repairs which pass the nondestructive test shall be taken as an indication of adequate repair. Large caps may be of sufficient extent to require destructive test sampling, at the Owner's discretion. Failed tests indicated that the repair shall be redone and retested until passing test results are obtained as specified. The liner installer shall record the number of each patch, date, welder's name, and test outcome.

3.03 GEOTEXTILES

A. The seams of the geotextile panels shall be placed parallel to the direction of fill placement and overlapped a minimum of 2 ft. Seams on slopes shall be oriented with the slope, and if overlapped, the geotextile shall be placed such that the upstream strip of the geotextile will overlap the next downstream strip. End-of-roll seams shall be offset a minimum of 5 ft between adjacent rolls.

B. Place and anchor the geotextile in a manner as to generally keep the geotextile in tension to the maximum extent practicable. Geotextile panels shall be weighted with sand bags or other ballast to keep the material in place until placement of the cover material.

C. Cover material shall be placed with low groundwater pressure (< 5 psi) equipment. The cover material shall be spread in the same direction as the geotextile seam is overlapped, and extreme care shall be taken so that the equipment operator spreads the cover material off of shallow stockpiles and onto the geotextile without damaging or inducing excess tensile stress in the geotextile. At no time shall construction equipment be permitted to track directly on the geotextile or perform pivot turns or any other operating practices which may cause damage to or shifting of the underlying geotextile. Any damage to the geotextile shall be repaired by the Contractor at no additional cost to the Owner.

3.04 PIPING PLACEMENT

A. Piping and associated appurtenances shall be installed in a manner and at the locations shown on the Drawings, the approved shop drawings, and as directed by the Owner's Agent to complete the Work.

B. Pipe joints and connections shall be made in accordance with the manufacturer's specifications and recommendations. Exercise care to ensure that piping material does not shift or crush, during backfilling each piping placement. Any damage shall be repaired at no additional cost to the owner.

C. Any necessary penetrations through the geotextile and/or geomembrane shall be made in accordance with the manufacturer's recommendations, and shall be observed and approved by the Owner's Agent prior to placement of cover materials.

3.05 QUALITY CONTROL

A. Contractor, and in the case of the geomembrane liner, liner installer, shall be responsible for all of the quality control monitoring, testing, and reporting activities that are specified in this Specification and the Contractor's approved QA/QC plans. Unless otherwise indicated, laboratory testing shall be conducted at an Owner-approved third party laboratory with materials furnished by the Contractor and at the expense of the Contractor.

B. The Daily QC log shall be maintained during all phases of the Storm Drainage and Treatment System installation. The Daily QC log shall document daily progression of the installation from delivery of materials through final acceptance, and shall designate those construction activities that influence the quality of all components of the Work.

END OF SECTION 02501

SECTION 02510 – TEMPORARY ENVIRONMENTAL CAP

PART 1 GENERAL

1.01 DESCRIPTION

A. This section includes the proposed new temporary environmental cap and repair of damaged existing temporary environmental cap.

B. Contractor shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to complete the new and repair of the existing temporary environmental cap.

C. The placement of temporary cap material and the repair of the existing cap will be closely coordinated with the installation of the groundwater barrier wall and groundwater extraction and treatment system being installed as part of the groundwater SCMs. Construction of temporary caps will not be initiated until required construction activities related to the groundwater barrier wall or extraction and treatment system are completed in these areas.

1.02 REFRENCES

A. Comply with the requirements of Section 1410 – Regulatory Requirements and as listed herein.

B. ASTM D 4632 Standard Test Method for Grab Breaking Load and Elongation of Geotextile.

C. ASTM D 4833 Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products.

D. ASTM D 882 - Standard Test Method for Tensile Properties of Thin Plastic Sheeting.

E. ASTM D 6690 - Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements.

F. AASHTO T 27 – Sieve Analysis of Fine and Coarse Aggregates.

G. AASHTO M 324 – Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements.

1.03 SUBMITTALS

A. See Section 01330 – Submittals for submittal procedures.

B. Contractor shall submit manufacture cut sheets for all material included in the temporary environmental cap, including geotextile fabric protection layers and plastic sheeting.

C. Submit sealant materials for sealing cracks in the existing asphalt cap.

1.04 DELIVERY AND STORAGE

A. Contractor is to manage delivery and storage of geotextile fabric and liner in accordance with manufacturer recommendations for handling and storage. All materials and equipment delivered and placed in storage shall be stored with protection from the weather, dirt, dust or other contaminants.

B. Store in original protective packaging until time of installation.

1.05 SYSTEM DESCRIPTION

A. The temporary environmental cap consists of three components:

1. Geotextile fabric placed both over and under the liner used to protect the plastic sheeting liner from penetrations from the underlying and overlying soil.
2. Plastic liner between two protective geotextile layers.
3. Crushed rock placed over the liner to provide the surface of the cap.

B. Layout:

1. Furnish, set, mark, and adjust cap location stakes in accordance with industry and professional standards.
   a. A qualified person experienced in layout and engineering fieldwork must be provided by the Contractor and assigned to the Contractor's crew for the duration of the Work requiring control.
   b. Necessary equipment, supplies, and instruments must be provided and unconditionally available to the layout engineer.
   c. Provide the same person and equipment, supplies, and instruments at no further cost to the Project for purposes of obtaining the Engineer confidence the layout activities are properly performed.
2. The Contractor is responsible for review of records pertaining to the existing underground utilities.
   a. The Contractor is responsible for avoiding damage to underground utilities.

b. Notify the Owner's Agent immediately about utilities which are encountered in locations or conditions differing from the available information; including the Contract Drawings.

3. The Contractor is responsible to notify the Owner's Agent immediately about proposed utilities that may be in conflict from the Contract Drawings.

4. Notify Owner's Agent not less than two days in advance of proposed utility interruptions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Geotextile fabric used to protect the plastic sheeting liner from penetrations from the underlying and overlying soil.

1. Filter fabric shall consist of non-woven geotextile meeting the following requirements:

a. Meet or exceed the properties specified in Table 02510-1:

Table 02510-1. Minimum Geotextile Properties

Geotextile Property	Test Method	Units	Value
Grab tensile strength	ASTM D 4632	Lb	
Machine direction	ASTM D 4632	Lb	80
Cross machine direction	ASTM D 4632	Lb	80
Grab elongation	ASTM D 4632	%	15
Puncture strength	ASTM D 4833	Lb	35

B. Plastic liner shall be Polyvinyl Chloride (PVC) and shall meet the following minimum requirements listed in Table 02510-2:

Table 02510-2. Minimum Liner Properties

Liner Property	Test Method	Units	Value
Tensile properties	ASTM D 882	Lbs/in	
Breaking factor	ASTM D 882	Lbs/in	25
Elongation break	ASTM D 882	Lbs/in	360%

C. Crushed Gravel for the temporary environmental cap shall be dense graded crushed rock including sand and it shall be uniformly graded from coarse to fine. Sieve analysis

shall be determined in accordance with AASHTO T 27. The aggregate shall be durable and free of deleterious material and shall meet the following grading requirements:

Table 02510–3

Size	Percent Passing (by weight)
¾”	100
½”	80 – 100
No. 4	45 – 65
No. 40	10 – 25
No. 200	10 max
% fracture	75 min
Sand equivalent	40 min

D. The portion retained on the US No. 4 sieve shall not contain more than 0.15% wood waste.

E. Imported granular material shall consist of granular material either naturally occurring or processed and shall meet the following requirements for grading and quality:

Table 02510–4

Size	Percent Passing (by weight)
1-1/4”	100
1”	90 – 100
No. 40	50 max
No. 200	10 max
Sand equivalent	30 min

F. Crack sealant. Furnish all sealant material for crack repair of the existing flexible pavement cap that is approved by the Owner’s Agent before being incorporated into the work. Before beginning work, furnish a complete written statement of the origin, composition and manufacturer of materials that are to be used. Furnish hot-poured sealant of the types intended for use in sealing cracks in asphalt concrete pavement that conform to the requirements of AASHTO M 324, Type II (ASTM D 6690 Type II).

2.02 EQUIPMENT FOR CRACK SEALING

A. Use proper equipment for the specific material listed according to the manufacturer’s recommendations. The equipment for sealing compounds shall be a melting kettle of

the double boiler, indirect heating type using oil as a heat transfer medium. The kettle shall be an effective, mechanically operated agitator equipped with a positive thermostatic temperature control.

PART 3 EXECUTION

3.01 GENERAL

A. New Temporary Environmental Cap.

1. Layout shall consist of staking all boundaries of the temporary environmental cap as shown on the drawings, identifying all potential conflicts and utilities that may interfere with the cap. Notify Owner's Agent immediately if conflicts or utilities are identified in the cap areas that are not accounted for the in the Contract Drawings.
2. Clearing shall consist of removing all vegetation from the area to be capped. Vegetation shall be grubbed to remove protruding roots that will impact the construction or integrity of the cap. Surface debris and sharp stones shall be removed from the area to be capped and the remaining surface shall be bladed smooth and rolled with a smooth drum roller to result in a smooth and even surface on which to construct the cap.
3. Cap grading at existing railroad tracks and abandoned railroad track beds. The cap will be constructed over railroad tracks or depressions where tracks were previously located. These areas shall be filled with imported granular material to the top of the rails and to provide a gradual transition to adjacent grades so that the transitions are no steeper than 2H:1V (2 Horizontal : 1 Vertical), down or up to the surrounding grades. The fill shall be compacted to a firm and non-yielding condition that, in the opinion of the Owner's Agent, is suitable for construction of the cap. Compaction shall be accomplished using equipment specifically designed for compaction of the granular material.
4. Cap grading at former manufacturing building foundations. The cap will be constructed over old manufacturing building foundations that, in some cases, contain small above grade structures (e.g., former equipment pads), and pits and cracks. These structures shall be demolished to the extent practicable and filled to grade to provide a level working surface for the placement of the cover material. Any pits, cracks, etc., shall be filled with imported granular material to the proper grade. The fill shall be placed so that it provides a gradual transition up or down to adjacent grades with slopes no steeper than 2H:1V. The fill shall be compacted to a firm and non-yielding condition that, in the opinion of the Owner's Agent, is suitable for construction of the cap. Compaction shall be accomplished using equipment specifically designed for compaction of the granular material.
5. Cap grading at former DDT storage area. The areas around the former DDT storage area shall be filled to the level of the tank bases to provide a level surface for the placement of the cap materials. Any pits, trenches, depressions, etc., shall be filled with imported granular material to the top of the tank bases. The fill shall be placed so that it provides a gradual transition up or down to adjacent grades with slopes no steeper than 2H:1V. The fill shall be compacted

to a firm and non-yielding condition that, in the opinion of the Owner's Agent, is suitable for construction of the cap. Compaction shall be accomplished using equipment specifically designed for compaction of the granular material.

6. Without prior approval from Owner's Agent, Contractor shall not place any more environmental cap than can be fully completed and protected with the finishing crushed gravel layer in the same day. Contractor shall be responsible for redoing any work that results from liner or geotextile layers that are not properly temporarily held in place during installation.

7. A layer of geotextile fabric will be placed over the entire area to be capped with edges of adjacent rows of fabric overlapping a minimum of 12 inches and a maximum of 18 inches. The geotextile fabric shall be placed so that there are no wrinkles in the remaining surface. Contractor shall be responsible for temporary measures (such as sandbags) to hold the geotextile fabric in place until subsequent layers of the cap can be placed.

8. The liner shall be placed over the geotextile fabric so that the entire area to be capped is fully covered with the liner. Edges of the liner shall have a minimum overlap of 12 inches and a maximum overlap of 18 inches. The liner shall be placed so that the liner is not punctured by the installation process. Once the liner has been placed in accordance with these specifications, Contractor shall notify the Owner's Agent so that the liner can be visually inspected for integrity and overlap requirements. Contractor shall receive approval of the liner installation prior to covering the liner. Contractor shall be responsible for temporary measures (such as sandbags) to hold the liner in place until subsequent layers of the cap can be placed.

9. A second layer of geotextile fabric shall be placed over the newly installed liner. This material shall be placed by hand so that the integrity of the underlying liner is not compromised by installation of the geotextile fabric. Contractor shall be responsible for temporary measures (such as sandbags) to hold the geotextile fabric in place until subsequent layers of the cap can be placed.

10. The crushed gravel shall be placed over the underlying geotextile fabric and liner in such a way that the underlying material is not compromised. Contractor shall not drive equipment directly over the geotextile fabric. Installation of the crushed rock shall proceed from one side to the other with equipment driving only over the crushed rock that has just been placed. If underlying areas of the cap are damaged by installation of the crushed rock, Contractor shall repair or replace the affected sections at no additional cost to the contract. The crushed rock shall be placed to a thickness of 2 (two) inches with a tolerance of plus ½" and minus 0 inches.

B. Crack Repair of Existing Temporary Asphalt Cap.

1. Follow manufacturer's recommendations for application of sealant. Mix and heat the sealant materials to a minimum temperature of 280 degrees F. Do not heat the sealant above 400 degrees F.

2. Where installation procedures, or any part of the procedures are required to be done according to the manufacturer of the sealing compound, submit catalogue data and copies of the recommendations before installing the sealant.

3. Clean all cracks designated for sealing of loose and foreign matter. Use a hot lance to perform this cleaning. Use this wand to both clean and dry the crack just prior to sealing.
4. Do not place any sealant without prior approval of the Owner's Agent. The Owner's Agent will inspect all cracks.
5. The face of the crack shall be surface dry, and the ambient and pavement temperature shall be both at least 45 degrees F and rising at the time of the application of the sealant.
6. Install the sealant so that the so that the in-place sealant is well bonded to pavement and free of voids or entrapped air.
7. Seal the cracks from the bottom up in a neat manner so that upon completion of the work the surface of the sealant material is flush to 3/16 inch below the adjacent pavement surface. Refill or "spot" all low areas before continuing work.
8. Level the sealant flush to the surface with a "V" shaped squeegee device. Squeegee the excess material so that it does not exceed 1.5 inches on either side of the crack.

END OF SECTION 02510

EXHIBIT 1

SUMMARY OF SOIL QUALITY

ERM. 2005. Upland Remedial Investigation Report Lots 3 & 4 and Tract A – Revision 1. Prepared for Arkema Inc., Portland, OR. ERM-West, Portland, OR.

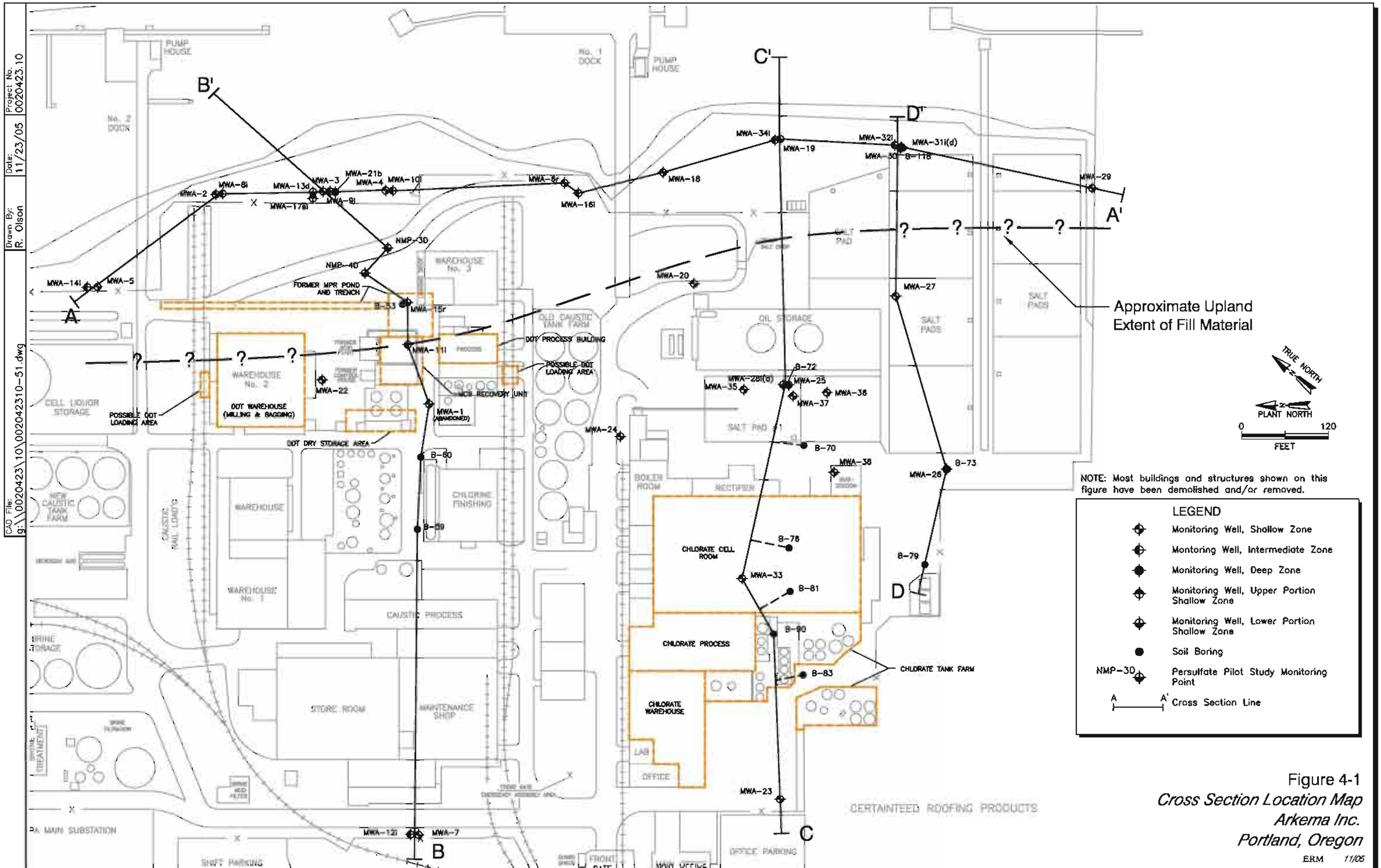
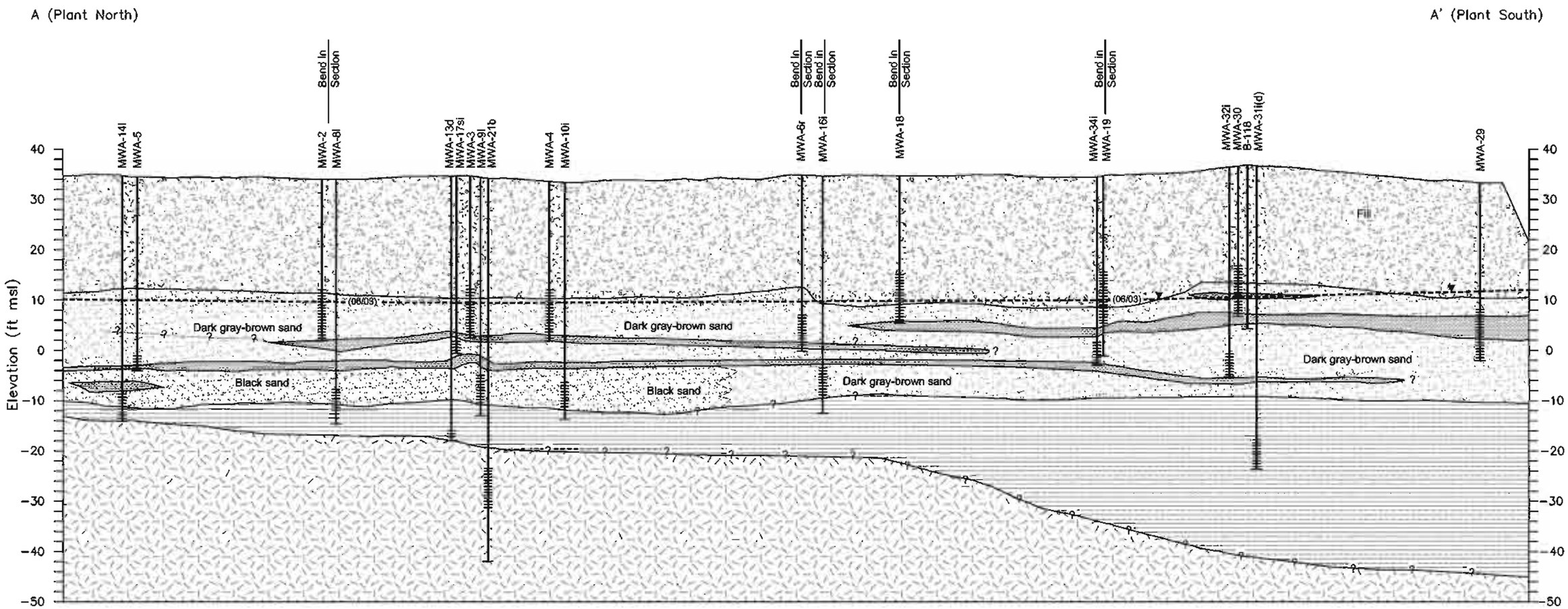


Figure 4-1
Cross Section Location Map
Arkema Inc.
Portland, Oregon

ERM 11/05

CAD File: G:\0020423\10\002042310-17.dwg
Drawn By: J. Estrado
Date: 11/23/05
Project No. 0020423.10



LEGEND

- Fill
- Sand with varying amounts of silt
- Silt with varying amounts of fine sand
- Silt with some clay and fine sand
- Basalt

B-59 — Geoprobe® boring number
MWA-1 — Well number
Cased interval
Screen interval
Shallow-zone groundwater surface (approximate); June 2003
Inferred soil or geologic contact (queried where uncertain)

(Vertical Exaggeration = 5X)

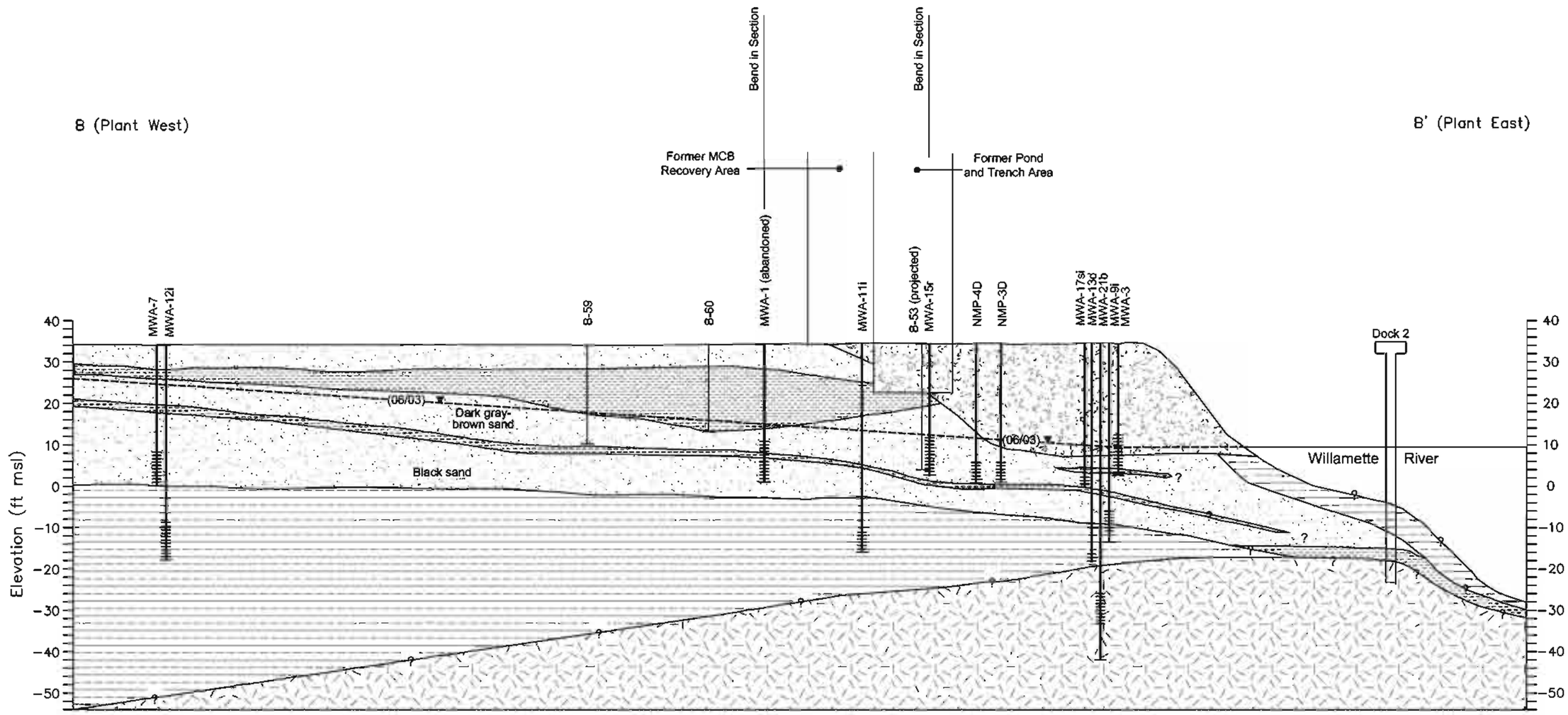
VERTICAL SCALE IN FEET 1" = 20'
0
20

HORIZONTAL SCALE IN FEET 1" = 100'
0
100

Figure 4-2
Cross Section A-A'
Arkema Inc.
Portland, Oregon

ERM 11/05

Project No. 0020423.10
Date: 11/23/05
Drawn By: J. Estrado
CAD File: g:\0020423\10\002042310-18.dwg



LEGEND

- Fill
- Sand with varying amounts of silt
- Silt with varying amounts of fine sand
- Silt with some clay and fine sand
- Basalt

B-59 — Geoprobe® boring number
MWA-1 — Well number
Cased Interval
Screen Interval
Shallow-zone groundwater surface (approximate); June 2003; Based on monitoring well data only
Inferred soil or geologic contact (queried where uncertain)

Stratigraphy Beneath River Provided by Exponent

(Vertical Exaggeration = 4X)

0
APPROX. VERTICAL SCALE IN FEET 1" = 25'
25

0 100
APPROX. HORIZONTAL SCALE IN FEET 1" = 100'

Figure 4-3
Cross Section B-B'
Arkema Inc.
Portland, Oregon

ERM 11/05

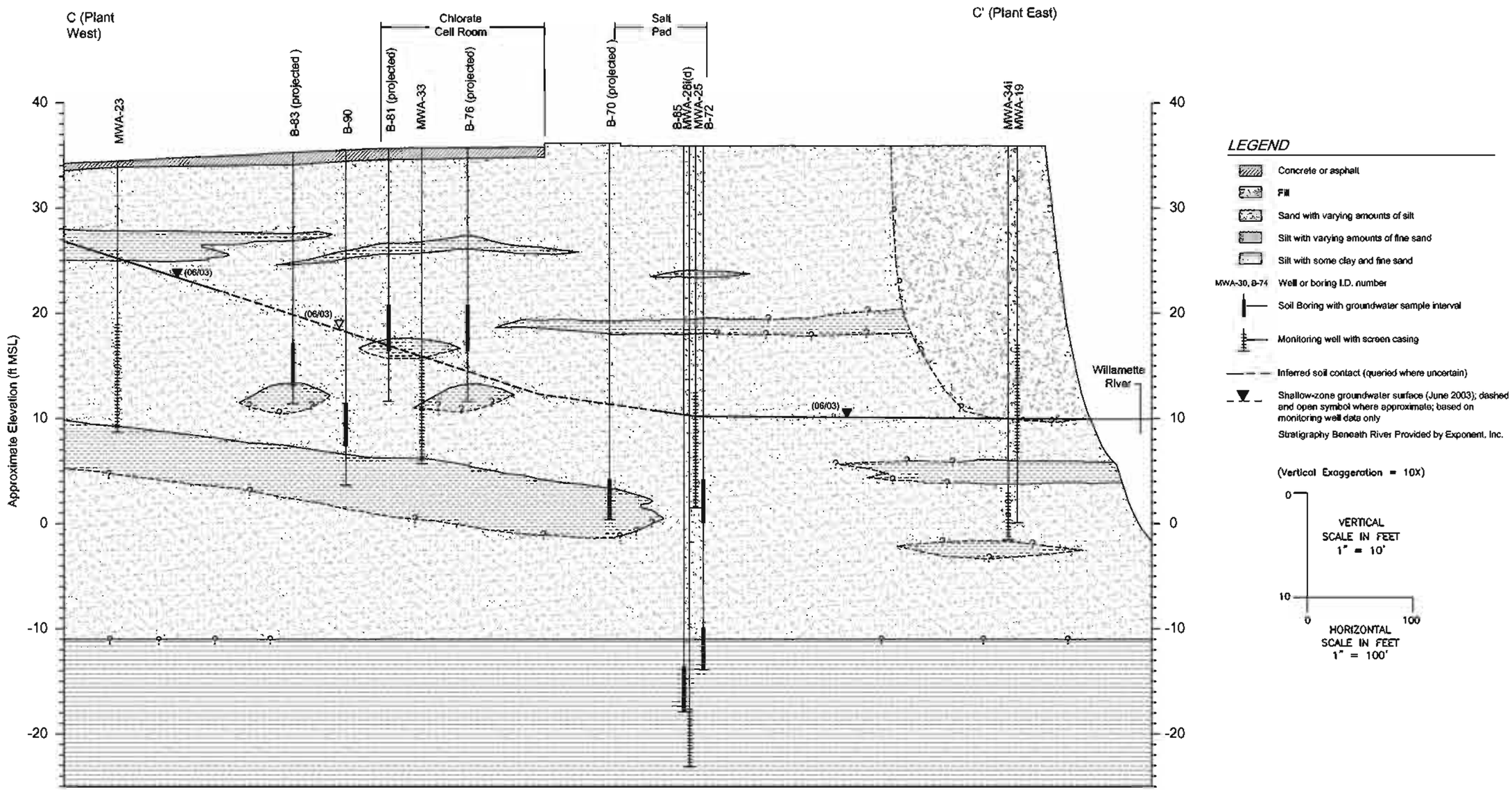


Figure 4-4
Cross Section C-C'
Arkema Inc.
Portland, Oregon

ERM 11/05

CAD File: g:\0020423\10\002042310-19.dwg
Drawn By: J. Estrado
Date: 11/23/05
Project No. 0020423.10

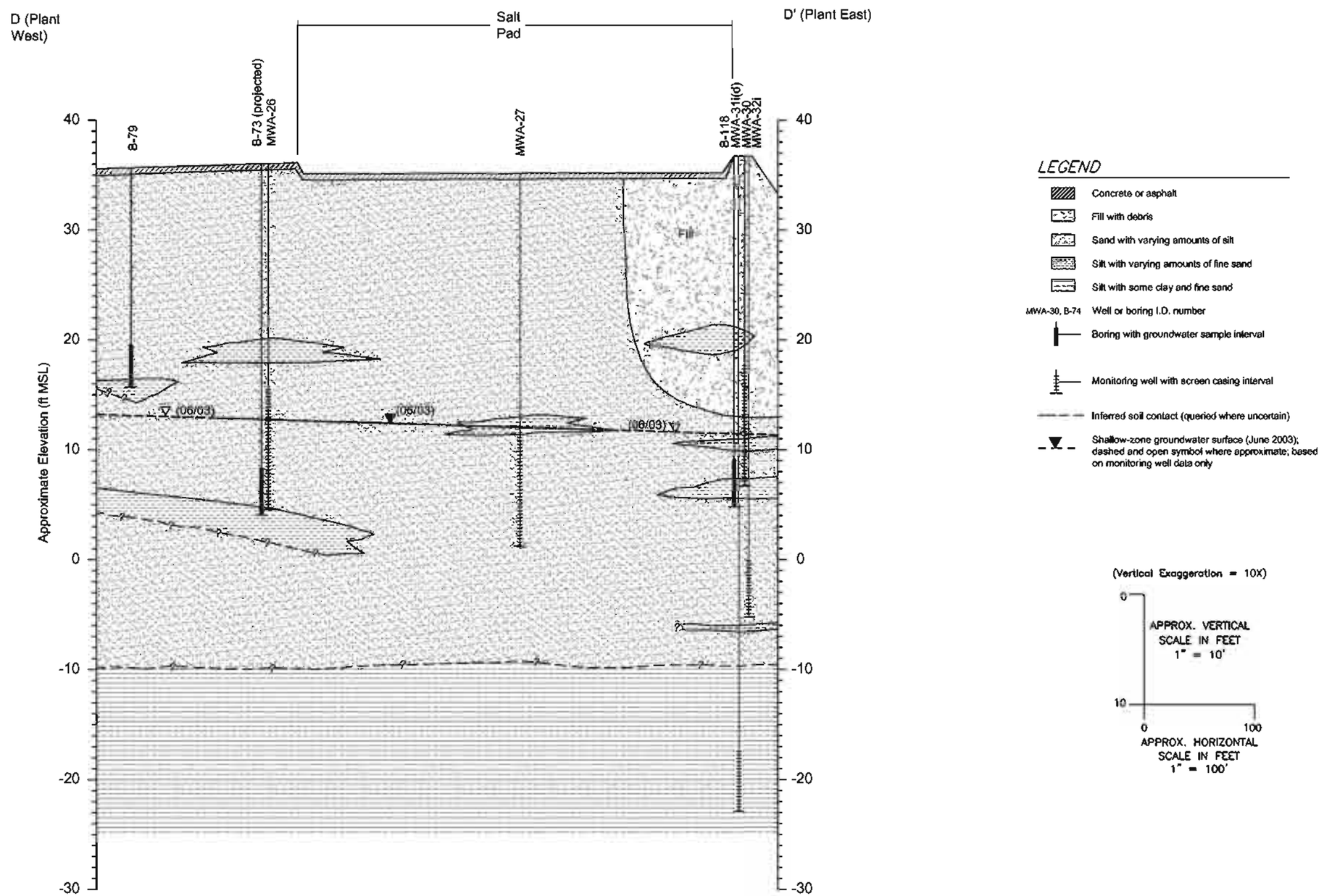
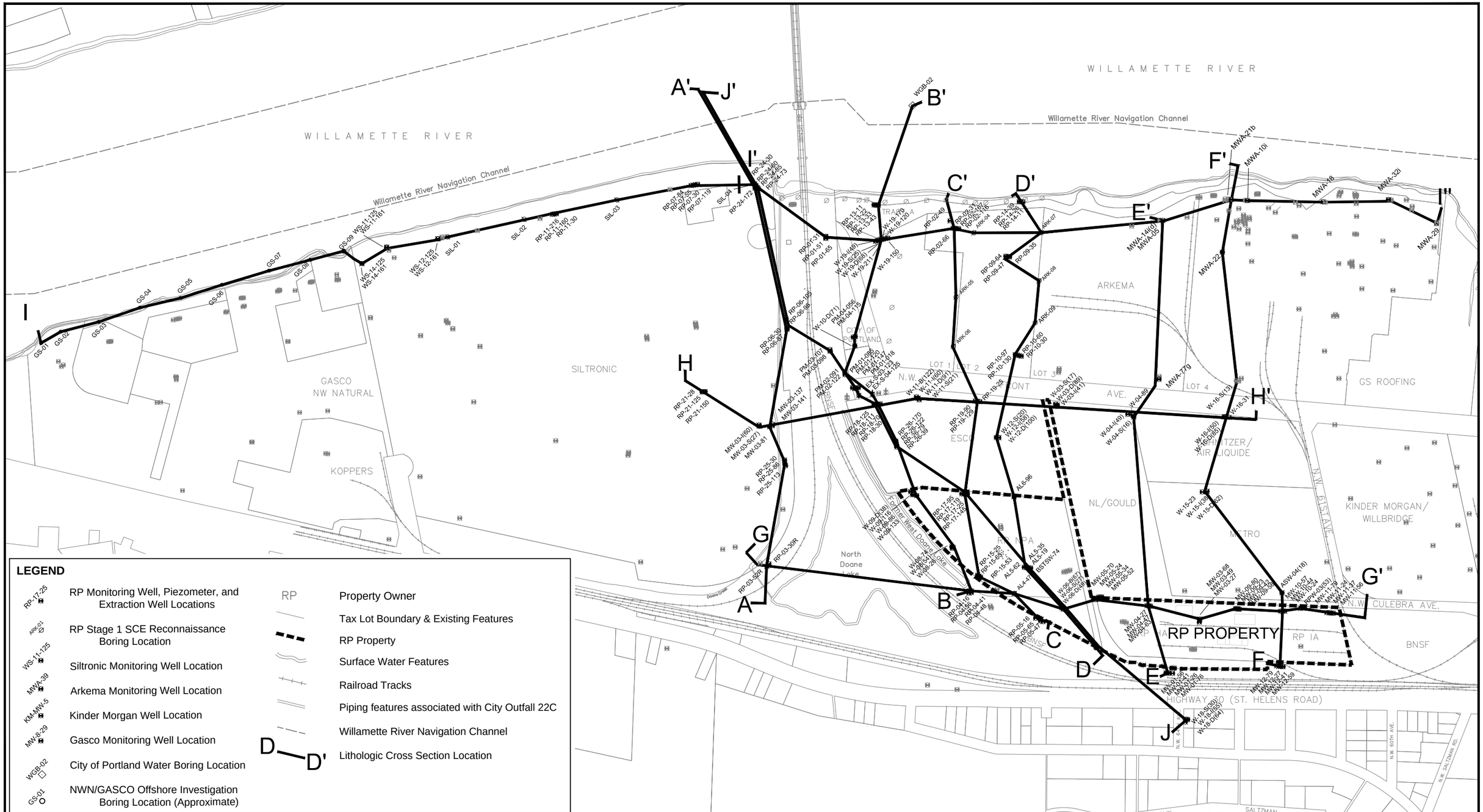


Figure 4-5
Cross Section D-D'
Arkema Inc.
Portland, Oregon

ERM 11/05

CAD File: g:\0020423\10\002042310-20.dwg
Drawn By: J. Estrado
Date: 11/23/05
Project No. 0020423.10

AMEC. 2010. RI/SCE Report, RP – Portland Site, Portland, Oregon. Prepared for StarLink Logistices, Inc., Bridgewater, NJ. AMEC Earth & Environmental, Portland, OR.



amec

Earth & Environmental
7376 S.W. Durham Road
Portland, OR. U.S.A. 97224

DRAWN BY:	BRJ
QC BY:	CJ
DATE DRAWN:	OCTOBER 2010
DATUM / PROJECTION:	NAD83 / OR SP N Int Ft
PROJECT NO:	061M107030.0202.001

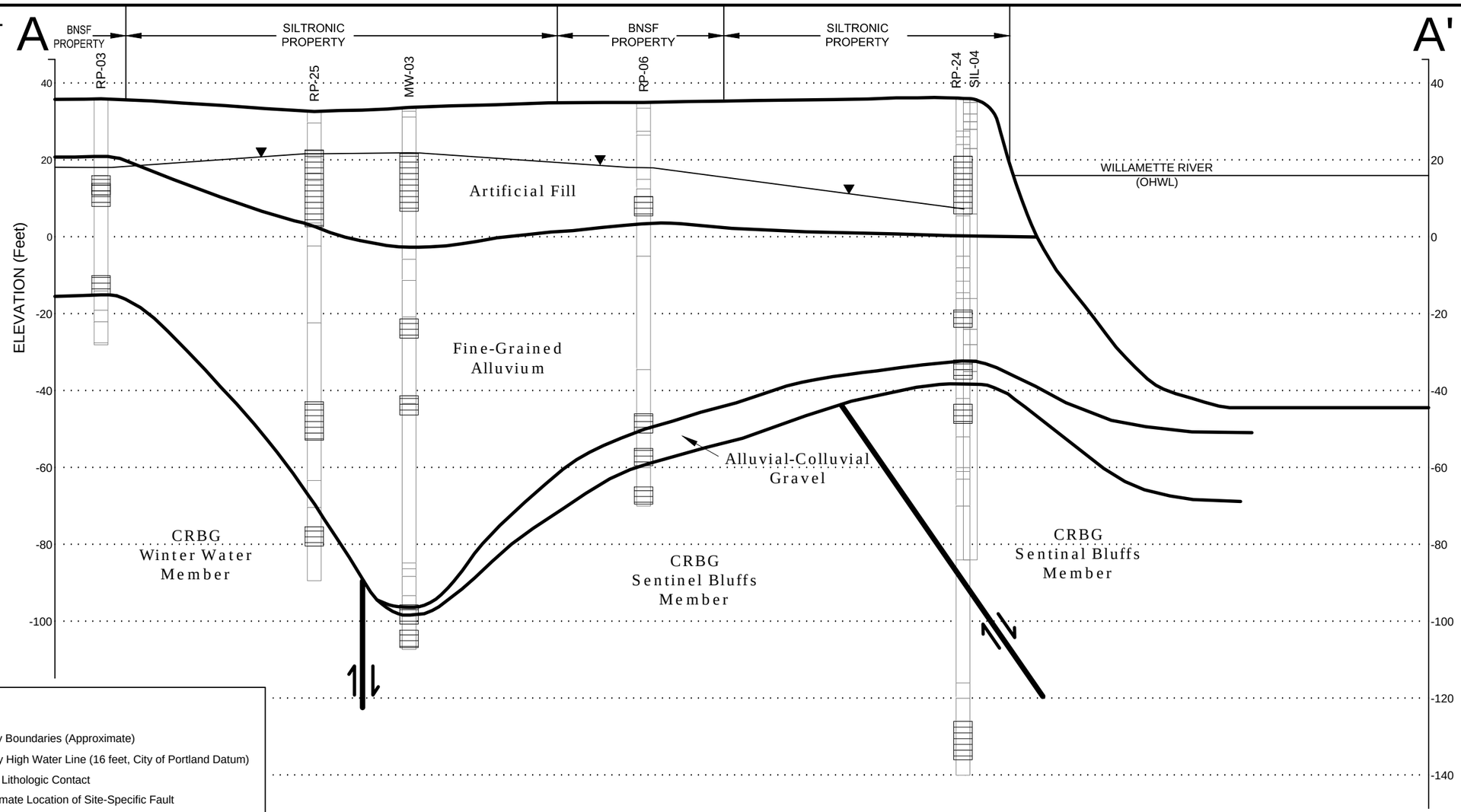
TITLE:

FIGURE 6-E
GEOLOGIC CROSS SECTION LOCATION MAP

REPORT:

RI / SCE REPORT
RP - PORTLAND SITE

P:\10703\0100 RI-FS-ROD\0104 RI Report\Draft RI\Figures\dwg\Figure 6-E Geologic Cross Section Location Map.dwg – XSections – Oct. 27, 2010 11:41am – brian.johnson



LEGEND

BNSF	Property Boundaries (Approximate)
OHWL	Ordinary High Water Line (16 feet, City of Portland Datum)
	Inferred Lithologic Contact
	Approximate Location of Site-Specific Fault
	Water Table
	Fault Showing Relative Direction of Movement
RP-17	Monitoring Well Cluster Identifier
	Screen Interval

CRBG = COLUMBIA RIVER BASALT GROUP

Notes:

Stratigraphy between depicted borings is interpreted from additional borings not shown on this cross section.
Stratigraphy at borings shown on cross section may incorporate observations from multiple borings at a single well cluster.

0' 125' 250' 375'

amec

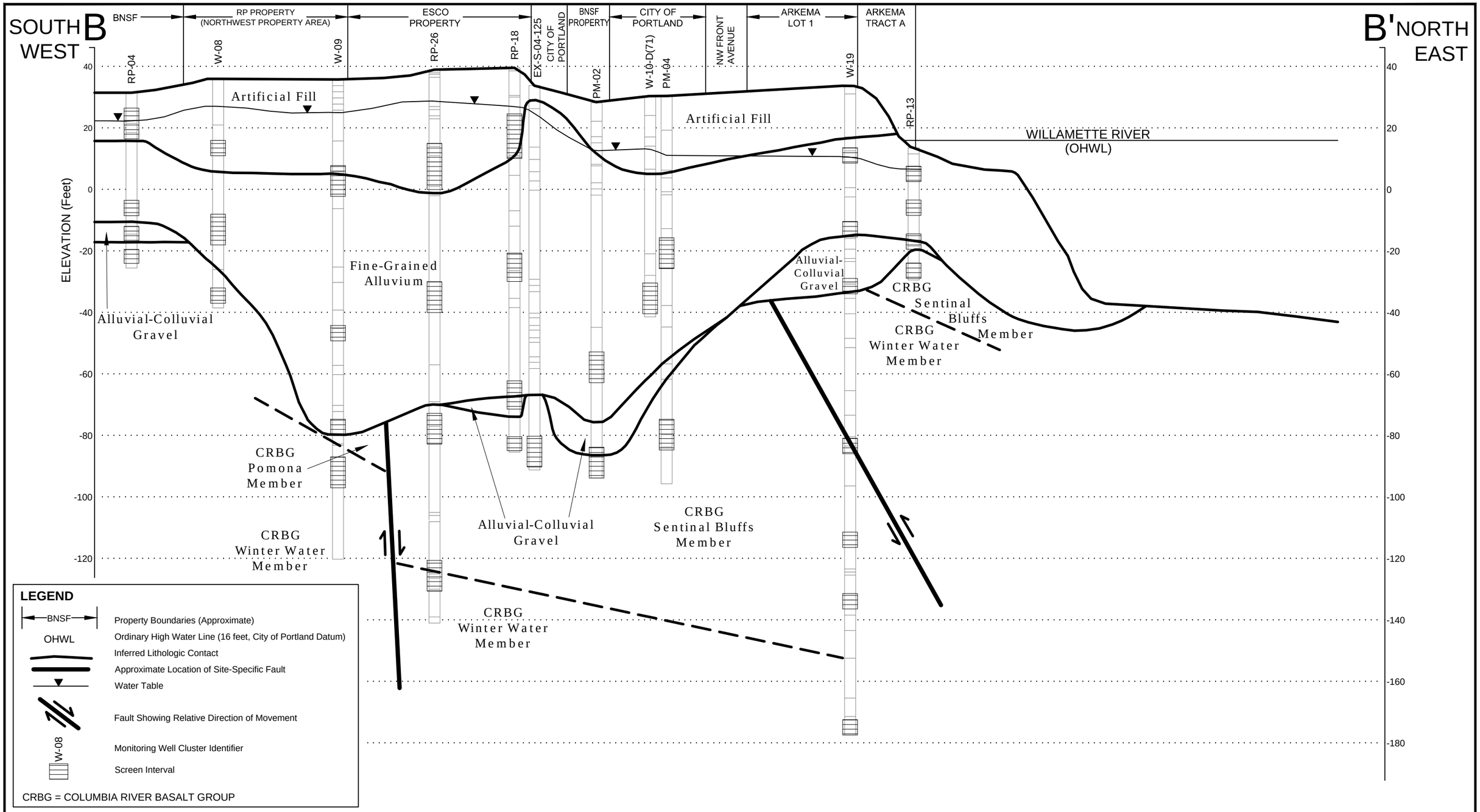
Earth & Environmental
7376 S.W. Durham Road
Portland, OR. U.S.A. 97224

DRAWN BY: BRJ
QC BY: DMF / CJ
DATE DRAWN: OCTOBER 2010
VERTICAL DATUM: City of Portland
PROJECT NO: 061M107030.0202.001

TITLE:
FIGURE 6-F
GEOLOGIC CROSS SECTION A-A'

REPORT:
RI / SCE REPORT
RP - PORTLAND SITE

P:\10703\0100 RI-FS-ROD\0104 RI Report\Draft RI\Figures\dwg\Figure 6-F Geologic Cross Section A-A'.dwg - Layout - Oct. 27, 2010 11:41am - brian.johnson



Notes:

Stratigraphy between depicted borings is interpreted from additional borings not shown on this cross section.
Stratigraphy at borings shown on cross section may incorporate observations from multiple borings at a single well cluster.

0' 125' 250' 375'

amec

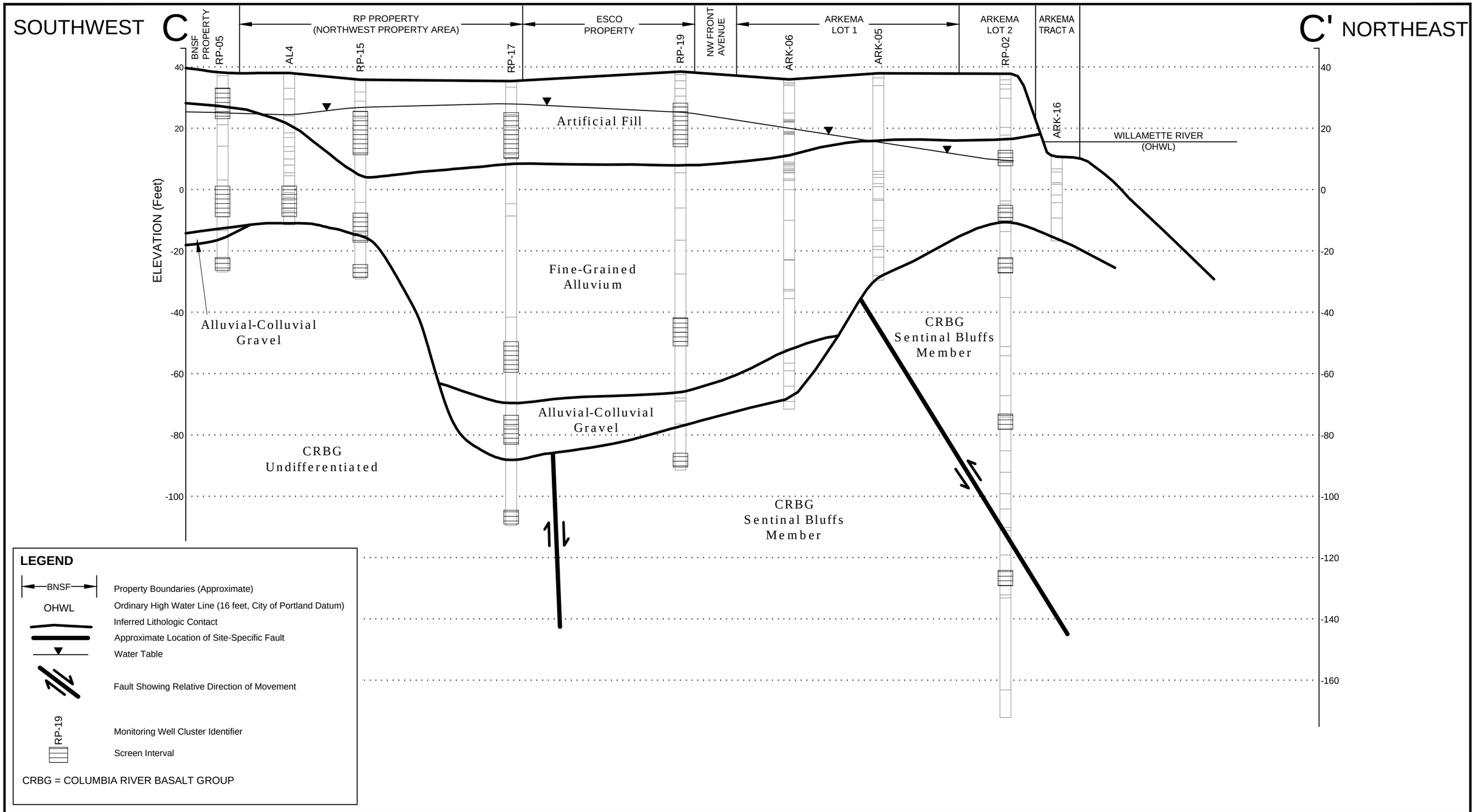
Earth & Environmental
7376 S.W. Durham Road
Portland, OR. U.S.A. 97224

DRAWN BY: BRJ
QC BY: DMF / CJ
DATE DRAWN: OCTOBER 2010
VERTICAL DATUM: City of Portland
PROJECT NO: 061M107030.0202.001

TITLE:
FIGURE 6-G
GEOLOGIC CROSS SECTION B-B'

REPORT:
RI / SCE REPORT
RP - PORTLAND SITE

P:\10703\0100 RI-FS-ROD\0104 RI Report\Draft RI\Figures\dwg\Figure 6-G Geologic Cross Section B-B'.dwg – Layout – Oct. 27, 2010 11:41am – brian.johnson



Notes:

Stratigraphy between depicted borings is interpreted from additional borings not shown on this cross section.
Stratigraphy at borings shown on cross section may incorporate observations from multiple borings at a single well cluster.

0' 125' 250' 375'

amec

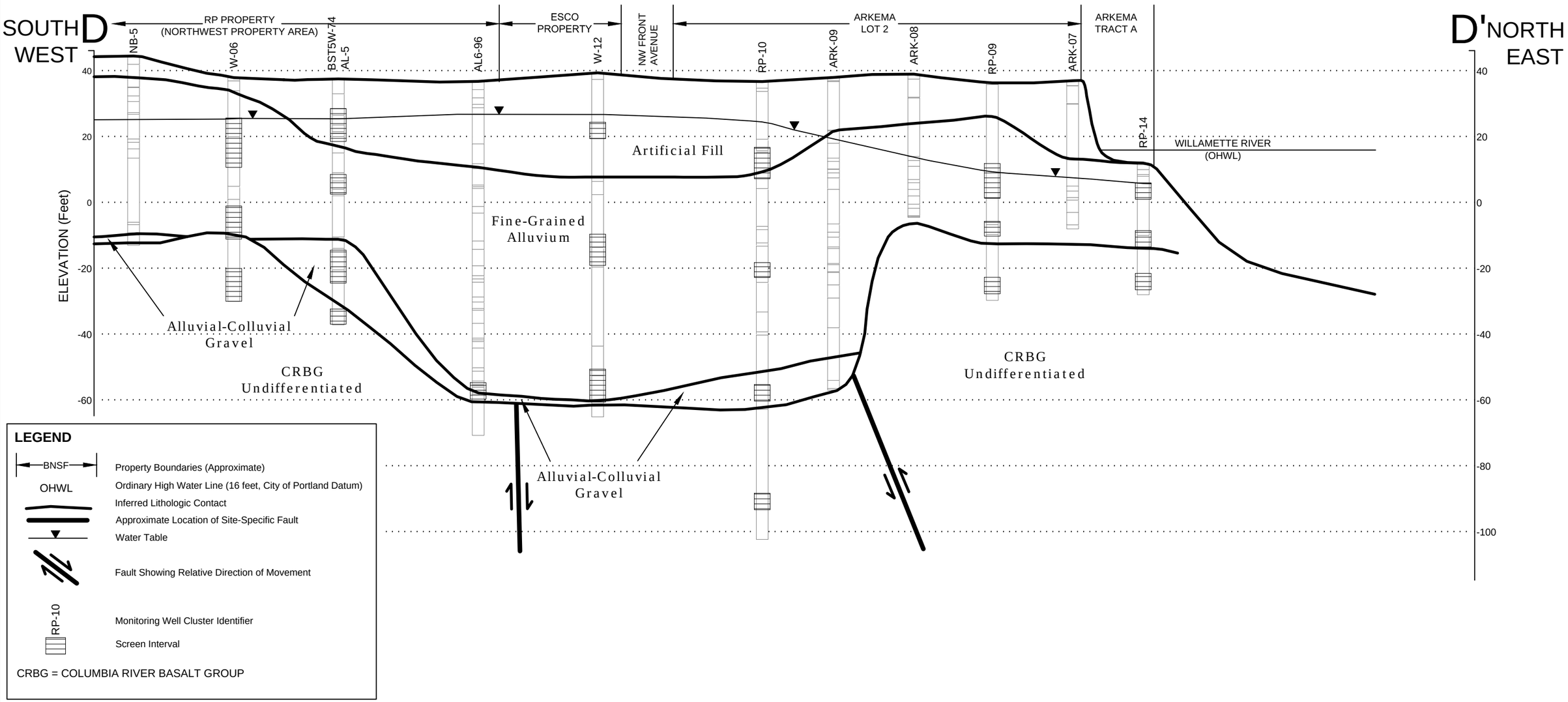
Earth & Environmental
7376 S.W. Durham Road
Portland, OR. U.S.A. 97224

DRAWN BY: BRJ
QC BY: DMF / CJ
DATE DRAWN: OCTOBER 2010
VERTICAL DATUM: City of Portland
PROJECT NO: 061M107030.0202.001

TITLE:
FIGURE 6-H
GEOLOGIC CROSS SECTION C-C'

REPORT:
RI / SCE REPORT
RP - PORTLAND SITE

P:\10703\0100 RI-FS-ROD\0104 RI Report\Draft RI\Figures\dwg\Figure 6-H Geologic Cross Section C-C'.dwg – Layout – Oct. 27, 2010 11:41am – brian.johnson



Notes:

Stratigraphy between depicted borings is interpreted from additional borings not shown on this cross section.
Stratigraphy at borings shown on cross section may incorporate observations from multiple borings at a single well cluster.

0' 125' 250' 375'

amec

Earth & Environmental
7376 S.W. Durham Road
Portland, OR. U.S.A. 97224

DRAWN BY:	BRJ
QC BY:	DMF / CJ
DATE DRAWN:	OCTOBER 2010
VERTICAL DATUM:	City of Portland
PROJECT NO:	061M107030.0202.001

TITLE:

FIGURE 6-I
GEOLOGIC CROSS SECTION D-D'

REPORT:

RI / SCE REPORT
RP - PORTLAND SITE

P:\10703\0100 RI-FS-ROD\0104 RI Report\Draft RI\Figures\dwg\Figure 6-I Geologic Cross Section D-D'.dwg - Layout - Oct. 27, 2010 11:41am - brian.johnson

DEPTH (ft bgs)	USCS SYMBOL	SOIL DESCRIPTION	VOLATILE READING (ppm)	TESTING AND LABORATORY DATA
0	GP	Medium dense, brown, fine to medium, sandy GRAVEL (FILL); dry.	0.0	028-01
	SP	Medium dense, gray, fine SAND with silt; moist.		
5			4.8	029-01
	SP	Medium dense, gray, fine SAND; moist. Slight solvent-like odor.		
	SM	Medium dense, gray, silty, fine SAND; moist.		
	SP	Medium dense, gray, fine SAND; moist.		
		Becomes wet.		
10			0.0	
			0.7	034-01
15				030-01
		Slight organic-like odor mixed with unidentified odor.		031-01
	ML	Medium stiff, gray, fine, sandy SILT; moist. Slight organic-like odor.		
20				
	SM	Medium dense, gray, silty, fine SAND; moist.	0.0	
	ML	Medium stiff, gray SILT with fine sand; moist.		
25	SM	Medium dense, gray, silty, fine SAND interbedded with medium sand and silt lenses, trace wood debris; moist.		
	ML	Stiff, brown, fine sandy SILT; moist.		
30				

GRAPHIC LOG | SAMPLE | GROUNDWATER | GW SCREENED INTERVAL | FIELD TESTING

BORING METHOD: Direct Push
ELEVATION REFERENCE: NA
BOREHOLE DIAMETER: 2.0 (in)
REMARKS:
DRILL RIG: Geoprobe
GROUND SURFACE ELEVATION: NA
CONTRACTOR: Cascade Drilling
LOGGED BY: L. Glonek, C. Johnson
DRILLING DATES: 08/12/2005 - 08/12/2005

RP - Portland
Stage 1 SCE

0-61M-107030 P69

AMEC
7376 SW Durham Road
Portland, Oregon
USA 97224
Tel (503) 639-3400
Fax (503) 620-7892

amec

LOG OF BORING ARK-04

DIRECT PUSH BORING (MULTIPLE SCREENS) 0-61M-107030-P69.GPJ AMEC PORTLAND.GDT 2/7/06

DEPTH (ft bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	VOLATILE READING (ppm)	GROUNDWATER	GW SCREENED INTERVAL	FIELD TESTING	TESTING AND LABORATORY DATA
30		ML	Stiff, brown, fine sandy SILT; moist.						
			Grades to grayish-brown.						
		SM	Medium dense, grayish-brown, silty, fine SAND; wet.						
35			Grades to fine SAND with silt; wet.						035-01
		ML	Medium stiff, grayish-brown SILT with fine sand; moist to wet.						
40		SP	Medium dense, brown, fine SAND; wet.		0.0				
45			Basalt chips in shoe.						032-01
			Total depth drilled = 47 ft bgs due to drill refusal.						033-01
50									
55									
60									

BORING METHOD: Direct Push

ELEVATION REFERENCE: NA

BOREHOLE DIAMETER: 2.0 (in)

REMARKS:

DRILL RIG: Geoprobe

GROUND SURFACE ELEVATION: NA

CONTRACTOR: Cascade Drilling

LOGGED BY: L. Glonek, C. Johnson

DRILLING DATES: 08/12/2005 - 08/12/2005

RP - Portland
Stage 1 SCE

0-61M-107030 P69

AMEC
7376 SW Durham Road
Portland, Oregon
USA 97224
Tel (503) 639-3400
Fax (503) 620-7892

LOG OF BORING ARK-04

DIRECT PUSH BORING (MULTIPLE SCREENS) 0-61M-107030-P69.GPJ AMEC PORTLAND.GDT 2/7/06

DEPTH (ft bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	VOLATILE READING (ppm)	GROUNDWATER	GW SCREENED INTERVAL	FIELD TESTING	TESTING AND LABORATORY DATA
0		GP	Medium dense, brown, fine to medium, sandy GRAVEL (FILL); dry.		0.0				045-01
		GP	Medium dense, dark gray, fine to medium, sandy GRAVEL; dry.						
		SM	Grayish-brown, fine SAND with silt; moist.						
		SP	Medium dense, brown, fine SAND; moist.						
5					0.0				046-01
		SP	Medium dense, gray, fine SAND; moist.						
10									
					0.0				
15									
					0.0				047-01
			Becomes wet.						
20									
					0.0				048-01
		ML	Medium stiff, dark gray SILT with fine sand; wet. Mild organic-like odor.						050-01
25		ML	Medium stiff, grayish-brown with dark gray mottled SILT with fine sand; wet.						
					0.0				
		ML	Medium stiff, brown SILT with fine sand; moist.						
30									

BORING METHOD: Direct Push

ELEVATION REFERENCE: NA

BOREHOLE DIAMETER: 2.0 (in)

REMARKS:

DRILL RIG: Geoprobe

GROUND SURFACE ELEVATION: NA

CONTRACTOR: Cascade Drilling

LOGGED BY: L. Glonek, C. Johnson

DRILLING DATES: 08/17/2005 - 08/17/2005

RP - Portland
Stage 1 SCE

0-61M-107030 P69

AMEC
7376 SW Durham Road
Portland, Oregon
USA 97224
Tel (503) 639-3400
Fax (503) 620-7892

amec

LOG OF BORING ARK-05

DEPTH (ft bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	VOLATILE READING (ppm)	GROUNDWATER	GW SCREENED INTERVAL	FIELD TESTING	TESTING AND LABORATORY DATA
30		ML			0.0				
		SP	Medium dense, brown, fine SAND; wet.						
		ML	Medium stiff, brown, fine, sandy SILT; wet.						
		SP	Medium dense, brown, fine SAND; wet.		0.0				
35									
		ML	Medium stiff, brown, fine, sandy SILT; wet.						
		SP	Medium dense, brown, fine SAND; wet.						
					0.0				
40									
		ML	Medium stiff, brown, fine sandy SILT; wet.		0.0				051-01
		SP	Medium dense, brown, fine SAND; wet.						
45									
					0.0				
		SM	Medium dense, brown, silty, fine SAND; wet.						
50					0.0				
		ML	Medium stiff, brown, fine, sandy SILT; wet.						
		SM	Medium dense, brown, silty, fine SAND; wet.						
55					0.0				
		ML	Medium stiff, brown, fine, sandy SILT; wet.						
		SM	Medium dense, brown, silty, fine SAND; wet.		0.0				
60									049-01

BORING METHOD: Direct Push

ELEVATION REFERENCE: NA

BOREHOLE DIAMETER: 2.0 (in)

REMARKS:

DRILL RIG: Geoprobe

GROUND SURFACE ELEVATION: NA

CONTRACTOR: Cascade Drilling

LOGGED BY: L. Glonek, C. Johnson

DRILLING DATES: 08/17/2005 - 08/17/2005

RP - Portland
Stage 1 SCE

0-61M-107030 P69

AMEC
7376 SW Durham Road
Portland, Oregon
USA 97224
Tel (503) 639-3400
Fax (503) 620-7892

amec

LOG OF BORING ARK-05

DEPTH (ft bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	VOLATILE READING (ppm)	GROUNDWATER	GW SCREENED INTERVAL	FIELD TESTING	TESTING AND LABORATORY DATA
60		SM							
			Total depth drilled = 64 ft bgs.						
65									
70									
75									
80									
85									
90									

BORING METHOD: Direct Push

BOREHOLE DIAMETER: 2.0 (in)

DRILL RIG: Geoprobe

CONTRACTOR: Cascade Drilling

LOGGED BY: L. Glonek, C. Johnson

ELEVATION REFERENCE: NA

GROUND SURFACE ELEVATION: NA

DRILLING DATES: 08/17/2005 - 08/17/2005

REMARKS:

RP - Portland
Stage 1 SCE

0-61M-107030 P69

AMEC
7376 SW Durham Road
Portland, Oregon
USA 97224
Tel (503) 639-3400
Fax (503) 620-7892

LOG OF BORING ARK-05

DIRECT PUSH BORING (MULTIPLE SCREENS) 0-61M-107030-P69.GPJ AMEC PORTLAND.GDT 2/7/06

DEPTH (ft bgs)	USCS SYMBOL	SOIL DESCRIPTION	TESTING AND LABORATORY DATA
0	GP	Medium dense, brown, fine to medium, sandy GRAVEL (FILL); dry.	052-01
	SP	Medium dense, brown, fine to medium SAND (FILL) with gravel; moist.	
	GP		
	SP	Medium dense, dark gray, fine to medium, sandy GRAVEL (FILL) with asphalt. Mild petroleum-like odor.	053-01
		Medium dense, brown with black, fine to medium SAND (FILL) with gravel; moist.	
	SP	Medium dense, brown, fine to medium SAND; moist.	
5			054-01
			055-01
10	SP	Medium dense, gray, fine SAND, some organics; wet.	
	ML	Medium stiff, gray SILT, trace organics; wet.	
	SP	Medium dense, gray, fine SAND; wet.	
	ML	Medium stiff, gray SILT; wet.	
	SP	Medium dense, gray, fine SAND; wet.	
	ML	Medium stiff, gray SILT; wet.	
15	SP	Medium dense, gray, fine SAND with trace gravel, trace organics; wet.	
	GW	Medium dense, gray, subrounded to subangular, sandy GRAVEL; wet.	
	ML	Medium stiff, gray SILT; wet.	
	SP	Medium dense, gray, fine SAND; wet.	
	ML	Medium stiff, gray SILT, trace organics; wet.	
	SP	Medium dense, gray, fine SAND with trace gravel, some organics; wet.	
20	SP	Medium dense, gray, fine SAND; wet.	
	PT	Wood debris.	
25	SP	Medium dense, gray, fine SAND, trace organics; wet.	
	ML	Medium stiff, gray-brown SILT with some organics; wet.	058-01
	SP	Medium dense, gray, fine SAND; wet.	
	ML	Stiff, gray-brown SILT with some organics.	
	SP	Medium dense, gray, fine SAND, trace organics; wet.	
	ML	Medium stiff, gray SILT, some organics; wet.	
30	SP	Medium dense, gray, fine SAND, trace organics; wet.	

BORING METHOD: Direct Push

ELEVATION REFERENCE: NA

BOREHOLE DIAMETER: 2.0 (in)

REMARKS:

DRILL RIG: Geoprobe

GROUND SURFACE ELEVATION: NA

CONTRACTOR: Cascade Drilling

LOGGED BY: L. Glonek, C. Johnson

DRILLING DATES: 08/18/2005 - 08/18/2005

RP - Portland
Stage 1 SCE

0-61M-107030 P69

AMEC
7376 SW Durham Road
Portland, Oregon
USA 97224
Tel (503) 639-3400
Fax (503) 620-7892

LOG OF BORING ARK-06

DIRECT PUSH BORING (MULTIPLE SCREENS) 0-61M-107030-P69.GPJ AMEC PORTLAND.GDT 2/7/06

DEPTH (ft bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	VOLATILE READING (ppm)	GROUNDWATER	GW SCREENED INTERVAL	FIELD TESTING	TESTING AND LABORATORY DATA
30		ML	Stiff, gray SILT; wet.						
		SP	Medium dense, gray SAND, trace organics; wet.						
		ML	Stiff, gray-brown SILT, some organics; wet.						
		SP	Medium dense, gray, fine to medium SAND, some organics; wet.						
		SM	Dense, gray-brown, silty SAND, trace organics; wet.						
35		ML	Stiff, gray, clayey SILT, trace organics; wet.						
		ML	Soft, gray-brown SILT with sand, trace organics; wet.						
		ML	Very stiff, blue-gray with brown mottled SILT, trace organics; wet.						
40		ML	Very stiff, brown, fine, sandy SILT; wet.						
45		SP	Medium dense, brown, micaceous, fine SAND; wet.						
		SP	Dense, brown SAND with trace silt; wet.						
		SP	Loose, brown, fine SAND; wet.						
50		SP	Medium dense, gray, fine SAND; wet.						
		SP	Loose, brown, fine SAND; wet.						
55									059-01
		ML	Medium stiff, brown, fine, sandy SILT; wet.						
60		SP	Medium dense, brown, fine SAND; wet.						

BORING METHOD: Direct Push

ELEVATION REFERENCE: NA

BOREHOLE DIAMETER: 2.0 (in)

REMARKS:

DRILL RIG: Geoprobe

GROUND SURFACE ELEVATION: NA

CONTRACTOR: Cascade Drilling

LOGGED BY: L. Glonek, C. Johnson

DRILLING DATES: 08/18/2005 - 08/18/2005

RP - Portland
Stage 1 SCE

0-61M-107030 P69

AMEC
7376 SW Durham Road
Portland, Oregon
USA 97224
Tel (503) 639-3400
Fax (503) 620-7892

amec

LOG OF BORING ARK-06

DEPTH (ft bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	VOLATILE READING (ppm)	GROUNDWATER	GW SCREENED INTERVAL	FIELD TESTING	TESTING AND LABORATORY DATA
60		SP	Medium dense, brown, fine SAND; wet.						
65									
		SP	Medium dense, brown, fine SAND wet.						
		SM	Medium dense, brown, silty SAND; wet.						
		SP	Loose, brown, fine SAND; wet.						
70									
		ML	Stiff, brown with orange and gray mottled, fine, sandy SILT; wet.						
		SP	Loose, brown, fine SAND; wet.						
		ML	Stiff, brown with orange and gray mottled, fine, sandy SILT; wet.						
75									056-01
			Total depth drilled = 80 ft bgs.						
80									057-01
85									
90									

BORING METHOD: Direct Push

ELEVATION REFERENCE: NA

BOREHOLE DIAMETER: 2.0 (in)

REMARKS:

DRILL RIG: Geoprobe

GROUND SURFACE ELEVATION: NA

CONTRACTOR: Cascade Drilling

LOGGED BY: L. Glonek, C. Johnson

DRILLING DATES: 08/18/2005 - 08/18/2005

RP - Portland
Stage 1 SCE

0-61M-107030 P69

AMEC
7376 SW Durham Road
Portland, Oregon
USA 97224
Tel (503) 639-3400
Fax (503) 620-7892

amec

LOG OF BORING ARK-06

DEPTH (ft bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	VOLATILE READING (ppm)	GROUNDWATER	GW SCREENED INTERVAL	FIELD TESTING	TESTING AND LABORATORY DATA
0		SP	Medium dense, brown, fine to medium SAND (FILL) with gravel; dry.						001-01
		SP	Asphalt (1/2-inch thick). Brown, fine SAND (FILL) with trace silt; moist.		0.0				
5									002-01
		CL	White, clay-like material (1-inch thick). (FILL)		0.0				
		SP	Medium dense, brown, fine SAND; moist.						003-01
			Becomes wet.			▽			
10					0.0				
					0.0				007-01
15		SP	Medium dense, gray-brown, fine SAND; wet.						
			Becomes moist.		0.0				
20									
					0.0				
		ML	Stiff, gray, fine, sandy SILT; wet.						
25					0.0				008-01
			Becomes moist.						
30					0.0				

BORING METHOD: Direct Push

ELEVATION REFERENCE: NA

BOREHOLE DIAMETER: 2.0 (in)

REMARKS:

DRILL RIG: Geoprobe

GROUND SURFACE ELEVATION: NA

CONTRACTOR: Cascade Drilling

LOGGED BY: L. Glonek, C. Johnson

DRILLING DATES: 08/09/2005 - 08/09/2005

RP - Portland
Stage 1 SCE

0-61M-107030 P69

AMEC
7376 SW Durham Road
Portland, Oregon
USA 97224
Tel (503) 639-3400
Fax (503) 620-7892

amec

LOG OF BORING ARK-07

DEPTH (ft bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	VOLATILE READING (ppm)	GROUNDWATER	GW SCREENED INTERVAL	FIELD TESTING	TESTING AND LABORATORY DATA
30		ML	Stiff, gray, fine, sandy SILT; wet.						004-01
		SP	Medium dense, brown, fine SAND; wet.						
		ML	Medium stiff, brown, fine, sandy SILT; wet.		0.0				
35		SP	Medium dense, brown, fine SAND; wet.						
		ML	Medium stiff, grayish-brown, fine, sandy SILT; wet.		0.0				
		ML	Stiff, grayish-brown SILT with trace fine sand; moist.						
40		SP	Medium dense, brown, fine SAND; wet.		0.0				
		SP	Medium dense, brown with orange mottled, silty SAND; wet.						
		SP	Medium dense, grayish-brown, fine SAND; wet.		0.0				
		ML	Medium stiff, gray, sandy SILT; moist.						005-01
		ML	Medium stiff, brown, fine, sandy SILT; wet.						
45			Total depth drilled = 45 ft bgs due to direct push refusal.						006-01
50									
55									
60									

BORING METHOD: Direct Push

ELEVATION REFERENCE: NA

BOREHOLE DIAMETER: 2.0 (in)

REMARKS:

DRILL RIG: Geoprobe

GROUND SURFACE ELEVATION: NA

CONTRACTOR: Cascade Drilling

LOGGED BY: L. Glonek, C. Johnson

DRILLING DATES: 08/09/2005 - 08/09/2005

RP - Portland
Stage 1 SCE

0-61M-107030 P69

AMEC
7376 SW Durham Road
Portland, Oregon
USA 97224
Tel (503) 639-3400
Fax (503) 620-7892

amec

LOG OF BORING ARK-07

DEPTH (ft bgs)	USCS SYMBOL	SOIL DESCRIPTION	VOLATILE READING (ppm)	TESTING AND LABORATORY DATA
0	GP	Medium dense, brown, fine, sandy GRAVEL (FILL); moist.	0.0	009-01
	SP	Medium dense, brown, fine SAND; moist.		
5			0.0	010-01
	ML	Medium stiff, brown, fine, sandy SILT; moist.		
	SP	Medium dense, brown, fine SAND; moist.	0.0	
10			0.0	011-01
			0.0	
		Becomes wet.		012-01
				016-01
15	ML	Dark gray, fine, sandy SILT; wet.		013-01
		Grades to gray.	0.0	
20	ML	Medium stiff to stiff, brownish-gray, fine, sandy SILT; moist to wet.	0.0	
25	SM	Loose to medium dense, brownish-gray, silty, fine SAND; wet.	0.0	
	ML	Medium stiff, brownish-gray, fine, sandy SILT; wet.		
	SP	Loose, brown, fine SAND with silt; wet.	0.0	
30				

BORING METHOD: Direct Push

ELEVATION REFERENCE: NA

BOREHOLE DIAMETER: 2.0 (in)

REMARKS:

DRILL RIG: Geoprobe

GROUND SURFACE ELEVATION: NA

CONTRACTOR: Cascade Drilling

LOGGED BY: L. Glonek, C. Johnson

DRILLING DATES: 08/10/2005 - 08/10/2005

RP - Portland
Stage 1 SCE

0-61M-107030 P69

AMEC
7376 SW Durham Road
Portland, Oregon
USA 97224
Tel (503) 639-3400
Fax (503) 620-7892

LOG OF BORING ARK-08

DIRECT PUSH BORING (MULTIPLE SCREENS) 0-61M-107030-P69.GPJ AMEC PORTLAND.GDT 2/7/06

DEPTH (ft bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	VOLATILE READING (ppm)	GROUNDWATER	GW SCREENED INTERVAL	FIELD TESTING	TESTING AND LABORATORY DATA
30		SP	Loose, brown, fine SAND with silt; wet.						
		SM	Medium dense, grayish-brown, silty, fine SAND; wet.						
		SP	Medium dense, grayish-brown, fine SAND with silt; wet.		0.0				
35		SM	Medium dense, grayish-brown, silty, fine SAND; wet.						
		SP	Loose, brown, fine SAND with trace silt; wet.		0.0				
40		SM	Medium dense, brown, silty, fine SAND; wet.						
		SP	Medium dense, brown, fine SAND with silt; wet.		0.0				
		SM	Medium dense, brown, silty, fine SAND; wet.						014-01
		GP	Brown, silty, fine SAND with angular gravel. Total depth drilled = 43.5 ft bgs due to direct push refusal.						015-01
45									
50									
55									
60									

BORING METHOD: Direct Push
ELEVATION REFERENCE: NA
BOREHOLE DIAMETER: 2.0 (in)
REMARKS:
DRILL RIG: Geoprobe
GROUND SURFACE ELEVATION: NA
CONTRACTOR: Cascade Drilling
LOGGED BY: L. Glonek, C. Johnson
DRILLING DATES: 08/10/2005 - 08/10/2005

RP - Portland
Stage 1 SCE

0-61M-107030 P69

AMEC
7376 SW Durham Road
Portland, Oregon
USA 97224
Tel (503) 639-3400
Fax (503) 620-7892

LOG OF BORING ARK-08

DIRECT PUSH BORING (MULTIPLE SCREENS) 0-61M-107030-P69.GPJ AMEC PORTLAND.GDT 2/7/06

DEPTH (ft bgs)	USCS SYMBOL	SOIL DESCRIPTION	VOLATILE READING (ppm)	TESTING AND LABORATORY DATA
0	SM	Medium dense, brown, silty SAND (FILL) with angular gravel; dry.		017-01
	SP	Asphalt debris. (FILL)		
		Medium dense, brown, fine SAND (FILL); moist.	0.0	
5			0.0	018-01
10			0.0	
		Becomes wet.		019-01
	SP	Medium dense, brown, fine SAND (FILL) with subangular gravel; wet.	0.0	
	SP	Medium dense, gray, fine SAND (FILL) with subangular gravel; wet.		020-01 & 027-01 (15-16)
15	ML	Medium stiff, gray SILT; wet.		023-01
	SP	Medium dense, gray, fine SAND; wet.	0.0	
20	ML	Medium stiff, gray, sandy SILT; wet.		
	ML	Stiff, gray, sandy SILT; wet.	0.0	
	ML	Stiff, gray with orange mottled SILT, trace organics; wet. Organic-like odor.		
25	SM	Loose, gray with orange mottled, silty SAND, trace organics. Organic-like odor.	0.0	
	ML	Stiff, gray SILT with trace organics; wet. Organic-like odor.		
	SP	Loose, gray-brown SAND; wet.		
	ML	Stiff, gray with orange mottled SILT, trace organics; wet.		
30	SP	Loose, gray with orange mottled, fine SAND; wet.		

GRAPHIC LOG | SAMPLE | GROUNDWATER | GW SCREENED INTERVAL | FIELD TESTING

BORING METHOD: Direct Push
ELEVATION REFERENCE: NA
BOREHOLE DIAMETER: 2.0 (in)
REMARKS:
DRILL RIG: Geoprobe
GROUND SURFACE ELEVATION: NA
CONTRACTOR: Cascade Drilling
LOGGED BY: L. Glonek, C. Johnson
DRILLING DATES: 08/11/2005 - 08/11/2005

RP - Portland
Stage 1 SCE

0-61M-107030 P69

AMEC
7376 SW Durham Road
Portland, Oregon
USA 97224
Tel (503) 639-3400
Fax (503) 620-7892

amec

LOG OF BORING ARK-09

DIRECT PUSH BORING (MULTIPLE SCREENS) 0-61M-107030-P69.GPJ AMEC PORTLAND.GDT 2/7/06

DEPTH (ft bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	VOLATILE READING (ppm)	GROUNDWATER	GW SCREENED INTERVAL	FIELD TESTING	TESTING AND LABORATORY DATA
30		SM	Medium dense, gray, silty SAND; wet.		0.0				
					0.0				
		ML	Stiff, gray SILT with trace organics; wet.						
35									025-01
					0.0				
									021-01
40									
		ML	Stiff, brown SILT with trace organics; wet.		0.0				
45		SM	Medium dense, brown, silty, fine SAND; wet.						
					0.0				
		SP	Dense, brown, fine SAND with silt; wet.						
		ML	Medium stiff, brown SILT with sand; wet.						
50					0.0				
		SP	Medium dense, brown SAND with silt; wet.						
		SP	Loose, brown, fine SAND; wet.						
55					0.0				
									026-01
		ML	Stiff, brown SILT; wet.						
		SP	Loose, brown, fine SAND; wet.						
					0.0				
		ML	Stiff, brown SILT; wet.						
60		SP	Loose, brown, fine SAND; wet.						

BORING METHOD: Direct Push

ELEVATION REFERENCE: NA

BOREHOLE DIAMETER: 2.0 (in)

REMARKS:

DRILL RIG: Geoprobe

GROUND SURFACE ELEVATION: NA

CONTRACTOR: Cascade Drilling

LOGGED BY: L. Glonek, C. Johnson

DRILLING DATES: 08/11/2005 - 08/11/2005

RP - Portland
Stage 1 SCE

0-61M-107030 P69

AMEC
7376 SW Durham Road
Portland, Oregon
USA 97224
Tel (503) 639-3400
Fax (503) 620-7892

amec

LOG OF BORING ARK-09

DEPTH (ft bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	VOLATILE READING (ppm)	GROUNDWATER	GW SCREENED INTERVAL	FIELD TESTING	TESTING AND LABORATORY DATA
60		SP	Medium dense, brown, fine SAND; wet.		0.0				
		SM	Medium dense, brown, silty, fine SAND; wet.						
65					0.0				
		ML	Stiff, brown, sandy SILT; wet.						
					0.0				
70									
					0.0				
75									
		SM	Medium dense, grayish-brown, silty, fine SAND; wet.		0.0				
80									
					0.0				
		ML	Stiff, brown SILT; wet. Total depth drilled = 84 ft bgs, direct push rods broke.						022-01
85									
90									

BORING METHOD: Direct Push

ELEVATION REFERENCE: NA

BOREHOLE DIAMETER: 2.0 (in)

REMARKS:

DRILL RIG: Geoprobe

GROUND SURFACE ELEVATION: NA

CONTRACTOR: Cascade Drilling

LOGGED BY: L. Glonek, C. Johnson

DRILLING DATES: 08/11/2005 - 08/11/2005

RP - Portland
Stage 1 SCE

0-61M-107030 P69

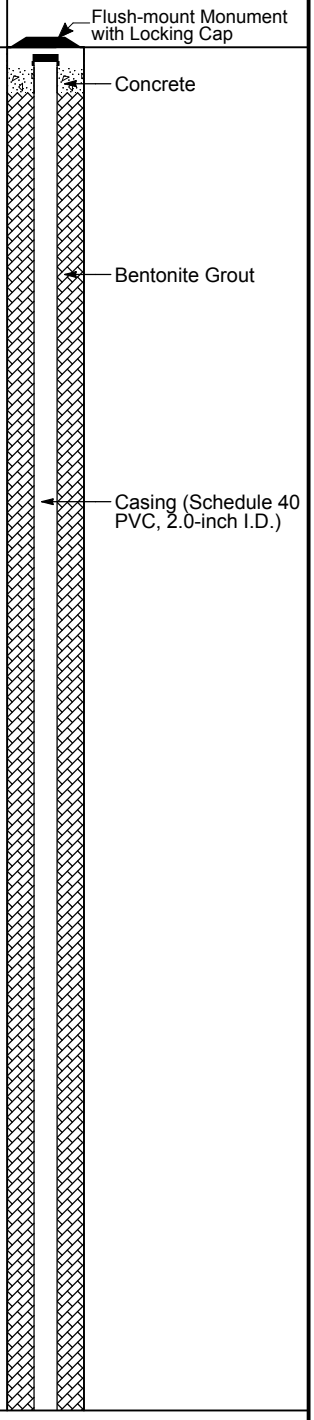
AMEC
7376 SW Durham Road
Portland, Oregon
USA 97224
Tel (503) 639-3400
Fax (503) 620-7892

amec

LOG OF BORING ARK-09

DEPTH (ft bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	BLOW COUNT SPT N VALUE	VOLATILE READING (ppm)	GROUNDWATER	FIELD AND LABORATORY TESTING
0		PCC	Construction debris, crushed concrete with rebar. (FILL)					
		SP	Medium dense, brown, fine SAND (FILL) with gravel; dry.			0.0		
5		SP	Medium dense, brown, fine SAND; dry to moist.			0.0		
10		SP	Medium dense, gray, fine SAND with trace silt; wet.			0.0		
15								
20								
25						0.0		
30								

WELL SCHEMATIC



BORING METHOD: Sonic

BOREHOLE DIAMETER: 6.0 (in)

DRILL RIG: Sonic

CONTRACTOR: Cascade Drilling

LOGGED BY: C. Johnson

ELEVATION REFERENCE: NA

GROUND SURFACE ELEVATION: NA

CASING ELEVATION: NA

START CARD/TAG ID: 176811/80946

DRILLING DATES: 09/19/2005 - 09/19/2005

REMARKS:
Three bollards surround flush-mount monument.

RP - Portland
Stage 1 SCE

0-61M-107030 P69

AMEC
7376 SW Durham Road
Portland, Oregon
USA 97224
Tel (503) 639-3400
Fax (503) 620-7892

LOG OF BORING RP-09-64

ENVR+WELL BORING 0-61M-107030-P69.GPJ AMEC PORTLAND.GDT 2/7/06

DEPTH (ft bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	BLOW COUNT SPT N VALUE	VOLATILE READING (ppm)	GROUNDWATER	FIELD AND LABORATORY TESTING	WELL SCHEMATIC
30		SP							Bentonite Grout; Casing (Schedule 40 PVC, 2.0-inch I.D.)
35									
		SP	Medium dense, brown, fine SAND; wet.						
40						0.0			
		SM	Medium dense, brown, silty, fine SAND; wet.						
45									
		SP	Medium dense, brown, fine SAND; wet.						
		GP	Becomes dark orange at 49 ft bgs. Gray, fine, sandy, slightly weathered, basalt GRAVEL with cobbles and silt; wet.						
50			Basalt cobble or boulder, slightly weathered, minor vesicles (< 2 mm), aphanitic between 51.5 to 52.5 ft bgs.						Bentonite Chips
55			Basalt cobble or boulder, moderately weathered, highly vesicular (up to 1/2-inch diameter), aphanitic, minor recrystalization in vesicles between 54 to 55 ft bgs.						10/20 Colorado Silica Sand
			Basalt cobble or boulder, slightly weathered, minor vesicles (< 5 mm), aphanitic between 57 to 58 ft bgs.						Well Screen
60									

BORING METHOD: Sonic
BOREHOLE DIAMETER: 6.0 (in)
DRILL RIG: Sonic
CONTRACTOR: Cascade Drilling
LOGGED BY: C. Johnson

ELEVATION REFERENCE: NA
GROUND SURFACE ELEVATION: NA
CASING ELEVATION: NA
START CARD/TAG ID: 176811/80946
DRILLING DATES: 09/19/2005 - 09/19/2005

REMARKS:
Three bollards surround flush-mount monument.

DEPTH (ft bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	BLOW COUNT SPT N VALUE	VOLATILE READING (ppm)	GROUNDWATER	FIELD AND LABORATORY TESTING	WELL SCHEMATIC
60		GP	Grades to dark gray.						Well Screen (Schedule 40 PVC, 2.0-inch I.D. with 0.010-inch slot size); 10/20 Colorado Silica Sand; Threaded End Cap
65			Total depth drilled = 66 ft bgs.						
70									
75									
80									
85									
90									

BORING METHOD: Sonic

BOREHOLE DIAMETER: 6.0 (in)

DRILL RIG: Sonic

CONTRACTOR: Cascade Drilling

LOGGED BY: C. Johnson

ELEVATION REFERENCE: NA

GROUND SURFACE ELEVATION: NA

CASING ELEVATION: NA

START CARD/TAG ID: 176811/80946

DRILLING DATES: 09/19/2005 - 09/19/2005

REMARKS:
Three bollards surround flush-mount monument.

RP - Portland
Stage 1 SCE

0-61M-107030 P69

AMEC
7376 SW Durham Road
Portland, Oregon
USA 97224
Tel (503) 639-3400
Fax (503) 620-7892

amec

LOG OF BORING RP-09-64

ENVR+WELL BORING 0-61M-107030-P69.GPJ AMEC PORTLAND.GDT 2/7/06

EXHIBIT 3

FORMER ARKEMA, INC. FACILITY
NPDES PERMIT

Oregon
Theodore R. Kulongoski, Governor

Department of Environmental Quality
Northwest Region Portland Office
2020 SW 4th Avenue, Suite 400
Portland, OR 97201-4987
(503) 229-5263
FAX (503) 229-6945
TTY (503) 229-5471

18 November 2004

John Burkhart
Arkema, Inc
6400 NW Front Ave
Portland, OR 97210

Re: Permit Transfer
File Number: 68471
Permit Number: 100752
Multnomah County

Dear Mr. Burkhart:

We have received your application for name change of NPDES Permit #100752 from Atofina Chemicals, Inc to Arkema Inc. along with the appropriate fee and are enclosing a copy of the permit. The Department considers the transfer to be effective 18 November 2004

We ask that you read the permit carefully and comply with all the conditions and requirements.

Should you have any questions please contact Elliot Zais in our Northwest Region Office at (503) 229-5292

Sincerely,

Neil Mullane
Administrator, Water Quality Program
Northwest Region Office

cjp
Enclosure

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM WASTE DISCHARGE PERMIT

Oregon Department of Environmental Quality
Northwest Region Office
2020 SW 4th Avenue, Suite 400, Portland, OR 97201
Telephone: (503) 229-5263

Issued pursuant to ORS 468B.050 and the Federal Clean Water Act

ISSUED TO:

Permittee:

Arkema, Inc.
6400 NW Front Avenue
Portland, OR 97210

SOURCES COVERED BY THIS PERMIT:

Type of Waste	Outfall Number	Outfall Location
Storm Water	001	R.M. 7.4
Storm Water	002	R.M. 7.4
Storm Water	003	R.M. 7.3
Storm Water	004	R.M. 7.3

PLANT TYPE AND LOCATION:

Former Chemical Manufacturing Facility
6400 NW Front Avenue
Portland, Oregon

RECEIVING STREAM INFORMATION:

Basin: Willamette
Sub-Basin: Lower Willamette
Receiving Stream: Willamette River
Hydro Code: 22=-WILL 7.4D
LLID: 1227618456580/7.4
County: Multnomah

EPA REFERENCE NO : OR 000159-7

This permit is issued in response to Renewal Application No. 992858 received November 29, 1995. Updated information submitted on August 21, 2003.

Neil Mullane
Manager, Water Quality Source Control
Northwest Region

11/18/02
Date

Permitted Activities

Until this permit expires or is modified or revoked, the permittee is authorized to construct, install, modify or operate a wastewater collection, treatment, control and disposal system and discharge to public waters adequately treated wastewaters only from the authorized discharge point or points established in Schedule A and only in conformance with all the requirements, limitations, and conditions set forth in the attached schedules as follows:

	Page
Schedule A - Waste Discharge Limitations	3-6
Schedule B - Monitoring and Reporting Requirements	7-8
Schedule C - Compliance Conditions and Schedules	9
Schedule D - Special Conditions	10
Schedule E – Industrial Pretreatment	Not Applicable
Schedule F - General Conditions	11-20

Unless specifically authorized by this permit, by another NPDES or WPCF permit, or by Oregon Administrative Rule, any other direct or indirect discharge to waters of the state is prohibited, including discharge to an underground injection control system.

Schedule A
Waste Discharge Limitations

1. **Preparation and Implementation of the Storm Water Pollution Control Plan (SWPCP)**
The permittee must prepare and implement the SWPCP according to the following:
   a. The SWPCP must be prepared according to the requirements in Schedule A.2 by a person knowledgeable in storm water management and familiar with the facility. The person(s) preparing the plan must be identified in the plan.
   b. The SWPCP must be signed in accordance with 40 CFR §122.22. Updates and revisions to the SWPCP must also be signed and certified pursuant to 40 CFR §122.22.
   c. The SWPCP must be prepared and implemented according to the time frames set forth in Schedule C.
   d. The SWPCP must be kept current and updated as necessary to reflect any changes in facility operation.
   e. The SWPCP and updates to the SWPCP must be submitted to the Department in accordance with Schedule C.
   f. A copy of the SWPCP must be kept at the facility and made available upon request to government agencies responsible for storm water management in the permittee's area.

2. **Storm Water Pollution Control Plan Requirements**
   a) **Site Description.** The SWPCP must contain the following information:
      i) A description of the industrial activities conducted at the site. Include a description of the significant materials (see Schedule D.3, Definitions) that are stored, used, treated and/or disposed of in a manner that allows exposure to storm water. Also describe the methods of storage, usage, treatment and/or disposal.
      ii) A general location map showing the location of the site in relation to surrounding properties, transportation routes, surface waters and other relevant features.
      iii) A site map including the following:
         (1) drainage patterns
         (2) drainage and discharge structures
         (3) outline of the drainage area for each storm water outfall
         (4) paved areas and buildings within each drainage area
         (5) areas used for outdoor manufacturing, treatment, storage, and/or disposal of significant materials
         (6) existing structural control measures for reducing pollutants in storm water runoff
         (7) material loading and access areas
         (8) hazardous waste treatment, storage and disposal facilities
         (9) location of wells including waste injection wells, seepage pits, drywells, etc.
         (10) location of springs, wetlands and other surface water bodies.
      iv) Estimates of the amount of impervious surface area (including paved areas and building roofs) relative to the total area drained by each storm water outfall.
      v) For each area of the site where a reasonable potential exists for contributing pollutants to storm water runoff, identify the potential pollutants that could be present in storm water discharges.
      vi) The name(s) of the receiving water(s) for storm water drainage. If drainage is to a municipal storm sewer system, the name(s) of the ultimate receiving waters and the name of the municipality.
      vii) Identification of the discharge outfall(s) and the point(s) where storm water monitoring will occur as required by Schedule B. If multiple discharge outfalls exist but will not all

be monitored (as allowed in Schedule B.1), a description supporting this approach must also be included.

b) **Site Controls.** The permittee must maintain existing controls and/or develop new controls appropriate for the site. The purpose of these controls is to eliminate or minimize the exposure of pollutants to storm water. In developing a control strategy, the SWPCP must have the following minimum components. A description of each component must be included in the SWPCP.

i) *Storm Water Best Management Practices.* If technically and economically feasible, the following best management practices must be employed at the site. A schedule for implementation of these practices must be included in the SWPCP if the practice has not already been accomplished. This schedule must be consistent with the requirements for developing and implementing the SWPCP in Schedule C of the permit.

(1) Containment - All hazardous substances (see Schedule D.3, Definitions) must be stored within berms or other secondary containment devices to prevent leaks and spills from contaminating storm water. If the use of berms or secondary containment devices is not possible, then hazardous substances must be stored in areas that do not drain to the storm sewer system.

(2) Oil and Grease - Oil/Water separators, booms, skimmers or other methods must be employed to eliminate or minimize oil and grease contamination of storm water discharges.

(3) Waste Chemicals and Material Disposal - Wastes must be recycled or properly disposed of in a manner to eliminate or minimize exposure of pollutants to storm water. All waste contained in bins or dumpsters where there is a potential for drainage of storm water through the waste must be covered to prevent exposure of storm water to these pollutants. Acceptable covers include, but are not limited to, storage of bins or dumpsters under roofed areas and use of lids or temporary covers such as tarps.

(4) Erosion and Sediment Control - Erosion control methods such as vegetating exposed areas, graveling or paving must be employed to minimize erosion of soil at the site. Sediment control methods such as detention facilities, sediment control fences, vegetated filter strips, bioswales, or grassy swales must be employed to minimize sediment loads in storm water discharges. For activities that involve land disturbance, the permittee must contact the local municipality to determine if there are other applicable requirements.

(5) Debris Control - Screens, booms, settling ponds, or other methods must be employed to eliminate or minimize debris in storm water discharges.

(6) Storm Water Diversion - Storm water must be diverted away from fueling, manufacturing, treatment, storage, and disposal areas to prevent exposure of uncontaminated storm water to potential pollutants.

(7) Covering Activities - Fueling, manufacturing, treatment, storage, and disposal areas must be covered to prevent exposure of storm water to potential pollutants. Acceptable covers include, but are not limited to, permanent structures such as roofs or buildings and temporary covers such as tarps.

(8) Housekeeping - Areas that may contribute pollutants to storm water must be kept clean. Sweeping, prompt clean up of spills and leaks, and proper maintenance of vehicles must be employed to eliminate or minimize exposure of storm water to pollutants.

ii) *Spill Prevention and Response Procedures.* Methods to prevent spills along with clean-up and notification procedures must be included in the SWPCP. These methods and procedures must be made available to appropriate personnel. The required clean up

material must be on-site or readily available. Spills prevention plans required by other regulations may be substituted for this provision providing that storm water management concerns are adequately addressed.

iii) *Preventative Maintenance.* A preventative maintenance program must be implemented to ensure the effective operation of all storm water best management practices. At a minimum the program must include:

(1) Monthly inspections of areas where potential spills of significant materials or industrial activities could impact storm water runoff.

(2) Monthly inspections of storm water control measures, structures, catch basins, and treatment facilities.

(3) Cleaning, maintenance and/or repair of all materials handling and storage areas and all storm water control measures, structures, catch basins, and treatment facilities as needed upon discovery. Cleaning, maintenance, and repair of such systems must be performed in such a manner as to prevent the discharge of pollution.

iv) *Employee Education.* An employee orientation and education program must be developed and maintained to inform personnel of the components and goals of the SWPCP. The program must also address spill response procedures and the necessity of good housekeeping practices. A schedule for employee education must be included in the SWPCP. The Department recommends this education and training occur at the time of an employee's hire and annually thereafter.

c) **Record Keeping and Internal Reporting Procedures.** The following information must be recorded and maintained at the facility and provided to the Department and other government agencies upon request. This information does not need to be submitted as part of the SWPCP.

i) Inspection, maintenance, repair and education activities as required by the SWPCP.

ii) Spills or leaks of significant materials that impacted or had the potential to impact storm water or surface waters. Include the corrective actions to clean up the spill or leak as well as measures to prevent future problems of the same nature.

3. **Oregon Administrative Rule 340-041-0026(3)(a)(D), Surface Water Temperature Management Plan** The discharge of storm water is not expected to cause a measurable increase in stream temperature because the discharges mainly occur at a time of year when ambient stream and runoff temperatures are relatively low. Compliance with this permit meets the requirement of OAR 340-041-0026(3)(a)(D) to develop and implement a surface water temperature management plan. If permitted storm water discharges in a particular basin are assigned waste load allocations under a Total Maximum Daily Load for temperature, then permittees in this basin will be required to implement additional management practices to reduce the temperature of the discharges. These practices include, but are not limited to, increased vegetation to provide for shading, underground conveyance systems or detention vaults, and filter treatment systems to reduce detention times.

4. **Storm Water Discharge Benchmarks for Outfalls 001, 002, 003, and 004**
Benchmarks are guideline concentrations not limitations. They are designed to assist the permittee in determining if the implementation of their SWPCP is reducing pollutant concentrations to below levels of concern. The following benchmarks apply to each point source discharge of storm water associated with industrial activity:

Parameter	Benchmark
Oil & Grease	10 mg/L
Copper	0.1 mg/L
Lead	0.4 mg/L
Zinc	0.6 mg/L
pH	5.5 – 9.0 S.U.
Total Suspended Solids	130 mg/L
Floating solids (associated with industrial activity)	No Visible Discharge
Oil & Grease Sheen	No Visible Sheen

5. **Review of SWPCP.** If benchmarks are not achieved, the permittee must investigate the source of the elevated pollutant levels and review and, if necessary, revise the SWPCP within 60 days of receiving sampling results. The purpose of this review is to determine if the SWPCP is being followed and to identify any additional technically and economically feasible site controls that need to be implemented to further improve the quality of storm water discharges. These site controls include best management practices, spill prevention and response procedures, preventative maintenance, and employee education procedures.
   a. **SWPCP Revision.** Any newly identified site controls must be implemented in a timely manner and incorporated into the SWPCP as an update. A new SWPCP is not required. If no additional site controls are identified, the permittee must state as such in an update to the SWPCP.
   b. **SWPCP Revision Submittal.** Results of this review must be submitted to the Department and made available upon request to government agencies responsible for storm water management in the permittee's area. The permittee must submit any revisions to the SWPCP within 14 days after the SWPCP is revised. If the Department does not review and comment on the revised SWPCP within 30 days, the permittee must implement the revisions as proposed. The permittee may proceed immediately with implementation of the following management practices as described in Schedule A.2.b without waiting for Department comment: waste chemical and materials disposal, debris control, storm water diversion, covering activities, housekeeping, and preventative maintenance.
   c. **Background or Natural Conditions.** If the permittee demonstrates that background or natural conditions not associated with industrial activities at the site cause an exceedance of a benchmark, then no further modifications to the SWPCP are required for that parameter. Upon successful demonstration of natural or background conditions through monitoring of the same storm event used to evaluate benchmarks the permittee would be eligible for the monitoring reduction as outlined in Schedule B.

6. **Water Quality Standards**
   Except as provided for in Oregon Administrative Rule (OAR) 340-045-0080, no wastes may be discharged and no activities may be conducted that violate Water Quality Standards as adopted in OAR 340-041-0445 except in the defined mixing zone:

   Outfalls 001, 002, 003 and 004: The mixing zone is that portion of the Willamette River within a 25-foot radius from the point of discharge. The Zone of Immediate Dilution (ZID) is that portion of the Willamette River within a radius of 2.5 feet from the point of discharge.

Schedule B
Monitoring and Reporting Requirements

1. **Monitoring Requirements**

a) **Outfalls 001, 002, 003 and 004: Storm Water Discharge to Willamette River**

Parameter[1]	Minimum Frequency [2,3]	Sample Type
Oil & Grease	1/quarter	Grab
Copper	1/quarter	Grab
Lead	1/quarter	Grab
Zinc	1/quarter	Grab
pH	1/quarter	Grab
Total Suspended Solids	1/quarter	Grab
Floating solids	1/month	Grab
Oil & Grease Sheen	1/month	Grab

[1] Parameters must be analyzed on samples collected from the same storm event.
[2] Monitoring is required when rainfall is sufficient to generate runoff.
[3] The permittee may apply for and receive Department approval for reduced monitoring if one year of sampling shows that the discharge is consistently meeting effluent limits in Schedule A of the NPDES permit. If substantive alterations to the facility are expected, the permittee will not be eligible for the reduction in monitoring.

b) **Multiple Point Source Discharges.** The permittee may reduce the number of storm water monitoring points provided the outfalls have substantially identical effluents. Substantially identical effluents are discharges from drainage areas serving similar activities where the discharges are expected to be similar in composition. Outfalls serving areas with no exposure of storm water to industrial activities are not required to be monitored.

c) **Reinstatement of Monitoring Requirements**

i) The permittee must conduct monitoring as specified in Schedule B.1.a if changes to site conditions are expected to affect storm water discharge characteristics.

ii) The Department may reinstate monitoring requirements as specified in Schedule B.1.a if prior monitoring efforts were improper or results were incorrect. The Department will notify the permittee of reinstatement in writing.

iii) Monitoring may also be reinstated if future sampling efforts by the permittee or the Department indicate benchmarks are being exceeded.

2. **Reporting Requirements**

a) **Reporting Frequency.** Monitoring results must be reported on approved forms. Reports must be submitted to the Department's Northwest Region – Portland Office by the 15th day of the following month.

b) The permittee must monitor the parameters as specified below at the locations indicated. The laboratory used by the permittee to analyze samples must have a quality assurance/quality control (QA/QC) program to verify the accuracy of sample analysis. If

QA/QC requirements are not met for any analysis, the results must be included in the report, but not used in the calculations required by this permit. When possible, the permittee must re-sample in a timely manner for parameters failing QA/QC requirements, analyze samples, and report results.

c) **Reporting of Non-Detect Sample Results.** For all pollutants, if a value is less than the permit limit and less than the "minimum quantitative level (MQL)", the permittee shall report Non-Detect "ND (detection level in mg/L)" for the parameter. For example, if the MQL for a pollutant is 10 µg/L and the value of the analytical result is below the MQL, the permittee shall report ND (0.010)" in the Discharge Monitoring Report.

d) **Monitoring Records Prepared in Ink.** All bench sheets, laboratory analysis sheets, and other records to support the data reported on the Discharge Monitoring Report (DMR) shall be prepared in ink. Pencil entries or *liquid paper* corrections shall be prohibited by appropriate laboratory operating procedures. Changes to any supporting records that may be required to correct the original data shall be made by lining through the original data. The date of the change and the initials of the individual making the change shall be recorded in ink adjacent to the change.

Schedule C
Compliance Conditions and Schedules

1. **Storm Water Pollution Control Plan (SWPCP) Submittal and Implementation.**
   a. Within 3 months of permit issuance, the permittee must prepare and submit a SWPCP. Except for site controls that require capital improvements (see Schedule D.3, Definitions), the permittee must implement the SWPCP within 6 months of permit issuance. The elements of the SWPCP are specified in Schedule A of the NPDES Permit.
   b. At least thirty (30) days prior to conducting activities that would result in soil disturbance at the facility, the permittee must update the SWPCP to include an erosion and sediment control component. The updated SWPCP must ensure that proper measures are implemented to control legacy contaminants (see Schedule C.2). The permittee must implement necessary erosion and sediment control measures to control the discharge of legacy contaminants before proceeding with activities that would result in soil disturbance.
   c. All other updates to the SWPCP must be submitted to the Department within 14 days after completion.

2. **Storm Water Characterization for Legacy and 303(d) Pollutants**. The permittee is required to conduct monitoring for the following legacy and 303(d) pollutants to determine whether they are of concern in the storm water discharge: total dissolved solids, iron, manganese, mercury, hexavalent chromium, DDT, DDT metabolites (DDD and DDE), PAHs, PCBs, chlorobenzene, pentachlorophenol, perchlorate and chloride. Monitoring is required for the above-referenced pollutants once per month at each outfall for a one year period. Monitoring is required during those months when rainfall generates runoff. The results of the monitoring will be submitted quarterly to the DEQ Cleanup Project Manager as part of the Quarterly Progress Report for the facility remedial investigation and feasibility study. A report summarizing the one year monitoring is to be submitted to the Department within fourteen (14) months after permit issuance date. If the monitoring indicates that the discharge has a potential to violate water quality standards for the legacy pollutants or 303(d) pollutants, the Department will notify the permittee and require that the permittee to submit appropriate fees to modify the permit to include effluent limits and/or implementation of additional controls.

3. The permittee is expected to meet the compliance dates that have been established in this schedule. Either prior to or no later than 14 days following any lapsed compliance date, the permittee must submit to the Department a notice of compliance or noncompliance with the established schedule. The Director may revise a schedule of compliance if he determines good and valid cause resulting from events over which the permittee has little or no control.

Schedule D
Specific Conditions

1. **Re-opening of Permit**
This permit may be reopened for the inclusion of additional limitations, monitoring requirements, or both. Upon completion of the Total Maximum Daily Load for the Willamette River, and the assignment of a Waste Load Allocation (WLA) to the Permittee, the WLA shall be incorporated into this permit, or subsequent permit renewal. Additional monitoring requirements may also be identified at the completion of the Remedial Investigation Report for the DEQ Cleanup Program, or the Record of Decision.

2. **Environmental Supervision and Management**
The permittee shall designate an environmental supervisor to coordinate and carry out all necessary functions related to maintenance and operation of waste collection, treatment, and disposal facilities. This person shall be allowed access to all information relevant to the generation of wastes in the various process areas.

3. **Definitions**
   a. *Capital Improvements* means the following improvements that require capital expenditures:
      i. Treatment best management practices including but not limited to settling basins, oil/water separation equipment, catch basins, grassy swales, detention/retention basins, and media filtration devices.
      ii. Manufacturing modifications that incur capital expenditures, including process changes for reduction of pollutants or wastes at the source.
      iii. Concrete pads, dikes and conveyance or pumping systems utilized for collection and transfer of storm water to treatment systems.
      iv. Roofs and appropriate covers for manufacturing areas.

   b. *Hazardous Substances* as defined in 40 CFR §302 Designation, Reportable Quantities, and Notification.

   c. *Material Handling Activities* include the storage, loading and unloading, transportation or conveyance of raw material, intermediate product, finished product, by-product or waste product.

   d. *Point Source* means a discharge from any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, or conduit.

   e. *Significant Materials* includes, but is not limited to: raw materials; fuels; materials such as solvents, detergents, and plastic pellets; finished materials such as metallic products; raw materials used in food processing or production; hazardous substances designated under section 101(14) of CERCLA; any chemical that a facility is required to report pursuant to section 313 of title III of SARA; fertilizers; pesticides; and waste products such as ash, slag, and sludge that have the potential to be released with storm water discharges.

4. **Availability of SWPCP and Monitoring Data.** The Storm Water Pollution Control Plan and/or storm water monitoring data must be made available to government agencies responsible for storm water management in the permittee's area.

Schedule F
General Conditions

SECTION A. STANDARD CONDITIONS

1. Duty to Comply

The permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of Oregon Revised Statutes (ORS) 468B.025 and is grounds for enforcement action; for permit termination, suspension, or modification; or for denial of a permit renewal application.

2. Penalties for Water Pollution and Permit Condition Violations

Oregon Law (ORS 468.140) allows the Director to impose civil penalties up to $10,000 per day for violation of a term, condition, or requirement of a permit.

In addition, a person who unlawfully pollutes water as specified in ORS 468.943 or ORS 468.946 is subject to criminal prosecution.

3. Duty to Mitigate

The permittee shall take all reasonable steps to minimize or prevent any discharge or sludge use or disposal in violation of this permit which has a reasonable likelihood of adversely affecting human health or the environment. In addition, upon request of the Department, the permittee shall correct any adverse impact on the environment or human health resulting from noncompliance with this permit, including such accelerated or additional monitoring as necessary to determine the nature and impact of the noncomplying discharge.

4. Duty to Reapply

If the permittee wishes to continue an activity regulated by this permit after the expiration date of this permit, the permittee must apply for and have the permit renewed. The application shall be submitted at least 180 days before the expiration date of this permit.

The Director may grant permission to submit an application less than 180 days in advance but no later than the permit expiration date.

5. Permit Actions

This permit may be modified, suspended, revoked and reissued, or terminated for cause including, but not limited to, the following:

a. Violation of any term, condition, or requirement of this permit, a rule, or a statute;

b. Obtaining this permit by misrepresentation or failure to disclose fully all material facts; or

c. A change in any condition that requires either a temporary or permanent reduction or elimination of the authorized discharge.

The filing of a request by the permittee for a permit modification or a notification of planned changes or anticipated noncompliance, does not stay any permit condition.

6. Toxic Pollutants

The permittee shall comply with any applicable effluent standards or prohibitions established under Section 307(a) of the Clean Water Act for toxic pollutants within the time provided in the regulations that establish those standards or prohibitions, even if the permit has not yet been modified to incorporate the requirement.

7. Property Rights

The issuance of this permit does not convey any property rights of any sort, or any exclusive privilege.

8. Permit References

Except for effluent standards or prohibitions established under Section 307(a) of the Clean Water Act for toxic pollutants and standards for sewage sludge use or disposal established under Section 405(d) of the Clean Water Act, all rules and statutes referred to in this permit are those in effect on the date this permit is issued.

SECTION B. OPERATION AND MAINTENANCE OF POLLUTION CONTROLS

1. Proper Operation and Maintenance

The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of this permit. Proper operation and maintenance also includes adequate laboratory controls, and appropriate quality assurance procedures. This provision requires the operation of back-up or auxiliary facilities or similar systems that are installed by a permittee only when the operation is necessary to achieve compliance with the conditions of the permit.

2. Duty to Halt or Reduce Activity

For industrial or commercial facilities, upon reduction, loss, or failure of the treatment facility, the permittee shall, to the extent necessary to maintain compliance with its permit, control production or all discharges or both until the facility is restored or an alternative method of treatment is provided. This requirement applies, for example, when the primary source of power of the treatment facility fails or is reduced or lost. It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

3. Bypass of Treatment Facilities

a. Definitions

(1) "Bypass" means intentional diversion of waste streams from any portion of the treatment facility. The term "bypass" does not include nonuse of singular or multiple units or processes of a treatment works when the nonuse is insignificant to the quality and/or quantity of the effluent produced by the treatment works. The term "bypass" does not apply if the diversion does not cause effluent limitations to be exceeded, provided the diversion is to allow essential maintenance to assure efficient operation.

(2) "Severe property damage" means substantial physical damage to property, damage to the treatment facilities or treatment processes which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

b. Prohibition of bypass.

(1) Bypass is prohibited unless:

(a) Bypass was necessary to prevent loss of life, personal injury, or severe property damage;

(b) There were no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if adequate backup equipment should have been installed in the exercise of reasonable engineering judgement to prevent a bypass which occurred during normal periods of equipment downtime or preventative maintenance; and

(c) The permittee submitted notices and requests as required under General Condition B.3.c.

(2) The Director may approve an anticipated bypass, after considering its adverse effects and any alternatives to bypassing, when the Director determines that it will meet the three conditions listed above in General Condition B.3.b.(1).

c. Notice and request for bypass.

(1) Anticipated bypass. If the permittee knows in advance of the need for a bypass, it shall submit prior written notice, if possible at least ten days before the date of the bypass.

(2) Unanticipated bypass. The permittee shall submit notice of an unanticipated bypass as required in General Condition D.5.

4. Upset

a. Definition. "Upset" means an exceptional incident in which there is unintentional and temporary noncompliance with technology based permit effluent limitations because of factors beyond the reasonable control of the permittee. An upset does not include noncompliance to the extent caused by operation error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventative maintenance, or careless or improper operation.

b. Effect of an upset. An upset constitutes an affirmative defense to an action brought for noncompliance with such technology based permit effluent limitations if the requirements of General Condition B.4.c are met. No determination made during administrative review of claims that noncompliance was caused by upset, and before an action for noncompliance, is final administrative action subject to judicial review.

c. Conditions necessary for a demonstration of upset. A permittee who wishes to establish the affirmative defense of upset shall demonstrate, through properly signed, contemporaneous operating logs, or other relevant evidence that:

(1) An upset occurred and that the permittee can identify the causes(s) of the upset;

(2) The permitted facility was at the time being properly operated;

(3) The permittee submitted notice of the upset as required in General Condition D.5, hereof (24-hour notice); and

(4) The permittee complied with any remedial measures required under General Condition A.3 hereof.

d. Burden of proof. In any enforcement proceeding the permittee seeking to establish the occurrence of an upset has the burden of proof.

5. Treatment of Single Operational Event

For purposes of this permit, A Single Operational Event which leads to simultaneous violations of more than one pollutant parameter shall be treated as a single violation. A single operational event is an exceptional incident which causes simultaneous, unintentional, unknowing (not the result of a knowing act or omission), temporary noncompliance with more than one Clean Water Act effluent discharge pollutant parameter. A single operational event does not include Clean Water Act violations involving discharge without a NPDES permit or noncompliance to the extent caused by improperly designed or inadequate treatment facilities. Each day of a single operational event is a violation.

6. Overflows from Wastewater Conveyance Systems and Associated Pump Stations

a. Definitions

(1) "Overflow" means the diversion and discharge of waste streams from any portion of the wastewater conveyance system including pump stations, through a designed overflow device or structure, other than discharges to the wastewater treatment facility.

(2) "Severe property damage" means substantial physical damage to property, damage to the conveyance system or pump station which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of an overflow.

(3) "Uncontrolled overflow" means the diversion of waste streams other than through a designed overflow device or structure, for example to overflowing manholes or overflowing into residences, commercial establishments, or industries that may be connected to a conveyance system.

b. Prohibition of overflows. Overflows are prohibited unless:

(1) Overflows were unavoidable to prevent an uncontrolled overflow, loss of life, personal injury, or severe property damage;

(2) There were no feasible alternatives to the overflows, such as the use of auxiliary pumping or conveyance systems, or maximization of conveyance system storage; and

(3) The overflows are the result of an upset as defined in General Condition B.4. and meeting all requirements of this condition.

c. Uncontrolled overflows are prohibited where wastewater is likely to escape or be carried into the waters of the State by any means.

d. Reporting required. Unless otherwise specified in writing by the Department, all overflows and uncontrolled overflows must be reported orally to the Department within 24 hours from the time the permittee becomes aware of the overflow. Reporting procedures are described in more detail in General Condition D.5.

7. Public Notification of Effluent Violation or Overflow

If effluent limitations specified in this permit are exceeded or an overflow occurs, upon request by the Department, the permittee shall take such steps as are necessary to alert the public about the extent and nature of the discharge. Such steps may include, but are not limited to, posting of

the river at access points and other places, news releases, and paid announcements on radio and television.

8. Removed Substances

Solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewaters shall be disposed of in such a manner as to prevent any pollutant from such materials from entering public waters, causing nuisance conditions, or creating a public health hazard.

SECTION C. MONITORING AND RECORDS

1. Representative Sampling

Sampling and measurements taken as required herein shall be representative of the volume and nature of the monitored discharge. All samples shall be taken at the monitoring points specified in this permit and shall be taken, unless otherwise specified, before the effluent joins or is diluted by any other waste stream, body of water, or substance. Monitoring points shall not be changed without notification to and the approval of the Director.

2. Flow Measurements

Appropriate flow measurement devices and methods consistent with accepted scientific practices shall be selected and used to ensure the accuracy and reliability of measurements of the volume of monitored discharges. The devices shall be installed, calibrated and maintained to insure that the accuracy of the measurements is consistent with the accepted capability of that type of device. Devices selected shall be capable of measuring flows with a maximum deviation of less than ± 10 percent from true discharge rates throughout the range of expected discharge volumes.

3. Monitoring Procedures

Monitoring must be conducted according to test procedures approved under 40 CFR Part 136, unless other test procedures have been specified in this permit.

4. Penalties of Tampering

The Clean Water Act provides that any person who falsifies, tampers with, or knowingly renders inaccurate, any monitoring device or method required to be maintained under this permit shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than two years, or by both. If a conviction of a person is for a violation committed after a first conviction of such person, punishment is a fine not more than $20,000 per day of violation, or by imprisonment of not more than four years or both.

5. Reporting of Monitoring Results

Monitoring results shall be summarized each month on a Discharge Monitoring Report form approved by the Department. The reports shall be submitted monthly and are to be mailed, delivered or otherwise transmitted by the 15th day of the following month unless specifically approved otherwise in Schedule B of this permit.

6. Additional Monitoring by the Permittee

If the permittee monitors any pollutant more frequently than required by this permit, using test procedures approved under 40 CFR 136 or as specified in this permit, the results of this monitoring shall be included in the calculation and reporting of the data submitted in the Discharge Monitoring Report. Such increased frequency shall also be indicated. For a pollutant parameter that may be sampled more than once per day (e.g., Total Chlorine Residual), only the average daily value shall be recorded unless otherwise specified in this permit.

7. Averaging of Measurements

Calculations for all limitations which require averaging of measurements shall utilize an arithmetic mean, except for bacteria which shall be averaged as specified in this permit.

8. Retention of Records

Except for records of monitoring information required by this permit related to the permittee's sewage sludge use and disposal activities, which shall be retained for a period of at least five years (or longer as required by 40 CFR part 503), the permittee shall retain records of all monitoring information, including all calibration and maintenance records of all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit, for a period of at least 3 years from the date of the sample, measurement, report or application. This period may be extended by request of the Director at any time.

9. Records Contents

Records of monitoring information shall include:

a. The date, exact place, time and methods of sampling or measurements;

b. The individual(s) who performed the sampling or measurements;

c. The date(s) analyses were performed;

d. The individual(s) who performed the analyses;

e. The analytical techniques or methods used; and

f. The results of such analyses.

10. Inspection and Entry

The permittee shall allow the Director, or an authorized representative upon the presentation of credentials to:

a. Enter upon the permittee's premises where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this permit;

b. Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;

c. Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit, and

d. Sample or monitor at reasonable times, for the purpose of assuring permit compliance or as otherwise authorized by state law, any substances or parameters at any location.

SECTION D. REPORTING REQUIREMENTS

1. Planned Changes

The permittee shall comply with Oregon Administrative Rules (OAR) 340, Division 52, "Review of Plans and Specifications". Except where exempted under OAR 340-52, no construction, installation, or modification involving disposal systems, treatment works, sewerage

systems, or common sewers shall be commenced until the plans and specifications are submitted to and approved by the Department. The permittee shall give notice to the Department as soon as possible of any planned physical alternations or additions to the permitted facility.

2. Anticipated Noncompliance

The permittee shall give advance notice to the Director of any planned changes in the permitted facility or activity that may result in noncompliance with permit requirements.

3. Transfers

This permit may be transferred to a new permittee provided the transferee acquires a property interest in the permitted activity and agrees in writing to fully comply with all the terms and conditions of the permit and the rules of the Commission. No permit shall be transferred to a third party without prior written approval from the Director. The permittee shall notify the Department when a transfer of property interest takes place.

4. Compliance Schedule

Reports of compliance or noncompliance with, or any progress reports on interim and final requirements contained in any compliance schedule of this permit shall be submitted no later than 14 days following each schedule date. Any reports of noncompliance shall include the cause of noncompliance, any remedial actions taken, and the probability of meeting the next scheduled requirements.

5. Twenty-Four Hour Reporting

The permittee shall report any noncompliance that may endanger health or the environment. Any information shall be provided orally (by telephone) within 24 hours, unless otherwise specified in this permit, from the time the permittee becomes aware of the circumstances. During normal business hours, the Department's Regional office shall be called. Outside of normal business hours, the Department shall be contacted at 1-800-452-0311 (Oregon Emergency Response System).

A written submission shall also be provided within 5 days of the time the permittee becomes aware of the circumstances. If the permittee is establishing an affirmative defense of upset or bypass to any offense under ORS 468.922 to 468.946, and in which case if the original reporting notice was oral, delivered written notice must be made to the Department or other agency with regulatory jurisdiction within 4 (four) calendar days. The written submission shall contain:

a. A description of the noncompliance and its cause;

b. The period of noncompliance, including exact dates and times;

c. The estimated time noncompliance is expected to continue if it has not been corrected;

d. Steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance; and

e. Public notification steps taken, pursuant to General Condition B.7.

The following shall be included as information that must be reported within 24 hours under this paragraph:

a. Any unanticipated bypass which exceeds any effluent limitation in this permit.

b. Any upset which exceeds any effluent limitation in this permit.

c. Violation of maximum daily discharge limitation for any of the pollutants listed by the Director in this permit.

The Department may waive the written report on a case-by-case basis if the oral report has been received within 24 hours.

6. Other Noncompliance

The permittee shall report all instances of noncompliance not reported under General Condition D.4 or D.5, at the time monitoring reports are submitted. The reports shall contain:

a. A description of the noncompliance and its cause;

b. The period of noncompliance, including exact dates and times;

c. The estimated time noncompliance is expected to continue if it has not been corrected; and

d. Steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance.

7. Duty to Provide Information

The permittee shall furnish to the Department, within a reasonable time, any information which the Department may request to determine compliance with this permit. The permittee shall also furnish to the Department, upon request, copies of records required to be kept by this permit.

Other Information: When the permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or any report to the Department, it shall promptly submit such facts or information.

8. Signatory Requirements

All applications, reports or information submitted to the Department shall be signed and certified in accordance with 40 CFR 122.22.

9. Falsification of Information

A person who supplies the Department with false information, or omits material or required information, as specified in ORS 468.953 is subject to criminal prosecution.

10. Changes to Indirect Dischargers - **[Applicable to Publicly Owned Treatment Works (POTW) only]**

The permittee must provide adequate notice to the Department of the following:

a. Any new introduction of pollutants into the POTW from an indirect discharger which would be subject to section 301 or 306 of the Clean Water Act if it were directly discharging those pollutants and;

b. Any substantial change in the volume or character of pollutants being introduced into the POTW by a source introducing pollutants into the POTW at the time of issuance of the permit.

c. For the purposes of this paragraph, adequate notice shall include information on (i) the quality and quantity of effluent introduced into the POTW, and (ii) any anticipated impact of the change on the quantity or quality of effluent to be discharged from the POTW.

11. Changes to Discharges of Toxic Pollutant - **[Applicable to existing manufacturing, commercial, mining, and silvicultural dischargers only]**

The permittee must notify the Department as soon as they know or have reason to believe of the following:

a. That any activity has occurred or will occur which would result in the discharge, on a routine or frequent basis, of any toxic pollutant which is not limited in the permit, if that discharge will exceed the highest of the following "notification levels:

(1) One hundred micrograms per liter (100 μg/L);

(2) Two hundred micrograms per liter (200 μg/L) for acrolein and acrylonitrile; five hundred micrograms per liter (500 μg/L) for 2,4-dinitrophenol and for 2-methyl-4,6-dinitrophenol; and one milligram per liter (1 mg/L) for antimony;

(3) Five (5) times the maximum concentration value reported for that pollutant in the permit application in accordance with 40 CFR 122.21(g)(7); or

(4) The level established by the Department in accordance with 40 CFR 122.44(f).

b. That any activity has occurred or will occur which would result in any discharge, on a non-routine or infrequent basis, of a toxic pollutant which is not limited in the permit, if that discharge will exceed the highest of the following "notification levels":

(1) Five hundred micrograms per liter (500 μg/L);

(2) One milligram per liter (1 mg/L) for antimony;

(3) Ten (10) times the maximum concentration value reported for that pollutant in the permit application in accordance with 40 CFR 122.21(g)(7); or

(4) The level established by the Department in accordance with 40 CFR 122.44(f).

SECTION E. DEFINITIONS

1. BOD means five-day biochemical oxygen demand.
2. TSS means total suspended solids.
3. mg/L means milligrams per liter.
4. kg means kilogram.
5. m^3/d means cubic meters per day.
6. MGD means million gallons per day.
7. Composite sample means a sample formed by collecting and mixing discrete samples taken at least one time per hour and based on time or flow.
8. FC means fecal coliform bacteria.
9. Technology based permit effluent limitations means technology-based treatment requirements as defined in 40 CFR 125.3, and concentration and mass load effluent limitations that are based on minimum design criteria specified in OAR 340-41.
10. CBOD means five-day carbonaceous biochemical oxygen demand.
11. Grab sample means an individual discrete sample collected over a period of time not to exceed 15 minutes.
12. Quarter means January through March, April through June, July through September, or October through December.
13. Month means calendar month.
14. Week means a calendar week of Sunday through Saturday.
15. Total residual chlorine means combined chlorine forms plus free residual chlorine.
16. The term "bacteria" includes but is not limited to fecal coliform bacteria, total coliform bacteria, and E. coli bacteria.

17. POTW means a publicly owned treatment works.
18. L/s means liters per second.
19. µg/L means microgram per liter.
20. °C means degrees Celsius.
21. TU_a means acute toxicity units.
22. TU_c means chronic toxicity units
23. NOEC means "no observed effect concentration."
24. LC_{50} means the effluent concentration at which 50 percent of the test organisms died.
25. "Shall" means a mandatory action or requirement; a duty to perform a specified function or activity.
26. "Must" means the same as "shall."
26. "May" means permissive; optional; not required.
27. m^3/s means cubic meters per second
28. RM means river mile (above mouth)
29. Rkm means river kilometer (above mouth)
30. "t" or "ton" means a mass of 1000 kg

EXHIBIT 4

FORMER ARKEMA, INC. FACILITY PHOTOGRAPHS OF CRACKS IN ASPHALT

Photo 1: Crack 1, looking east

Photo 2: Crack 1 close up

Photo 3: Crack 1 close up

Photo 4: Crack 2, looking north

Photo 5: Crack 2 close up

Photo 6: Crack 3, looking east

Photo 7: Crack 3 close up

Photo 8: Crack 4, looking north

Photo 9: Crack 4 close up, plant growth through asphalt

Photo 10: Crack 5 close up, plant growth through asphalt

Photo 11: From Crack 5, looking south at additional plant growth through asphalt

Photo 12: Crack 6

Photo 13: Crack 6 close up, crack next to concrete structure

Photo 14: Crack 7, plant growth through asphalt

Photo 15: Crack 7 close up, plant growth through asphalt

Photo 16: Crack 8 close up, former patch area

Photo 17: Crack 8 area

Photo 18: Crack 9, former hole patch

Photo 19: Crack 10, plant growth through asphalt

Photo 20: Crack 11, plant growth through asphalt

Photo 21: Crack 11 close up, plant growth through asphalt

Photo 22: Crack 12 close up, plant growth through asphalt

Photo 23: Crack 13 area, plant growth through asphalt

Photo 24: Crack 13 close up

Photo 25: Crack 14 former hole patch area

Photo 26: Crack 14 close up, former hole patch area

Photo 27: Crack 16 former patch area

Photo 28: Crack 16 former patch area