REPORT

DRAFT
GROUNDWATER SOURCE CONTROL
FINAL DESIGN REPORT
NW NATURAL GASCO SITE

Prepared for

NW Natural

Prepared by

Anchor QEA, LLC

In Association with

Sevenson Environmental Services, Inc.

May 2011

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CERTIFICATION STATEMENT

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Anchor QEA, LLC

5/5/2011

Date

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LIST OF ACRONYMS AND ABBREVIATIONS

3D	three dimensional
µg	microgram
bgs	below ground surface
COI	chemical of interest
COP	City of Portland datum
Corps	U.S. Army Corps of Engineers
CVOC	chlorinated volatile organic compound
DEQ	Oregon Department of Environmental Quality
DNAPL	Dense Non-Aqueous Phase Liquid
EPA	U.S. Environmental Protection Agency
FAMM	Fuel and Marine Marketing
FDR	Final Design Report
FEMA	Federal Emergency Management Agency
FS	Feasibility Study
gpm	gallon per minute
GWFFS	Groundwater/DNAPL Source Control and NAPL Focused Feasibility Study
HAI	Hahn Associates, Inc.
HC&C	hydraulic control and containment
HMI	Human Machine Interface
IDR	Groundwater Source Control Interim Design Report
L	liter
LNG	liquefied natural gas
LWG	Lower Willamette Group
MGP	manufactured gas plant
NAPL	Non-Aqueous Phase Liquid
NPDES	National Pollutant Discharge Elimination System
PacTerm	Pacific Terminal Services, Inc.
PAH	polycyclic aromatic hydrocarbon
PGE	Portland General Electric
PLC	programmable logic control
POTW	publicly owned treatment works
QA	quality assurance

QC	quality control
ORP	oxidation reduction potential
RAO	remedial action objective
RI	Remedial Investigation
Site	Gasco Site in Portland, Oregon
SSPA	SS Papadopoulos and Associates
STI	Subsurface Technologies, Inc.
SVOC	semivolatile organic compound
TarGOST	tar-specific green optical screening tool
TCE	trichloroethene
TZW	transition zone water
VFD	variable frequency drive
VOC	volatile organic compound
WAD	weak acid dissociable
WBZ	water bearing zone
WSE	Water Systems Engineering, Inc.

1 INTRODUCTION

As directed by the Oregon Department of Environmental Quality (DEQ), NW Natural has completed design of the groundwater and Dense Non-Aqueous Phase Liquid (DNAPL) source control measure for the Gasco Site in Portland, Oregon (Site). This is a one hundred percent design for a complete hydraulic containment system that can be constructed and operated upon approval by DEQ. Adjustments to the design can be made as required by DEQ; however, NW Natural believes that all of the design considerations requested to date by DEQ have been incorporated. The design is based on over three years of preliminary and interim design submittals and addresses all pertinent DEQ design requests.

This source control work is being completed consistent with the requirements of: 1) the Joint Order (DEQ Order No. ECVC-NWR-00-27 to NW Natural and Siltronic Corporation, dated October 4, 2000), and 2) the Voluntary Agreement (DEQ No. WMCVM-NWR-94-13, dated August 8, 1994, as amended July 19, 2006). The Site location is shown on Figure 1-1. On March 21, 2008, DEQ selected source control actions to address potential impacts to the Willamette River from manufactured gas plant and solvent contamination at the Gasco and Siltronic properties. This draft Final Design Report (FDR) incorporates the findings from numerous design studies, as requested by DEQ. This report includes:

- Existing conditions (Section 2)
- Groundwater extraction and treatment system (Section 3)
- Permits (Section 4)
- Construction schedule and sequence (Section 5)

1.1 Background

On behalf of NW Natural, Anchor Environmental, LLC prepared and submitted the *Preliminary Design Report, Groundwater Source Control Report* to DEQ in June 2008 (Anchor 2008a). Due to a recent merger, Anchor Environmental is now known as Anchor QEA, LLC. This FDR describes groundwater and DNAPL source control measures for Segments 1 and 2. These two shoreline segments cover the entire length of the NW Natural shoreline and a portion of the Siltronic shoreline. The Site map showing the locations of source control Segments 1 and 2 is on Figure 1-2.

The *Groundwater Source Control Interim Design Report* (IDR; Anchor QEA 2009a) was provided to DEQ in November 2009. DEQ provided comments on the IDR on March 26, 2010. A copy of

the March 26 comment letter is in Appendix A. Following a series of meetings with NW Natural, DEQ sent NW Natural a June 11, 2010 email directing NW Natural to defer hydraulic control and containment (HC&C) along a portion of Segment 1 and proceed with design and implementation of HC&C in Segment 2 and the remainder of Segment 1. In a July 14, 2010 e-mail, NW Natural invoked dispute resolution for the source control direction detailed in DEQ's June 11 e-mail. NW Natural then sent DEQ a Request for Formal Dispute Resolution on July 20, 2010. A comprehensive technical response to DEQ's March 26 comment letter was attached to the July 20 letter, along with a number of drawings and other information requested by DEQ. A copy of the July 20 letter with attachment is in Appendix B. Several meetings and information exchanges then occurred between NW Natural and DEQ in an effort to resolve the dispute. During this period, NW Natural suspended source control design activities. A meeting was held between DEQ and NW Natural on December 13, 2010, which laid the groundwork for settling the dispute. In e-mail correspondence dated December 15, 2010 (Jim Anderson to Bob Wyatt), December 17, 2010 (Bob Wyatt to Jim Anderson), and December 22, 2010 (Jim Anderson to Bob Wyatt), DEQ and NW Natural summarized agreements reached during the December 13 meeting (Appendix B). The conditions of the December 2010 settlement that influenced the final design are further described in Section 1.2.

1.2 Remedial Action Objectives

The source control physical removal action goals identified in the IDR for Segments 1 and 2 are as follows:

- Groundwater – Prevent discharge of upland groundwater to the Willamette River, as measured by analyzing groundwater hydrology data from Site wells and the river
- DNAPL – Prevent the migration of upland DNAPL to the river

At DEQ's request, the following clarifications apply to the above remedial action objectives (RAOs):

- Source control measure alternatives have been evaluated specific to mitigating migration to the Willamette River along shoreline Segments 1 and 2 by DNAPL in the Fill water bearing zone (WBZ) and Alluvium WBZ and contaminated groundwater in the Alluvium WBZ.
- DNAPL removal will be included to the extent necessary to control and contain the potential movement of DNAPL from former effluent management areas on the NW Natural and Siltronic properties that could result from the operation of the hydraulic

containment system.

According to the December 2010 settlement, DEQ and NW Natural agree that uplands DNAPL removal and the vertical barrier will be evaluated during the uplands Feasibility Study (FS). As requested by DEQ, the vertical barrier that is carried forward into the FS will be 625 feet long and constructed using sheet pile methods to a depth of -60 feet City of Portland datum (COP). However, per the second RAO, source control should prevent migration of DNAPL to the river. To address this RAO, this FDR contains a performance monitoring plan to assess DNAPL migration.

The December 2010 settlement provided some additional detail related to the source control final design and the uplands FS, as follows:

- DEQ's technical issues with the IDR, as expressed in the March 26, 2010 comment letter and written comments issued by DEQ during dispute resolution, must be addressed during final design. Appendix A includes a copy of the March 26, 2010 letter. Appendix A also includes a table that identifies each of DEQ's requests as presented in the letter and where those requests are addressed in this FDR.
- The uplands FS must fully evaluate remedial action alternatives for DNAPL associated with former tar pond area(s), such as DNAPL management systems, removal, solidification/stabilization, etc. As requested by DEQ NW Natural will carry all DEQ comments on the vertical barrier in the March 26, 2010 letter into the upland FS.

1.3 Integration with In-River Cleanup

In September 2009, EPA, NW Natural, and Siltronic signed an Administrative Settlement Agreement and Order of Consent that includes a Statement of Work that describes how the riverbank cleanup work will be part of the in-river cleanup.

The details of source controls presented in this FDR show that the construction of the extraction wells would not restrict future riverbank cleanup options. As discussed in Section 5, it is NW Natural's goal to commence system operation in 2011, well in advance of riverbank and in-river sediment cleanup. This FDR includes an interceptor trench to provide groundwater source control for the Fill WBZ. As explained further in this report, the Fill WBZ interceptor trench source control action would present a potential limiting factor on the design of riverbank cleanup actions that could occur during the river sediment cleanup. For that reason, it is

proposed that the Fill WBZ interceptor system be installed coincident with the riverbank cleanup during the future river sediment cleanup. By taking that approach, the design of the Fill WBZ source control action presented herein can be integrated with the riverbank remedy and river sediment cleanup.

2 EXISTING CONDITION

2.1 Hydrogeology and Conceptual Site Model

2.1.1 General Geology and Groundwater Occurrence

The upland hydrogeology was described in the *Remedial Investigation Report* (HAI 2007). DEQ has requested extensive additional investigations as part of source control evaluations that have provided more detail on Site hydrogeology, particularly near the Willamette River shoreline. These additional investigations were conducted along the shoreline and offshore and were reported in the *Phase 1 Report and Phase 2 Field Sampling Approach, Gasco Siltronic Groundwater Source Evaluation* (Anchor 2007b) and the *Offshore Investigation Report* (Anchor 2008b). The findings of the offshore investigations are described in Section 3.2.1.1. DEQ also requested that tar-specific green optical screening tool (TarGOST) investigations be conducted to further define the nature and extent of upland DNAPL. The TarGOST investigations are described in Section 3.2.1.6.

Figure 2-1 shows the locations of the monitoring wells on Segments 1 and 2, including both NW Natural and Siltronic properties. Table 2-1 lists the construction details of the existing and proposed monitoring wells, extraction wells, and piezometers. Figures 2-2a, b, and c are detailed maps showing well locations, pipelines, roads, buildings, and other features along Segments 1 and 2.

Figures 2-3a, b, and c through 2-8 are detailed geologic cross sections are focused on the shoreline area. The locations of these cross sections are shown in plan view in Figure 2-1. Figures 2-3a, b, and c depict three portions of the A-A' cross section that is parallel to the river shoreline covering Segments 1 and 2. Cross sections B-B' through F-F' on Figures 2-4 through 2-8 extend from the upland into the river. Cross sections G-G' and H-H' on Figures 3-8 and 3-9 are discussed in the DNAPL monitoring Section 3.2.2.5.3. These cross sections were constructed using the geologic information from several sources, including:

- Upland remedial investigation borings and monitoring wells (HAI 2007)
- Shoreline and offshore borings (Anchor 2008b)
- Supplemental monitoring wells (Anchor 2008a)
- TarGOST borings (HAI 2008)
- Siltronic borings and monitoring wells (MFA 2007)
- Monitoring wells, extraction wells, and piezometers installed for the Segment 2 capture

zone tests (see Appendix I for well logs)

The Site hydrogeology and conceptual site model is based on the findings described in the RI Report (HAI 2007) and in subsequent reports (Anchor 2007a, 2008a; Anchor QEA 2009b). The three upland hydrogeologic units are the Fill WBZ, Alluvium WBZ, and the underlying Columbia River Basalt. Groundwater in the Fill and Alluvium WBZs is recharged from underflow originating in the hills west of the Site and from infiltration of incident precipitation on the Site. Figures 2-9a and b are groundwater potentiometric surface maps completed in the Fill and Alluvium WBZs. These contour maps illustrate the groundwater elevation patterns that result in groundwater discharge to the river.

Groundwater in the Fill WBZ is recharged primarily from infiltration of precipitation, because much of the Site is unpaved. Groundwater in the Fill WBZ both recharges the underlying alluvium and travels laterally with discharge to the river. Groundwater in the Alluvium WBZ discharges to the river. Upland groundwater flow has been simulated by a site specific MODFLOW model developed for the Site. The use of the MODFLOW model in designing the source control measures is described in Section 3.2.1.4.

2.1.2 Fill WBZ

The Fill WBZ is comprised of dredge spoils pumped from the river combined with upland derived fill, including soil, bricks, concrete, and other debris. Figures 2-3a, b, and c through 2-8 show the lateral extent and thickness of the fill. At the river shoreline, the bank is armored with conventional riprap boulders. Most of the upland fill surface is unpaved. The fill overlies a silt layer that is the uppermost sedimentary unit of the underlying alluvium. The top of the silt was the former ground surface prior to fill placement. The depth to groundwater in the Fill WBZ increases toward the river, so the saturated thickness in the Fill WBZ nearshore monitoring wells is much less than the saturated thickness of monitoring wells on the west side of the Site. Many of the nearshore Fill WBZ monitoring wells dry up during the late summer and fall. The horizontal hydraulic conductivity of the Fill WBZ is variable, but the average horizontal hydraulic conductivity is very low, less than 1 foot per day. This conductivity is based on slug tests performed in 2010 on nine nearshore Fill WBZ monitoring wells. A report of the slug test findings is in Appendix C.

2.1.3 Alluvium WBZ

As a result of the paleochannel in the basalt bedrock shown on Figures 2-3a, b, and c, the depth of the Alluvium WBZ ranges from about 50 to 200 feet below ground surface (bgs) at the river shoreline. The alluvium is thinnest near the north (downstream) property line with the U.S. Moorings site. The subsurface profiles on Figures 2-3a, b, and c through 2-8 show that the interbedded silts and sands in the upland alluvium are similar to those present in the offshore alluvium.

The upper silt unit is the hydrogeologic boundary between the alluvium and the overlying fill. Subsurface profiles on Figures 2-3a, b, and c through 2-8 show that the upper silt is quite variable in thickness but generally continuous across the site. The subsurface profiles also show that the Alluvium WBZ underlying the silt unit is comprised of two sand units: the upper alluvium and the lower alluvium. The upper alluvium is fine sand with numerous discontinuous silt layers, indicated on the profiles with a solid green color. The lower alluvium is primarily medium sand with fewer silt beds, indicated on the profiles with a green diagonal hatch pattern. Figures 2-3a, b, and c show that the thickness of the upper and lower alluviums increases from north to south along the shoreline as the depth to bedrock increases. As explained below, the hydraulic conductivity of the upper alluvium is much lower than the lower alluvium.

Aquifer tests have been conducted at wells PW-1-80, PW-3-85, PW-3-118, PW-7-93, PW-8-39, PW-8-68, and PW-9-92. Slug tests have also been conducted in nine Fill WBZ wells and 15 upper alluvium wells. The findings from the test of PW-1-80 were reported by HAI (2006). The findings from the tests of PW-3-85 and PW-3-118 were reported by Anchor Environmental and SS Papadopulos and Associates (SSPA; 2008). The results of testing the well PW-3 are further described in Section 3.2. The findings from the tests of PW-7-93, PW-8-39, and PW-9-92 are incorporated into the MODFLOW model. The findings from the slug tests are in the technical memorandum in Appendix C. The hydraulic conductivity data from the slug tests have also been incorporated in the Site groundwater MODFLOW model. The MODFLOW model is further described in Section 3.2. Based on the pump and slug tests, the hydraulic conductivity of the upper alluvium is higher in Segment 1 than in Segment 2. From the area of well PW-3 north to the area of well PW-8, the hydraulic conductivity of the upper alluvium decreases from about 10 feet per day to about 1 foot per day. The hydraulic conductivity parameter in the MODFLOW model is 300 feet per day for the lower alluvium.

In some areas, an alluvial gravel layer is present at the contact between the base of the Alluvium WBZ and the basalt bedrock.

2.1.3.1 Alluvium WBZ Aquitard

During interim design of source controls, the Site geologic cross sections (Figures 2-3a, b, and c through 2-8) were revised based on the new geologic information obtained from the TarGOST borings and new monitoring well borings. It was determined that an aquitard (silt layer) is present within the lower alluvium between elevations -100 and -120 feet. As shown on Figure 2-3a, the aquitard is composed of a single silt bed on the north portion of the shoreline and is generally more than 10 feet thick. In the southern portion of the shoreline, the aquitard is somewhat lower in elevation and consists of either a single silt bed or multiple closely spaced silt interbeds. The aquitard silt is likely a geomorphic over-bank deposit that was placed during historic river flood events when the floodplain was at a lower elevation.

Figure 2-10 is an isopach map showing the thickness of the aquitard. The Site geologic information indicates that the aquitard is thickest on the north portion of the NW Natural property and the north portion of the Siltronic property. These areas were likely historic floodplain areas at lower elevation that accumulated more silt during flood events. Table 1 in Appendix D provides the geologic data used at each upland boring location to map the presence of the aquitard. The geologic data in Table 1 was also used to add the aquitard layer to the Site MODFLOW model. As shown on Table 1 the geologic logs from the TarGOST borings were also used to delineate the aquitard. Appendix D contains a memo that assesses the TarGOST geologic data and concludes that the data are reliable for the purpose of delineating geologic units at the site.

Review of the Site groundwater quality data shows that the aquitard has a significant effect on groundwater quality in the Alluvium WBZ. Table 2-2 shows a comparison of the concentrations of benzene, naphthalene, free cyanide, and total cyanide in monitoring wells screened in the Alluvium WBZ above and below the aquitard. The concentrations of each of the four analytes are also shown on Figure 2-11. The data shown on Figure 2-11 are from the September 2008 sampling event and from one-time groundwater grab samples obtained from exploratory borings. These data are generally representative of the data in Table 2-2.

The monitoring wells used for comparison are wells clustered at the same location at the Site, but screened above and below the aquitard. With few exceptions, the concentrations of benzene

and naphthalene in wells screened below the aquitard are less than 1 microgram per liter (μg/L), which is typically an order of magnitude or more lower than the concentration in wells screened above the aquitard. The average benzene concentration from the September 2008 sampling event was 99.5 percent lower in samples taken from below the aquitard than samples taken from above the aquitard. The average naphthalene concentration from the September 2008 sampling event was 99 percent lower in samples from below the aquitard than samples taken from above the aquitard. Free cyanide concentrations are generally present at trace concentrations in the Alluvium WBZ and are even lower below the aquitard. The average free cyanide concentration from the September 2008 sampling event was 94 percent lower in samples from below the aquitard than samples taken from above the aquitard. For total cyanide, there is also a substantial decrease in concentration below the aquitard. Total cyanide concentrations are generally at least an order of magnitude higher above the aquitard than below the aquitard. The average total cyanide concentration from the September 2008 sampling event was 85 percent lower in samples from below the aquitard than in samples taken from above the aquitard. The groundwater quality data shows that more than 99 percent of the mass of manufactured gas plant (MGP) -related contamination is located above the aquitard.

2.1.4 Offshore Groundwater

The offshore investigation found that a groundwater plume of dissolved MGP-related chemicals of interest (COIs) extends from upland source areas into the river channel sediments. The three dimensional (3D) subsurface profiles on Figures 2-12a, b, and c, show that the MGP-related groundwater plume is present in the upland Alluvium WBZ and extends into the alluvium under the river channel. These 3D profiles of the shoreline show the offshore extent of cyanide, benzene, toluene, benzo(a)pyrene, and naphthalene in groundwater (Anchor 2008b). A seepage evaluation conducted in the late summer and fall of 2007 when the river levels were at their seasonal low estimated that the range of groundwater seepage from Site upland Segments 1 and 2 into the river ranged from about 225 to 253 gallons per minute (gpm) at the time of the investigation (Anchor 2008b). Because the low seasonal river level results in a higher head difference between upland groundwater and the river, it is expected that the measured seepage amount is near the maximum that is expected to occur on a seasonal basis. The findings from the offshore investigations were considered in establishing the source control RAO of preventing discharge of upland groundwater into the river.

The offshore investigations included a detailed assessment of the nature and extent of DNAPL in the river sediments. Figures 2-13a and b show the extent of dissolved free cyanide and total

cyanide in groundwater, as measured in groundwater grab samples obtained in river shoreline borings drilled in river sediments along the base of the riverbank in 2007. The borings were extended from the river sediment mudline to basalt bedrock. Sonic drilling methods were used to obtain continuous sediment cores, which were screened for NAPL using several screening techniques. The profiles on Figures 2-13a and b also show that DNAPL was detected in shallow river sediment in several of the borings. DNAPL was not detected in any of the borings below an elevation of approximately 17 feet COP datum. However, DNAPL has been detected in the upland alluvial WBZ at elevations down to -70 feet COP datum.

A release or releases of spent trichloroethene (TCE) on the Siltronic property have resulted in groundwater contamination. Siltronic has defined the nature and extent of the chlorinated volatile organic compound (CVOC) plumes (MFA 2007). Figure 2-14 shows the approximate width of the combined CVOC plume at the riverbank. Siltronic is currently implementing an in situ source removal action (MFA 2007).

2.2 Current Land Use

The entire Site is zoned industrial, and a detailed description of historic and current industrial operations is in Section 2 of the RI Report (HAI 2007). This description of current land use is summarized from the RI Report. The industrial facilities are shown on Figure 1-2. Segment 1 extends across the NW Natural and Siltronic property line and includes about 400 feet of the northern end of the Siltronic property. Segment 2 is all on NW Natural property and extends from Segment 1 to the northern boundary of the NW Natural property. The Fuel and Marine Marketing (FAMM) terminal and NW Natural Liquefied Natural Gas (LNG) storage and distribution facility are upland of Segment 1.

Koppers Inc., leases the southwestern portion of the NW Natural property at 7540 NW St. Helens Road. The Koppers plant location is outside of the footprint of source control activities proposed in this report. However, the Koppers coal tar pitch pipeline does cross the shoreline in Segment 1, so a description of the Koppers operation is included herein. Koppers operates a coal tar pitch distillation plant and imports coal tar pitch and related products via rail tank cars and bulk cargo ships. Koppers either stores or remanufactures these products prior to distribution. As of 2005, the management of solid pencil pitch has reportedly been primarily phased out. Liquid coal tar pitch is received by Koppers at the NW Natural dock where it is pumped from the vessel, through an aboveground heated pipeline, to a storage tank on the

Koppers lease area (HAI 2007). The location of the Koppers pipeline is shown on the maps in Figures 1-2 and 2-1.

Pacific Terminal Services, Inc. (PacTerm), under contract with FAMM, operates a fuel storage and distribution facility at the northern portion of the NW Natural property. The terminal receives, stores, blends, and ships marine fuels and lubricants, using both barge and truck for shipment (HAI 2007).

Siltronic operates a silicon wafer manufacturing plant adjacent to the NW Natural property. The U.S. Moorings facility adjoins the NW Natural property to the north.

3 GROUNDWATER EXTRACTION AND TREATMENT SYSTEM

3.1 Basis of Design

3.1.1 Extraction System Performance Goals

As described in Section 1.2, the source control RAOs are:

- Source control physical removal action goals for Segments 1 and 2:
  - Groundwater – Prevent discharge of upland groundwater to the Willamette River, as measured by analyzing groundwater hydrology data from Site wells and the river
  - DNAPL – Prevent the migration of upland DNAPL to the river
- At DEQ's request, the following clarifications apply to the above RAOs:
  - Source control measure alternatives have been evaluated specific to mitigating migration to the Willamette River along Segments 1 and 2 by DNAPL in the Fill and Alluvium WBZs and contaminated groundwater in the Alluvium WBZ.
  - DNAPL removal will be included to the extent necessary to control and contain the potential movement of DNAPL from former effluent management areas on the NW Natural and Siltronic properties that could result from the operation of the hydraulic containment system.

The overall goal of these RAOs is hydraulic containment to protect the river. Procedures for assessing the performance of source controls will follow the guidelines as described in *A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems* (EPA 2008). The EPA guidance contains recommendations for assessing system performance to achieve capture using methods that measure hydraulic containment and water quality performance.

The RAOs are designed to achieve hydraulic containment; therefore, the performance monitoring methods described in Section 3.2.2.5 are primarily those that use hydrology data to confirm capture. Because groundwater is contaminated on both the upland and the river sides of the shoreline extraction wells, there is no plume boundary that can be used to measure water quality performance. However, Section 3.2.2.5 includes plans to monitor groundwater quality for the purpose of assessing trends of specific parameters. The shoreline extraction well system is designed to contain upland groundwater and minimize vertical and horizontal gradients that could mobilize DNAPL. To monitor the potential for DNAPL migration, a monitoring program has been designed (see Section 3.2.2.5.3).

3.1.2 Treatment System Performance Goals

The groundwater treatment system is designed to achieve the DEQ-mandated effluent criteria listed in Table 3-1. Although the effluent criteria are the key discharge permit conditions that must be met, other permit conditions must be met as well. The National Pollutant Discharge Elimination System (NPDES) permit application was submitted to DEQ in February 2011, and all of DEQ's information requests related to the permit have been met. When the treatment system discharge permit is provided by DEQ, all permit conditions will be assessed to determine how they affect the treatment system performance goals and operating protocols. An approved NPDES permit is needed before the treatment system can be constructed.

3.1.3 Extraction/Treatment System Shutdown

The groundwater extraction system is designed to operate continuously to achieve hydraulic containment. Individual wells would be temporarily shut down for maintenance or repair, but the rest of the extraction wells would continue to operate for those periods. Replacement well pumps will be kept in inventory on site at all times. With replacement pumps available on site, the replacement of a well pump should be completed within 24 hours of shutdown. When a well is shut down for maintenance, the system will automatically increase the pumping rate on the adjacent wells to maintain capture. The pipeline system is designed to allow cleaning of the pipeline from each well without shutting down the adjacent wells. Section 3.2.2.5.5 addresses maintenance and repair of the treatment system.

The entire well system might experience temporary shutdown that could result from the following factors:

- River flooding above an elevation of 28 feet COP datum
- Power outage
- Treatment system shutdown
- Other force majeure events

As explained below, the treatment system is designed with a high degree of component redundancy to prevent system shutdown for repair and maintenance.

Due to hydraulic gradient reversal, river level rises that cause the river elevation to be higher than the nearshore upland groundwater elevation will cause river water to temporarily recharge nearshore groundwater, thereby preventing groundwater discharge to the river.

These natural gradient reversals will occur seasonally during daily river tidal fluctuation or during increases in river levels due to upstream precipitation or hydraulic damming caused by high levels in the Columbia River. Under these gradient reversal conditions, the extraction well discharge rate will be reduced accordingly. Extraction well pumping rates will be reduced and may temporarily stop during extended periods of gradient reversal, but the wells will restart to maintain capture as the river level declines.

The 100-year Federal Emergency Management Agency (FEMA) flood elevation is 28 feet COP datum. River flooding above this level rarely occurs and is generally temporary, lasting a few hours or days at most. Under such extreme flood conditions, there will be extenuating circumstances associated with Site access, Site flooding, and personnel travel as well as other issues that could dictate a shutdown of the source control system.

The northwest industrial area is a high Portland General Electric (PGE) priority for restoration of power in the event of an outage. Based on records from PGE, the longest historic power outage that has occurred in the northwest industrial area is less than 12 hours. However, to ensure the continuous operation of the extraction wells and treatment system, a backup diesel generator is incorporated into the treatment system design. The generator would start up in the event of a PGE power failure. The backup generator is further described in Appendix E.

The treatment system is designed with redundant treatment system components such as pumps and filters. This redundancy should prevent shutdown of the plant during normal maintenance or replacement of these components. The redundancy built into the treatment system design is further described in Appendix E.

DEQ requested an evaluation of the period of time that system shutdown could occur before an unacceptable water quality impact in the river occurs. However, the final design of the extraction and treatment system includes a backup generator to provide power in the event of a PGE power failure. As explained in the previous paragraphs, the extraction and treatment system's final design allows maintenance and repair of the components during continued operation of the overall system. The extraction and treatment system design now includes redundant components, a backup power system, and the ability to repair or maintain components while maintaining overall system operation. These design changes largely mitigate the system shutdown conditions under which DEQ requested that a water quality assessment

be conducted. Therefore a water quality assessment may no longer be necessary; however, NW Natural is open to further discussion with DEQ on the need for a water quality assessment.

3.2 Groundwater Extraction System

3.2.1 Design Studies

3.2.1.1 Offshore Investigations

On behalf of NW Natural, Anchor QEA conducted a series of investigations in the Willamette River, offshore of the Site, during the period from July 2006 to October 2007. This work was required by DEQ to determine the nature and extent of contamination in offshore groundwater and river sediments. DEQ required this work to inform the source control design as it relates to the connection between upland sources and the river. The investigations included comprehensive sampling and testing of groundwater, sediments, and river water. The following summary of work completed and findings is from the Executive Summary of the *Offshore Investigation Report* (Anchor 2008b).

The primary objectives of the investigations were to assess the following issues:

- Understand how the vertical and horizontal extent of chemicals in groundwater beneath the river and transition zone water (TZW) may be related to chemical concentrations measured in upland groundwater.
- Understand how groundwater and TZW concentrations may be related to direct historical deposition of materials in the river.
- Determine if the chemical concentrations in the biologically active TZW in navigation channel sediments have been directly impacted by historical deposition of waste materials in the river.
- Determine the potential variability in measured shallow sediment TZW chemical concentrations due to tidal fluctuations in the Willamette River.
- Provide additional lines of evidence for verifying groundwater discharge and providing general level estimates of groundwater discharge rates within river sediments adjacent to the Site.
- Evaluate the potential for transport of cyanide measured in groundwater and TZW to surface water and any conversion to free cyanide under select river conditions.
- Collect data that may be useful for assessing in-river risks from cyanide (i.e., low tide versus high tide conditions and/or river current velocity and direction).

Following is a summary of the work completed to achieve these objectives:

- Barge-mounted drilling equipment was used to complete borings along four offshore transects: transects A, B, C, and D. Transect A is located at edge of shoreline, and transect D is located approximately 550 feet from shoreline.
- A total of 106 groundwater samples and 83 sediment samples were tested for cyanide species, semivolatile organic compounds (SVOCs), volatile organic compounds (VOCs), and metals.
- A total of 30 borings were drilled along transects B, C, and D. A total of 105 groundwater samples and 21 sediment samples were tested for cyanide species, SVOCs, VOCs, and metals.

Ultrasonic seepage meters were installed at seven offshore locations to measure seepage rates over a 5-day period. Mini-piezometers were installed at three offshore locations. A total of 30 TZW porewater samples were obtained over multiple tidal cycles. A total of 12 near bottom river water samples were obtained at the mini-piezometer locations. Willamette River water samples were collected at 20 offshore locations. A total of 180 river water samples were tested for total cyanide, amenable cyanide, free cyanide, selected metals, and conventional parameters.

For the purpose of describing the nature and extent of MGP-related COIs, this summary focuses on free cyanide, total cyanide, benzene, toluene, naphthalene, and benzo(a)pyrene. These six target analytes have a wide range of subsurface fate and transport properties, and their distribution are generally representative of the MGP-related COIs.

Free cyanide was detected in trace concentrations in a very small percentage of the groundwater samples. These results are significant because the free cyanide compound is considered the toxic form of cyanide. The detected concentrations were generally below 10 μg/L.

Total cyanide is present in groundwater in all offshore transects at generally all depths sampled. Total cyanide is very soluble and chemically stable and does not adsorb significantly to the sediment matrix. Therefore, total cyanide is one of the most widely distributed of the MGP-related COIs.

Benzene, toluene, and naphthalene are also widely distributed, but their plume patterns are variable, reflective of both historical overland transport of effluent to the river and groundwater transport from upland sources. Consistent with a much higher tendency of benzo(a)pyrene to adsorb to organic carbon, its distribution in groundwater is quite limited compared to naphthalene (another polycyclic aromatic hydrocarbon [PAH]), which is much more mobile in groundwater. The presence of elevated benzo(a)pyrene concentrations in offshore groundwater is primarily associated with the occurrence of non-aqueous phase liquid (NAPL) in shallow sediments. Although trace concentrations of benzo(a)pyrene are detected in some of the deeper groundwater samples, these concentrations are likely associated with the suspended solids in the groundwater grab samples obtained during this investigation.

Seepage data from the 2005 Lower Willamette Group (LWG) investigations at the NW Natural and Siltronic properties were combined with seepage data from the 2007 Gasco seepage investigation to estimate a range of total seepage rates from 225 to 253 gpm from the area offshore of the NW Natural and Siltronic properties. This rate is comparable to the extraction well pumping rate that modeling indicates would be necessary to achieve upland groundwater source control.

No free cyanide was detected in any surface water sample. There was one detection of free cyanide (unfiltered) in shallow TZW (1.5 to 2.5 feet below mudline), but all other TZW samples were non-detect for free cyanide.

3.2.1.2 Pilot Extraction Well PW-3 Testing

Pilot extraction wells PW-3-85 and PW-3-118 were installed for field testing to obtain site-specific aquifer properties to inform the MODFLOW model and, ultimately, the design of the groundwater/DNAPL source control system. In previous reports, these wells were named PW-4-85 and PW-4-118, but were renamed so that well names are sequential according to their spatial orientation. This description of the test procedures and findings is summarized from Appendix F of the *Groundwater/DNAPL Source Control and NAPL Focused Feasibility Study* (GWFFS; Anchor 2007a). The two PW-3 extraction wells are located near the Siltronic property line.

The PW-3 pump test consisted of pumping the shallow screen interval (PW-3-85) and intermediate screen interval (PW-3-118) both individually and together. The test included separate step-drawdown tests on each screen interval and a combined constant rate test on both

screen intervals. The tests were conducted in July 2007 and included extensive continuous (1-minute frequency) monitoring of water levels in the pumping wells and observations wells for extended periods before, during, and after pumping. A summary of the rate and duration of tests is provided in Table 3-2.

Water levels during the tests were affected by river stage changes, which were primarily due to tidal fluctuations during the test period.

Analysis of the constant rate test at PW-3-85 shows two responses: an early time response and a later time response. The early time response is indicative of conditions close to the pumping well before the influence of the river boundary becomes significant. The later time response is likely influenced by the river boundary.

Analyses of the PW-3-85 and PW-3-118 step-drawdown and constant rate tests show a considerable difference in the hydraulic conductivity in the upper and lower alluvium. In both tests, the influence of the river boundary appears to affect the pump tests as seen in the rapid equilibration of the water levels with time. These variations in aquifer properties are accounted for in the properties assigned to the MODFLOW model layers. Analysis of the pump test data provided the aquifer properties of hydraulic conductivity and storage coefficient that were used in development and calibration of the MODFLOW model.

Water level data collected by transducers after the PW-3 pump test are shown on Figure 3-1. This figure illustrates the high tidal efficiencies at the various wells. Water levels at the wells closely follow the stage fluctuations in the river and are only slightly attenuated and delayed in time compared to the river stage fluctuation. The attenuated fluctuation in the wells compared to the river tidal fluctuation is referred to as the tidal efficiency and is usually reported as a percentage of the river stage fluctuation. The Segment 2 Capture Zone Test Report in Appendix I provides more detail on tidal efficiency in the nearshore alluvium. The delay in the peak water levels in the well compared to the timing in the river is referred to as the lag time.

3.2.1.3 2010 and 2011 Well Pump and Slug Tests

Aquifer tests have been conducted at wells PW-1-80, PW-3-85, PW-3-118, PW-7-93, PW-8-39, PW-8-68, and PW-9-92. Slug tests have also been conducted in nine Fill WBZ wells and 15 upper alluvium wells. The findings from the test of PW-1-80 were reported by HAI (2006). The findings from the tests of PW-3-85 and 118 were reported by Anchor and SSPA (2008). The

results of testing the PW-3 wells are further described in Section 3.2.1.2. The findings from the tests of PW-7-93, PW-8-39, and PW-9-92 are reported in the Segment 2 Capture Zone Test Report in Appendix I. The findings from the slug tests are in the technical memorandum in Appendix C. The slug tests reported in Appendix C indicate that the average hydraulic conductivity of the Fill WBZ is less than 1 foot per day. The hydraulic conductivity data from the upper alluvium slug tests have been incorporated in the site groundwater MODFLOW model. The MODFLOW model is further described in Section 3.2.1.4. Based on the pump tests and the slug tests, the hydraulic conductivity of the upper alluvium is higher in Segment 1 than in Segment 2. From the area of well PW-3 north to the area of well PW-8, the hydraulic conductivity of the upper alluvium decreases from about 10 feet per day to about 1 foot per day. The hydraulic conductivity of the lower alluvium is about 300 feet per day.

3.2.1.4 Groundwater MODFLOW Model

Following submittal of the Preliminary Design Report (Anchor 2008a), DEQ requested additional groundwater flow modeling as part of source control design. The additional modeling work was reported in the following documents:

- *Groundwater Flow Model and DNAPL Evaluation Supplemental Report* (Anchor and SSPA 2008)
- *NW Natural Gasco, Pump Test Analysis and MODFLOW Model Summary* (SSPA 2008a, updated from the version in the *Groundwater/DNAPL Source Control Focused Feasibility Study*, Appendix E.)
- *NW Natural Gasco: Additional Groundwater Flow Analysis* (SSPA 2008b)
- *Supporting information on Groundwater Modeling related to the Groundwater Source Control Interim Design Report, NW Natural Gasco Site, Portland, OR* (SSPA 2009)
- Additional figures, based on additional model runs, as requested by DEQ in 2009

These reports are provided in Appendix F. The following findings affect source control design and are taken directly from the October 2008 model report:

1. The Site groundwater elevation data for March 27, 2000, represents a reasonable worst-case condition for future modeling and design purposes.
2. Overall, the calibration to March 2000 worst case conditions with the change in the upland boundary head, recharge rate, and adjustment of the deep alluvium hydraulic conductivity zone increases the overall groundwater flow in the model by 30 percent

from the average calibrated model condition. This is accounted for in the particle track map on Figure 3-2.

Although the model was calibrated to the March 27, 2000 water level data, the model was subsequently modified at DEQ's request. Specifically, DEQ requested that the intermediate and deep alluvium zones with the highest conductivity in the model area be arbitrarily extended upland to the basalt bedrock. DEQ requested this change to increase the overall groundwater flow rate predicted by the model making the model more conservative with respect to predicted pumping rates to capture upland groundwater. However, this change also takes the model out of calibration with respect to water level data. Consequently, model comparisons to water level data are not valid and have not been done. Similarly, the conservative assumptions requested by DEQ to increase groundwater flow rates satisfy the need for sensitivity analyses to simulate more conservative conditions.

Groundwater inflows to the primary hydrostratigraphic units along the west side of the Willamette River in the model area are shown in the following table. All groundwater flow in the model area discharges to the Willamette River.

Unit	Groundwater Inflow[1] (gpm)	Source of Groundwater Inflow
Fill	200	Surface recharge
Fill	15	Upland flow from shallow alluvium or bedrock
Upper Alluvium	305	Flow from bedrock
Lower Alluvium above the Aquitard	650	Flow from bedrock

1 - Values are rounded to the nearest 5 gpm.

Groundwater inflows in the above table include contributions from the U.S. Moorings and Siltronic sites outside the capture zone of the Gasco extraction and treatment system. No groundwater inflow to either the silt units or to the lower alluvium below the aquitard is included in the model. The silt units are too fine to support substantial groundwater flow from the upland alluvium or bedrock. The lower alluvium below the aquitard represents only a small footprint more than 130 feet below ground surface and there is no indication that groundwater inflows occur at this depth. The model was used to successfully predict the water level response in the lower alluvium during the PW-3-118 pumping test (SSPA 2008b), which indicates that no substantial groundwater inflows occur below the aquitard.

For this FDR, the model was further modified to address DEQ comments. Specifically,

- The model area was extended to include the U.S. Moorings site.
- The model grid spacing was redefined from 40 by 40 feet to 20 by 20 feet. As in the original model, a uniform grid spacing is used throughout the model area.
- The hydraulic conductivity of the shallow alluvium was modified to represent the spatial heterogeneity observed in pumping test results at PW-1-80, PW-3-85, and PW-8-39.

Model parameters of various hydrostratigraphic units are provided in the following table.

Unit	Hydraulic Conductivity (ft/d)	Vertical Anisotropy (dimensionless)	Specific Storage (ft^{-1})	Specific Yield[1] (dimensionless)
Fill	10	0.01	1.00E-05	0.05
Silt	0.5	0.01	1.00E-05	0.05
Upper Alluvium	1 to 10[2]	0.1	1.00E-05	0.05
Lower Alluvium above Aquitard	300	0.2	1.00E-05	0.05
Lower Alluvium below Aquitard	300	0.2	1.00E-05	0.05

Notes:

1 - Applies to the top-most active unconfined layer only. The relatively low value of 0.05 was used during tidal cycle simulations and therefore represents dewatering over tidal cycles.

2 - Varies based on pumping test results at PW-1-80, PW-3-85, and PW-8-39, and on slug test results as shown in Appendix C.

Section 3.2.1.3 describes the slug tests completed at the site. The hydraulic conductivity findings of the slug tests completed in the Fill WBZ were not used in the MODFLOW model. As shown in the table above a hydraulic conductivity of 10 feet per day was used for the model, whereas the slug test results indicate an average hydraulic conductivity of less than 1 foot per day. The model was not modified to reflect the slug test findings because the model calibrated well with the site groundwater water level data using a hydraulic conductivity value of 10 feet per day. Using 10 feet per day also results in higher recharge to the Fill WBZ, which is more conservative from the standpoint of determining flow to the Fill WBZ interceptor trench and sizing of the pump and treat system.

Figure 3-2 is a particle track map showing the model-predicted capture zone in the Alluvium WBZ induced from pumping at the 14 extraction well locations. The modeled total extraction flow rate for this analysis was 260 gpm.

The modeled design presented in this FDR includes paired upper and lower alluvium wells in Segment 1 with additional upper alluvium wells between the well pairs. This provides for horizontal gradients from the river to the wells and upward vertical gradients from the lower to the upper alluvium. The inward and upward vertical gradients are designed to provide full capture of site groundwater while not exacerbating offshore or vertical migration of DNAPL.

Anchor QEA is in the process of conducting transient model simulations using river stage data from mid November 2010 to mid March 2011. The transient simulations will look at how pumping rates vary over tidal and stage changes to maintain inward and upward gradients from the river to the extraction wells. Results from the variable rate pumping test conducted in April 2011 will be used in this analysis. The outflow variation is not expected to be large and the treatment system design capacity is flexible enough to account for seasonal and tidal flow variation.

3.2.1.5 Groundwater Gradient Analysis

Predicted groundwater gradients are shown on Figures 3-3a and b. The gradients are directed upward and upland on the river side of the extraction wells to avoid exacerbating potential movement of DNAPL. Vertical gradients are greater in the upper alluvium than in the lower alluvium even though upper alluvium wells are pumping at lower rates. This is due to the lower hydraulic conductivity of the upper alluvium. The vertical gradient decreases more rapidly with distance from the pumping wells in the upper alluvium than in the lower alluvium, which is also due to the lower hydraulic conductivity of the upper alluvium.

3.2.1.6 TarGOST DNAPL Investigations

The nature and extent of DNAPL at the Site was presented in the RI Report (HAI 2007). DEQ requested further delineation of the extent of DNAPL using TarGOST technology. On behalf of NW Natural, Hahn Associates, Inc. (HAI), conducted TarGOST investigations in 2007 and 2008. For this project, the term DNAPL is defined to include tar, mobile oil, and residual oil. DEQ requested this information to help evaluate the design of nearshore source control alternatives

and to refine the delineation of DNAPL in the former effluent pond area and on the Siltronic property.

The TarGOST exploration technology uses a cone penetrometer drill tool equipped with a detector that is pushed to selected subsurface sampling depths. The detector measures the fluorescent signature and magnitude to identify the presence of various petroleum compounds. The device was specifically calibrated to respond to DNAPL tar and oil at the Site by conducting test borings at locations where the DNAPL occurrence was known from previous investigations. The technology is reliable for the detection of the presence of tar and oil but cannot differentiate between tar and oil or determine if the material is mobile. The cone penetrometer measures the change in earth resistance as it is pushed into the ground, and the magnitude of resistance is correlated to soil types, such as sand, silt, and clay. Thus, the penetrometer logs are used to determine soil type.

Figure 3-4a shows the nature and extent of DNAPL (tar and oil) in the fill. Figure 3-4b shows the areal extent of tar and oil detected in the alluvium above the depth of 100 feet bgs. Figure 3-4c shows the areal extent of tar and oil detected in the alluvium below 100 feet. The TarGOST investigation generally confirmed the findings of the previous RI investigation but did refine the DNAPL boundaries in some areas of the Site. The detections of DNAPL and the thickness of geologic materials detected in the TarGOST borings were used to refine the geologic profiles in Figures 2-3a, b, and c through 2-8. The TarGOST boring logs are provided in Appendix G.

DEQ requested in the March 26, 2010 letter that we add the detection of sheen to the subsurface profiles in the design report because DEQ believes that sheen is an indicator for the presence of DNAPL. Both Anchor QEA and HAI have been using prescribed techniques for delineating the presence of DNAPL; including the following methods, field visual logging of soil core, field UV screening of soil core samples, and TarGOST explorations. Detections of DNAPL using these prescribed methods are the basis of the DNAPL delineated on subsurface profiles and on the DNAPL maps on Figures 3-4a, b, and c in this FDR. These combined methods for DNAPL detection are considered to be consistent and accurate. NW Natural does not agree that sheen is a consistent or otherwise reliable indicator for the presence of DNAPL. As such, interpretation of the differing magnitudes of sheen as the equivalent of a DNAPL observation would not enhance our understanding of the distribution of DNAPL.

3.2.1.7 DNAPL Movement

At the request of DEQ, Anchor QEA evaluated the potential for DNAPL mobilization in the former effluent pond area as a result of future source control groundwater pumping. The findings of this modeling were presented to DEQ in a March 18, 2009, technical memorandum that is summarized here and described in detail in Appendix H.

The model results, summarized in Table 3-3, show that changes in groundwater gradient in the former effluent pond area due to upper alluvium depth extraction well pumping would cause maximum distances traveled over a 3-year period to range between approximately 3.3 to 7.3 feet at distances of 90 and 50 feet upgradient of the extraction well. The data in Table 3-3 refer to the behavior of DNAPL pools, not residual DNAPL. The evaluation concluded that mobilization of residual DNAPL (as opposed to pools) would not occur at the Site in the former effluent pond area, because groundwater gradients that result from pumping, and the material properties of the aquifer matrix and of the DNAPL, produce a capillary number that is well below the critical value.

From this analysis, enhanced groundwater movement in the former effluent pond area due to shoreline extraction wells is minimal and would not substantially change DNAPL distribution over time. These calculations are conservative approximations of the potential distances that DNAPL could travel, and the true estimate would be less if the capillary term were factored into the calculation.

3.2.1.8 DNAPL Removal Pilot Plan

A *DNAPL Removal Pilot Plan* (Anchor 2008c) was submitted to DEQ in October 2008. The first objective of the plan was to conduct a field test using pilot DNAPL extraction wells to determine how pumping of shoreline source control wells would affect DNAPL migration in the former effluent pond area. This test was designed to respond to DEQ's concern about DNAPL migration under the influence of the shoreline extraction wells. The second objective of the test was to provide information to aid in future design of a DNAPL extraction system. DEQ issued a January 22, 2009, comment letter stating that it was unlikely that the first objective of the test would be met, but recommended that NW Natural proceed with the test to achieve the secondary objective. Because DEQ did not support conducting the test for its first objective, NW Natural informed DEQ in a February 10, 2009, letter of its intent to postpone

implementation of DNAPL pilot testing until it can be conducted in the context of the upland FS process.

Since submittal of the DNAPL Removal Pilot Plan (Anchor 2008c), NW Natural conducted the evaluation of potential DNAPL mobilization as described in Section 3.2.1.7. The predicted migration distances shown in Table 3-3 indicate that the migration of DNAPL is expected to be insignificant under the influence of the shoreline extraction wells. The findings of that analysis further support NW Natural's plan to evaluate DNAPL removal as part of the upland FS process, not as part of shoreline source control activities.

3.2.1.9 Segment 2 Extraction Well Pilot Test

On September 23, 2009, the *Segment 2 Capture Zone Field Test Plan* (Anchor QEA 2009c) was submitted to EPA for review. The revised and approved plan included the installation of four shoreline extraction wells, upland monitoring wells, and offshore piezometers in Segment 2. The Segment 2 field test was completed in 2010; the findings were provided to EPA and DEQ (Anchor QEA 2011), and the report is provided in Appendix I. The extraction wells, monitoring wells, and piezometers were equipped with electric water level transducers. The three extraction wells were pumped at varying rates with concurrent measurement of gradient changes in the wells. The purpose of the test was to assess how operation of the extraction wells affect offshore seepage of groundwater in the river to support the development and evaluation of sediment remedial alternatives (e.g., sediment capping). The findings of the evaluation will be used for design of the in-river sediment cleanup to be conducted under the authority of EPA.

In summary, the Segment 2 Capture Zone Field Test Plan (Anchor QEA 2009c) showed that conventional extraction wells operated near the shoreline can successfully contain offshore seepage at least as far offshore as the FAMM dock, and likely beyond. The tests provided the information needed for future modeling of seepage control in the river, as it will apply to design of the in-river sediment cleanup.

The Segment 2 capture zone tests also provided some information for upland source control design. The tests showed that the upper alluvium in the vicinity of pilot wells PW-7, 8, and 9 has lower hydraulic conductivity than the upper alluvium in Segment 1. The aquifer properties derived from the Segment 2 field tests have been incorporated into the MODFLOW model being used for source control design. The tests also showed that in the vicinity of extraction

wells PW-7, PW-8, and PW-9, pumping of lower alluvium extraction wells has little or no short-term measurable water level effect on nearby wells screened in the overlying Fill WBZ.

3.2.2 Extraction System Design

There are two main components of the groundwater containment system. Groundwater in the Fill WBZ will be captured in an interceptor trench constructed near the top of the riverbank. For reasons discussed in the following section, the interceptor trench will be constructed coincident with the river sediment cleanup. Groundwater in the Alluvium WBZ will be captured by an extraction well system that will be constructed and placed in operation upon DEQ approval of source control final design. The extraction well system design is presented in Section 3.2.2.2. The groundwater flow rate from the Fill WBZ interceptor trench is anticipated to be less than 10 percent of the total flow from the alluvium. Implementation of the alluvium pump and treat system is therefore a higher priority than groundwater source control in the Fill WBZ. Both the Fill WBZ interceptor trench and the Alluvium WBZ extraction well system will pump groundwater to the treatment plant for discharge to the river under a NPDES permit.

3.2.2.1 Fill WBZ Interceptor Trench

The planned location of the Fill WBZ interceptor trench is shown on Figures 2-2a, b, and c. The purpose of the trench is to intercept groundwater in the Fill WBZ before it discharges to the river. The trench will be constructed near the top of the riverbank in Segments 1 and 2. The trench will be located between the extraction well system and the top of the riverbank. The trench construction methods and materials are described in Appendix J. The interceptor trench design drawings and subsurface profiles are also in Appendix J.

As described in Appendix J, a horizontal collector pipe will be installed at the bottom of the trench, which will be backfilled with permeable gravel. Each segment of the trench collector pipe will drain by gravity to a sump. There will be a manhole at each sump, and each sump will be equipped with a pump that is hooked by pipeline to the treatment system. Figures 2-2a, b, and c show the locations of the manholes and connecting pipelines. The depth of the collector pipe will be in the upper portion of the alluvial silt layer underlying the fill. Placing the collector pipe just below the base of the fill is intended to allow the trench to capture all of the groundwater in the Fill WBZ.

As described in Section 2.1.2, the average hydraulic conductivity of the Fill WBZ is quite low, less than 1 foot per day. Therefore, the expected total flow from the trench is expected to be very low, with wet season total flow not more than 20 gpm.

Construction of the trench on both properties is expected to be very difficult in many shoreline areas because of the presence of shoreline structures. The FAMM tank farm, FAMM office building, Siltronic outfall, and docking and mooring structures are all very difficult to work around from an equipment access standpoint. In these areas, the trench will be constructed at the top of the riverbank or partially on the riverbank slope due to the presence of the shoreline structures.

Riverbank cleanup will coincide with the in-river sediment cleanup, as described in the EPA SOW. A number of riverbank cleanup options will be considered in the sediment cleanup EECA that would require earthwork at or near the top of the riverbank. The presence of the interceptor trench near the top of the riverbank would, therefore, limit the range of riverbank cleanup alternatives that could be considered. The sediment cleanup will likely include dredging of sediment at or near the toe of the riverbank. The sediment cleanup design will include an analysis of riverbank stability as part of the dredging design. The presence of an interceptor trench near the top of the riverbank could restrict dredging options from the riverbank stability standpoint. Total flow from the Fill WBZ interceptor trench is anticipated to be less than 20 gpm. The expected flow from the interceptor trench is less than 10 percent of the anticipated total flow from the alluvium pump and treat system, and implementation of the alluvium source control system is therefore a higher priority than the Fill WBZ interceptor trench. For these reasons, the Fill WBZ interceptor trench source control action is recommended to be constructed at the same time as the in-river sediment and riverbank cleanup occurs. This sequence will have the benefit of allowing integration of the interceptor trench design into the overall riverbank cleanup design. The interceptor trench design presented in Appendix J will likely require modification when it is integrated with the riverbank cleanup design.

3.2.2.2 Alluvium Extraction Wells

3.2.2.2.1 Well Location and Screen Depth

Figures 2-1 and 2-2a, b, and c show the locations of the planned shoreline extraction wells. These maps show 14 extraction well locations, PW-1 through PW-14. Locations PW-1 through PW-10 were in the preliminary and interim design reports. Locations PW-11 through PW-14

were added during final design to reduce the horizontal and vertical gradients in the upper alluvium, as previously discussed in Sections 3.2.1.4 and 3.2.1.5. The original 10 well locations are numbered sequentially from south to north, starting with well location PW-1 on the Siltronic property, to location PW-10 near the north end of Segment 2. As shown on Figure 2-2b, the new locations PW-11 through PW-14 are located between the original wells on Segment 1.

Hydraulic gradient control and stratigraphy are the two primary design factors controlling well spacing and screen elevation. In comments on the IDR (Appendix A), DEQ withheld approval of the design of proposed extraction wells PW-3 through PW-6 because of concerns about the potential for these wells to mobilize and spread DNAPL. DEQ also withheld approval of the design of wells PW-1 and PW-2, because it felt that the design of the well screen depths did not adequately consider groundwater quality. For the reasons explained below, this FDR contains significant changes to the Segment 1 well spacing, number of wells, and screen depth.

The Segment 1 extraction well final design adds well screens in the upper alluvium at locations PW-1 through PW-6. The design also added to Segment 1 upper alluvium wells at PW-11, PW-12, PW-13, and PW-14. The upper alluvium screens in Segment 1 were added for the following reasons:

1. The average thickness of the upper alluvium in Segment 1 is more than double the thickness of the upper alluvium in Segment 2, so placement of upper alluvium well screens in Segment 1 will help attain capture. The presence of numerous silt layers are expected to restrict flow in the upper alluvium.
2. Most of the mass of contamination in Segment 1 is in the upper alluvium, so placement of well screens in the upper alluvium will provide closer access to the zones of higher contaminant concentrations.
3. In the DNAPL zones on the NW Natural portion of Segment 1, the placement of wells in the upper alluvium will allow a greater degree of vertical gradient control, which will minimize the potential to mobilize and spread DNAPL.
4. Adding upper alluvium wells PW-11 through PW-14 greatly reduces the horizontal spacing between extraction wells in the zones of shallow DNAPL, which allows reduction of the individual well discharge rate necessary to maintain capture and, thereby, reduces the horizontal hydraulic gradient in the vicinity of each well. This reduction of horizontal gradient helps minimize the potential for inducing migration of DNAPL.

Two factors were considered when selecting the elevation of the upper alluvium well screens in Segment 1. The wells are placed shallow enough to facilitate control of vertical gradients and, thereby, reduce the potential to mobilize DNAPL. The wells are also placed deep enough to allow sufficient drawdown to attain the pumping rates needed for gradient control. If the upper alluvium wells are placed too high, they could risk inducing drawdown into the well screen, which could either restrict the potential yield of these shallow wells or exacerbate the formation of iron slimes and precipitates that can result from exposure of the well screens to cascading water in the casing.

Regarding DEQ's request to further consider groundwater quality in the design of extraction well screen locations, it is felt that the placement of upper alluvium well screens in Segment 1 will provide greater access to contaminant mass than the interim design. However, this design does not attempt to place screens in the absolute highest zones of contamination, because this placement would impair the performance of the wells from the standpoint of attaining hydraulic capture and maintaining gradient control. At the request of DEQ (Appendix A), the proposed extraction well screens have been added to Figures 2-11a and b, which are subsurface profiles showing groundwater quality data for selected COIs. These revised figures afford DEQ the opportunity to review the well screen locations in conjunction with groundwater quality data.

Figures 2-11a, b, and c also serve to respond to DEQ's IDR comment (Appendix A) that the need for an additional extraction well adjacent to PW-1 be evaluated in the final design report. In other words, DEQ requested that NW Natural evaluate the need to extend Segment 1 farther on Siltronic property. In response to DEQ's request FDR Figure 2-11 has been created by modifying IDR Figure 2-10 in two ways: 1) groundwater quality data was added from groundwater grab samples obtained in one-time borings completed by NW Natural and Siltronic; and 2) the figure was extended to include approximately 450 additional feet of Siltronic shoreline. The COIs benzene, naphthalene, vinyl chloride, total cyanide, and free cyanide were selected for these figures because they are indicative of both the MGP dissolved plume and the Siltronic dissolved plume. The naphthalene and total cyanide COIs have lower attenuation factors than the other organic and inorganic COIs, and therefore are representative of the maximum extent of the MGP plume. The additional data were reviewed by NW Natural in conjunction with the information in the Source Control *Evaluation Report "Segment 3" Siltronic Property Related to NW Natural Gasco Site* (Anchor 2009b). NW Natural has not yet received comments from DEQ on the Segment 3 source control evaluation report. Based on review of

Figure 2-11 and the Segment 3 source control evaluation report, NW Natural does not see a technical basis for extending Segment 1 further on the Siltronic property.

The extraction well locations and spacing are also based upon the findings of the design studies described in Section 3.2.1 and specifically the MODFLOW model work described in Section 3.2.1.4. From these 14 locations, the extraction well system will prevent groundwater in the Alluvium WBZ from migrating to the river, as represented on Figure 3-2. Due to equipment access or underground utility considerations, the well locations may be modified slightly from those shown on the maps in this report. The well locations are spaced a suitable distance from the shoreline to accommodate the installation of the Fill WBZ interceptor trench.

Table 2-1 lists construction details of all existing and proposed wells. The existing and proposed source control wells are also shown on Figures 2-3a, b, and c through 2-8. The proposed well numbers with the U designation will have an upper alluvium screen and the well numbers with the L designation will have a lower alluvium screen. As shown in Table 2-1 and on Figures 2-3a, b, and c through 2-8, the following locations are planned to have paired wells. The wells that already exist are noted:

- PW-1U, 1L
- PW-2U, 2L
- PW-3U, 3-118 (3-118 installed)
- PW-4U, 4L
- PW-5U, 5L
- PW-6U, 6L
- PW-8-39, 8-68 (both installed)

The following locations are planned to have one well:

- PW-7-93 (installed)
- PW-9-92 (installed)
- PW-10L
- PW-11U
- PW-12U
- PW-13U
- PW-14U

At each well location, the anticipated screen length will be between 15 and 20 feet. The screen length was selected for each location based on the need to have low entrance velocity of groundwater into the well screen. Maintaining a low entrance velocity is considered beneficial for minimizing the rate of formation of mineral deposits and bacterial slimes that will accumulate in the well screen and alluvial sands/silts in the soil outside the well screens.

On Figures 2-3a, b, and c, some of the upper alluvium well screens are shown to bisect a silt layer. The design intent is to keep the upper alluvium screens in approximately the same elevation range. For the purpose of these design profiles, the well screen elevations are shown to be nearly the same, even though a silt layer is shown to be present in some of the screen intervals. The geologic well log will be reviewed in the field to determine if the silt layer is actually at the elevation shown on the profile. If it is, the screen elevation will be shifted up or down to avoid placing the screen across the silt. If the silt is very thin and there is no reasonable way to avoid placing the screen across the silt, the screen will be placed across the silt layer. The same logic applies to the lower alluvium screens, some of which are also shown bisecting a silt layer.

3.2.2.2.2 Well Materials, Construction, Development

The components of the proposed extraction wells are shown on Figure 3-5. The primary components are:

- Six-inch diameter steel casing
- Six-inch diameter Johnson wire-wrapped stainless screen
- Fifteen to 20 feet total screen length at each location with a screen slot size of 0.035 inch
- Gradation 10/20 annular backfill sand
- Five-foot-long stainless steel casing sump below the screen

The annular backfill sand grain size was designed based on grain size analyses completed on the "GS" borings completed in 2006. The annular backfill sand recommended herein was used in the construction of extraction wells PW-3, PW-7, PW-8, and PW-9 and was determined to be appropriate based on the results of well screen development and pump tests.

In the past DEQ has requested that a "DNAPL funnel" be installed at the junction of the base of the well screen and the casing sump. DEQ has requested this device to be installed to funnel DNAPL migrating in the annulus down into the well sump. Such a device can be installed on

the extraction and monitoring wells that are located in the upper alluvium of Segment 1 on NW Natural property where DNAPL may enter the borehole. However, there is no feasible way to place annular backfill material around the sump because the funnel blocks the annular space. So for those wells where a "DNAPL funnel" has been installed there can be no material of any kind placed in the annulus around the sump. If that condition is acceptable to DEQ and the Oregon Water Resources Department, it is possible to install these devices on selected wells in potential DNAPL zones as described above.

The wells are planned to be drilled using sonic drilling technology. This technology was selected, because cable-drilling methods are very slow, air rotary drilling can result in personnel health and safety issues due to contaminated return air, and mud rotary drilling methods generate larger volumes of contaminated drilling wastes that require off-site disposal. Sonic drilling methods were used to install pilot extraction wells PW-7, PW-8, and PW-9 and provided good results.

The sonic drill will obtain a continuous soil core, which will be examined in the field by an Anchor QEA geologist to create a complete geologic log. This log will be used to determine the extraction well screen depths. Table 2-1 lists the currently planned extraction well screen intervals.

As shown on Figure 3-5, the annulus above each screen will be sealed with bentonite grout per Oregon Water Resource well construction requirements. For all wells that will penetrate known DNAPL zones, the bentonite grout will be mixed with organoclay. The planned ratio of bentonite to organoclay is 90 to 10 by volume. A variance from Oregon Water resources well construction requirements will be obtained prior to initiating field work. Such a variance has previously been obtained at the Site for other borings drilled in DNAPL zones.

Appendix K describes how solid waste materials derived from well drilling, well construction, and screen development activities will be characterized and disposed. Contaminated water from drilling and development activities will be treated in the on-site carbon treatment system and discharged to the COP publicly owned treatment works (POTW) under the facility Industrial Wastewater Discharge Permit.

Appendix K also describes the procedures for construction and screen development for the extraction, monitoring, and observation wells.

3.2.2.3 Conveyance and Control System

A process and instrumentation diagram of the extraction well conveyance and control system is shown on Figure 3-6. The lower alluvium extraction wells will be equipped with 5 horsepower centrifugal pumps, and the upper alluvium wells will be equipped with 1 to 2 horsepower centrifugal pumps. The centrifugal pumps will be powered by motors controlled by variable frequency drives that are directed from a panel equipped with a programmable logic control (PLC) system. The PLC system will be equipped with human machine interface (HMI) data acquisition, programmable for alarm condition notification and capable of future expandability, if needed.

Being powered by variable frequency drive allows the pump discharge to be continuously adjusted as controlled by the PLC system. Figure 3-6 shows that water level transducers will be installed to monitor the groundwater elevation in selected wells. A water level transducer has already been installed on the FAMM dock to monitor the Willamette River elevation.

April 2011 field testing of the VFD system on extraction wells PW-7-93, PW-8-68, and PW-9-92 showed that the VFD system was successful at maintaining groundwater capture by real time adjustment of extraction well pump speed in concert with the tide induced groundwater elevation changes. The capture assessment discussion in Section 3.2.2.5.2 describes how water elevation data from the control wells will be used to change the extraction well discharge rates to maintain capture.

A water level transducer will be installed in each of the extraction wells. Transducers will also be installed in the new monitoring wells shown on Figures 2-2a, b, and c and 2-3a, b, and c and listed in Table 3-4. As shown in Table 3-4, a subset of the transducers will be used to monitor groundwater elevations for the purpose of controlling the extraction well discharge rate. In Table 3-4, those wells are termed control wells.

The well field controls and piping diagram on Figure 3-6 also shows that the upper alluvium extraction wells located in the NW Natural portion of Segment 1 will have installed DNAPL recovery pumps. Based on existing information on DNAPL occurrence, it is possible that DNAPL will enter these wells and accumulate in the bottom sump below the screen. If DNAPL accumulates in the well sumps, an air actuated piston pump will be used for DNAPL recovery.

The DNAPL will be pumped to holding tanks and removed for off-site recycling as is current practice for DNAPL recovered from Site monitoring wells MW-6-32 and MW-13-31. All extraction well sumps will be regularly monitored for the presence of DNAPL, and a DNAPL recovery pump will be added to any wells where DNAPL accumulates in the sump.

3.2.2.4 Anti-Fouling Design and Maintenance

Under the direction of Anchor QEA, Water Systems Engineering, Inc. (WSE), conducted laboratory testing of representative groundwater samples from MW-1-55, PW-4-85, and PW-3-118. The purpose of the testing was to determine how susceptible the wells would be to the formation of minerals and bacterial slime that would reduce the permeability of the well screens, annular backfill, and aquifer formation sands. The WSE study found that the aquifer chemistry suggests a moderate to high potential for fouling from the formation of mineral deposits and bacterial growth.

Until recently, it was planned to use chemical treatment as recommended by WSE to maintain the well screens, annular backfill, and formation sands in permeable condition. However, there has been concern that the use of traditional chlorine-based, acid, and caustic chemicals for this purpose could cause the formation of cyanide gas, creating a potential worker health and safety issue.

Therefore, a different method for maintaining well performance is planned to be tested at the Site. This new method is available under the trade name of Aqua Gard and was developed by Subsurface Technologies, Inc. (STI). Information on the Aqua Gard technology is in Appendix L.

The Aqua Gard system uses a perforated injection pipe that is permanently installed in the well to inject liquid carbon dioxide into the well screen, surrounding annulus, and aquifer formation materials. Because the Aqua Gard injection system is permanently installed on the well head, the well pump does not have to be removed to perform the Aqua Gard treatment. Prior to injection of the liquid carbon dioxide, the extraction well pump is turned off. The physical agitation that occurs during vaporization of the liquid carbon dioxide dislodges accumulated mineral deposits and bacterial slimes. Carbonic acid also forms during this process, which dissolves some of the material. Following injection of the liquid carbon dioxide, a suitable period of time (generally several hours) is allowed to elapse to ensure that all of the liquid carbon dioxide has vaporized, then the pump in the treated well is restarted. Within a short

period following restart of the well pump, the affected groundwater, dislodged minerals, and organic materials will be pumped to the facility groundwater treatment system.

Based on the experience of STI at other sites, it is estimated that semi-annual treatment will maintain the well screens and formation sands in good condition. The frequency of maintenance required to attain efficient operation of the well system will not be certain until 1 or 2 years of well operation have been experienced.

To determine if semi-annual treatment is sufficient, the performance of the well system will be reviewed monthly during the first year of operation by preparing a specific capacity graph for each well that is updated monthly. Well specific capacity is the ratio of drawdown to discharge. If regular monitoring of specific capacity indicates that well performance is declining, that could mean that more frequent Aqua Gard treatment is needed.

Another more direct way to assess the need for treatment is to use a downhole camera to visually inspect the well screen and casing for the presence of mineral deposits and bacterial slime. A downhole camera may be used for this purpose but only if semi-annual Aqua Gard treatment does not seem to maintain well performance. It would be necessary to remove the well pump and transducer assemblies from the well casing to allow the use of a downhole camera, so this assessment method will not be used unless necessary.

3.2.2.5 Performance Monitoring

3.2.2.5.1 Monitoring Well Network

Monitoring of the performance of the extraction well system requires the installation of additional monitoring wells and piezometers. The proposed monitoring wells and piezometers are listed on Table 2-1 and shown on the Figures 2-2a, b, and c and 2-3a, b, and c. The rationale for the location and screen depth for these monitoring points are described in Section 3.2.2.5.2. Table 3-4 shows the proposed performance well monitoring network, consisting of existing and proposed wells to be used for assessing extraction system performance as described in the following sections.

3.2.2.5.2 Capture Assessment

This plan for measuring the capture performance of the source control system is designed to meet or exceed EPA guidance in *A Systematic Approach for Evaluation of Capture Zones at Pump*

and Treat Systems (EPA 2008). The extraction well system will be operated to maintain an average hydraulic condition of gradient reversal such that upland groundwater is not discharging to the river. As explained herein, the average gradient reversal will be maintained by controlling the extraction well discharge rate based on transducer monitoring of groundwater elevations at designated control wells. Site-specific groundwater discharge and groundwater elevation data will also be used in the DEQ-approved site MODFLOW and PATH3D models to produce particle track maps for assessing capture.

Table 3-4 lists the existing and proposed shoreline monitoring wells, extraction wells, and piezometers that are in the performance monitoring plan. The network of existing shoreline monitoring wells was carefully evaluated to determine which wells have suitable location and screen elevation to be useful to assess the capture performance of the extraction well system. As shown in Table 3-4, many of the existing monitoring wells were suitable for this purpose. Because the current shoreline monitoring well network was designed primarily to characterize the nature and extent of contamination, some of the existing well locations are not suitable for capture evaluation. Therefore, Table 3-4 lists the proposed monitoring wells, extraction wells, and piezometers that are needed to provide the necessary water level data to fully evaluate capture performance of the entire source control system.

Table 3-4 shows the wells that will be equipped with water level transducers. All the water level transducers will also measure water temperature. In the interim design it was planned to have the extraction well transducers also measure groundwater conductance. During final design it was determined that we would have to remove those transducers on a frequent basis to calibrate the conductance meter that is built into the transducer probe. In order to remove the transducer it would be necessary to disconnect it from the PLC system and during that period it would not be functioning as a control transducer. Therefore, we have determined that it is impractical to have any of the transducers measure conductance because it would be necessary to disconnect the transducers frequently for calibration.

Groundwater elevation data from the monitoring wells is measured by the PLC system and will be used to control the extraction well discharge rate. Each extraction well will be surrounded on two sides by monitoring wells containing water level transducers. Each extraction well will be assigned to one control well. Based on the findings from initial startup and testing it may be necessary to change the control well that is assigned to some of the extraction wells. The control well locations are roughly equidistant between extraction wells. In some cases, existing

monitoring wells will be used, but in many cases, new monitoring wells must be installed for this purpose. For example, extraction well PW-4U is flanked by monitoring wells MW-29U, and MW-30U, as shown on Figure 2-3b and in Table 3-4. Table 3-4 indicates which wells will be equipped with transducers and those that will be designated as control wells. On the Figure 2-3 subsurface profiles the control wells are designated with an asterisk. The control function is generally assigned to the monitoring wells that are screened in approximately the same elevation of the aquifer as the extraction well.

The PLC system will continuously monitor the real time elevation of groundwater in each of the control wells compared to the real time elevation of water in the Willamette River. The PLC continuously adjusts the well pumping rate using the VFD system to maintain the groundwater elevation in the control wells below the river elevation to maintain the condition of gradient reversal. The groundwater elevation will naturally change constantly in response to river-induced tidal effects. This constant change requires the transducer controlled system to adjust the well pump discharge rate to maintain the condition of gradient reversal. Although the monitoring transducers are not used to control the well pumping rate, they are used to make sure that the gradient reversal that is measured in the control wells also occurs in the deeper portion of the aquifer. After initial startup of the system, a period of monitoring will be required to ensure that the correct wells are being used as control wells. In some cases, it may be necessary to change control wells if they better reflect the gradient reversal at that location.

The PLC system is designed to allow a unique elevation delta to be assigned to each control well transducer. The assigned elevation delta is the elevation difference between the river elevation and the groundwater elevation at the control well. The heterogeneous nature of the geology means that each control well responds in a unique way to pumping from the extraction wells. Having a larger delta means that the extraction well has to pump at a higher discharge rate to achieve the assigned delta. Based upon field observations made during the April 2011 VFD testing it is anticipated that some tuning of the control well elevation deltas will be done during startup to balance the pumping rates between the extraction wells.

During the startup process we will prepare a memo that provides the recommended elevation deltas for operating the system. The recommended deltas will be based on field testing and balancing the deltas to achieve consistent capture. The system performance reports (Section 3.2.2.5.5) will include an evaluation of the appropriateness of the selected elevation deltas.

In a March 2011 meeting with Anchor QEA, DEQ suggested that monitoring wells with screens below the aquitard be designated as control wells, specifically MW-21-165, MW-24L, MW-27L, MW-28L, MW-31L, and MW-34L. Based on the results of the VFD testing of wells PW-7-93, PW-8-68, and PW-9-92 completed in April 2011, it is not feasible to use those wells as control wells. A report of the VFD test findings is being prepared for submittal to EPA and DEQ on May 25, 2011. Those wells are separated from the extraction wells by a significant vertical distance and by the low permeability aquitard. This means that the water level response in those wells is significantly smaller than control wells installed at the same elevation as the extraction wells. Due to the vertical distance and the presence of the aquitard the timing of the water level response is also somewhat delayed relative to the response time of a closer well at the same elevation as the extraction well. For these reasons the wells proposed by DEQ will not provide adequate information for the PLC system to effectively control the gradient reversal conditions. Therefore this final design does not use the monitoring wells below the aquitard as control wells. Accordingly the screen elevations of proposed control wells MW-24L, 27L, 28L, 31L, and 34L are above the aquitard as shown on Figure 2-3b. Existing monitoring wells MW21-165, 18-180, 19-180, 5-175, 14-161, and 11-161 screened below the aquitard will be equipped with water level transducers and the water level elevations will be monitored to make sure that capture below the aquitard is achieved. This may require adjustment of the elevation delta at some of the control wells to cause a higher pump rate in some extraction wells to achieve capture below the aquitard.

Table 3-4 also lists a number of piezometers that have been installed or are planned to be installed in the river. Some will be installed along the shoreline and others are already constructed and attached to the FAMM dock, as shown on Figures 2-2a and 2-2b. The piezometers will be installed at multiple depths below the river mudline. The subsurface profiles on Geologic Cross Sections B-B′ and C-C′ (Figures 2-4 and 2-5) show the depths and locations of several of the existing river piezometers. These piezometers are equipped with water level transducers. As provided in the description of the Segment 2 capture zone test in Section 3.2.1.9, the groundwater elevation data from the river piezometers will be used to assess the effect on offshore seepage that is achieved by the shoreline extraction wells. This information will be used for design of the in-water river sediment cleanup plan.

3.2.2.5.3 DNAPL Monitoring

In comments to the IDR (Appendix A), DEQ commented that operation of the extraction wells could potentially mobilize and spread DNAPL and that potential expansion of the distribution

of DNAPL is a significant factor for source control measures planning and design. As described in Section 3.2.2.2.1, the number, depth, and locations of Segment 1 extraction wells were redesigned to minimize the potential for DNAPL mobilization. Mobile DNAPL is expected to migrate into shallow Segment 1 extraction wells that are inadvertently screened in mobile DNAPL. However, the reduced horizontal and vertical gradients that will result from the currently proposed extraction well network are not expected to mobilize DNAPL beyond a distance of a few feet from each extraction well.

To further address DEQ's concerns, a DNAPL monitoring component has been added to the system performance monitoring program. The DNAPL monitoring program consists of three main elements:

- TarGOST sampling
- Monitoring and recovery of DNAPL entering wells
- Monitoring of DNAPL entering the treatment system oil-water separators

These elements are described below, followed by a summary of the reporting to be prepared for submittal to DEQ to document the DNAPL monitoring program results and conclusions.

TarGOST Sampling

TarGOST sampling methods will be used to monitor for the migration of DNAPL into areas adjacent to the former effluent ponds where DNAPL has not been detected to date. DNAPL observations in this area are shown on cross-sections D-D', E-E', F-F', G-G', and H-H', depicted in Figures 2-6 2-7, 2-8, 3-8, and 3-9, respectively. Three general zones (shown on Figure 3-10) have been selected for TarGOST sampling based on the following criteria:

- Previous borings in the area have had no DNAPL observations in the upper alluvium
- Adjacent to the estimated extent of DNAPL in the upper alluvium (shown on Figure 3-10)
- Adjacent to source control pumping wells (two of the three zones)

An approximately 10-foot-by-10-foot portion of each zone will be selected for monitoring. These areas will be selected based on their proximity to pumping wells (areas closer to pumping wells will be targeted) and/or proximity to localized geological conditions that may increase the likelihood of DNAPL migration. Note that TarGOST monitoring will not be

conducted in areas where DNAPL has been detected very near to a pumping well. Potential TarGOST monitoring areas are shown on Figure 3-11.

Baseline borings will be advanced in each area to confirm the absence of DNAPL in the upper alluvium prior to start up of the extraction well system. Three TarGOST borings will be advanced along the periphery of each of the three targeted areas. If DNAPL is detected, then the area will be rejected, a new 10-foot-by-10-foot portion of the TarGOST sample area will be selected, and additional baseline borings installed. If DNAPL is not detected in the upper alluvium of each of the three baseline borings, then the location will be retained as a TarGOST monitoring area.

The three TarGOST monitoring areas will be retested for the presence of DNAPL in the upper alluvial at the end of Years 1, 3, and 5 of operation of the source control system. One TarGOST boring will be installed in each area within the triangle formed by the baseline borings. After 5 years of extraction system operation, the monitoring program will be evaluated to determine if continued TarGOST monitoring is needed.

In the event of a DNAPL detection during TarGOST monitoring, the following assessment steps would be taken:

1. Advancement of an additional confirmation TarGost boring
2. If confirmed, advancement of a push probe within the monitoring area to collect soil core across the depth of DNAPL detection
3. Shipment of the core to a laboratory for physical description and photography under white light and UV light
4. Resting of select subsamples from the core for DNAPL saturation and mobility testing.

Data obtained from the preceding tests would be used to support conclusions and recommendations regarding the need for adjustments to either the hydraulic control or to the DNAPL monitoring program.

The TarGOST sampling results will be included in the DNAPL monitoring report discussed later in this section. Appendix M presents further detail on protocols to be followed during TarGOST boring installation.

Monitoring and Recovery of DNAPL Entering Wells

The low per-well pumping rate of approximately 5 gpm for each of the upper alluvium wells in Segment 1 is not expected to generate a high enough hydraulic gradient to cause DNAPL migration, with the exception of mobile DNAPL adjacent to the well screen. As shown on Figure 3-11, DNAPL is thought to be present near the proposed location of wells only in select areas of Segment 1 (including wells PW-6U, PW-6L, PW-14U, PW-5U, PW-5L, PW-3U, and PW-11U). Nevertheless, all pumping wells have been designed to facilitate the collection and removal of any DNAPL that enters the well. Each well will be installed with a sump to collect DNAPL and have the capacity for installation of a dedicated DNAPL removal pump, should it become necessary. The pumping wells will be monitored for DNAPL entry according to the schedule discussed later in this section. DNAPL will be removed from the wells, to the extent practicable, and the volume recorded.

Although DNAPL is not expected to enter control and monitoring wells, each well included in the system performance monitoring program (described in Section 3.2.2.5.2 and listed in Table 3-4) will be monitored for DNAPL entry. As with pumping wells, monitoring and control wells installed as part of this program will be fitted with a sump below the screen. DNAPL entry will also be monitored in several existing wells along the Segment 1 riverbank where DNAPL entry has previously been detected. These include wells MW-16-45, PW-1-80, and MW-18-30. Accumulated DNAPL will be removed from the wells, to the extent practicable, and the volume recorded.

The monitoring and control wells will be installed ahead of source control system startup to allow a period of time for observing whether DNAPL enters the wells under natural non-pumping conditions. This period, as well as observations collected during well drilling, will be used to evaluate the potential for DNAPL to enter the well during source control system operation. However, it should be noted that DNAPL entry into some on-site monitoring wells under natural gradients was first observed several years after installation. Thus, the presence of DNAPL in a control or monitoring well during system operation does not in itself indicate that the source control system is causing DNAPL to enter the well.

Upon system startup, the pumping, control, and monitoring wells listed on Table 3-4 will be closely monitored for DNAPL entry. Wells will be monitored daily during the first week of operation, and weekly for the following 3 weeks. After this period, the monitoring frequency will be consistent with the water quality trend monitoring program described in Section

3.2.2.5.4. These wells will be monitored monthly for Year 1 of source control operation, quarterly for Year 2, and semi-annually for Years 3, 4, and 5, then annually thereafter. After 5 years of source control operation, the monitoring program would be evaluated to determine if continued monitoring is needed.

The frequency of DNAPL removal, where needed, will be based on the rate of DNAPL entry into the well. As previously discussed, DNAPL entry is only expected in pumping wells installed in select areas of Segment 1. The pumping wells have been designed such that an air actuated piston pump can be installed to remove DNAPL that accumulates in the well sump, should such a system be necessary. Manual and/or other pumping methods may be selected for DNAPL removal, as appropriate. DNAPL removed from each well will be containerized separately for each well such that a removal volume can be estimated for each well.

Observations of DNAPL entry and DNAPL removal volumes will be included in the DNAPL monitoring reporting discussed later in this section.

Monitoring of the Oil-Water Separators

The low per-well pumping rate of approximately 5 gpm for each of the upper alluvium wells in Segment 1 is not expected to generate a high enough hydraulic gradient to cause DNAPL migration, with the exception of mobile DNAPL adjacent to the well screen. Thus, DNAPL entering a well is expected to collect in the well sump and not be pulled into the pumping system itself. DNAPL that does enter the system will be recovered in the oil-water separators at the beginning of the treatment system. The amount of DNAPL collected in each oil-water separator will be observed and recorded as part of the routine monitoring of the treatment system performance. As necessary, DNAPL will be removed from the separators and disposed of off site. The estimated amount of DNAPL observed in the system and removed from the system for off-site disposal (if any) during for each monitoring period will be included in the DNAPL monitoring reporting discussed below.

DNAPL Monitoring Reporting

Results from the previously described groundwater well monitoring and oil-water separator monitoring activities will be included in the system operation quarterly reports to be prepared for submittal to DEQ.

A more detailed DNAPL Monitoring Report will be prepared for submittal to DEQ following completion of each TarGOST monitoring event. This report will summarize the results for all DNAPL monitoring activities, including a trends analysis of the data.

3.2.2.5.4 Water Quality Trend Monitoring

Groundwater quality trends will be monitored at selected wells during operation of the source control system. Because both upland and nearshore groundwater is contaminated with the same COIs at similar concentrations, there is no chemical plume boundary or water quality compliance boundary to assess. The groundwater quality data will not be used for assessing whether the source control actions are successful at achieving shoreline containment. Therefore, the water quality monitoring plan is not intended to be used to judge the success of the source control action, but rather to measure water quality changes that occur during operation of the extraction well system. A subset of the existing and proposed new wells is intended for water quality trend monitoring. The groundwater quality data will be provided to Siltronic for its evaluation of potential hydraulic impacts to the enhanced in situ bioremediation source control measure.

Table 3-4 lists the existing and proposed shoreline monitoring wells. The table shows that the existing shoreline monitoring wells are sampled semi-annually in the current upland monitoring program. With the addition of the new wells shown in Table 3-4, it is planned that the sampling frequency for the existing wells be reduced to annual for the next 5 years. This reduction is justified, because the new proposed wells provide additional spatial coverage of the shoreline zone, which makes semi-annual monitoring of the currently existing wells unnecessary. After 5 years of source control operation, the monitoring program would be evaluated to determine if continued monitoring of the existing wells is needed.

The proposed new wells on Table 3-4 are divided into those with a recommended tiered monitoring frequency and those with a recommended annual monitoring frequency. The extraction wells at all 14 locations will be on the tiered monitoring plan. As explained in the footnote on Table 3-4, the extraction wells in the tiered plan will be sampled monthly for Year 1 of source control operation, quarterly for Year 2, semi-annually for Years 3, 4, and 5, then annually thereafter. The main purpose of the frequent monitoring in the first 5 years is to assess changes in influent groundwater quality that could affect the operation of the treatment plant.

The proposed new monitoring wells will be sampled following well construction and development. Thereafter, these wells will be sampled on an annual basis for the purpose of documenting trends in analyte concentrations. The groundwater sampling and laboratory testing protocols are described in the Sampling and Analysis Plan in Appendix O.

The proposed new Fill WBZ monitoring wells to be installed adjacent to the extraction wells will also be sampled following construction and development. The new Fill WBZ wells will be sampled annually, as part of the continuing source control monitoring program.

The proposed new piezometers in the river will be sampled following construction and development. Thereafter, selected piezometers will be sampled annually as shown in Table 3-4.

Groundwater samples obtained in the source control monitoring program will be tested using the following methods.

- EPA Method 8260 for VOCs
- EPA Method 8270 SIM for PAHs
- Standard Method 4500-CN for weak acid dissociable (WAD) cyanide
- D-4282 for free cyanide

The plan to test for WAD and free cyanide is based on the findings of the Anchor QEA assessment of cyanide testing methods requested by DEQ. The findings of that assessment were reported in an August 17, 2010 memo to DEQ, a copy of which is provided in Appendix O. DEQ has not commented on the August 17, 2010 memo.

In the March 26, 2010 comment letter (Appendix A) DEQ recommended that the source control groundwater quality trend monitoring program be expanded from the analyte list shown above to include the following analytes:

- Typical field measured water quality parameters
- NW Natural and Siltronic facility COI
- All parameters on groundwater treatment system discharge list, and any additional constituents that could influence extraction well and/or groundwater treatment system operation and performance
- 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene
- Inorganic indicators of river water, including calcium, potassium, sodium, iron(total and dissolved), magnesium,(total and dissolved), sulfate, chloride, bicarbonate, carbonate,

and nitrate.

Each of DEQ's recommendations have been evaluated for possible addition to the source control monitoring program and following is an assessment of each recommendation.
The current design recommendation to test groundwater for PAHs, VOCs, free cyanide, and WAD cyanide is based on the following goals.

1. To test for a representative list of the primary MGP-related and Siltronic VOCs that are driving the source control actions at the site.
2. The purpose of the testing is to evaluate groundwater quality trends that will occur over time, not to evaluate whether groundwater containment is achieved. The design of performance monitoring for groundwater containment is described in Section 3.2.2.5.2.

Regarding DEQ's recommended measurement of typical field water quality measurements, the field samplers will test for Ph, conductance, temperature, and oxidation reduction potential (ORP) as part of the sampling process.

Regarding DEQ's recommended addition of all Gasco and Siltronic COIs, it is not clear how this additional analyte data will be used. A massive data set already exists for the Site that identifies all of the COIs that are present. These data have been updated twice yearly in Environmental Monitoring Reports prepared by HAI for DEQ. NW Natural does not understand how the additional COI data will be used to evaluate the performance of the source control action and will consider further guidance that may come from DEQ on how these data would be used. The currently proposed monitoring of PAHs, VOCs, free cyanide, and WAD cyanide will provide a very good picture of the trends of water quality changes that occur during operation of the extraction/treatment system.

Regarding DEQ's recommended addition of all of the constituents on the groundwater permit discharge list and any constituents that could affect the operation of the extraction/treatment system, there is potential value in testing the influent to the treatment system for these additional parameters. To accomplish this, it is proposed to test the combined influent to the treatment system, but not all of the wells in the monitoring program. If an analyte is detected in the combined influent that seems to be an issue for the treatment system, it can then be determined if sampling of individual extraction wells is needed to determine the source. We will wait for DEQ to provide the recommended NPDES monitoring plan before preparing this additional analyte list.

Per DEQ's recommendation, we will add 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene to the VOC reporting list.

Regarding DEQ's recommendation to test the wells for inorganic indicators of river water, it is agreed that the issue of river inflow to the extraction wells is a matter of general interest, but not an important factor for judging the success of the source control system. To satisfy DEQ's information request the following is proposed:

- During the initial month of operation each of the extraction wells will be sampled weekly, and the samples will be tested for the analytes recommended by DEQ.
- Samples from each extraction well will then be tested monthly during the first six months of operation.

Monitoring of the extraction wells in the above described manner will provide a good data set to evaluate the inflow of river water to the extraction wells.

3.2.2.5.5 Maintenance, Repair, and Reporting

The operation of the extraction well system will be instrumented for remote monitoring of water elevation and flow. Fiber optics will be used for communication of water elevation and flow rates in each extraction well. The system will have automatic alarms that will be triggered for water level changes outside of the set point differential level in the control wells and for sustained extraction well pump shutdowns. The extraction well system will also be connected to treatment system alarms that indicate a shutdown of treatment operations. The extraction well system will have the capability for remote monitoring of system functions, automatic notification of alarms to e-mail, pager, and phone message to designated response personnel, and adjustment to system operational parameters. When those alarm conditions occur, NW Natural will respond to make the necessary adjustments or repairs.

An extraction system operations and maintenance manual will be prepared for DEQ review prior to startup of the system. The manual will have a description of the alarm systems.

For the first 5 years of system operation, quarterly reports will be prepared for submittal to DEQ. These reports will describe the system capture performance, as measured using the methods described in Section 3.2.2.5.2. The reports will describe system operational events,

including temporary well shutdowns for equipment repair or maintenance, and provide the groundwater quality data from the monitoring program, including updated trend graphs. After the first 5 years of quarterly reporting, there will be an evaluation of reporting requirements and reporting frequency.

There will also be the reports required by DEQ for the discharge permit for treated groundwater. It is assumed that DEQ will specify the reporting requirements when the agency issues the permit.

3.3 Groundwater Treatment System Design

Sevenson's one hundred percent treatment system final design report is in Appendix E. The interim treatment system design was prepared following the treatment system pilot test, which was completed in September 2009. The *Wastewater Pilot Plant Testing Plan* (Sevenson 2009) was provided to DEQ on May 4, 2009. DEQ provided a preliminary comment letter on May 13, and Sevenson prepared a May 15 response letter addressing DEQ's comments. A revised pilot plan was provided to DEQ on June 29, 2009. Sevenson constructed and operated the pilot treatment system and the Pilot Plant Report was provided to DEQ in December, 2010 (Appendix N). The treatment system final design (Appendix E) is based on both the findings of the Pilot Plant operation and subsequent bench scale testing, as described in Appendix E.

As described in Appendix E, the treatment plant is designed to treat a maximum day flow of 619 gpm and a maximum hour flow of 805 gpm, significantly more than the interim design. The determination of the design flows is described in the Basis of Plant Design section of Appendix E. The wastewater treatment plant design and materials balance is in Attachment A of Appendix E. The treatment plant design drawings are in Attachment A to Appendix E. The treatment system process flow diagram is on Figure 3-11.

As described in Section 5, NW Natural is proposing that DEQ review the treatment system design on an expedited schedule compared to review of the complete FDR. This expedited review and approval would allow NW Natural to order the long lead treatment system components that take several months to deliver. If DEQ can accomplish this it would enable NW Natural to construct and begin operating the treatment system in 2011, which is an important NW Natural goal. The treatment system design in Appendix E follows logically the design predicted in the December, 2010 Pilot Plant Report, so NW Natural is anticipating that DEQ will find that the design is consistent with that report.

4 PERMITS

As discussed in Section 3.1.2, Sevenson Environmental Services submitted to DEQ in February, 2011 the application for an NPDES permit to discharge treated groundwater to the Willamette River.

The source control project will require a stormwater permit, expanded consultation with the COP on Greenway requirements, and access to the Siltronic property. Some of the permits and authorizations have already been received; all of the regulatory requirements are described below. Permit information is also summarized in Table 4-1.

The COP Bureau of Development issued a Greenway Letter of Determination on June 22, 2009, related to the installation of wells and placement of access road material in the greenway setback; the determination will not expire. The COP concluded that Greenway Review was exempted within the code for cleanup related activities, so a modified Greenway Review was (and will be) used for this project to address any activities within the greenway setback (i.e., wells installed in the greenway and roads installed to access those well locations) to ensure that the activities are in substantive compliance. This Letter of Determination does not cover installation of an interceptor trench, the treatment buildings, or any work on the Siltronic property. While these activities would still be considered exempt, a separate consultation and modified Greenway Review may be required for activities above ordinary high water that fall under the authority of DEQ. A copy of this design report will be provided to the COP for their review and their determination on what additional Greenway requirements may exist.

A NPDES 1200-C permit will also be required for potential uplands construction-related stormwater impacts of this project. This stormwater construction permit is required for projects that disturb more than 1 acre of land on site due to any combination of clearing, grading, excavation, or stockpiling of fill material. The Oregon DEQ issues the NPDES stormwater permits.

5 CONSTRUCTION SCHEDULE AND SEQUENCING

Figure 5-1 depicts the current working schedule for the groundwater source control design and implementation. The schedule is termed "working," because findings of design level studies, DEQ review cycles, and DEQ decisions could impact the schedule in terms of alleviating the need for certain tasks, highlighting the need for additional design tasks, and/or causing duration changes to particular tasks. With the understanding that ongoing work could impact even major milestones within the schedule, key estimated target dates for design and construction are described below.

One important factor that affects the treatment system construction schedule is the ordering of long lead components of the treatment system. These components have to be built to order and require several months to deliver. To fast track construction of the treatment system NW Natural should order the long lead treatment system components in June, 2011, as shown on the schedule in Figure 5-1. To enable order of the long lead items, NW Natural is requesting that DEQ review the treatment system design report (Appendix E) on an expedited schedule compared to the overall FDR. If DEQ could review and approve the treatment system design by June 13, as shown on the schedule, then the long lead items could be ordered in time to largely construct the system in 2011. It is also important that the DEQ NPDES discharge permit be issued on schedule so that construction mobilization of the treatment system can take place.

As shown on the Figure 5-1 schedule chart, the key dates for the source control design and implementation are:

- Submittal of Draft Final Design Report to DEQ – May 9, 2011
- DEQ Review and Approve Treatment System Design – June 13, 2011
- NW Natural order treatment system long lead components – June 14, 2011
- DEQ complete review of Draft Final Design Report – July 5, 2011
- NW Natural submit Final Design Report to DEQ – August 17, 2011
- DEQ complete review of Final Design Report – September 15, 2011
- Public Comment complete and final Staff Report – October 31, 2011
- Treatment System NPDES Permit Approval – August 11, 2011
- Complete construction of Groundwater Extraction System – December 2011

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TABLES

Table 2-1

Existing and Proposed Shoreline Area Monitoring Wells, Extraction Wells, and Piezometers

Well Number	Water-Bearing Zone	Date Installed	Installation Method	Monument Type	Screen Type	Slot Size (inches)	Sand Pack (Colorado)	Well Diam. (inches)	Ground Surface (feet COP)	Top of Casing		Well Depth[1]		Top Screen		Base Screen	
										(feet COP)	(feet bgs)	(feet bgs)	(feet COP)	(feet bgs)	(feet COP)	(feet bgs)	(feet COP)
Existing Monitoring Well																	
MW-1-22	Surficial Fill	24-Oct-95	Hollow-Stem	Above-grade	Slotted PVC	0.020	10-20	2	32.00	34.75	(2.8)	22.0	10.0	11.0	21.0	21.0	11.0
MW-1-55	Alluvial	10-Jul-07	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	33.10	35.75	(2.7)	57.0	-23.9	45.0	-11.9	55.0	-21.9
MW-1-82	Alluvial	9-Jul-07	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	33.50	36.08	(2.6)	85.4	-51.9	72.0	-38.5	82.0	-48.5
MW-2-32	Surficial Fill	6-Nov-95	Hollow-Stem	Flush	Slotted PVC	0.020	10-20	2	34.83	34.50	0.3	32.5	2.3	21.5	13.3	31.5	3.3
MW-2-61	Alluvial	8-Oct-98	Hollow-Stem	Flush	Slotted PVC	0.020	10-20	2	34.61	34.42	0.2	61.5	-26.9	50.0	-15.4	60.0	-25.4
MW-2-104	Alluvial	25-Jun-07	Sonic	Flush	Continuous wrap stainless steel	0.020	10-20	2	34.86	34.88	(0.0)	116.5	-81.6	94.0	-59.1	104.0	-69.1
MW-3-26	Surficial Fill	1-Nov-95	Hollow-Stem	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.30	34.13	(2.8)	26.0	5.3	15.0	16.3	25.0	6.3
MW-3-56	Alluvial	1-Nov-95	Hollow-Stem	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.51	34.10	(2.6)	56.0	-24.5	45.0	-13.5	55.0	-23.5
MW-4-35	Surficial Fill	31-Oct-95	Hollow-Stem	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.70	34.54	(2.8)	35.0	-3.3	24.0	7.7	34.0	-2.3
MW-4-57	Alluvial	30-Oct-95	Hollow-Stem	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.70	34.53	(2.8)	57.0	-25.3	46.0	-14.3	56.0	-24.3
MW-4-101	Alluvial	16-Oct-98	Dual Wall	Above-grade	Slotted PVC (pre-pack)	0.010	20-40	2	31.80	34.36	(2.6)	120.0	-88.2	89.5	-57.7	99.5	-67.7
MW-5-32	Surficial	27-Oct-95	Hollow-Stem	Above-grade	Slotted PVC	0.020	10-20	2	25.10	27.83	(2.7)	32.0	-6.9	21.0	4.1	31.0	-5.9
MW-5-100	Alluvial	23-Oct-98	Dual Wall	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	25.40	27.31	(1.9)	100.0	-74.6	88.0	-62.6	98.0	-72.6
MW-5-175	Alluvial	22-Oct-98	Dual Wall	Above-grade	Slotted PVC (pre-pack)	0.010	20-40	2	25.20	27.19	(2.0)	175.0	-149.8	163.0	-137.8	173.0	-147.8
MW-16-45	Alluvial	20-Jul-04	Sonic	Above-grade	Slotted stainless steel	0.010	10-20	2	30.81	33.12	(2.3)	49.0	-18.2	30.0	0.8	45.0	-14.2
MW-16-65	Alluvial	19-Jul-04	Sonic	Above-grade	Slotted stainless steel	0.010	10-20	2	30.75	33.21	(2.5)	68.0	-37.3	55.0	-24.3	65.0	-34.3
MW-17-79	Alluvial	26-Jul-05	Sonic	Above-grade	Continuous wrap stainless steel	0.010	10-20	2	32.56	34.83	(2.3)	82.0	-49.4	38.5	-5.9	78.5	-45.9
MW-18-30	Surficial Fill	27-Feb-07	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.61	34.27	(2.7)	30.0	1.6	19.0	12.6	29.0	2.6
MW-18-	Alluvial	22-Apr-10	Soinc	Above-grade	Continuous wrap stainless steel	0.010	10-20	2	31.93	34.65	(2.7)	126.0	-94.1	115.0	-83.1	125.0	-93.1
MW-18-	Alluvial	26-Feb-07	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.70	33.90	(2.2)	230.0	-198.3	170.0	-138.3	180.0	-148.3
MW-19-22	Surficial Fill	6-Mar-07	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	27.40	29.82	(2.4)	23.0	4.4	12.0	15.4	22.0	5.4
MW-19-	Alluvial	12-Mar-07	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	27.20	29.42	(2.2)	126.0	-98.8	115.0	-87.8	125.0	-97.8
MW-19-	Alluvial	2-Mar-07	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	27.28	29.81	(2.5)	227.0	-199.7	170.0	-142.7	180.0	-152.7
MW-20-	Alluvial	8-Mar-07	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	25.63	27.84	(2.2)	213.0	-187.4	110.0	-84.4	120.0	-94.4
MW-21-12	Surficial Fill	6-Jul-07	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	20.34	23.25	(2.9)	14.0	6.3	7.0	13.3	12.0	8.3
MW-21-75	Alluvial	5-Jul-07	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	20.22	23.11	(2.9)	77.0	-56.8	65.0	-44.8	75.0	-54.8
MW-21-	Alluvial	2-Jul-07	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	20.32	23.43	(3.1)	118.0	-97.7	105.0	-84.7	115.0	-94.7
MW-21-	Alluvial	28-Jun-07	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	20.35	23.15	(2.8)	193.0	-172.7	156.0	-135.7	166.0	-145.7
MW-22-80	Alluvial	28-Jan-10	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	33.59	36.01	(2.5)	80.9	-47.3	69.9	-36.3	79.9	-46.3
MW-23-27	Surficial Fill	16-Feb-10	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	32.77	34.72	(2.3)	28.0	4.8	17.7	15.1	27.7	5.1
MW-23-75	Alluvial	16-Feb-10	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	32.91	34.87	(2.5)	75.7	-42.8	64.7	-31.8	74.7	-41.8
MW-23-	Alluvial	5-Feb-10	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	32.88	35.05	(2.5)	124.3	-91.4	113.3	-80.4	123.3	-90.4
MW-24-70	Alluvial	3-Feb-10	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	31.42	33.83	(2.4)	71.1	-39.7	60.1	-28.7	70.1	-38.7
MW-24-	Alluvial	2-Feb-10	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	31.34	33.76	(2.5)	131.1	-99.8	120.1	-88.8	130.1	-98.8
PW-01-80	Alluvial	8-Aug-01	Sonic	Flush	Continuous wrap stainless steel	0.020	10-20	6	32.00	31.80	0.2	82.0	-50.0	39.5	-7.5	79.5	-47.5

Table 2-1

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Well Number	Water-Bearing Zone	Date Installed	Installation Method	Monument Type	Screen Type	Slot Size (inches)	Sand Pack (Colorado)	Well Diam. (inches)	Ground Surface (feet COP)	Top of Casing		Well Depth[1]		Top Screen		Base Screen	
										(feet COP)	(feet bgs)	(feet bgs)	(feet COP)	(feet bgs)	(feet COP)	(feet bgs)	(feet COP)
Proposed Monitoring Wells																	
MW-21U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	20.00	23.00	(3.0)	41.0	-21.0	30.0	-10.0	40.0	-20.0
MW-22U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	32.00	35.00	(3.0)	52.0	-20.0	41.0	-9.0	51.0	-19.0
MW-23U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	33.00	36.00	(3.0)	53.0	-20.0	42.0	-9.0	52.0	-19.0
MW-25L	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	24.00	27.00	(3.0)	65.0	-41.0	54.0	-30.0	64.0	-40.0
MW-26U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	32.00	35.00	(3.0)	50.0	-18.0	39.0	-7.0	49.0	-17.0
MW-27L	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.00	34.00	(3.0)	117.0	-86.0	106.0	-75.0	116.0	-85.0
MW-28L	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.00	34.00	(3.0)	122.0	-91.0	111.0	-80.0	121.0	-90.0
MW-29U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	27.00	30.00	(3.0)	47.0	-20.0	36.0	-9.0	46.0	-19.0
MW-30U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	28.00	31.00	(3.0)	48.0	-20.0	37.0	-9.0	47.0	-19.0
MW-31L	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	27.00	30.00	(3.0)	118.0	-91.0	107.0	-80.0	117.0	-90.0
MW-32U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	26.00	29.00	(3.0)	51.0	-25.0	40.0	-14.0	50.0	-24.0
MW-33U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	24.00	27.00	(3.0)	49.0	-25.0	38.0	-14.0	48.0	-24.0
MW-34L	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	24.00	27.00	(3.0)	110.0	-86.0	99.0	-75.0	109.0	-85.0
MW-35U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	33.00	36.00	(3.0)	53.0	-20.0	42.0	-9.0	52.0	-19.0
MW-36U	Alluvial		Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	34.00	37.00	(3.0)	54.0	-20.0	43.0	-9.0	53.0	-19.0
Existing Observation Well																	
OW-7-17	Surficial Fill	23-Feb-10	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	24.20	26.51	(2.3)	17.7	6.5	12.5	11.7	17.5	6.7
OW-8-15	Surficial Fill	12-Feb-10	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	24.56	26.42	(1.9)	15.3	9.3	10.1	14.5	15.1	9.5
OW-8-28	Alluvial	13-Aug-10	Hollow-Stem	Above-grade	Slotted PVC	0.020	10-20	2	23.79	26.38	(2.6)	29.0	-5.2	23.1	0.7	28.1	-4.3
OW-9-25	Surficial Fill	8-Mar-10	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	33.11	35.38	(2.3)	25.3	7.8	20.0	13.1	25.0	8.1
Proposed Observation Well																	
OW-1F	Surficial Fill	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	2	35.00	38.00	(3.0)	37.0	-2.0	28.0	7.0	33.0	2.0
OW-2F	Surficial Fill	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	2	34.00	37.00	(3.0)	34.0	0.0	27.0	7.0	32.0	2.0
OW-5F	Surficial Fill	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	2	32.00	35.00	(3.0)	32.0	0.0	25.0	7.0	30.0	2.0
OW-10F	Surficial Fill	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	2	32.00	35.00	(3.0)	22.0	10.0	15.0	17.0	20.0	12.0
Existing Extraction Well																	
PW-3-85	Alluvial	19-Jun-03	Cable Tool	Above-grade	Continuous wrap stainless steel	0.035	10-20	8	25.00	26.80	(1.8)	95.0	-70.0	75.0	-50.0	85.0	-60.0
PW-3-118	Alluvial	12-Jun-03	Cable Tool	Above-grade	Continuous wrap stainless steel	0.035	10-20	8	25.50	27.00	(1.5)	128.0	-102.5	108.0	-82.5	118.0	-92.5
PW-7-93	Alluvial	22-Feb-10	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	8	24.19	26.74	(2.6)	95.5	-71.3	73.5	-49.3	93.5	-69.3
PW-8-39	Alluvial	13-Aug-10	Hollow-Stem	Above-grade	Continuous wrap stainless steel	0.035	10-20	15	23.22	25.69	(2.5)	50.0	-26.8	24.2	-1.0	39.2	-16.0
PW-8-68	Alluvial	11-Feb-10	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	8	24.64	27.13	(2.5)	70.0	-45.4	48.0	-23.4	68.0	-43.4
PW-9-92	Alluvial	1-Mar-10	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	8	33.02	35.78	(2.8)	94.6	-61.6	72.6	-39.6	92.6	-59.6

Table 2-1

Existing and Proposed Shoreline Area Monitoring Wells, Extraction Wells, and Piezometers

Well Number	Water-Bearing Zone	Date Installed	Installation Method	Monument Type	Screen Type	Slot Size (inches)	Sand Pack (Colorado)	Well Diam. (inches)	Ground Surface (feet COP)	Top of Casing		Well Depth[1]		Top Screen		Base Screen	
										(feet COP)	(feet bgs)	(feet bgs)	(feet COP)	(feet bgs)	(feet COP)	(feet bgs)	(feet COP)
Proposed Extraction Well																	
PW-1U	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	35.00	38.00	(3.0)	60.0	-25.0	40.0	-5.0	55.0	-20.0
PW-1L	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	24.19	26.74	(2.6)	120.0	-95.8	98.0	-73.8	118.0	-93.8
PW-2U	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	34.00	37.00	(3.0)	59.0	-25.0	39.0	-5.0	54.0	-20.0
PW-2L	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	24.19	26.74	(2.6)	112.0	-87.8	90.0	-65.8	110.0	-85.8
PW-3U	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	25.00	28.00	(3.0)	50.0	-25.0	30.0	-5.0	45.0	-20.0
PW-4U	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	30.00	33.00	(3.0)	55.0	-25.0	35.0	-5.0	50.0	-20.0
PW-4L	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	24.19	26.74	(2.6)	123.0	-98.8	101.0	-76.8	121.0	-96.8
PW-5U	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	32.00	35.00	(3.0)	57.0	-25.0	37.0	-5.0	52.0	-20.0
PW-5L	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	24.19	26.74	(2.6)	119.0	-94.8	97.0	-72.8	117.0	-92.8
PW-6U	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	32.00	35.00	(3.0)	57.0	-25.0	37.0	-5.0	52.0	-20.0
PW-6L	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	24.19	26.74	(2.6)	108.0	-83.8	86.0	-61.8	106.0	-81.8
PW-10L	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	24.19	26.74	(2.6)	66.0	-41.8	49.0	-24.8	64.0	-39.8
PW-11U	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	25.00	28.00	(3.0)	50.0	-25.0	30.0	-5.0	45.0	-20.0
PW-12U	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	27.00	30.00	(3.0)	52.0	-25.0	32.0	-5.0	47.0	-20.0
PW-13U	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	32.00	35.00	(3.0)	57.0	-25.0	37.0	-5.0	52.0	-20.0
PW-14U	Alluvial	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	6	32.00	35.00	(3.0)	57.0	-25.0	37.0	-5.0	52.0	-20.0
Existing Piezometer																	
PZ1-5	Alluvial	17-Mar-05	Manual	Above-grade	Solinst push point		NA	1	9.96	36.07	(26.1)	5.6	4.3	4.5	5.5	5.4	4.6
PZ1-20	Alluvial	17-Mar-05	Manual	Above-grade	Solinst push point		NA	1	10.15	36.43	(26.3)	20.5	-10.3	19.3	-9.2	20.2	-10.1
PZ1-50	Alluvial	23-Nov-09	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.17	37.67	(27.5)	50.4	-40.2	45.2	-35.0	50.2	-40.0
PZ2-5	Alluvial	18-Mar-05	Manual	Above-grade	Solinst push point		NA	1	2.89	37.90	(35.0)	6.7	-3.8	5.5	-2.6	6.4	-3.5
PZ2-20	Alluvial	17-Mar-05	Manual	Above-grade	Solinst push point		NA	1	3.38	37.89	(34.5)	21.7	-18.4	20.6	-17.2	21.5	-18.1
PZ2-43	Alluvial	3-Dec-09	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	3.76	37.96	(34.2)	43.6	-39.8	38.4	-34.6	43.4	-39.6
PZ2-77	Alluvial	2-Dec-09	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	3.05	38.65	(35.6)	77.2	-74.2	72.0	-69.0	77.0	-74.0
PZ4-12	Alluvial	4-Dec-09	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	-8.63	34.67	(43.3)	12.0	-20.6	6.8	-15.4	11.8	-20.4
PZ4-41	Alluvial	24-Nov-09	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	-8.33	33.07	(41.4)	41.4	-49.7	36.2	-44.5	41.2	-49.5
PZ5-5	Alluvial	20-Nov-09	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.70	16.51	(5.5)	5.0	5.7	3.8	6.9	4.8	5.9
PZ5-20	Alluvial	20-Nov-09	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.72	16.24	(5.5)	20.3	-9.6	15.1	-4.4	20.1	-9.4
PZ5-55	Alluvial	20-Nov-09	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.79	16.31	(5.5)	55.3	-44.5	50.1	-39.3	55.1	-44.3
PZ5-85	Alluvial	19-Nov-09	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.79	16.44	(5.4)	85.2	-74.4	80.0	-69.2	85.0	-74.2
Proposed Piezometer																	
PZ6-5	Alluvial		Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.00	16.00	(6.0)	5.5	4.5	4.0	6.0	5.0	5.0
PZ6-50	Alluvial		Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.00	16.00	(6.0)	50.5	-40.5	45.0	-35.0	50.0	-40.0
PZ6-150	Alluvial		Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.00	16.00	(6.0)	150.5	-140.5	145.0	-135.0	150.0	-140.0
PZ7-5	Alluvial		Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.00	16.00	(6.0)	5.5	4.5	4.0	6.0	5.0	5.0
PZ7-50	Alluvial		Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.00	16.00	(6.0)	50.5	-40.5	45.0	-35.0	50.0	-40.0
PZ7-150	Alluvial		Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.00	16.00	(6.0)	150.5	-140.5	145.0	-135.0	150.0	-140.0

Notes:

bgs = below ground surface COP = City of Portland Datum

btc = below top of casing PVC = polyvinyl chloride

[1] Actual completion depths may differ depending on actual lithology encountered during drilling

Table 2-2
Comparison of Groundwater Quality Above (Upper Alluvium) and Below (Deep Alluvium) the Aquitard

Well	Zone	Sample Dates	Benzene µg/L (ppb)		Naphthalene µg/L (ppb)		Total Cyanide mg/L (ppm)		Free Cyanide mg/L (ppm)	
MW-21-12	Surficial Fill	7/19/2007	0.5	U	2.9	U	0.0537		0.0048	
		5/14/2008	0.2	J	1.2		0.05		0.01	J
		9/15/2008	-		-		-		-	
		12/8/2008	0.31	J	0.94		0.09		0.005	J
MW-21-75	Upper Alluvium	7/18/2007	0.5	UJ	0.135	J	0.0648	J	0.0043	J
		5/14/2008	0.045	U	0.081		0.12		0.009	J
		9/15/2008	0.045	U	0.097		0.09		0.012	
		12/8/2008	0.045	U	0.048		0.14		0.005	J
MW-21-115	Upper Alluvium	7/18/2007	0.5	UJ	0.0989	J	0.0123	J	0.003	UJ
		5/15/2008	0.045	U	0.053		0.01		0.003	J
		9/15/2008	0.045	U	0.1		0.02		0.003	U
		12/8/2008	0.045	U	0.042		0.01		0.005	U
MW-21-165	Deep Alluvium	7/18/2007	0.5	UJ	0.0971	J	0.005	UJ	0.003	UJ
		5/14/2008	0.14	J	0.12		0.002	U	0.003	U
		9/15/2008	0.045	U	0.09		0.02	U	0.003	U
		12/8/2008	0.14	J	0.036		0.005	J	0.005	J
MW-16-45	Upper Alluvium	8/26/2004	2880		7500		0.138		-	
		12/22/2004	2680		8140		-		-	
		4/1/2005	2970		6060		-		-	
		6/21/2005	3190		10400		-		-	
		10/3/2005	3710		7820		0.131		-	
		4/3/2006	4210		29400		0.117		0.0013	U
		12/12/2006	5000		11000		0.14		0.005	U
		7/31/2007	4230		64100		0.412		0.003	U
		5/21/2008	4800		4800	J	0.51		0.005	
		9/17/2008	5600		12000		0.67		0.006	J
MW-16-65	Upper Alluvium	8/26/2004	1370		3600		0.402		-	
		8/26/2004	1250		3870		-		-	
		12/22/2004	1290		0.1	U	-		-	
		3/31/2005	1240		4840		-		-	
		6/21/2005	917		5700		-		-	
		10/3/2005	991		2900		0.25		-	
		4/3/2006	1090		3190		0.301		0.0149	
		10/23/2006	930		2500		0.31		0.005	U
		6/28/2007	698		837		0.18	J	0.003	UJ
		5/13/2008	690		2500		0.42		0.009	J
		9/11/2008	680	J	1200		0.28		0.007	J
MW-16-125	Upper Alluvium	9/30/2005	2.95		0.577		0.0775		NS	
		3/30/2006	0.5		0.452		0.0777		0.0016	
		10/16/2006	0.26		0.13		0.13		0.005	U
		6/28/2007	0.5		0.165		0.114	J	0.003	UJ

Table 2-2
Comparison of Groundwater Quality Above (Upper Alluvium) and Below (Deep Alluvium) the Aquitard

Well	Zone	Sample Dates	Benzene µg/L (ppb)		Naphthalene µg/L (ppb)		Total Cyanide mg/L (ppm)		Free Cyanide mg/L (ppm)	
MW-18-30	Surficial Fill	7/31/2007	10100		-		1.65		0.003	
		5/14/2008	8600		1700000		2.22		0.006	J
		9/17/2008	-		-		-		-	
		12/9/2008	-		-		-		-	
MW-18-180	Deep Alluvium	6/28/2007	0.5	U	0.575		0.0242	J	0.003	UJ
		5/13/2008	0.045	U	0.082		0.03		0.003	J
		9/11/2008	0.07	J	0.18		0.04		0.006	J
		12/9/2008	0.045	U	0.044		0.03		0.01	
MW-19-22	Surficial Fill	7/30/2007	6.58		297		0.121		0.003	U
		5/13/2008	1.0		270		0.12		0.004	J
		9/10/2008	3.4		230		0.12		0.007	J
		12/9/2008	4.0		120		0.14		0.013	
MW-19-125	Upper Alluvium	6/27/2007	16.7		2.95		0.0755		0.0087	
		5/14/2008	13		49		0.23		0.007	J
		9/10/2008	2.7		27		0.15		0.004	J
		12/9/2008	0.58		15		0.1	J	0.011	
MW-19-180	Deep Alluvium	6/27/2007	0.5	U	0.0954		0.0172		0.003	U
		5/13/2008	0.17	J	0.11		0.02		0.003	J
		9/10/2008	0.19	J	0.11		0.02		0.005	J
		12/9/2008	0.22	J	0.031		0.02		0.012	
MW-20-120	Upper Alluvium	6/28/2007	75		39.9		0.118		0.003	UJ
		5/15/2008	120		120		0.16		0.007	J
		9/10/2008	55		84		0.14		0.005	J
		12/9/2008	70		51		0.14		0.013	
MW-5-32	Surficial Fill/Alluvium	12/5/1995	0.5	U	11		0.101		-	
		3/19/1996	0.5	U	1		0.11		-	
		3/19/1996	-		0.61		-		-	
		6/20/1996	0.5	U	0.42		0.05		-	
		10/1/1996	0.5	U	10	U	0.14		-	
		2/25/1997	0.5	U	0.16		0.11		-	
		8/27/1997	0.5	U	1.0	U	0.14		-	
		2/17/1998	0.5	U	0.1	U	0.17		-	
		6/2/1998	0.5	U	0.67		0.18		-	
		8/26/1998	0.5	U	3.4		0.23		-	
		11/18/1998	0.5	U	0.1	U	0.25		-	
		2/16/1999	0.5	U	0.1	U	0.13		-	
		5/14/1999	0.5	U	0.95		0.15		-	
		8/24/1999	0.749		0.12		0.18		-	
		10/27/1999	0.5	U	0.1	U	0.19		-	
		3/30/2000	0.5	U	0.1	U	0.02	U	-	
		10/5/2000	0.5	U	0.1	U	-		-	
		3/29/2001	0.5	U	0.13		0.178		-	

Table 2-2
Comparison of Groundwater Quality Above (Upper Alluvium) and Below (Deep Alluvium) the Aquitard

Well	Zone	Sample Dates	Benzene µg/L (ppb)		Naphthalene µg/L (ppb)		Total Cyanide mg/L (ppm)		Free Cyanide mg/L (ppm)	
MW-5-32	Surficial Fill/Alluvium	8/16/2004	0.5	U	0.1	U	0.521		-	
		4/1/2005	0.5	U	0.136		-		-	
		9/27/2005	0.5	U	0.999		0.09		-	
		3/29/2006	0.5	U	0.192	U	0.106		0.0031	
		10/18/2006	0.14	U	0.068	J	0.09		0.005	J
		6/25/2007	0.5	U	4.63		-		-	
		7/30/2007	-		-		0.106		0.003	U
		5/14/2008	0.045	U	0.24		0.11		0.006	J
		9/10/2008	0.34	J	0.34		0.09		0.007	J
MW-5-100	Upper Alluvium	11/18/1998	5000		7100		0.66		-	
		2/17/1999	6650		5010		0.66		-	
		5/14/1999	11400		7440		0.44		-	
		8/25/1999	11800		13300		0.84		-	
		10/28/1999	10300		7450		0.69		-	
		3/30/2000	9550		9800		0.56		-	
		10/6/2000	9180		10100		-		-	
		10/6/2000	9020		9200		-		-	
		3/29/2001	9560		9600		0.142		-	
		4/5/2002	8750		82300		1.8		-	
		4/5/2002	8950		4310		1.54		-	
		3/19/2003	6600		5600		0.56		-	
		8/24/2004	11500		11900		0.816		-	
		4/1/2005	19800		8730		-		-	
		9/21/2005	12300		6530		0.869		-	
		4/4/2006	11300		8390		0.814		0.0283	
		10/27/2006	11000		7100		1.06		0.005	J
		6/25/2007	10100		7320		-		-	
		7/30/2007	-		-		0.747		0.0074	J
		5/14/2008	12000		7800		0.99		0.041	
		9/10/2008	11000		9900		0.91		0.036	
MW-5-175	Deep Alluvium	10/16/2006	0.14	U	0.047		0.04		0.005	U
		6/25/2007	0.5	U	0.114		0.0145	J	0.0022	J
		5/14/2008	0.05	J	0.076		0.02		0.005	J
		9/10/2008	0.045	U	0.075		0.01		0.004	J
WS-14-125	Upper Alluvium	6/12/2007	5430		7580		0.273		0.00563	J
		5/15/2008	6400		7800		0.33		0.008	J
		8/4/2008	4000		NS[1]		0.11		0.014	
		9/25/2008	4500		6800		0.29		0.032	
WS-14-161	Deep Alluvium	6/12/2007	0.09	U	15.7		0.005	U	0.003	UR
		5/15/2008	0.44	J	140		0.002	U	0.003	J
		8/4/2008	0.34		NS[1]		0.01	U	0.01	U
		9/25/2008	0.79		120		0.002	U	0.003	J

Table 2-2
Comparison of Groundwater Quality Above (Upper Alluvium) and Below (Deep Alluvium) the Aquitard

Well	Zone	Sample Dates	Benzene µg/L (ppb)		Naphthalene µg/L (ppb)		Total Cyanide mg/L (ppm)		Free Cyanide mg/L (ppm)	
WS-11-125	Upper Alluvium	2/14/2008	799		NS[1]		0.62		0.01	U
		5/15/2008	560		11000		0.61		0.006	J
		8/6/2008	290		NS[1]		0.46		0.031	
		9/29/2008	350		11000		0.53		0.003	U
WS-11-161	Deep Alluvium	6/12/2007	8.53		49.9		0.005	U	0.003	UR
		5/15/2008	25		110		0.01	J	0.004	J
		8/6/2008	19.8		NS[1]		0.01	U	0.01	U
		9/29/2008	23		89		0.002	U	0.003	U
WS-12-125	Upper Alluvium	6/12/2007	6.44		0.544		0.452		0.0078	J
		5/21/2008	6.6		0.088	U	0.53		0.007	
		8/6/2008	4.58		NS[1]		0.35		0.027	
		9/25/2008	6.2		0.056		0.43		0.149	
WS-12-161	Deep Alluvium	6/12/2007	0.09	U	0.0952	U	0.006	J	0.003	UR
		5/21/2008	0.07	J	0.021	U	0.008		0.005	
		8/5/2008	0.3	U	NS[1]		0.01	U	0.01	U
		9/25/2008	0.06	J	0.025		0.002	U	0.006	J
WS-8-33	Surficial Fill	10/9/2001	107		485		0.02	UJ	-	
		12/13/2001	68		287	J	0.854		-	
		4/3/2002	89.1		110		0.416		-	
		4/3/2002	87.4		101		0.615		-	
		7/10/2002	65.9		77.4		0.724		-	
		7/10/2002	68.1		77.6		0.726		-	
		5/21/2008	76		130	J	0.6		0.006	
		9/39/2008	110		170		0.77		0.01	
WS-8-59	Upper Alluvium	10/8/2001	14.7		22.7		0.468		-	
		10/8/2001	21.4		22.5		0.456		-	
		12/12/2001	26.8		10.5		0.725	J	-	
		12/12/2001	27		10.8		0.066	J	-	
		4/3/2002	13		1.13		1.42		-	
		7/10/2002	20.8		0.63		0.459		-	
		7/16/2007	7.08		0.0971	U	0.538		0.0061	
		5/21/2008	13		0.37	J	0.45		0.004	
		9/29/2008	2.7		0.16		0.63		0.003	U

Notes:

U - Not Detected at the detection Limit

J - Estimated value

R - Rejected value

1 - NS = Not Sampled

Table 3-1
Groundwater Treatment System Effluent Criteria

Discharge Limitations		
Parameter	**Monthly Average**	**Daily Maximum**
Benzene	0.66 (µg/L)	1.1 (µg/L)
Benzo(a)Anthracene	Not to exceed EPA Method 625 Quantitation Limit of 1 µg/L	
Benzo(a)Pyrene	Not to exceed EPA Method 625 Quantitation Limit of 1 µg/L	
Benzo(b)Flouranthene	Not to exceed EPA Method 625 Quantitation Limit of 1 µg/L	
Benzo(k)Flouranthene	Not to exceed EPA Method 625 Quantitation Limit of 1 µg/L	
Copper	Not to exceed EPA Method 200.8 Quantitation Limit of 10 µg/L	17.7 (µg/L)
Chromium VI	Not to exceed EPA Method 218.6 Quantitation Limit of 10 µg/L	16 (µg/L)
Chrysene	Not to exceed EPA Method 625 Quantitation Limit of 1 µg/L	
Free Cyanide	Not to exceed ASTM Method 4282-95 Quantitation Limit of 10 µg/L	
Dibenzo(a,h)Anthracene	Not to exceed EPA Method 625 Quantitation Limit of 1 µg/L	
Indeno(1,2,3-Cd)Pyrene	Not to exceed EPA Method 625 Quantitation Limit of 1 µg/L	
Iron (Dissolved)	300.0 (µg/L)	520 (µg/L)
Manganese (Dissolved)	50.0 (µg/L)	86.6 (µg/L)
Mercury	Not to exceed EPA Method 245.7 Quantitation Limit of 0.01 µg/L	
Pentachlorophenol	Not to exceed EPA Method 625 Quantitation Limit of 2 µg/L	
pH	6.5 S.U.	8.5. S.U.
Temperature	7-day average of the Daily Maximums not to exceed 68 degrees Fahrenheit	

Table 3-2
Extraction Well PW-3 Pump Tests

Test	Pumping Rate (gpm)	Duration (minutes)
PW-3-85 Step-Drawdown Test		
Step 1	20	240
Step 2	30	251
Step 3	40	954
PW-3-118 Step-Drawdown Test		
Step 1	30	240
Step 2	40	240
Step 3	50	521
Constant Rate Test		
PW-3-85	40	420
PW-3-118	50	420

Table 3-3
Predicted Horizontal DNAPL Travel Distance due to Increased Gradient from Nearshore Groundwater Pumping

Groundwater Gradient Increase in Former Effluent Pond Area[1]	Velocity (ft/day)	Distance traveled (ft) over the following time periods			
		0.5 years	1 year	2 years	3 years
0.0063	0.0030	0.5	1.1	2.2	3.3
0.0141	0.0067	1.2	2.4	4.9	7.3

Notes:

1 - Gradients computed 50 ft and 90 ft upgradient from the location of the upper alluvium extraction well screen. Lower gradients are predicted upgradient from the lower alluvium extraction well.

Table 3-4
Source Control Performance Monitoring Plan

Well ID	Water-Bearing Zone	Monitoring Water Level Transducer	Controlling Water Level Transducer	Current Sampling	Source Control Sampling Program		
				Semi-Annual	Tiered[2]	Annual[3]	DNAPL Monitoring[5]
Existing Shoreline Monitoring Wells							
MW-1-22	Surficial Fill			X		X	
MW-1-55	Alluvial			X		X	
MW-1-82	Alluvial			X		X	
MW-2-32	Surficial Fill			X		X	
MW-2-61	Alluvial			X		X	
MW-2-104	Alluvial			X		X	
MW-3-26	Surficial Fill			X		X	X
MW-3-56	Alluvial			X		X	X
MW-4-35	Surficial Fill			X		X	X
MW-4-57	Alluvial		X	X		NS[4]	X
MW-4-101	Alluvial			X		X	X
MW-5-32	Surficial Fill/Alluvial	X		X		X	X
MW-5-100	Alluvial			X		X	X
MW-5-175	Alluvial	X		X		X	X
MW-16-45	Alluvial			NS		NS	X
MW-16-65	Alluvial			X		X	X
MW-17-79	Alluvial		X	X		NS[4]	X
MW-18-30	Surficial Fill	X		NS		NS	X
MW-18-125	Alluvial			X		X	X
MW-18-180	Alluvial	X		X		X	X
MW-19-22	Surficial Fill	X		X		X	X
MW-19-125	Alluvial			X		X	X
MW-19-180	Alluvial	X		X		X	X
MW-20-120	Alluvial			X		X	X
MW-21-12	Surficial Fill			X		X	
MW-21-75	Alluvial		X	X		NS[4]	
MW-21-115	Alluvial			X		X	
MW-21-165	Alluvial	X		X		X	
MW-22-80	Alluvial		X	NS		NS[4]	
MW-23-27	Surficial Fill			NS		X	
MW-23-75	Alluvial		X	NS		NS[4]	
MW-23-123	Alluvial			NS		X	
MW-24-70	Alluvial		X	NS		NS[4]	X
MW-24-130	Alluvial		X	NS		NS[4]	X
Monitored Siltronics Wells							
WS-11-161	Alluvial	X		X		X	
WS-12-125	Alluvial		X	X		NS[4]	
WS-14-161	Alluvial	X		X		X	
WS-22-112	Alluvial		X	X		NS[4]	
WS-26-86	Alluvial		X	X		NS[4]	

Table 3-4
Source Control Performance Monitoring Plan

Well ID	Water-Bearing Zone	Monitoring Water Level Transducer	Controlling Water Level Transducer	Current Sampling	Source Control Sampling Program		
				Semi-Annual	Tiered[2]	Annual[3]	DNAPL Monitoring[5]
Proposed Monitoring Wells							
MW-21U	Alluvial	X				X	
MW-22U	Alluvial	X				X	
MW-23U	Alluvial	X				X	
MW-25L	Alluvial		X			NS[4]	
MW-26U	Alluvial		X			NS[4]	X
MW-27L	Alluvial		X			NS[4]	X
MW-28L	Alluvial		X			NS[4]	X
MW-29U	Alluvial		X			NS[4]	X
MW-30U	Alluvial		X			NS[4]	X
MW-31L	Alluvial		X			NS[4]	X
MW-32U	Alluvial		X			NS[4]	X
MW-33U	Alluvial		X			NS[4]	X
MW-34L	Alluvial		X			NS[4]	X
MW-35U	Alluvial		X			NS[4]	
MW-36U	Alluvial		X			NS[4]	
Existing Observation Well							
OW-7-17	Surficial Fill	X				X	
OW-8-15	Surficial Fill	X				X	
OW-8-28	Surficial Fill					X	
OW-9-25	Surficial Fill	X				X	
Proposed Observation Wells							
OW-1F	Surficial Fill	X				X	
OW-2F	Surficial Fill	X				X	
OW-5F	Surficial Fill	X				X	X
OW-10F	Surficial Fill	X				X	
Existing Extraction Wells							
PW-01-80	Alluvial			NS		NS	X
PW-3-85	Alluvial	X			X		X
PW-3-118	Alluvial	X			X		X
PW-7-93	Alluvial	X			X		
PW-8-39	Alluvial	X			X		
PW-8-68	Alluvial	X			X		
PW-9-92	Alluvial				X		
Proposed Extraction Wells							
PW-1U	Alluvial	X			X		
PW-1L	Alluvial	X			X		
PW-2U	Alluvial	X			X		
PW-2L	Alluvial	X			X		
PW-3U	Alluvial	X			X		X
PW-4U	Alluvial	X			X		X
PW-4L	Alluvial	X			X		X

Table 3-4
Source Control Performance Monitoring Plan

Well ID	Water-Bearing Zone	Monitoring Water Level Transducer	Controlling Water Level Transducer	Current Sampling	Source Control Sampling Program		
				Semi-Annual	Tiered[2]	Annual[3]	DNAPL Monitoring[5]
PW-5U	Alluvial	X			X		X
PW-5L	Alluvial	X			X		X
PW-6U	Alluvial	X			X		X
PW-6L	Alluvial	X			X		X
PW-10L	Alluvial	X			X		
PW-11U	Alluvial	X			X		X
PW-12U	Alluvial	X			X		X
PW-13U	Alluvial	X			X		X
PW-14U	Alluvial	X			X		X
Existing Piezometers							
PZ1-5	Alluvial	X		NS		NS	
PZ1-20	Alluvial	X		NS		NS	
PZ1-50	Alluvial	X		NS		NS	
PZ2-5	Alluvial	X		NS		NS	
PZ2-20	Alluvial	X		NS		NS	
PZ2-43	Alluvial	X		NS		NS	
PZ2-77	Alluvial	X		NS		NS	
PZ4-12	Alluvial	X		NS		NS	
PZ4-41	Alluvial	X		NS		NS	
PZ5-5	Alluvial	X		NS		X	
PZ5-20	Alluvial	X		NS		X	
PZ5-55	Alluvial	X		NS		X	
PZ5-85	Alluvial	X		NS		X	
Proposed Piezometers							
PZ6-5	Alluvial	X				X	
PZ6-50	Alluvial	X				X	
PZ6-150	Alluvial	X				X	
PZ7-5	Alluvial	X				X	
PZ7-50	Alluvial	X				X	
PZ7-150	Alluvial	X				X	

Notes:

NS = Not Sampled

[1] 2009 Groundwater Monitoring Program, Hahn and Associates, Inc. The sampling frequency of these wells will be changed from semi-annual to annual.

[2] Tiered Monitoring Program entails monthly sampling for the first year, followed by quarterly sampling for the second year, semi-annual sampling until year 5, and then annual sampling thereafter.

[3] Annually sampled wells will be initially sampled following well installation and development, and then on an annual basis thereafter.

[4] Control wells cannot be sampled without disruption to the pumping of the associated pumping well it controls. Newly installed wells will be initially sampled following well installation and development.

[5] Wells will be gauged for DNAPL daily at startup of Segment 1 pumping for 1 week; weekly for the next 3 weeks; monthly until the completion of 1 year; then following the monitoring program discussed above.

Table 4-1
Permit Information

	Trigger	Jurisdiction	Review Time	Submitted?	Fee (estimate)
Greenway Letter of Determination	Work within Greenway Setback; however, formal permitting is not required for cleanup projects	City of Portland	Minimum of 4 weeks from receipt of complete application	Received determination for borings and access road development	~$3,500
1200-C	Disturbance of more than 1 acre of land and potential for stormwater to enter surface waters	State of Oregon, City of Portland	~60 days; 90 days if more than 5 acres are involved, as this triggers public review		$1,510 for year 1, $765 for each additional year permit is active

FIGURES

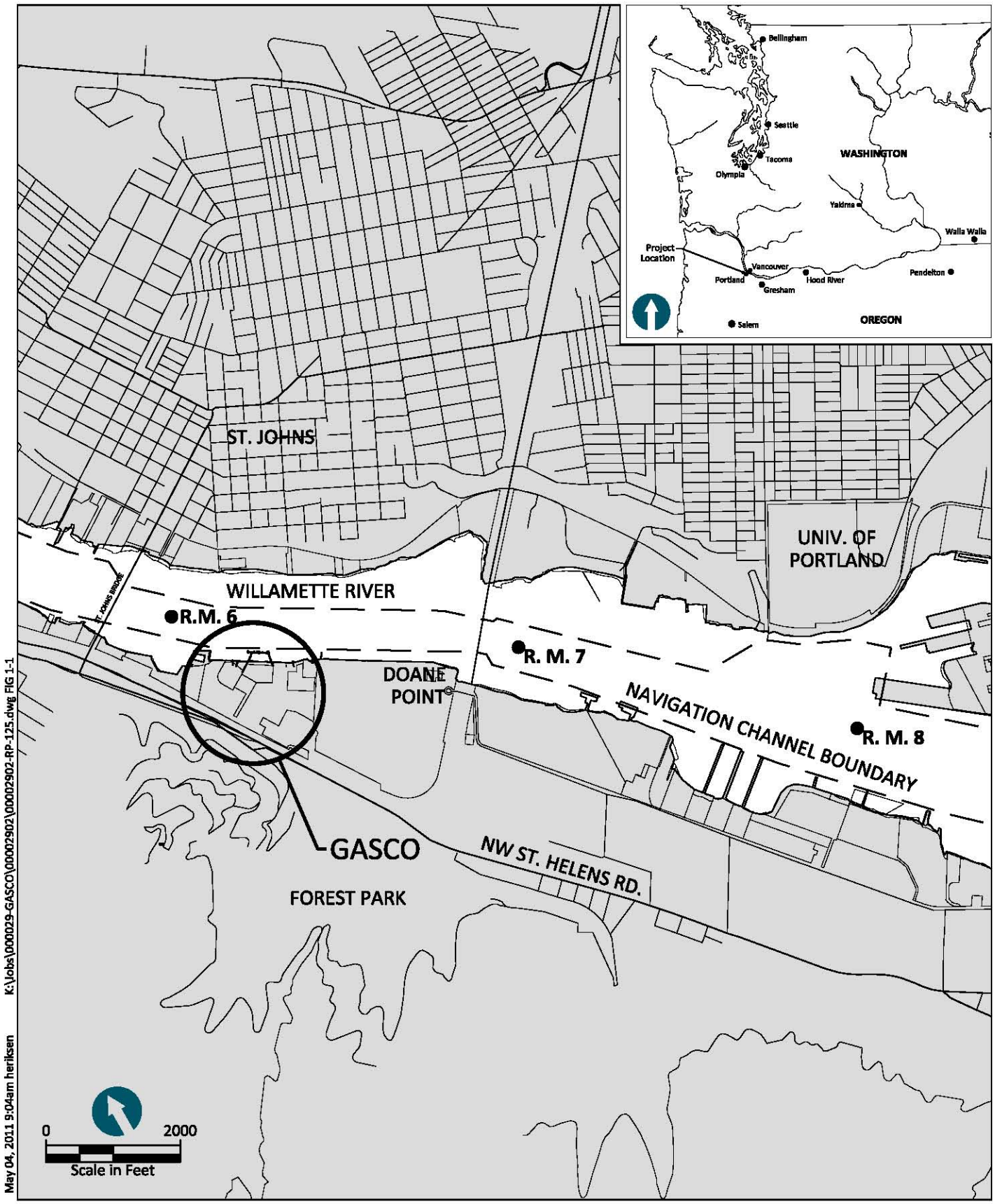


Figure 1-1
Site Vicinity Map
Draft Final Design Report
Gasco Groundwater Source Control

ANCHOR QEA

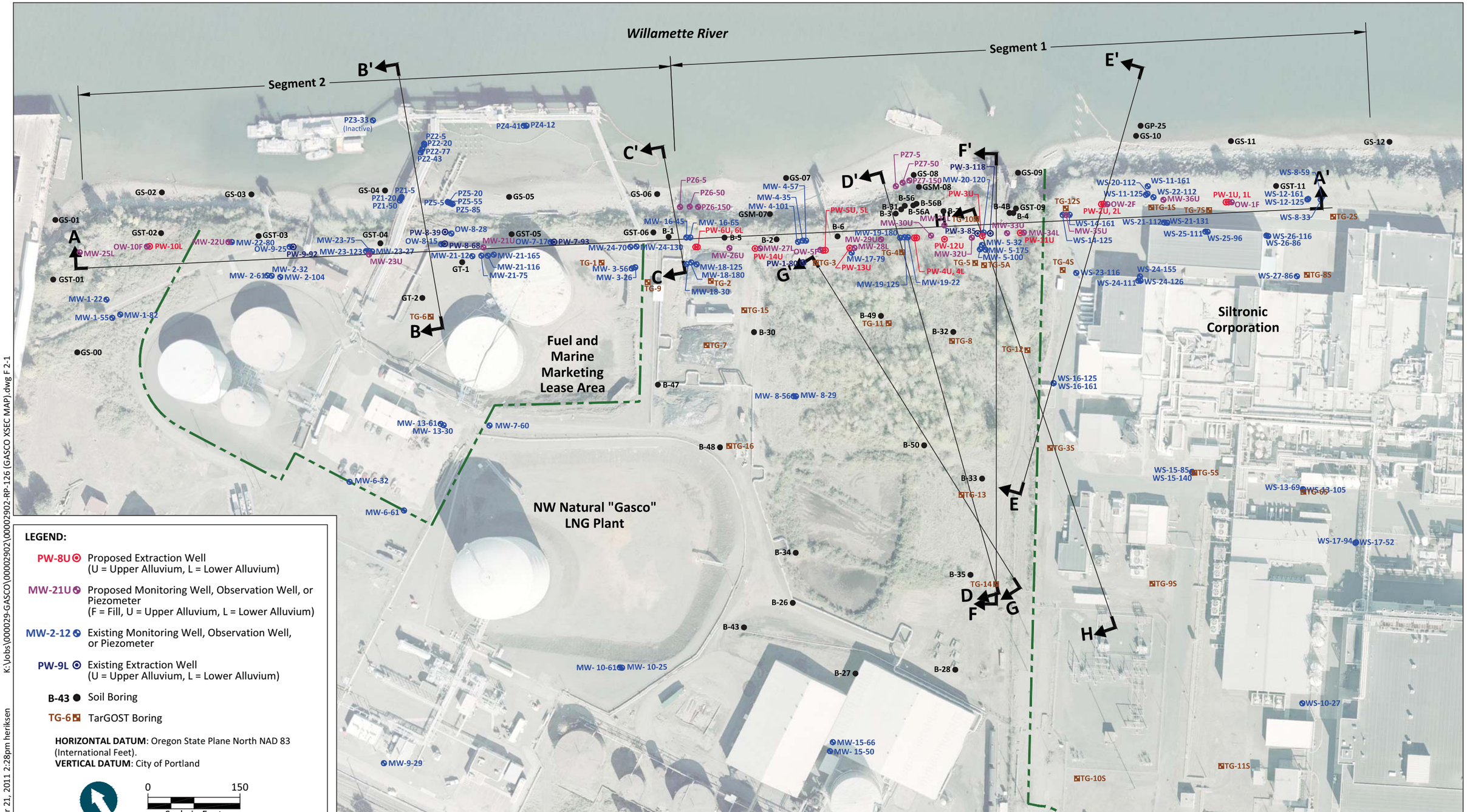
Q:\Jobs\000029-02_GascoMaps\2011_03\Site_map.mxd nkochie 3/31/2011 9:37:35 AM

Horizontal Datum: NAD83 HARN Oregon State Plane North International Feet
Vertical Datum of river bathymetry: NAVD88
Vertical Datum of upland topography: City of Portland

ANCHOR QEA

Feet
0 75 150 225 300

Figure 1-2
General Site Map
Gasco Groundwater Source Control
Draft Final Design Report



K:\Jobs\000029-GASCO\00002902\00002902-RP-126 (GASCO XSEC MAP).dwg F 2-1

Apr 21, 2011 2:28pm heriksen

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PRIVILEGED AND CONFIDENTIAL
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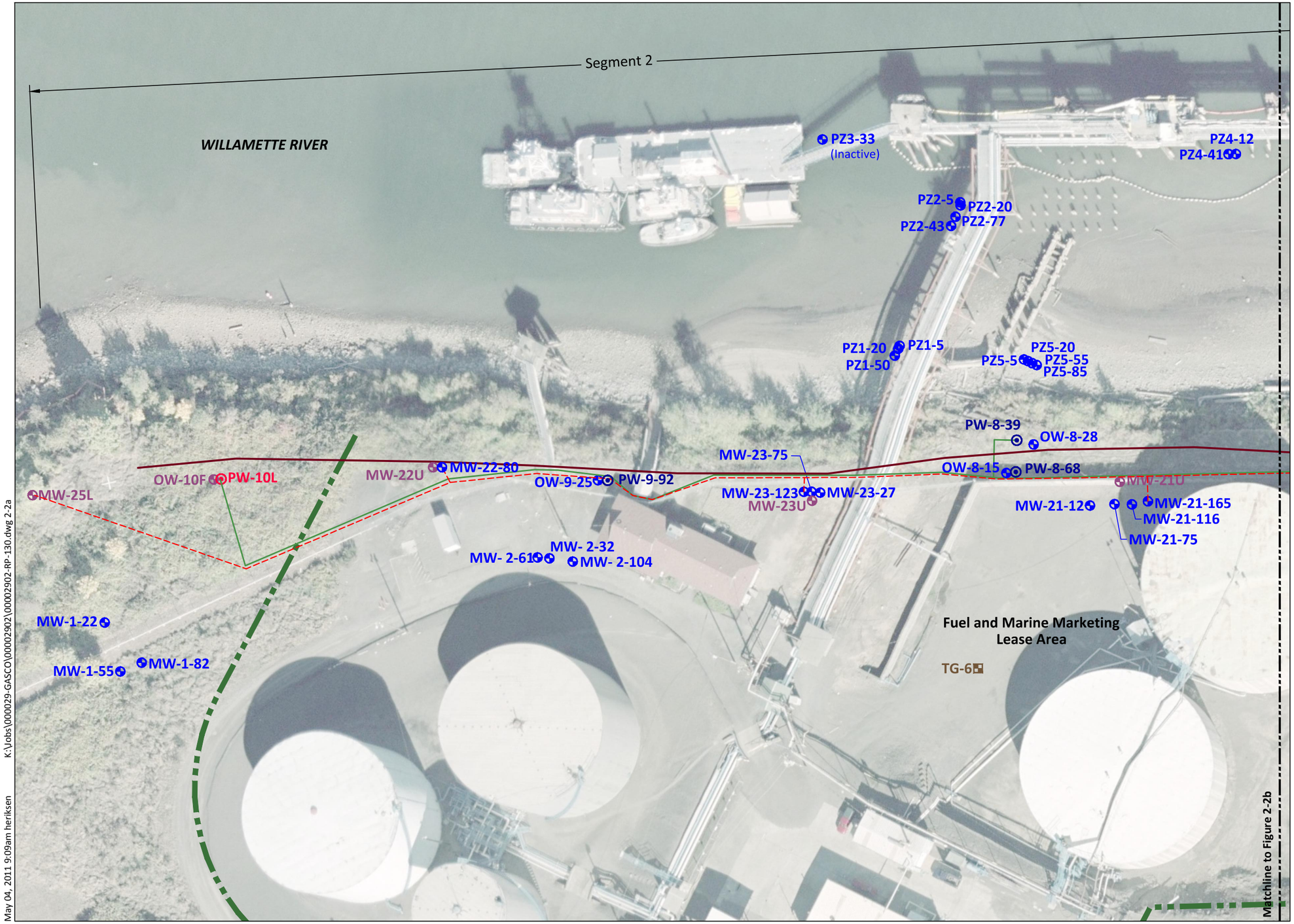
PREPARED AT THE REQUEST OF COUNSEL

DRAFT

Figure 2-1
Monitoring Well and Cross Section Location Map
Draft Final Design Report
Gasco Groundwater Source Control



LEGEND:

- PW-8U — Proposed Extraction Well (U = Upper Alluvium, L = Lower Alluvium)
- MW-21U — Proposed Monitoring Well, Observation Well, or Piezometer (F = Fill, U = Upper Alluvium, L = Lower Alluvium)
- MW-2-12 — Existing Monitoring Well, Observation Well, or Piezometer
- PW-9L — Existing Extraction Well (U = Upper Alluvium, L = Lower Alluvium)
- TG-6 — TarGOST Boring
- Fill WBZ Trench Alignment with Sump
- Source Control Main Pipeline Route
- Source Control Level Data Route

0 60
Scale in Feet

HORIZONTAL DATUM: Oregon State Plane North NAD 83 (International Feet).
VERTICAL DATUM: City of Portland

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May 04, 2011 9:09am heriksen

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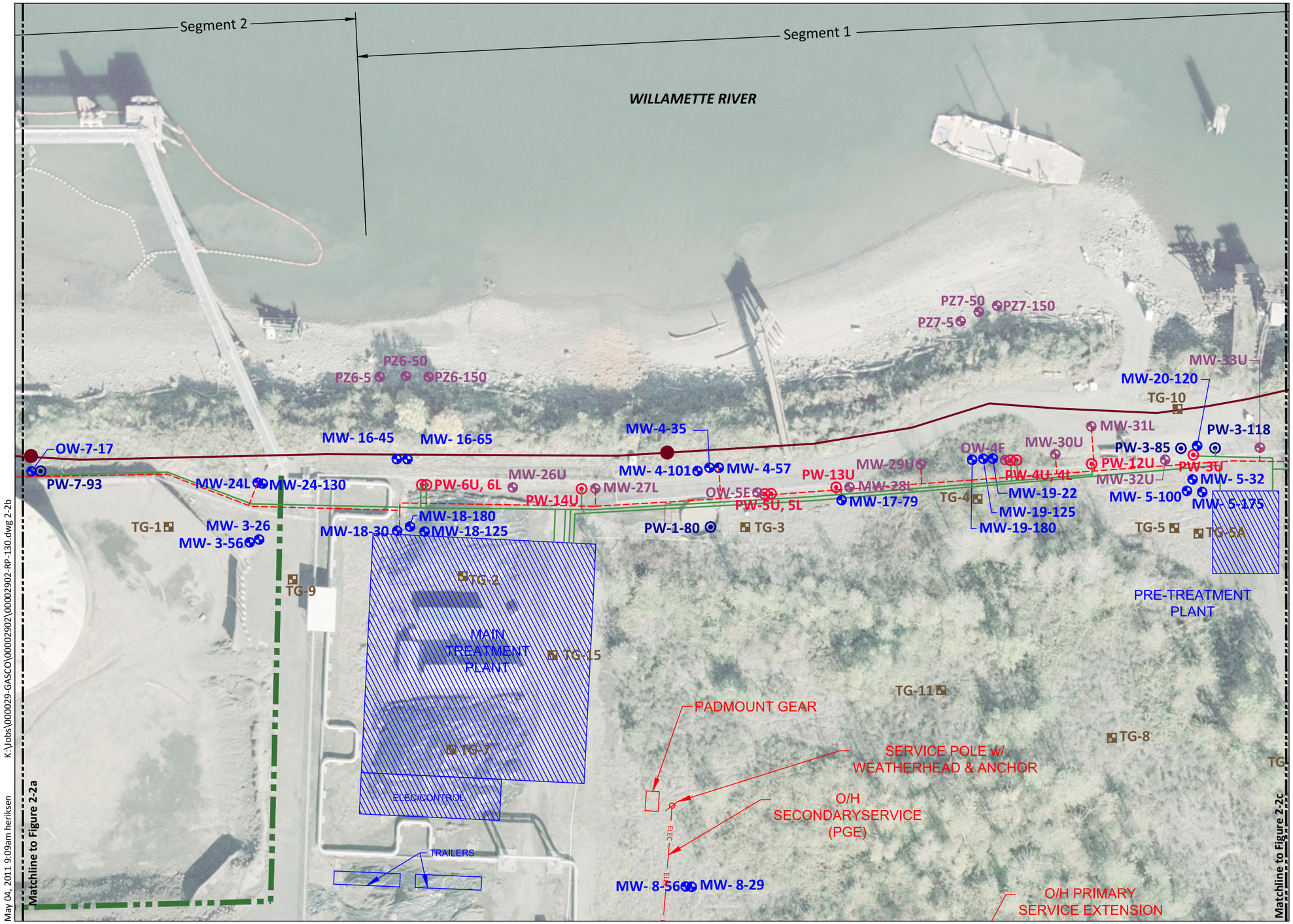
Figure 2-2a
Map of Groundwater Extraction □ Treatment System
Draft Final Design Report
Gasco Groundwater Source Control



LEGEND:

- **PW-8U** Proposed Extraction Well (U = Upper Alluvium, L = Lower Alluvium)
- **MW-21U** Proposed Monitoring Well, Observation Well, or Piezometer (F = Fill, U = Upper Alluvium, L = Lower Alluvium)
- **MW-2-12** Existing Monitoring Well, Observation Well, or Piezometer
- **PW-9L** Existing Extraction Well (U = Upper Alluvium, L = Lower Alluvium)
- **TG-4** TarGOST Boring
- Fill WBZ Trench Alignment with Sump
- Source Control Main Pipeline Route
- Source Control Level Data Route

0 60
Scale in Feet

HORIZONTAL DATUM: Oregon State Plane North NAD 83 (International Feet).
VERTICAL DATUM: City of Portland

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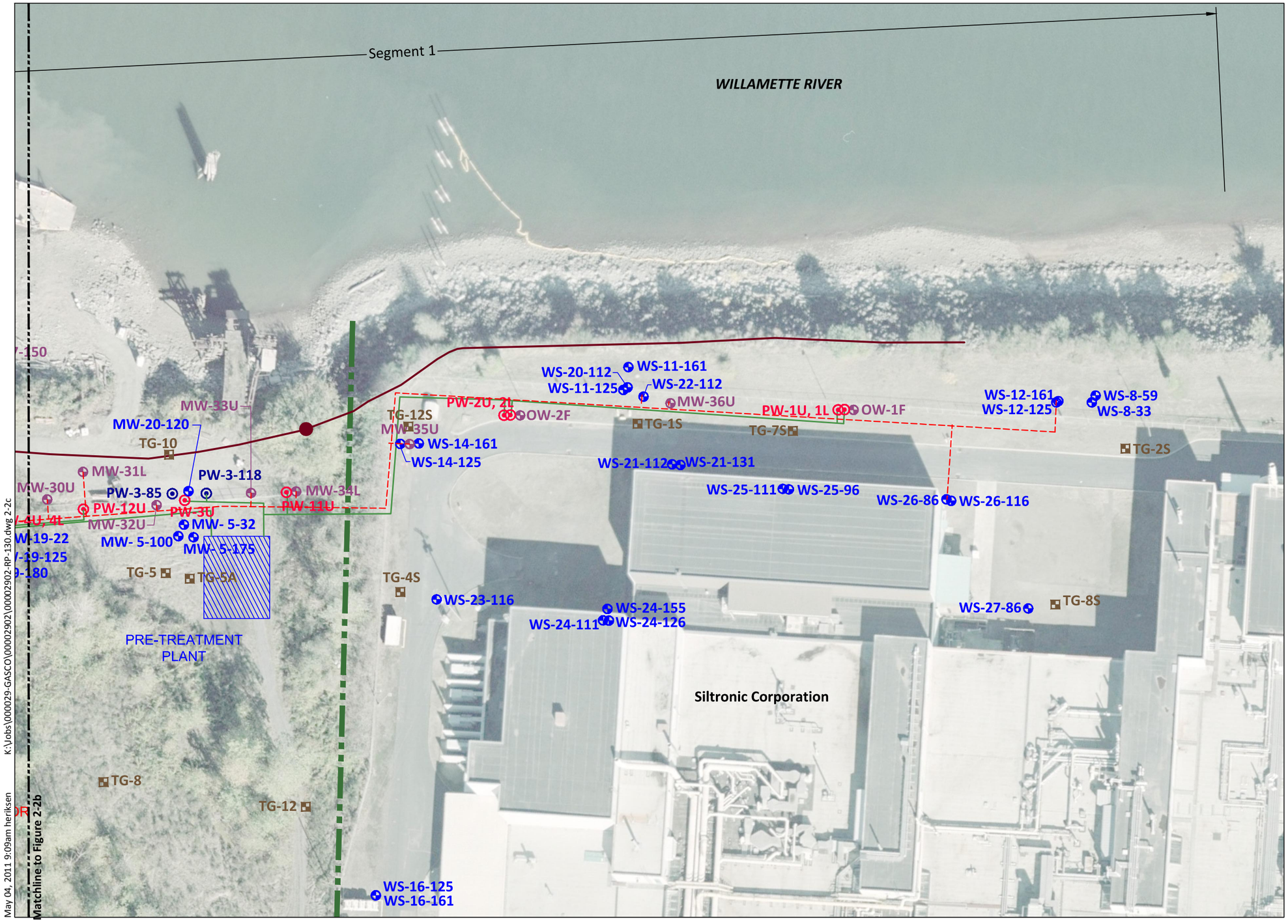
Figure 2-2b
Map of Groundwater Extraction □ Treatment System
Draft Final Design Report
Gasco Groundwater Source Control



LEGEND:

- **PW-8U** Proposed Extraction Well (U = Upper Alluvium, L = Lower Alluvium)
- **MW-21U** Proposed Monitoring Well, Observation Well, or Piezometer (F = Fill, U = Upper Alluvium, L = Lower Alluvium)
- **MW-2-12** Existing Monitoring Well, Observation Well, or Piezometer
- **PW-9L** Existing Extraction Well (U = Upper Alluvium, L = Lower Alluvium)
- **TG-4** TarGOST Boring
- Fill WBZ Trench Alignment with Sump
- Source Control Main Pipeline Route
- Source Control Level Data Route

0 60
Scale in Feet

HORIZONTAL DATUM: Oregon State Plane North NAD 83 (International Feet).
VERTICAL DATUM: City of Portland

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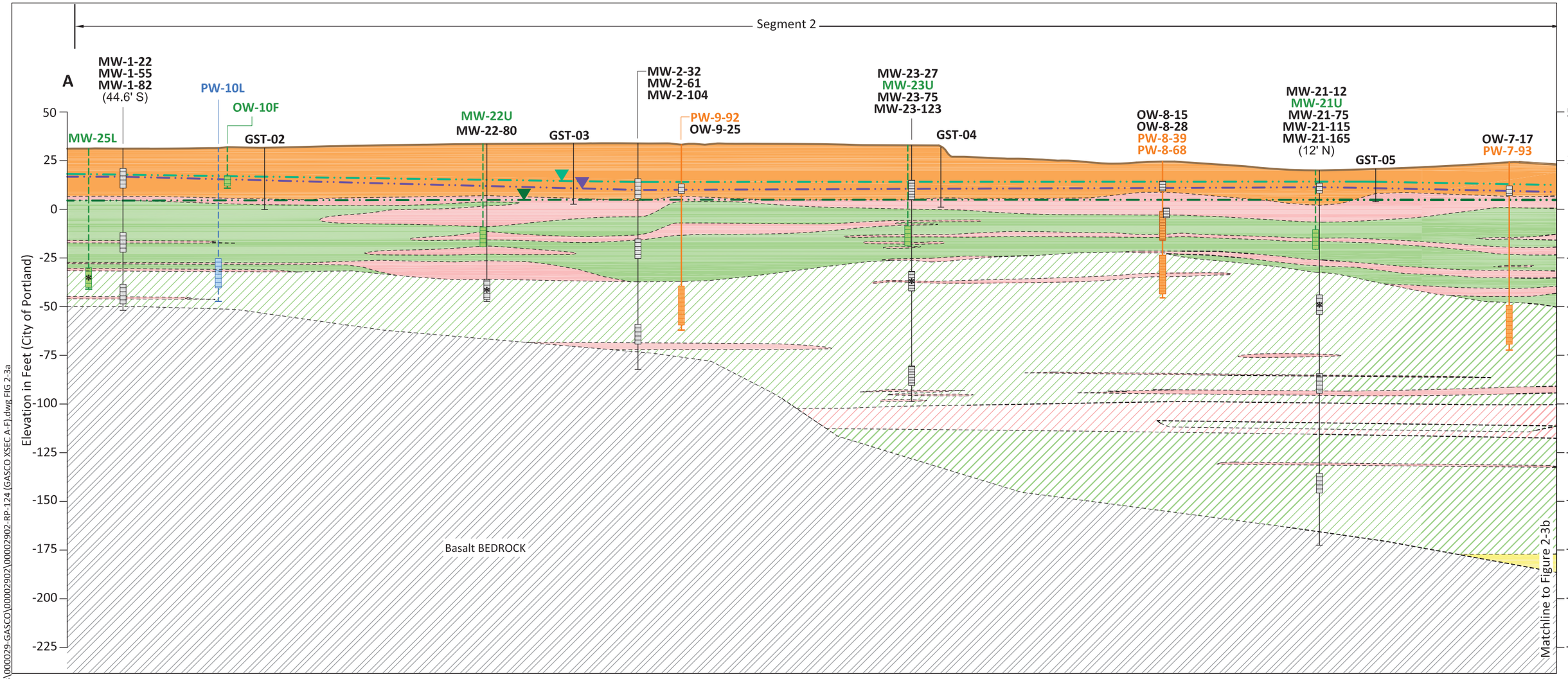
Figure 2-2c
Map of Groundwater Extraction □ Treatment System
Draft Final Design Report
Gasco Groundwater Source Control



K:\Jobs\000029-GASCO\00002902\00002902-RP-124 (GASCO XSEC A-F).dwg FIG 2-3a

Apr 19, 2011 10:52am heriksen

LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily fine to medium grained SAND and SILTY-SAND interbedded with thin silt and sandy-silt layers
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Potentiometric Surface of Surficial Fill (measured June 3, 2009)
- Potentiometric Surface of Surficial Fill (measured August 5, 2009)
- Potentiometric Surface of Alluvium (measured August 5, 2009)
- Existing Ground Surface

MW-21-16 — Boring ID
(57' E) — Offset Distance in Feet

Proposed Extraction Well
Existing Extraction Well
Proposed Well or Piezometer
Existing Well or Piezometer
— Well Screen

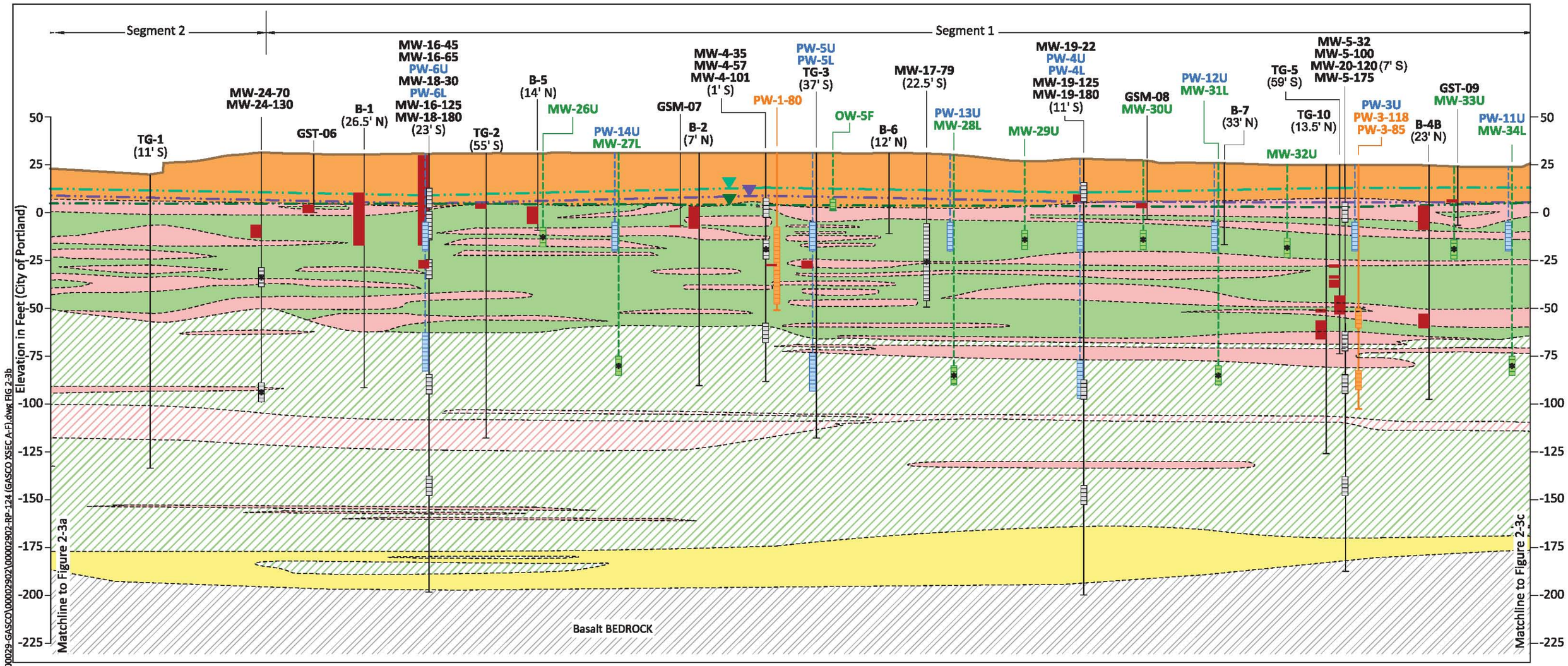
* — Control Well

0 50
Scale in Feet

NOTE: Geologic contacts are inferred between borings.

ANCHOR QEA

Figure 2-3a
Geologic Cross Section A-A'
Draft Final Design Report
Gasco Groundwater Source Control



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily fine to medium grained SAND and SILTY-SAND interbedded with thin silt and sandy-silt layers
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Potentiometric Surface of Surficial Fill (measured June 3, 2009)
- Potentiometric Surface of Surficial Fill (measured August 5, 2009)
- Potentiometric Surface of Alluvium (measured August 5, 2009)
- Existing Ground Surface

MW-21-16 — Boring ID
(57' E) — Offset Distance in Feet

Existing Extraction Well
Proposed Extraction Well
Proposed Well or Piezometer
Existing Well or Piezometer

— NAPL and/or Tar Interval
— Well Screen
— Control Well

0 50
Scale in Feet

NOTE: Geologic contacts are inferred between borings.

K:\Jobs\000029-GASCO\00002902\00002902-RP-124 (GASCO XSEC A-F).dwg FIG 2-3b
Apr 21, 2011 2:19pm heriksen

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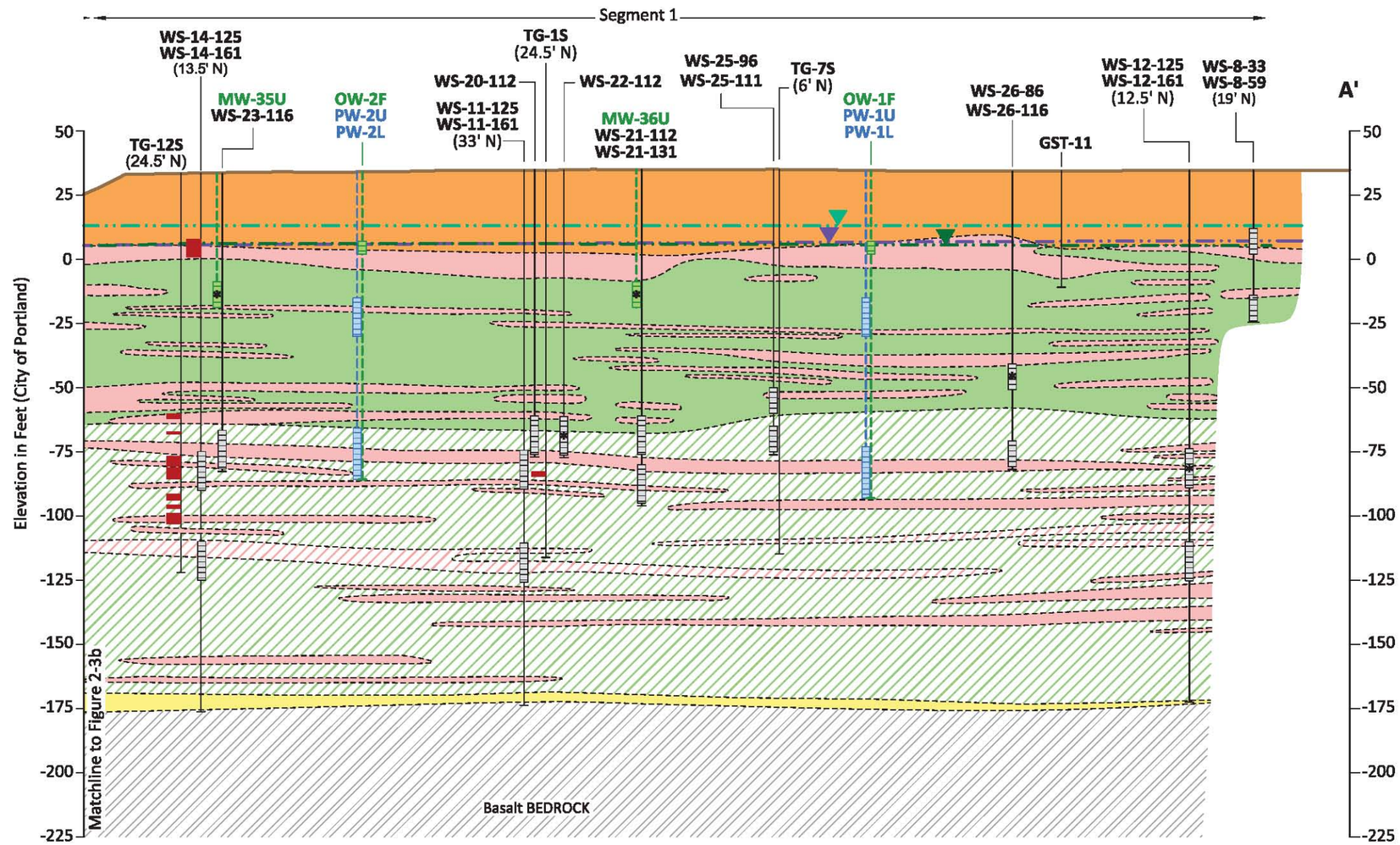
Figure 2-3b
Geologic Cross Section A-A'
Draft Final Design Report
Gasco Groundwater Source Control



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily fine to medium grained SAND and SILTY-SAND interbedded with thin silt and sandy-silt layers
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Potentiometric Surface of Surficial Fill (measured June 3, 2009)
- Potentiometric Surface of Surficial Fill (measured August 5, 2009)
- Potentiometric Surface of Alluvium (measured August 5, 2009)
- Existing Ground Surface

MW-21-16 — Boring ID
(57' E) — Offset Distance in Feet

Existing Extraction Well
Proposed Extraction Well
Proposed Well or Piezometer
Existing Well or Piezometer

— NAPL and/or Tar Interval
— Well Screen
* — Control Well

0 50
Scale in Feet

NOTE: Geologic contacts are inferred between borings.

K:\Jobs\000029-GASCO\00002902\00002902-RP-124 (GASCO XSEC A-F).dwg FIG 2-3c
Apr 21, 2011 2:20pm heriksen

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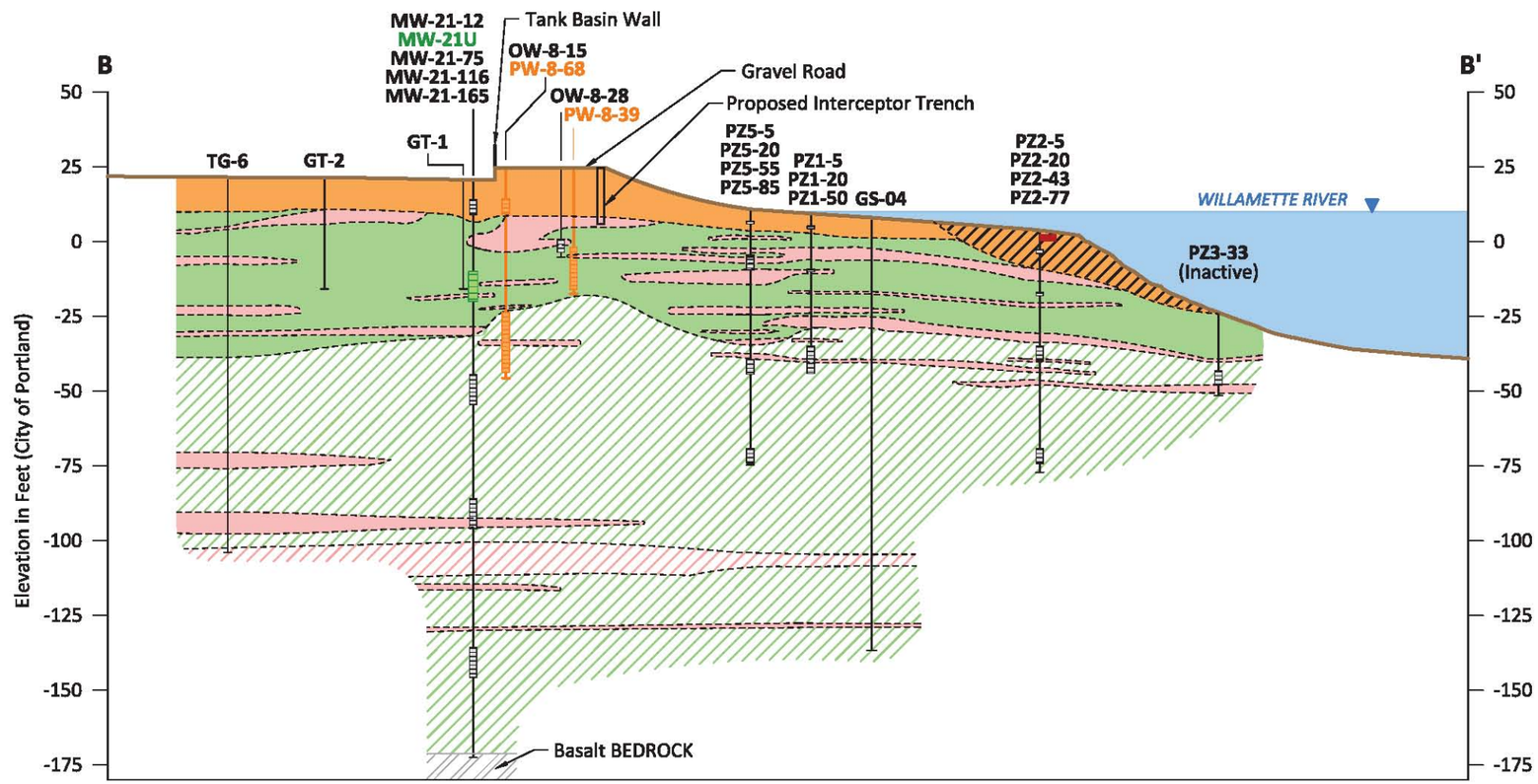
Figure 2-3c
Geologic Cross Section A-A'
Draft Final Design Report
Gasco Groundwater Source Control



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily fine to medium grained SAND and SILTY-SAND interbedded with thin silt and sandy-silt layers
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- SAND and SILT mixed with wood chips and anthropogenic material (wood, metal, cardboard)
- Basalt BEDROCK
- Existing Ground Surface
- Approximate Willamette River Elevation

PZ2-5 — Boring ID

Existing Extraction Well — NAPL and/or Tar Interval

Proposed Well or Piezometer — Well Screen

Existing Well or Piezometer — Control Well

0 50
Scale in Feet

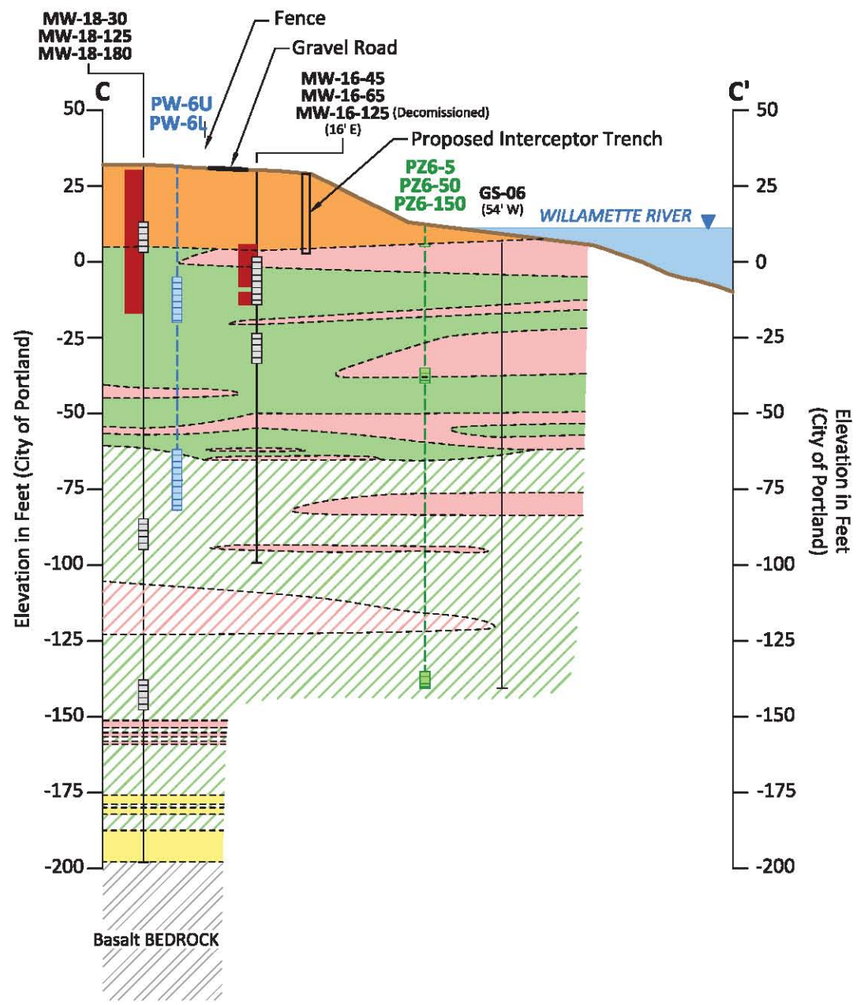
NOTES:
Geologic contacts are inferred between borings.

K:\Jobs\000029-GASCO\00002902\00002902-RP-124 (GASCO XSEC A-F).dwg FIG 2-4

Apr 19, 2011 11:51am heriksen

ANCHOR QEA

Figure 2-4
Geologic Cross Section B-B'
Draft Final Design Report
Gasco Groundwater Source Control



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily fine to medium grained SAND and SILTY-SAND interbedded with thin silt and sandy-silt layers
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Existing Ground Surface
- Approximate Willamette River Elevation

GS-06 — Boring ID
(54' W) — Offset Distance in Feet

Proposed Extraction Well
Proposed Well or Piezometer
Existing Well or Piezometer

— NAPL and/or Tar Interval
— Well Screen

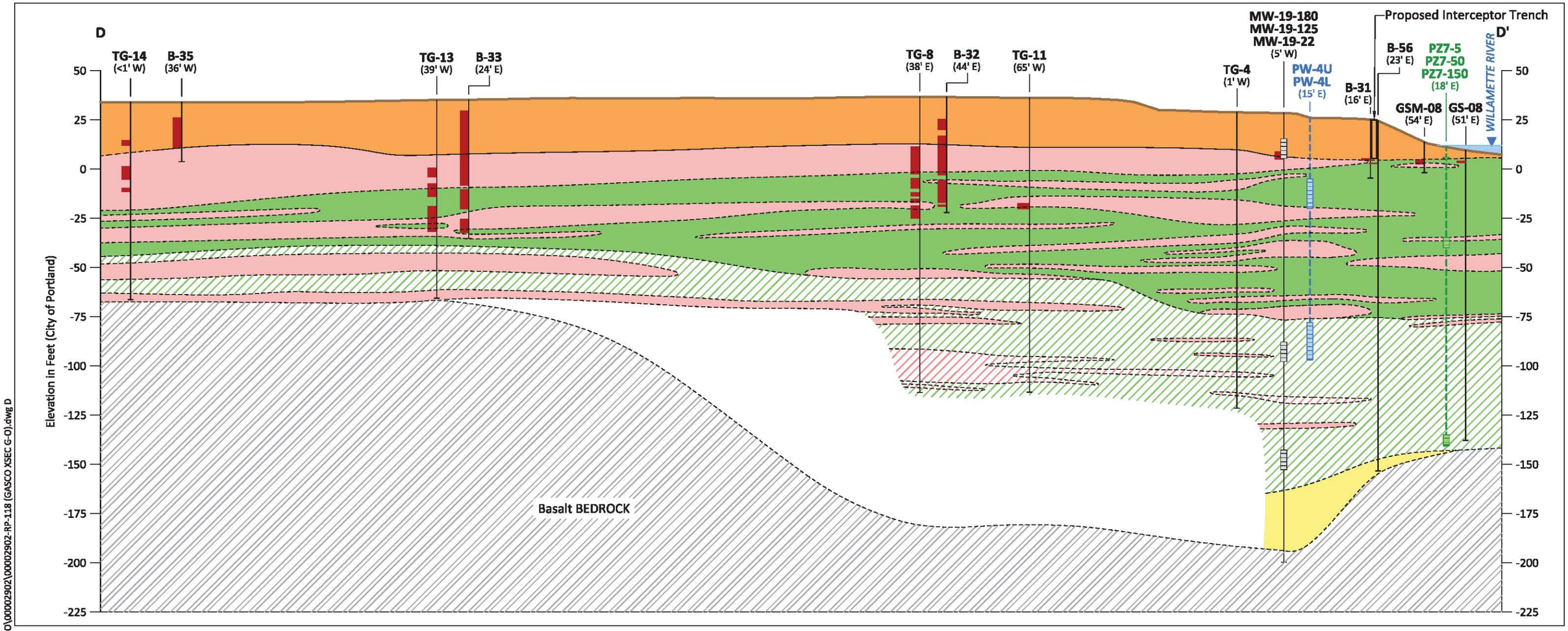
0 50
Scale in Feet

NOTES:
Geologic contacts are inferred between borings.

Apr 19, 2011 12:18pm heriksen K:\Jobs\000029-GASCO\00002902\00002902-RP-124 (GASCO XSEC A-F).dwg FIG 2-5

ANCHOR QEA

Figure 2-5
Geologic Cross Section C-C'
Draft Final Design Report
Gasco Groundwater Source Control



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily fine to medium grained SAND and SILTY-SAND interbedded with thin silt and sandy-silt layers
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK

Existing Ground Surface

TG-8 — Boring ID
(38' E) — Offset Distance in Feet

Proposed Well or Piezometer
Proposed Extraction Well
Existing Well or Piezometer

— NAPL and/or Tar Interval

— Well Screen

0 50
Scale in Feet

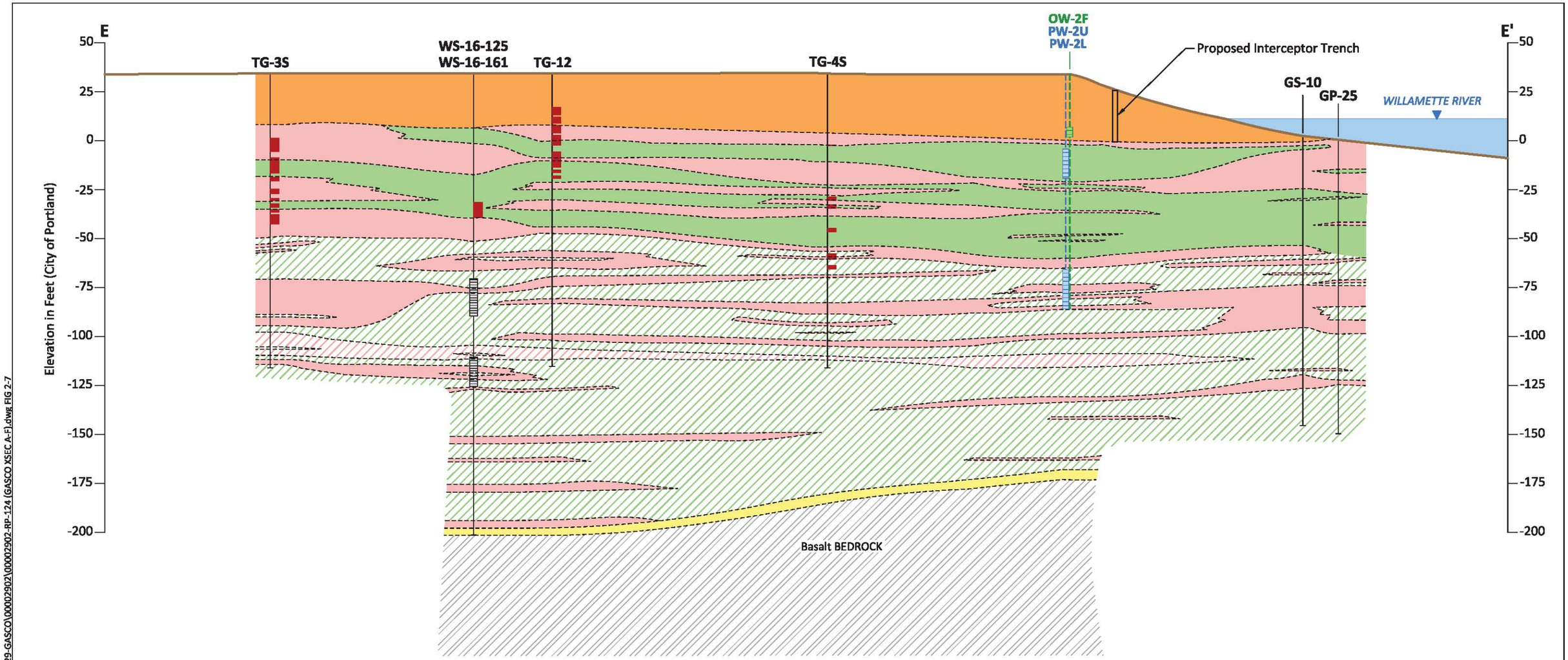
NOTE: Geologic contacts are inferred between borings.

K:\Jobs\000029-GASCO\00002902\00002902-RP-118 (GASCO XSEC G-O).dwg D

Apr 22, 2011 8:41am heriksen

ANCHOR QEA

Figure 2-6
Geologic Cross Section D-D'
Draft Final Design Report
Gasco Groundwater Source Control



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily fine to medium grained SAND and SILTY-SAND interbedded with thin silt and sandy-silt layers
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Existing Ground Surface
- Approximate Willamette River Elevation

TG-3S — Boring ID

Proposed Extraction Well
Proposed Well or Piezometer
Existing Well or Piezometer

— NAPL and/or Tar Interval

— Well Screen

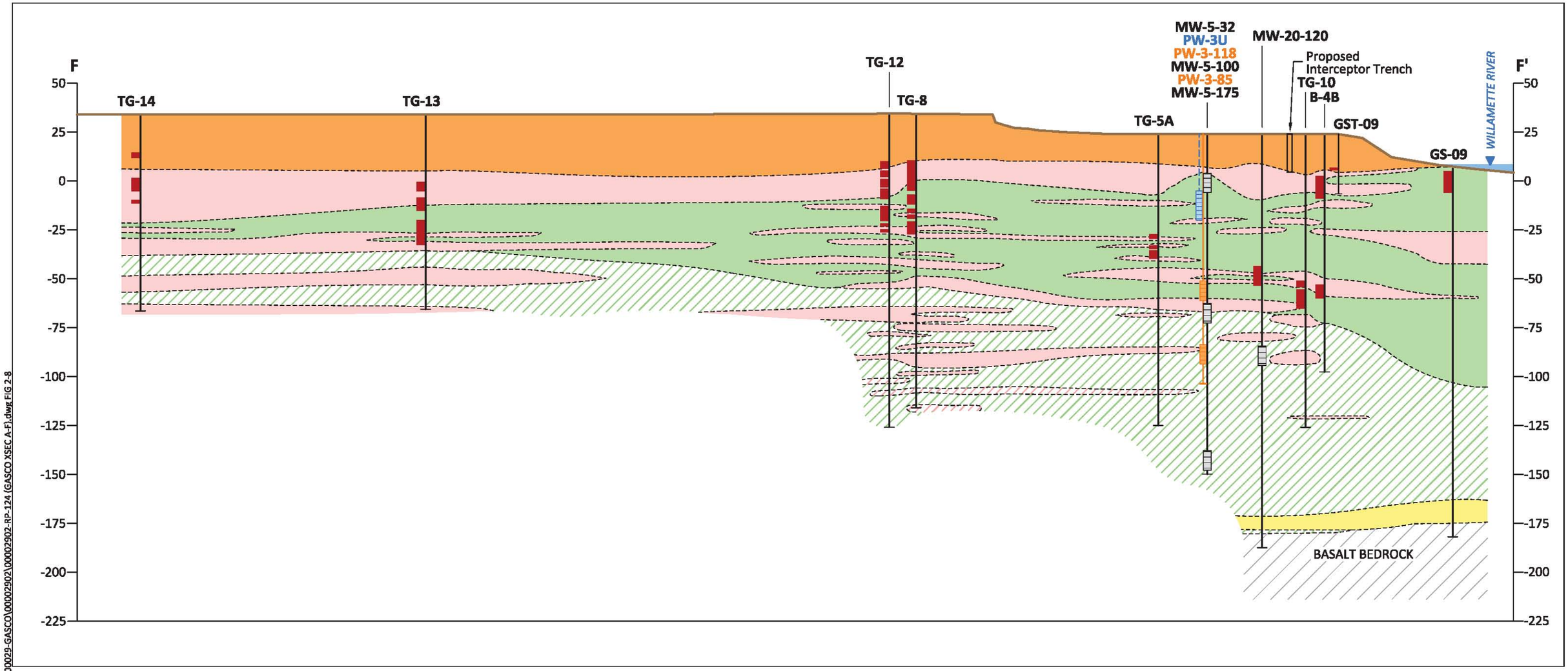
0 50
Scale in Feet

NOTES:
Geologic contacts are inferred between borings.

K:\Jobs\000029-GASCO\00002902\00002902-RP-124 (GASCO XSEC A-F).dwg, FIG 2-7
Apr 05, 2011 3:06pm heriksen

ANCHOR QEA

Figure 2-7
Geologic Cross Section E-E'
Draft Final Design Report
Gasco Groundwater Source Control



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily fine to medium grained SAND and SILTY-SAND interbedded with thin silt and sandy-silt layers
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Existing Ground Surface
- Approximate Willamette River Elevation

TG-5A — Boring ID

Existing Extraction Well
Proposed Extraction Well
Proposed Well or Piezometer
Existing Well or Piezometer

— NAPL and/or Tar Interval

— Well Screen

0 50
Scale in Feet

NOTES:
Geologic contacts are inferred between borings.

K:\Jobs\000029-GASCO\00002902\00002902-RP-124 (GASCO XSEC A-F).dwg FIG 2-8

Apr 21, 2011 11:10am heriksen

ANCHOR QEA

Figure 2-8
Geologic Cross Section F-F'
Draft Final Design Report
Gasco Groundwater Source Control

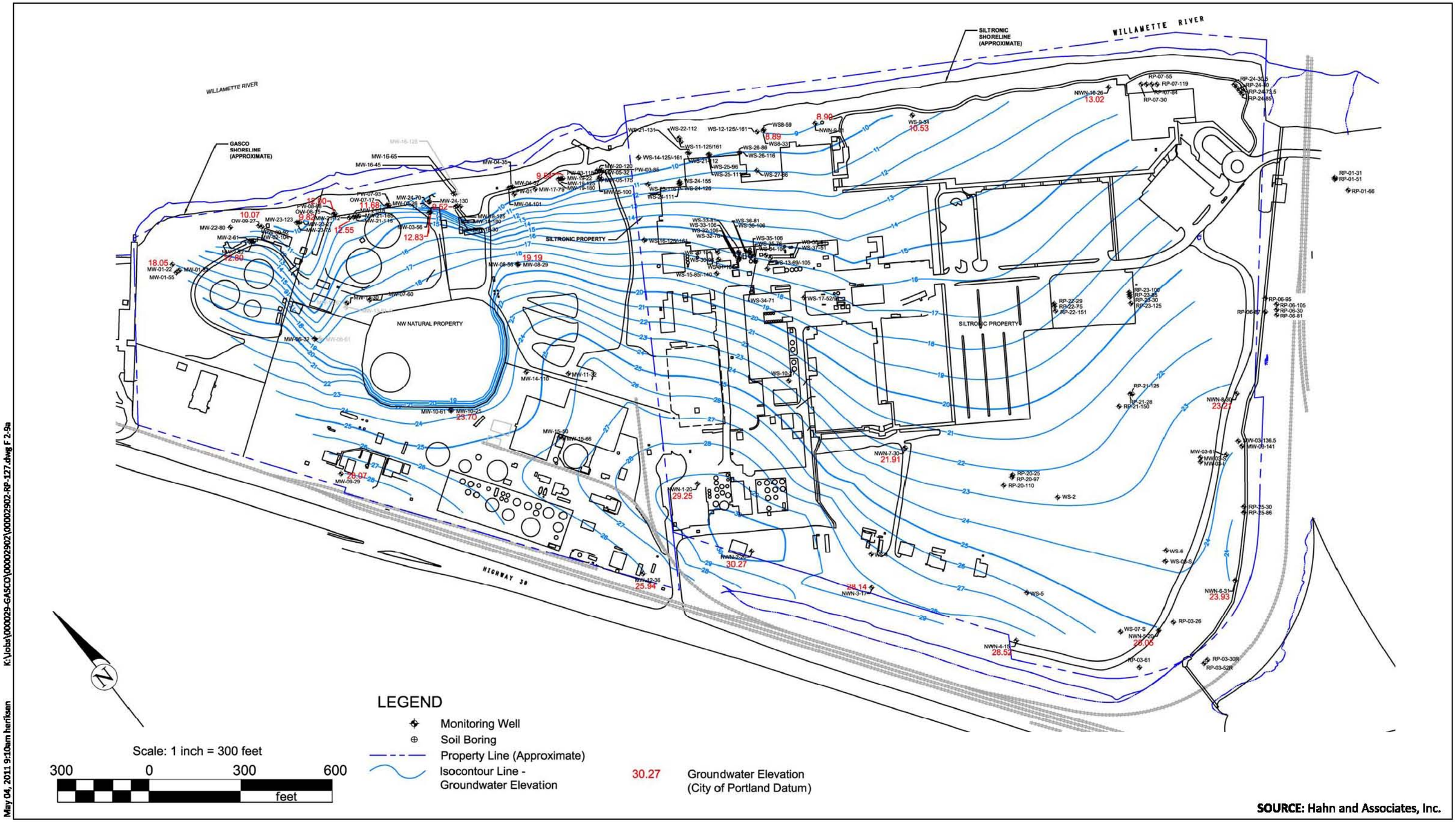
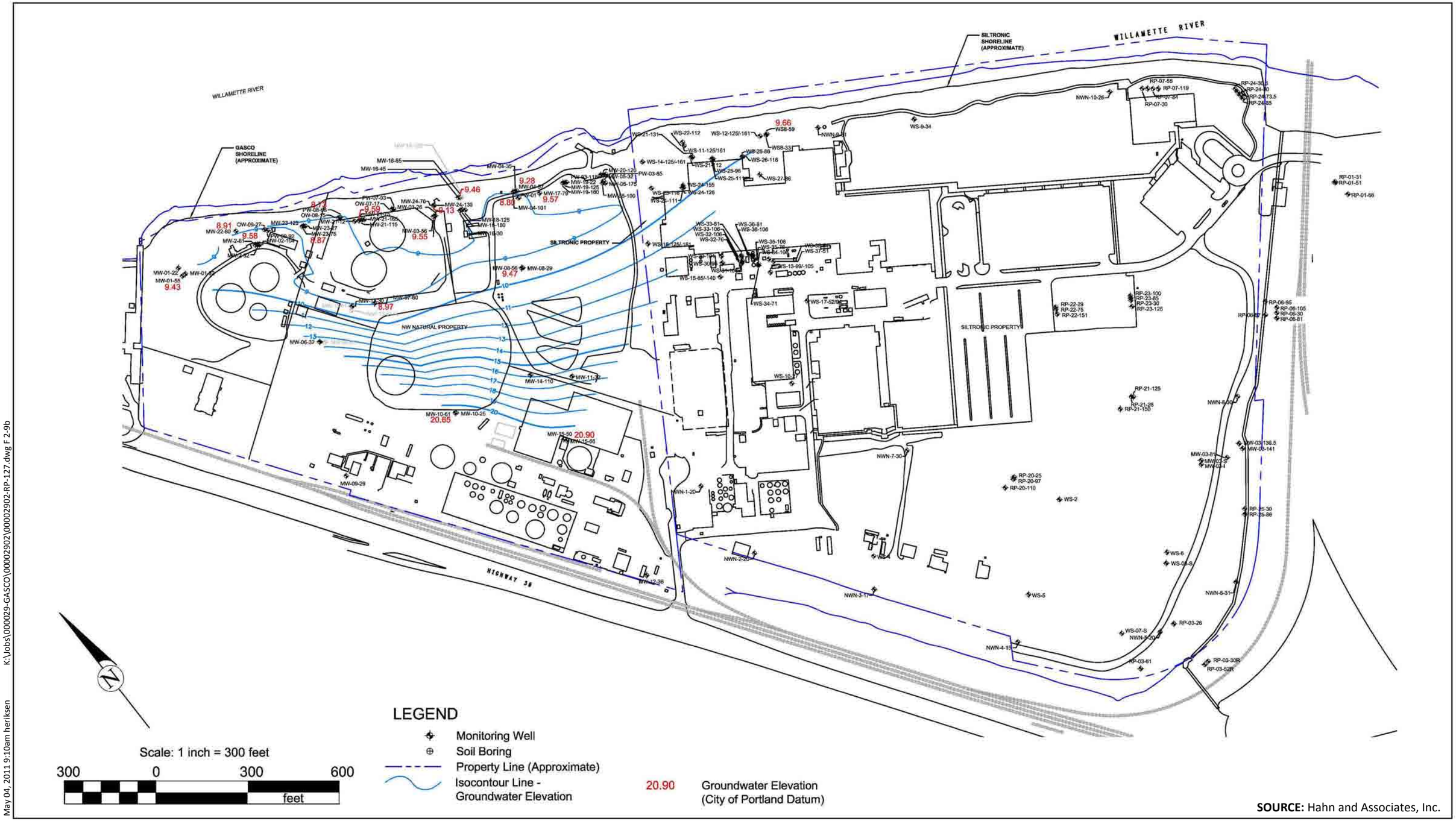


Figure 2-9a
Groundwater Elevation Map - Surficial Fill WBZ Wells - May 18, 2010
Gasco Groundwater Source Control
Interim Design Report

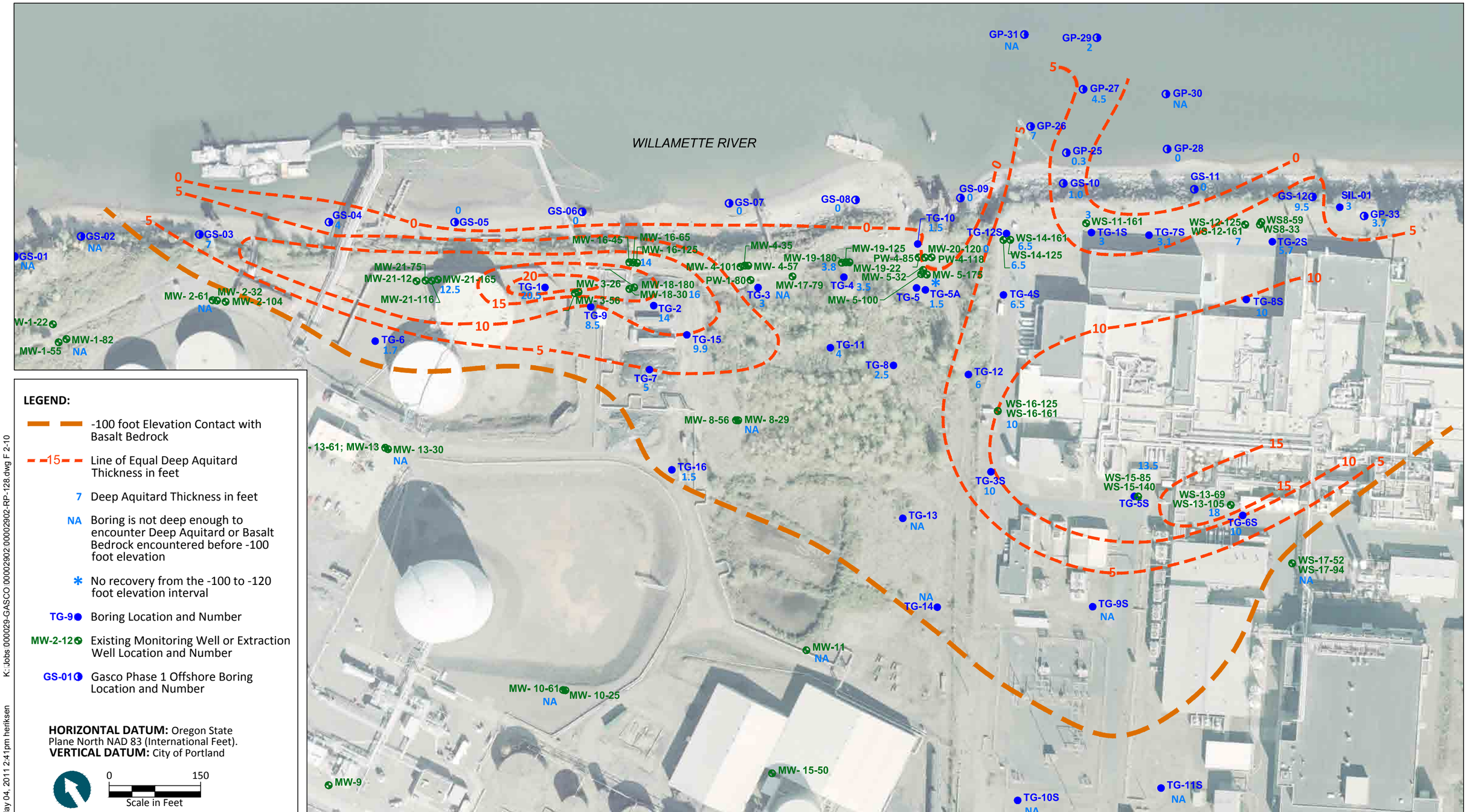
ANCHOR QEA



May 04, 2011 9:10am heriksen K:\Jobs\000029-GASCO\00002902\00002902-RP-127.dwg F 2-9b

Figure 2-9b
Groundwater Elevation Map - Alluvial WBZ Wells - May 18, 2010
Gasco Groundwater Source Control
Interim Design Report

ANCHOR QEA



LEGEND:

- -100 foot Elevation Contact with Basalt Bedrock
- 15 Line of Equal Deep Aquitard Thickness in feet
- 7 Deep Aquitard Thickness in feet
- NA Boring is not deep enough to encounter Deep Aquitard or Basalt Bedrock encountered before -100 foot elevation
- * No recovery from the -100 to -120 foot elevation interval
- TG-9 Boring Location and Number
- MW-2-12 Existing Monitoring Well or Extraction Well Location and Number
- GS-01 Gasco Phase 1 Offshore Boring Location and Number

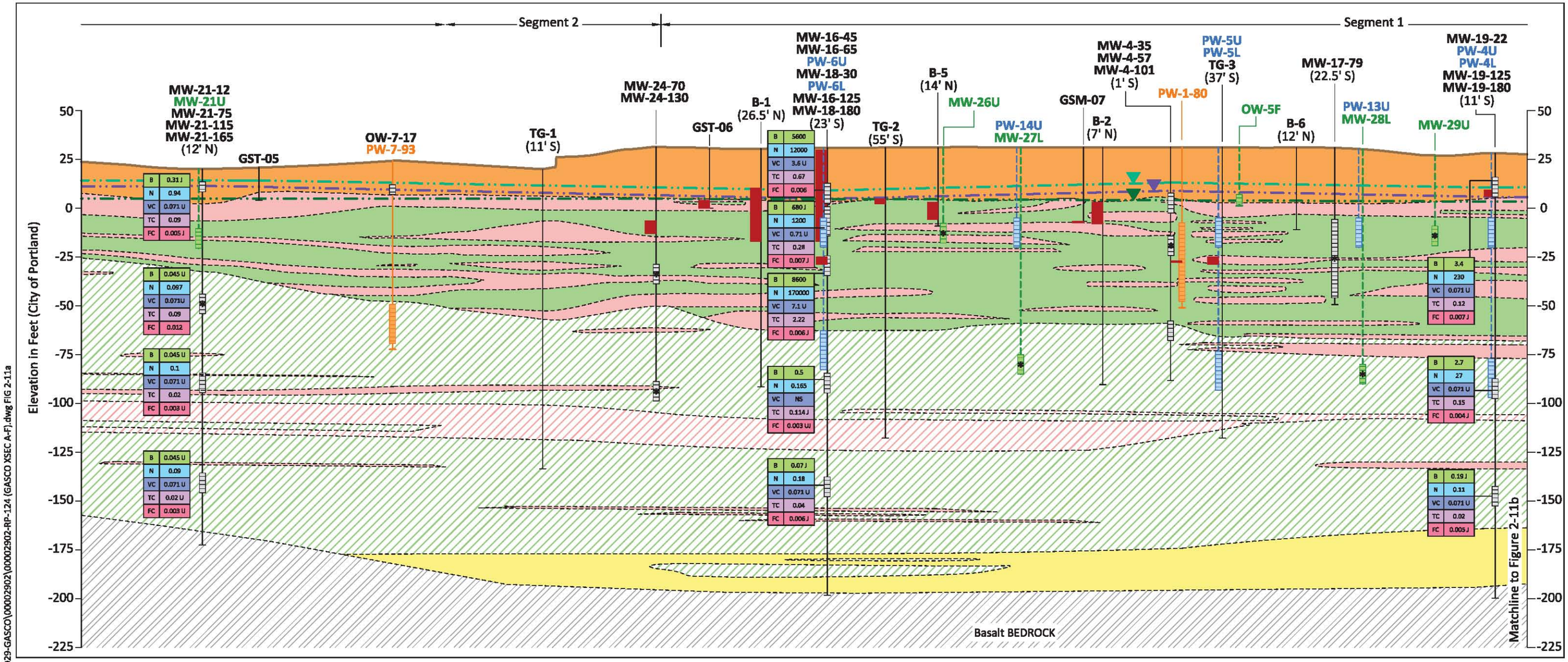
HORIZONTAL DATUM: Oregon State Plane North NAD 83 (International Feet).
VERTICAL DATUM: City of Portland

0 150
Scale in Feet

K:\Jobs\000029-GASCO\00002902\00002902-RP-128.dwg F 2-10
May 04, 2011 2:41pm henksen

ANCHOR QEA

Figure 2-10
Deep Aquitard Isopach Map
Draft Final Design Report
Gasco Groundwater Source Control



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily fine to medium grained SAND and SILTY-SAND interbedded with thin silt and sandy-silt layers
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Potentiometric Surface of Surficial Fill (measured June 3, 2009)
- Potentiometric Surface of Surficial Fill (measured August 5, 2009)
- Potentiometric Surface of Alluvium (measured August 5, 2009)

- B — Benzene in ppb
- N — Naphthalene in ppb
- VC — Vinyl Chloride in ppb
- TC — Total Cyanide in ppm
- FC — Free Cyanide in ppm
- U — Not Detected at the Detection Limit
- J — Estimated Value
- NS — Not Sampled

- Existing Ground Surface
- MW-21-16 — Boring ID
- (57' E) — Offset Distance in Feet
- Existing Extraction Well
- Proposed Extraction Well
- Proposed Well or Piezometer
- Existing Well or Piezometer
- NAPL and/or Tar Interval
- Well Screen
- * — Control Well

0 50
Scale in Feet

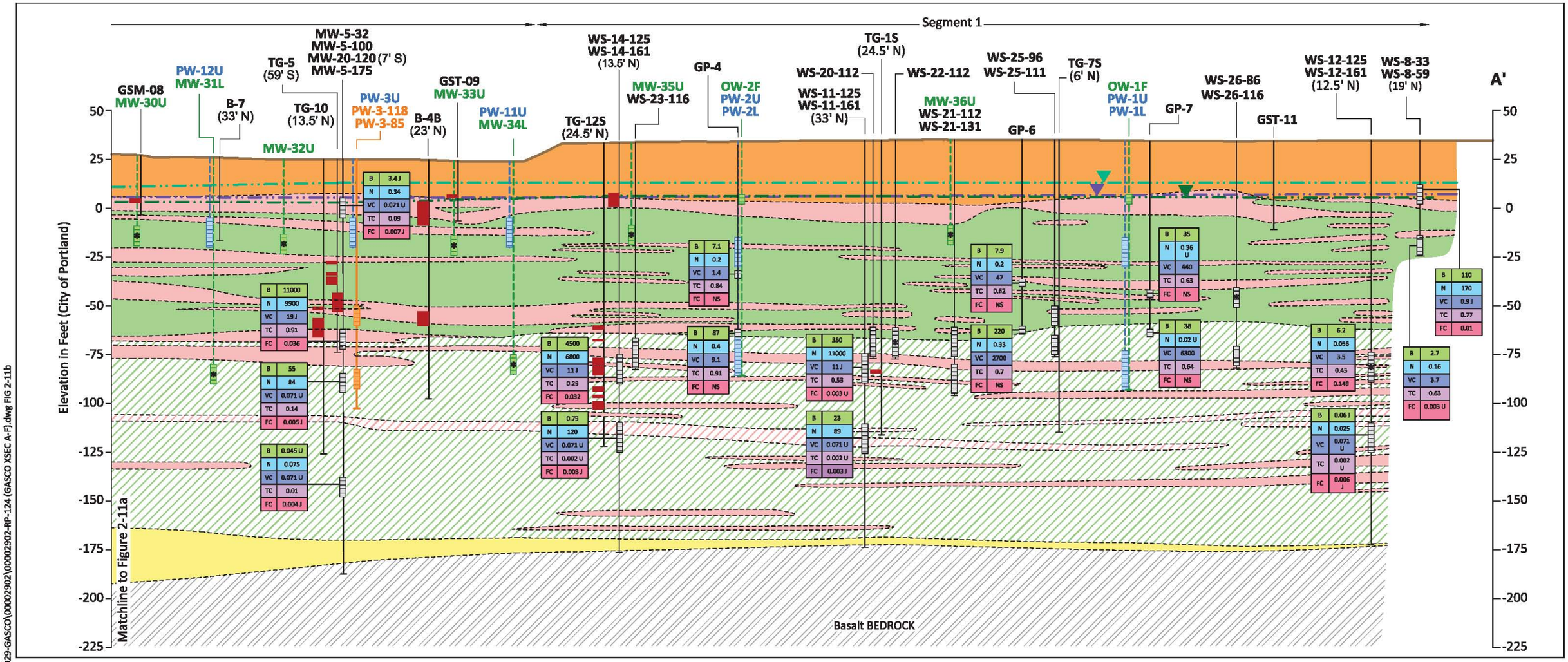
NOTE: Geologic contacts are inferred between borings.

K:\Jobs\000029-GASCO\00002902\00002902-RP-124 (GASCO XSEC A-F).dwg FIG 2-11a

Apr 21, 2011 2:20pm herliksen

ANCHOR QEA

Figure 2-11a
Shoreline Groundwater Quality Data, Section A-A'
Draft Final Design Report
Gasco Groundwater Source Control



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily fine to medium grained SAND and SILTY-SAND interbedded with thin silt and sandy-silt layers
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Potentiometric Surface of Surficial Fill (measured June 3, 2009)
- Potentiometric Surface of Surficial Fill (measured August 5, 2009)
- Potentiometric Surface of Alluvium (measured August 5, 2009)

B	Benzene in ppb
N	Naphthalene in ppb
VC	Vinyl Chloride in ppb
TC	Total Cyanide in ppm
FC	Free Cyanide in ppm
U	Not Detected at the Detection Limit
J	Estimated Value
NS	Not Sampled

- Existing Ground Surface
- MW-21-16 — Boring ID
- (57' E) — Offset Distance in Feet
- Existing Extraction Well
- Proposed Extraction Well
- Proposed Well or Piezometer
- Existing Well or Piezometer
- NAPL and/or Tar Interval
- Well Screen
- * — Control Well

0 50
Scale in Feet

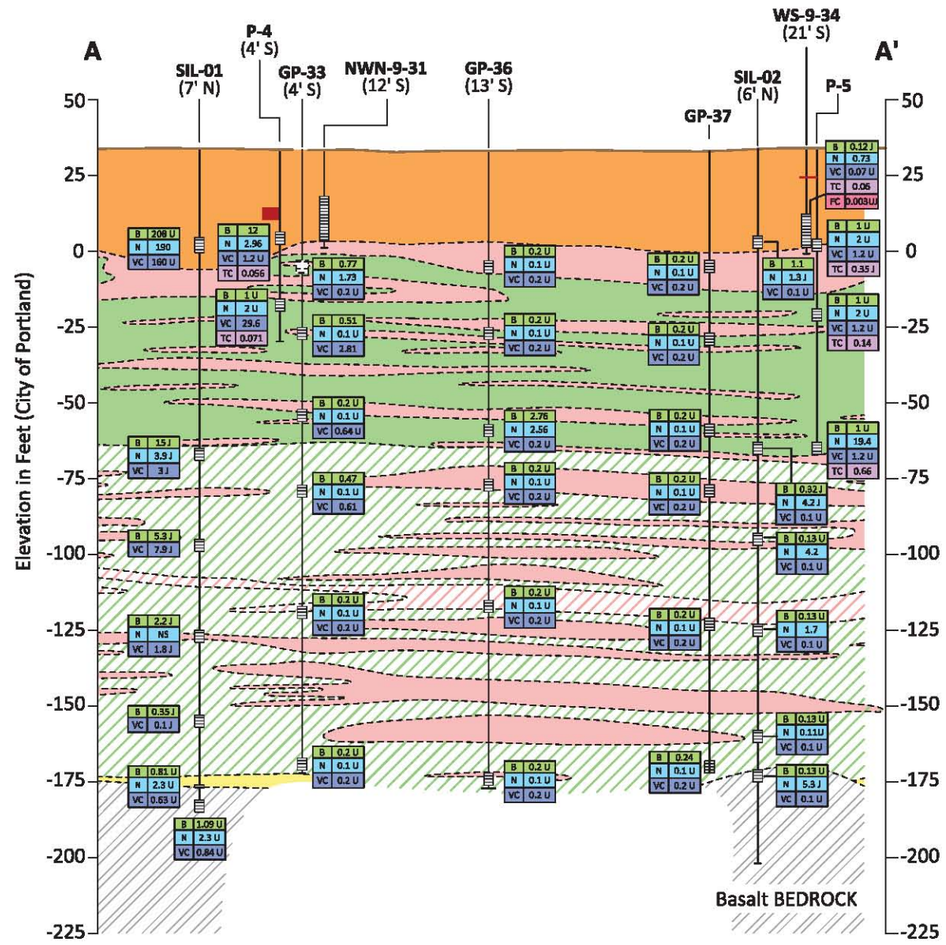
NOTE: Geologic contacts are inferred between borings.

K:\Jobs\000029-GASCO\00002902\00002902-RP-124 (GASCO XSEC A-F1).dwg FIG 2-11b

Apr 21, 2011 4:09pm herlksen

ANCHOR QEA

Figure 2-11b
Shoreline Groundwater Quality Data, Section A-A'
Draft Final Design Report
Gasco Groundwater Source Control



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily fine to medium grained SAND and SILTY-SAND interbedded with thin silt and sandy-silt layers
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK

- B — Benzene in ppb
- N — Naphthalene in ppb
- VC — Vinyl Chloride in ppb
- TC — Total Cyanide in ppm
- FC — Free Cyanide in ppm
- U — Not Detected at the Detection Limit
- J — Estimated Value
- NS — Not Sampled

- Existing Ground Surface
- P-47 (22' S) — Boring ID — Offset Distance in Feet
- NAPL and/or Tar Interval
- Well Screen

0 100
Scale in Feet
Vertical exaggeration x2

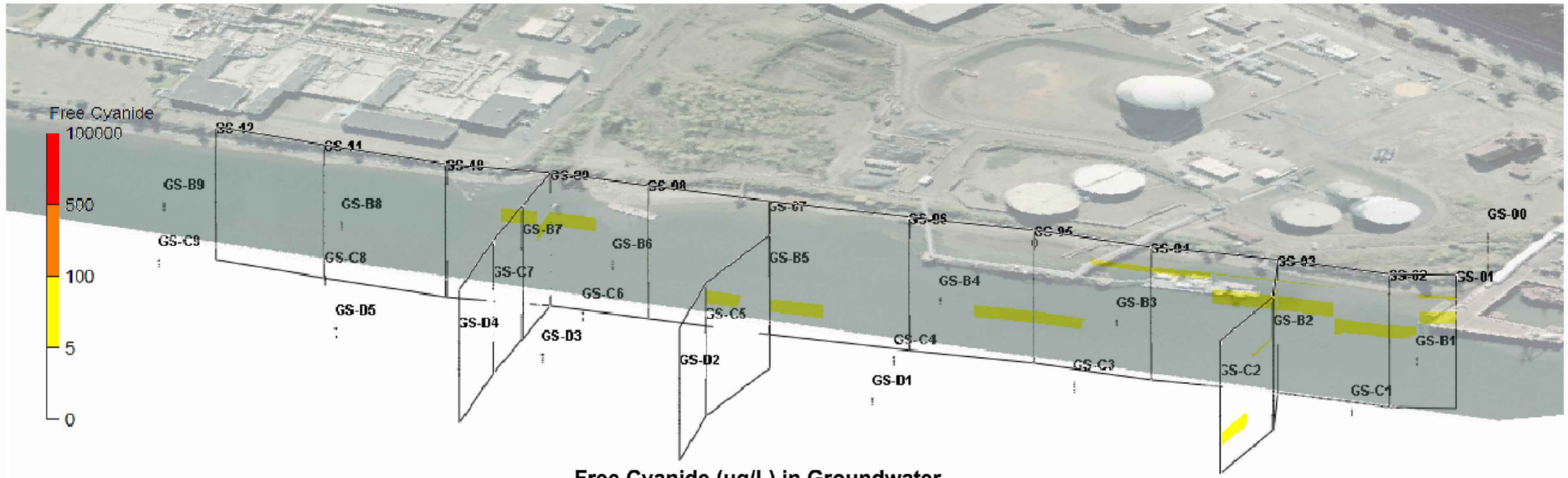
NOTE: Geologic contacts are inferred between borings.

K:\Jobs\000029-GASCO\00002902\00002902-RP-124 (GASCO XSEC A-F).dwg FIG 2-11c

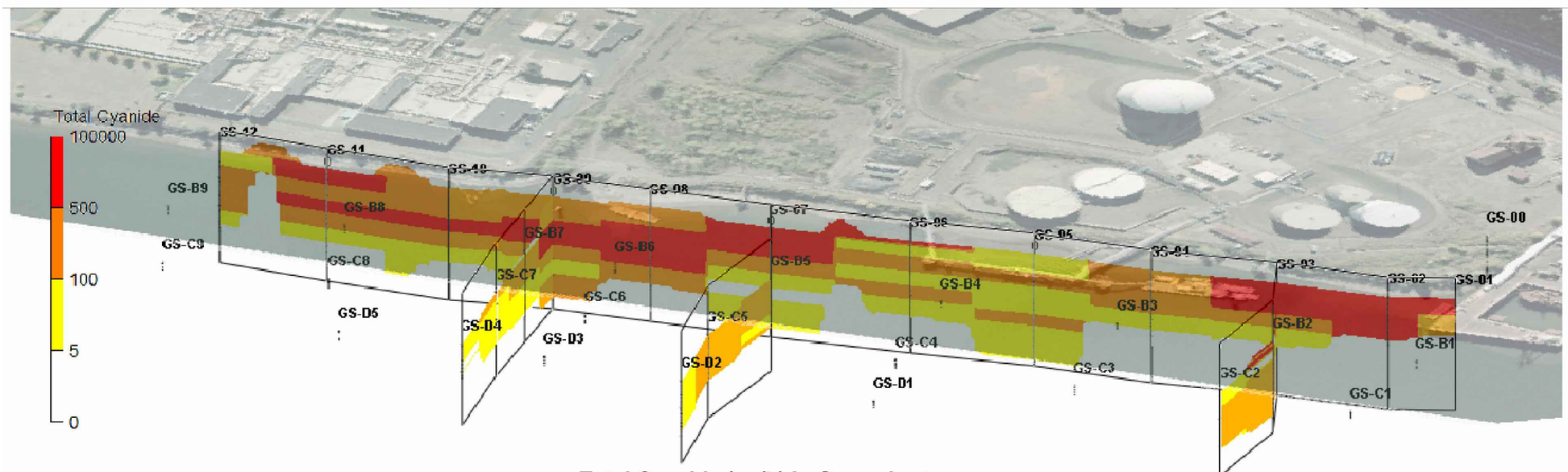
Apr 19, 2011 1:24pm herlksen

ANCHOR QEA

Figure 2-11c
Shoreline Groundwater Quality Data, Segment 3
Draft Final Design Report
Gasco Groundwater Source Control



Free Cyanide (ug/L) in Groundwater



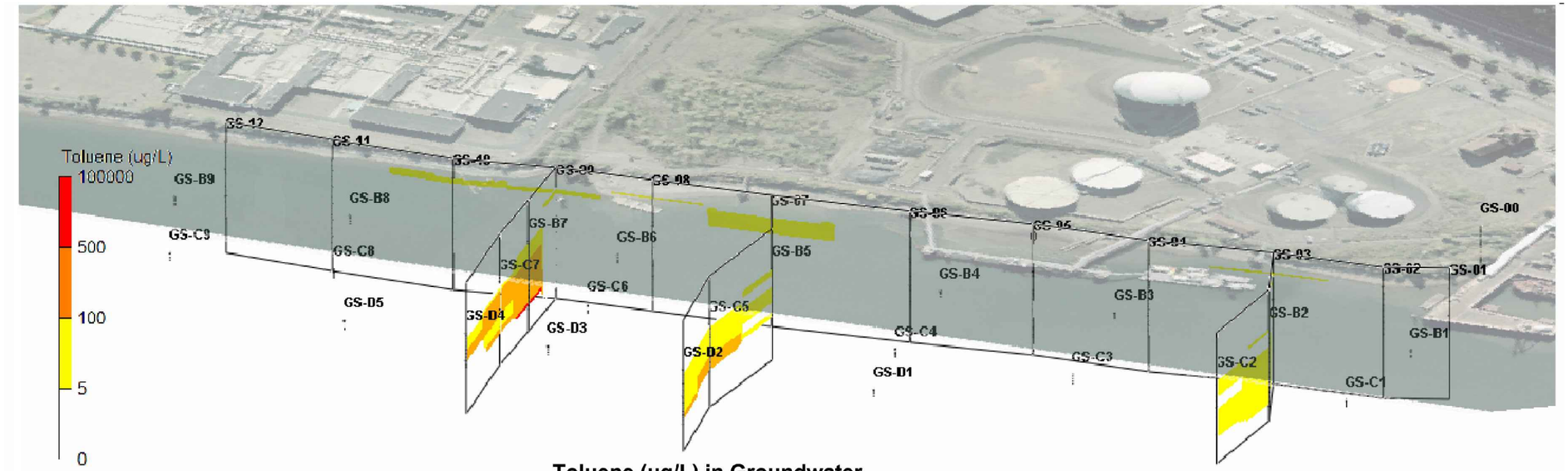
Total Cyanide (ug/L) in Groundwater

NOTE: Locations are approximate and are for visualization purposes only.

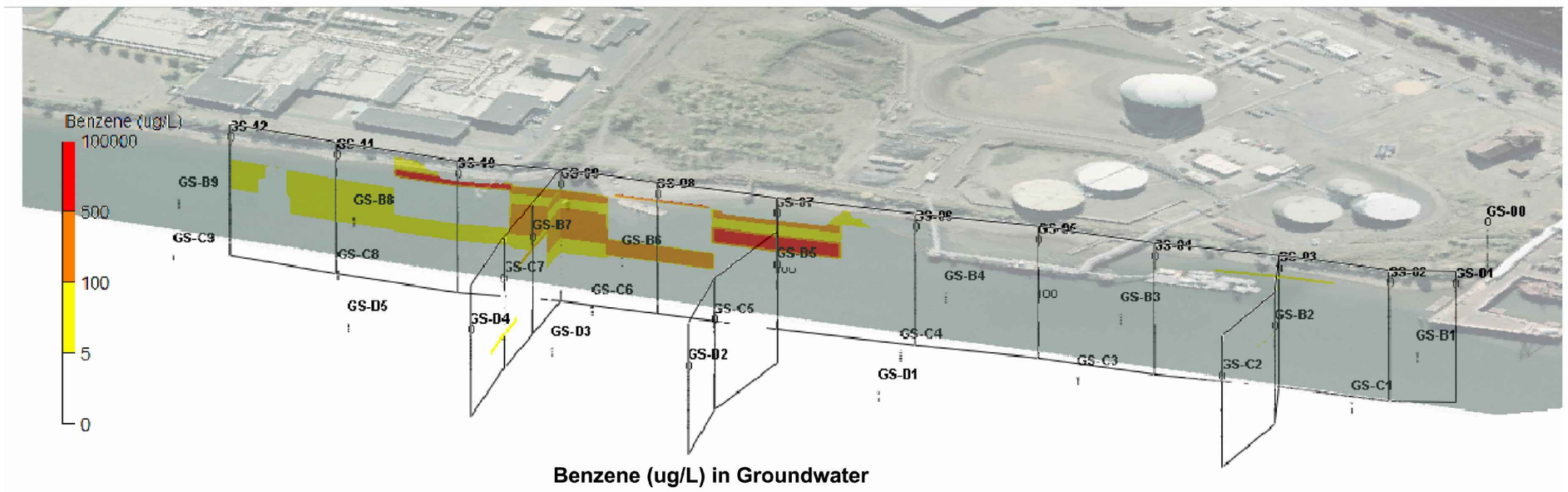
May 04, 2011 9:21am heriksen K:\Jobs\000029-GASCO\00002902\00002902-RP-033.dwg FIG 2-12a

ANCHOR QEA

Figure 2-12a
3D MGP Plume Maps - Free and Total Cyanide
Draft Final Design Report
Gasco Groundwater Source Control



Toluene (ug/L) in Groundwater



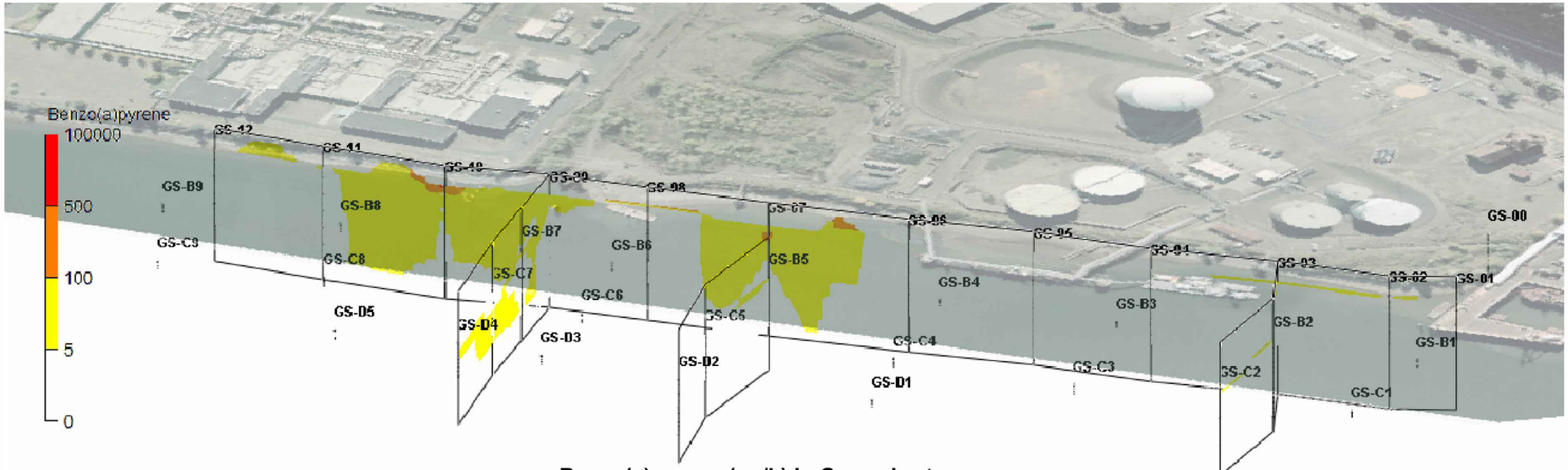
Benzene (ug/L) in Groundwater

NOTE: Locations are approximate and are for visualization purposes only.

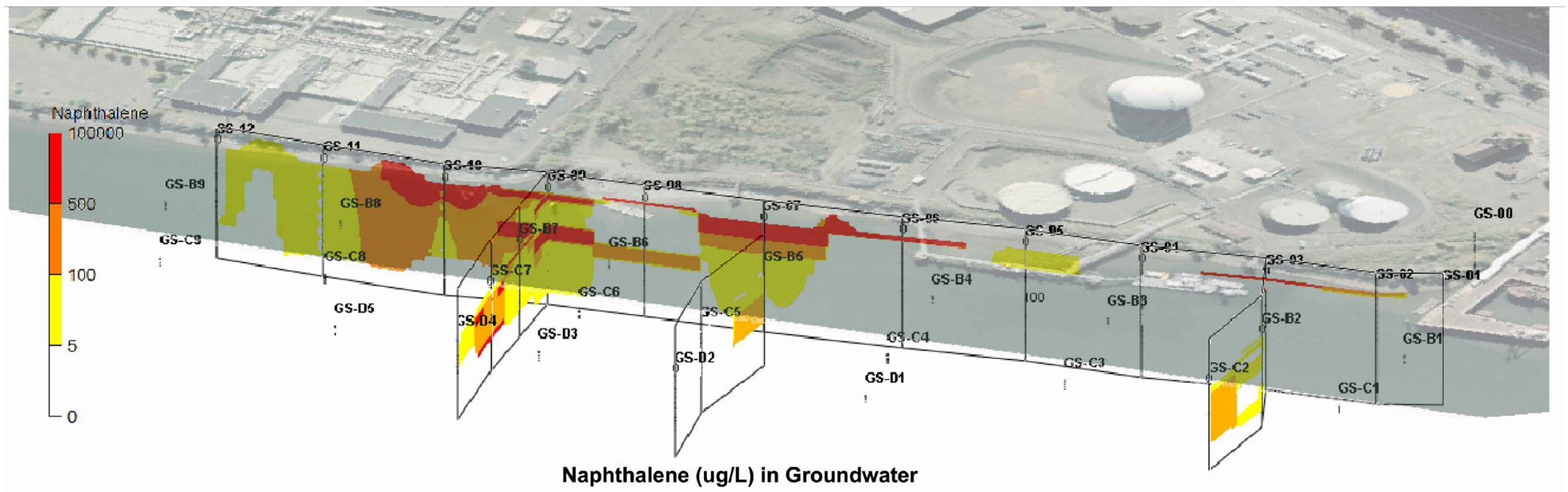
May 04, 2011 9:21am heriksen K:\Jobs 000029-GASCO 00002902 00002902-RP-033.dwg FIG 2-12b

ANCHOR QEA

Figure 2-12b
3D MGP Plume Maps - Toluene and Benzene
Draft Final Design Report
Gasco Groundwater Source Control



Benzo(a)pyrene (ug/L) in Groundwater



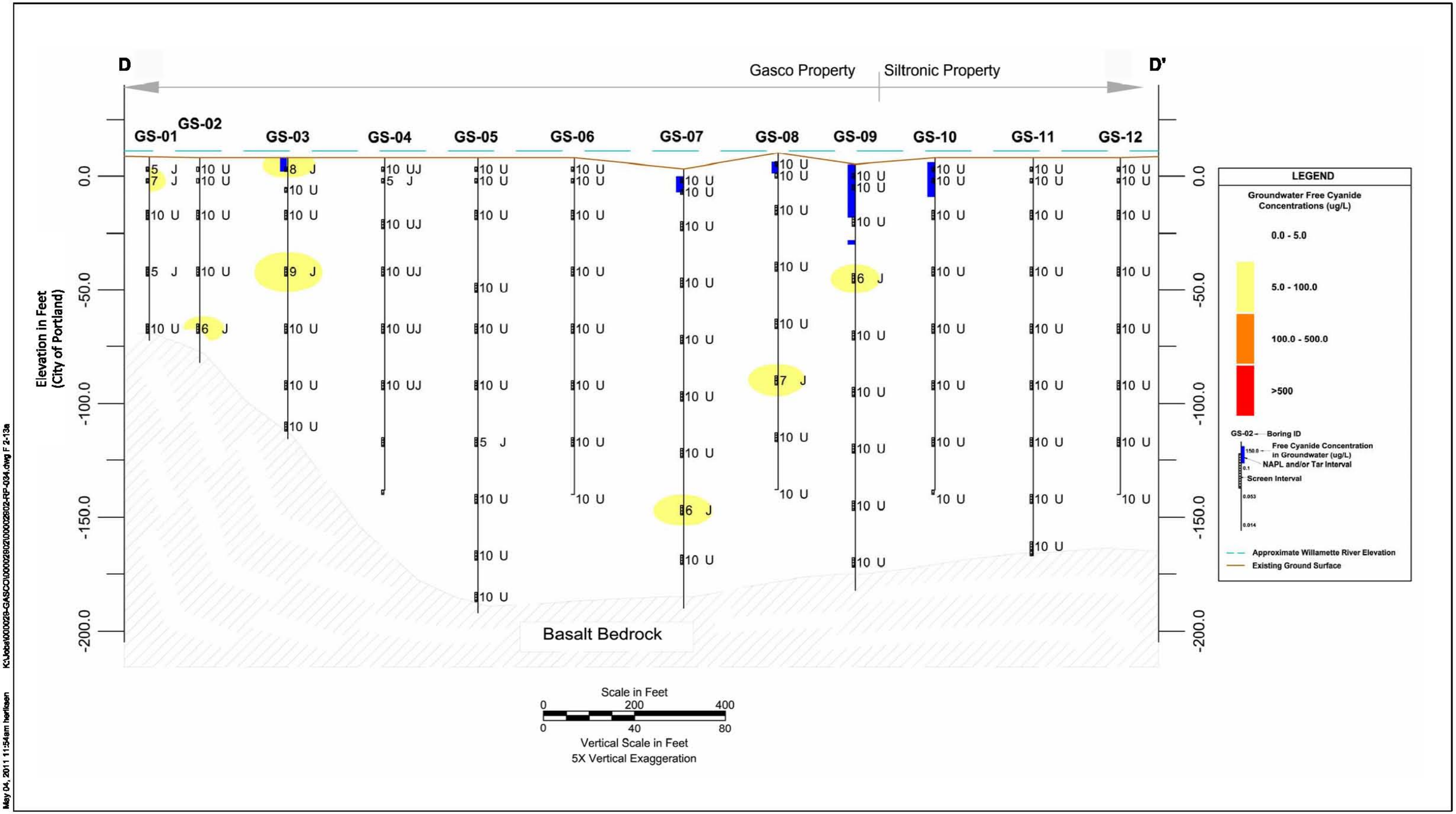
Naphthalene (ug/L) in Groundwater

NOTE: Locations are approximate and are for visualization purposes only.

May 04, 2011 9:21am heriksen K:\Jobs 000029-GASCO 00002902 00002902-RP-033.dwg FIG 2-12c

ANCHOR QEA

Figure 2-12c
3D MGP Plume Maps - Benzo(a)pyrene and Naphthalene
Draft Final Design Report
Gasco Groundwater Source Control

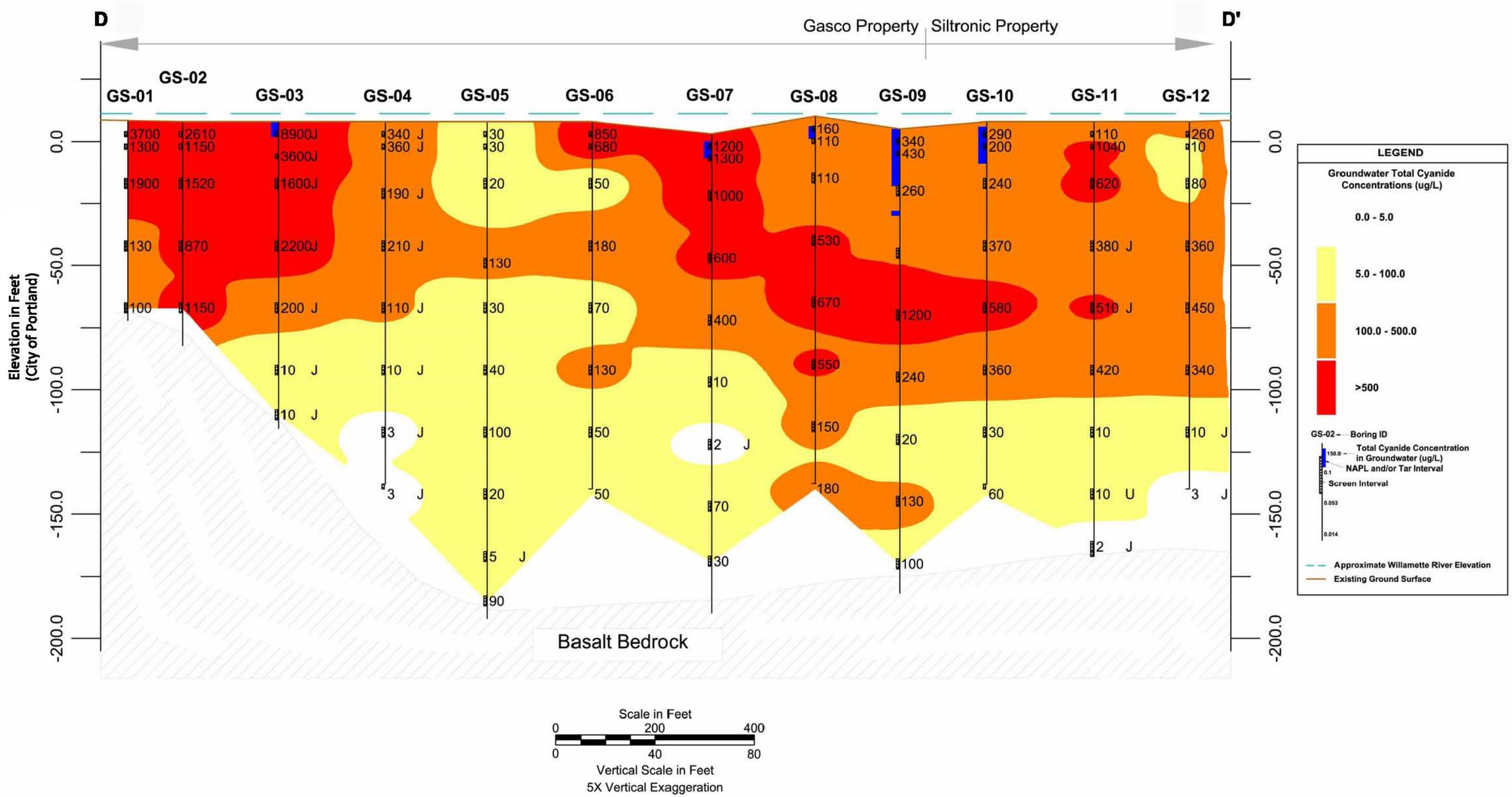


K:\Jobs\000029-GASCO\00002802\00002802-RP-034.dwg F 2-13a

May 04, 2011 11:54am herlksen

ANCHOR QEA

Figure 2-13a
Subsurface Profile D-D' - Free Cyanide
Draft Final Design Report
Gasco Groundwater Source Control

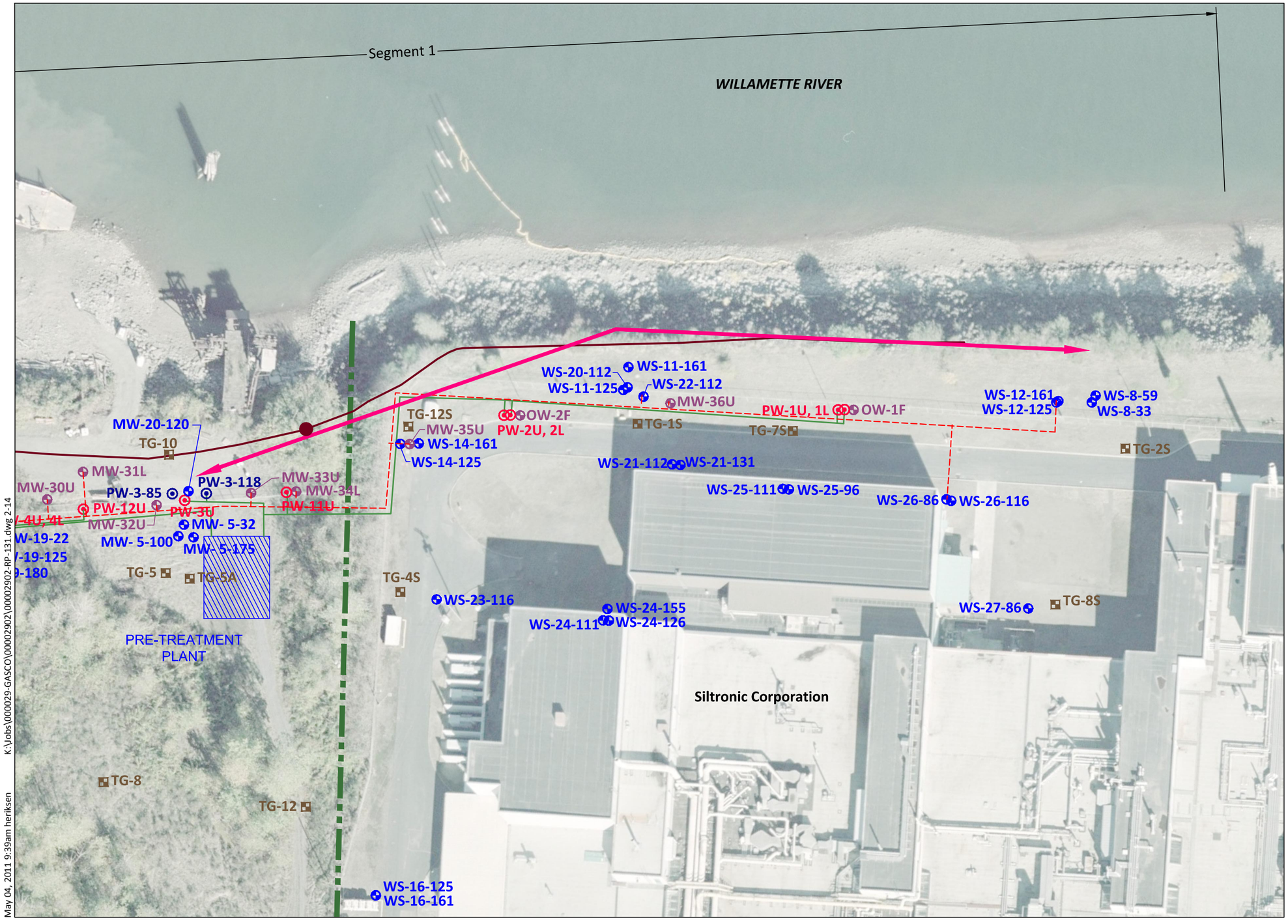


K:\Jobs\000029-GASCO\00002802\00002902-RP-034.dwg F 2-13b

May 04, 2011 9:34am herlksen

ANCHOR QEA

Figure 2-13b
Subsurface Profile D-D' - Total Cyanide
Draft Final Design Report
Gasco Groundwater Source Control



LEGEND:

- PW-8U — Proposed Extraction Well (U = Upper Alluvium, L = Lower Alluvium)
- MW-21U — Proposed Monitoring Well (F = Fill, U = Upper Alluvium, L = Lower Alluvium)
- MW-2-12 — Existing Monitoring Well, Observation Well, or Piezometer
- PW-9L — Existing Extraction Well (U = Upper Alluvium, L = Lower Alluvium)
- Fill WBZ Trench Alignment with Sump
- Source Control Main Pipeline Route
- Source Control Level Data Route
- Siltronic Plume Extent

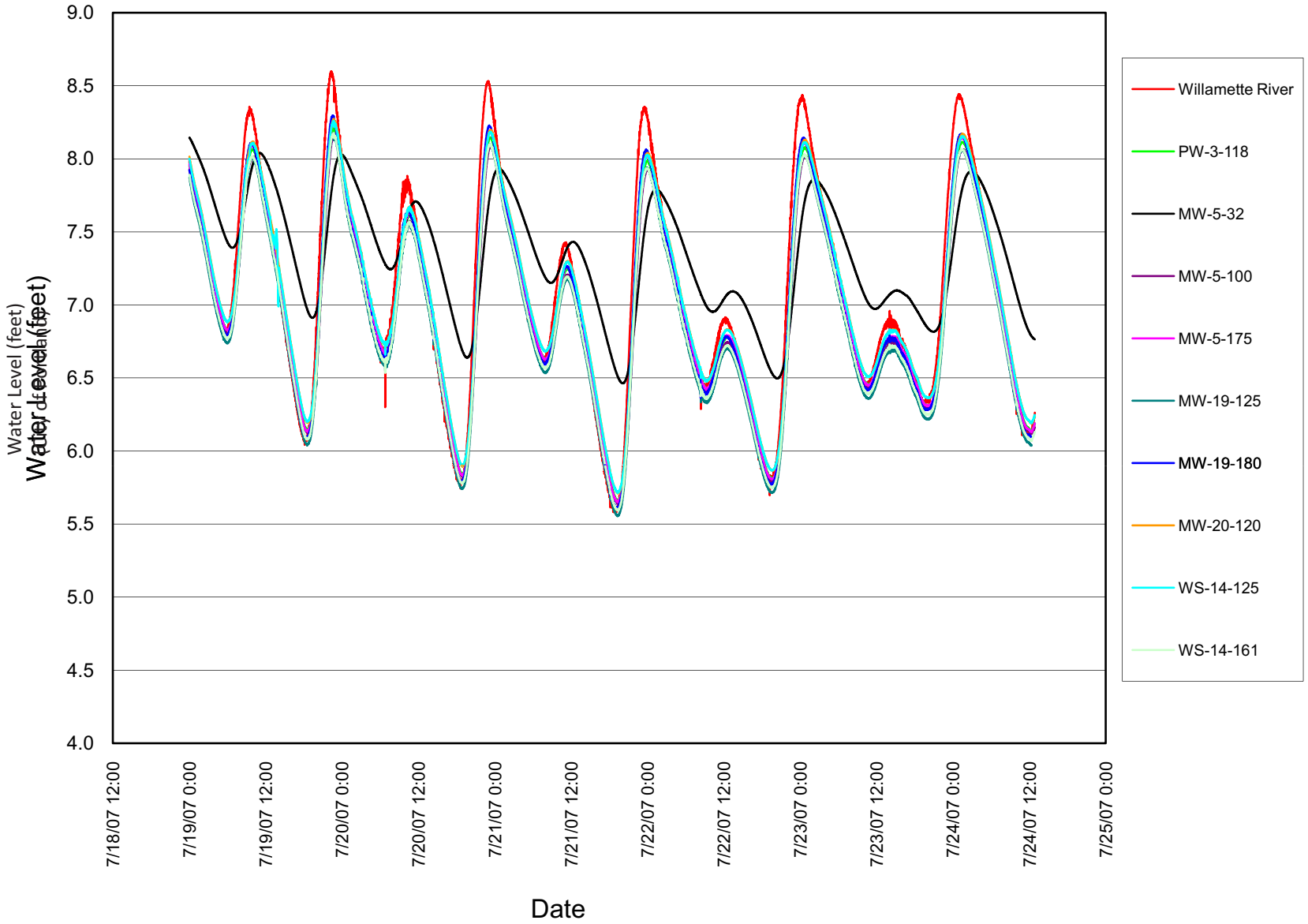
0 60
Scale in Feet

HORIZONTAL DATUM: Oregon State Plane North NAD 83 (International Feet).
VERTICAL DATUM: City of Portland

K:\Jobs\000029-GASCO\00002902\00002902-RP-131.dwg 2-14
May 04, 2011 9:39am heriksen

ANCHOR QEA

Figure 2-14
Siltronic CVOC Plume Map
Draft Final Desing Report
Gasco Groundwater Source Control



05/24/2010 cdavidson K:\Jobs\000029-GASCO\00002902\CorelDRAW figs\IDR\00002902-RP-007.cdr

Figure 3-1
River and Groundwater Tidal Fluctuations
Draft Final Design Report
Gasco Groundwater Source Control

ANCHOR QEA

LEGEND:

Pumping Well

Partical Path in Alluvium

0 150

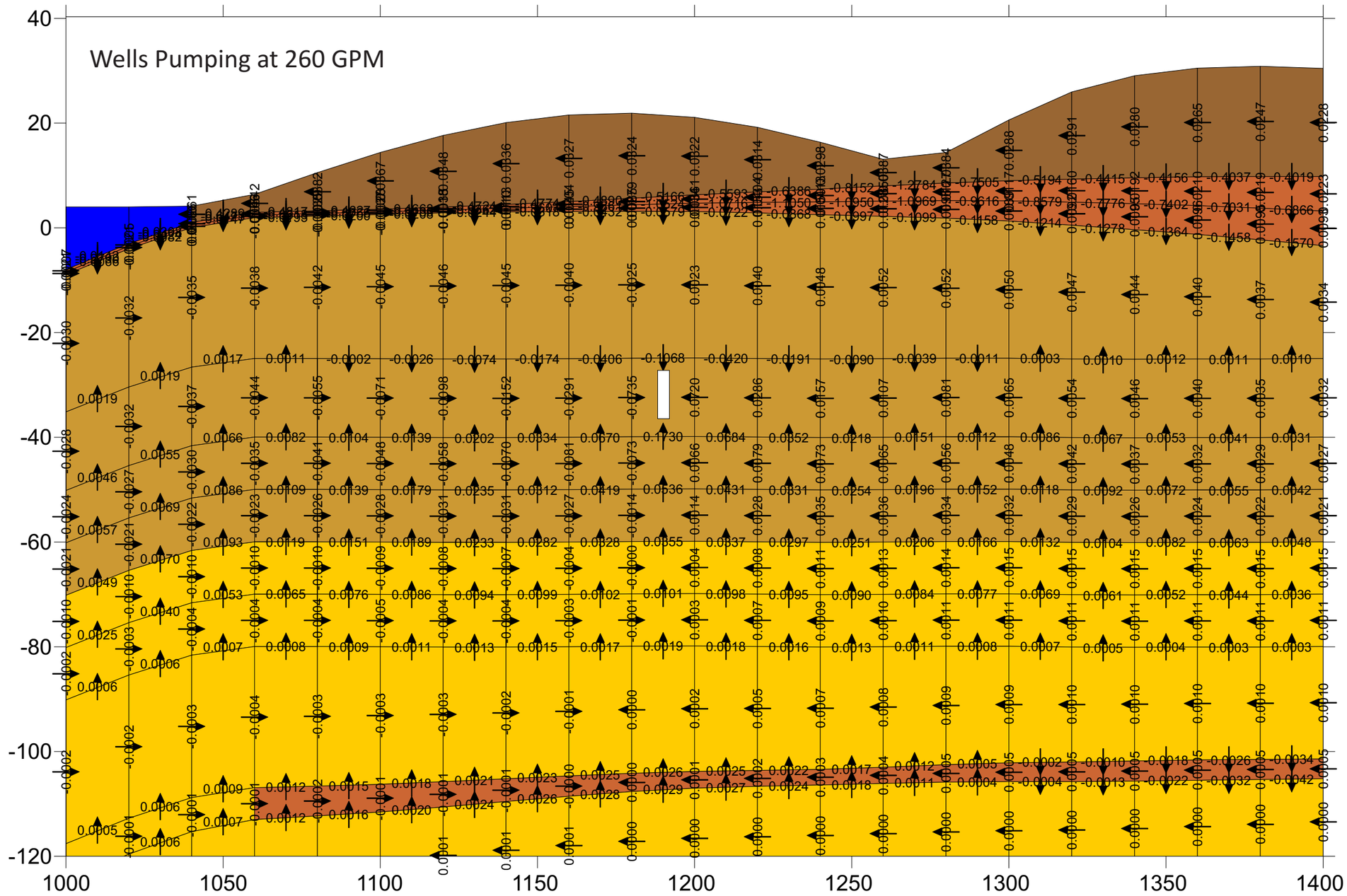
Scale in Feet

K:\Jobs\000029-GASCO\00002902\00002902-RP-129.dwg F 3-2

May 04, 2011 9:40am heriksen

ANCHOR QEA

Figure 3-2
Particle Track Capture Map
Draft Final Design Report
Gasco Groundwater Source Control

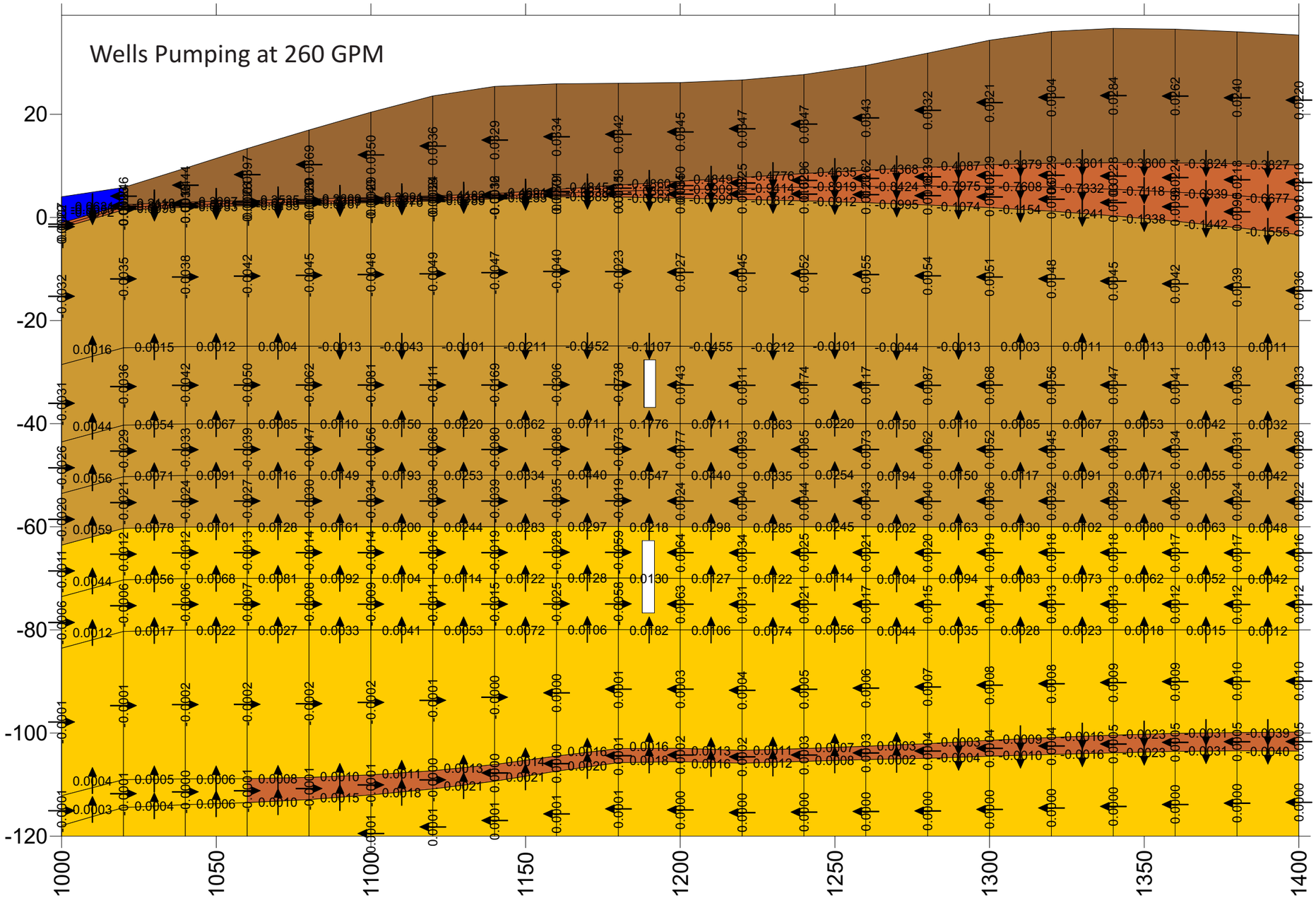


VERTICAL DATUM: City of Portland

05/4/2011 heriksen K:\Jobs\000029-GASCO\00002902\CorelDRAW figs\IDR\00002902-RP-002.cdr

ANCHOR QEA

Figure 3-3a
Groundwater Gradient Profile, Upper Alluvium Wells
Draft Final Design Report
Gasco Groundwater Source Control

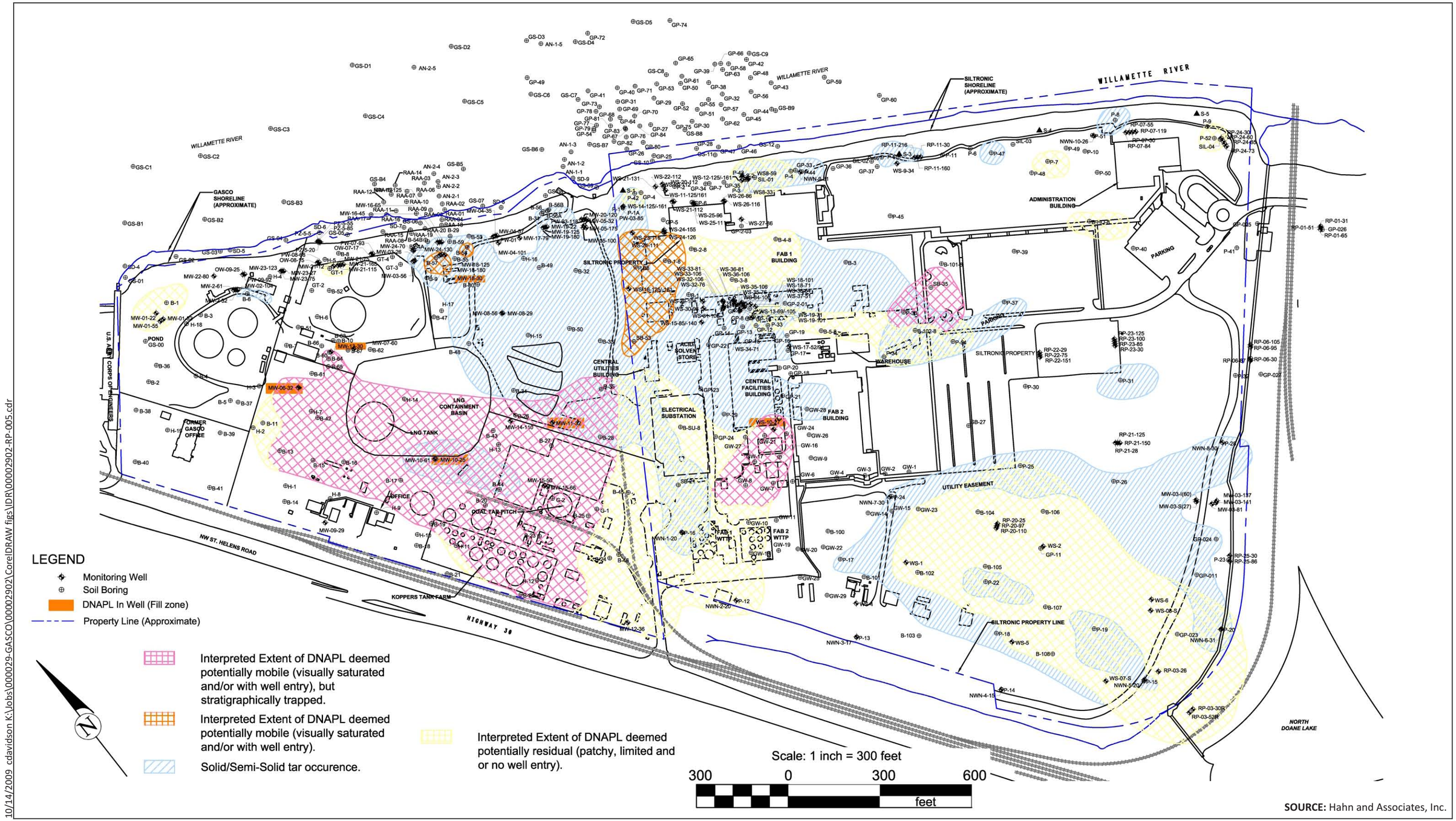


VERTICAL DATUM: City of Portland

05/4/2011 heriksen K:\Jobs\000029-GASCO\00002902\CorelDRAW figs\IDR\00002902-RP-002.cdr

ANCHOR QEA

Figure 3-3b
Groundwater Gradient Profile, Upper and Lower Alluvium Wells
Draft Final Design Report
Gasco Groundwater Source Control



10/14/2009 cdavidson K:\Jobs\000029-GASCO\00002902\CorelDRAW figs\IDR\00002902-RP-005.cdr

SOURCE: Hahn and Associates, Inc.

ANCHOR QEA

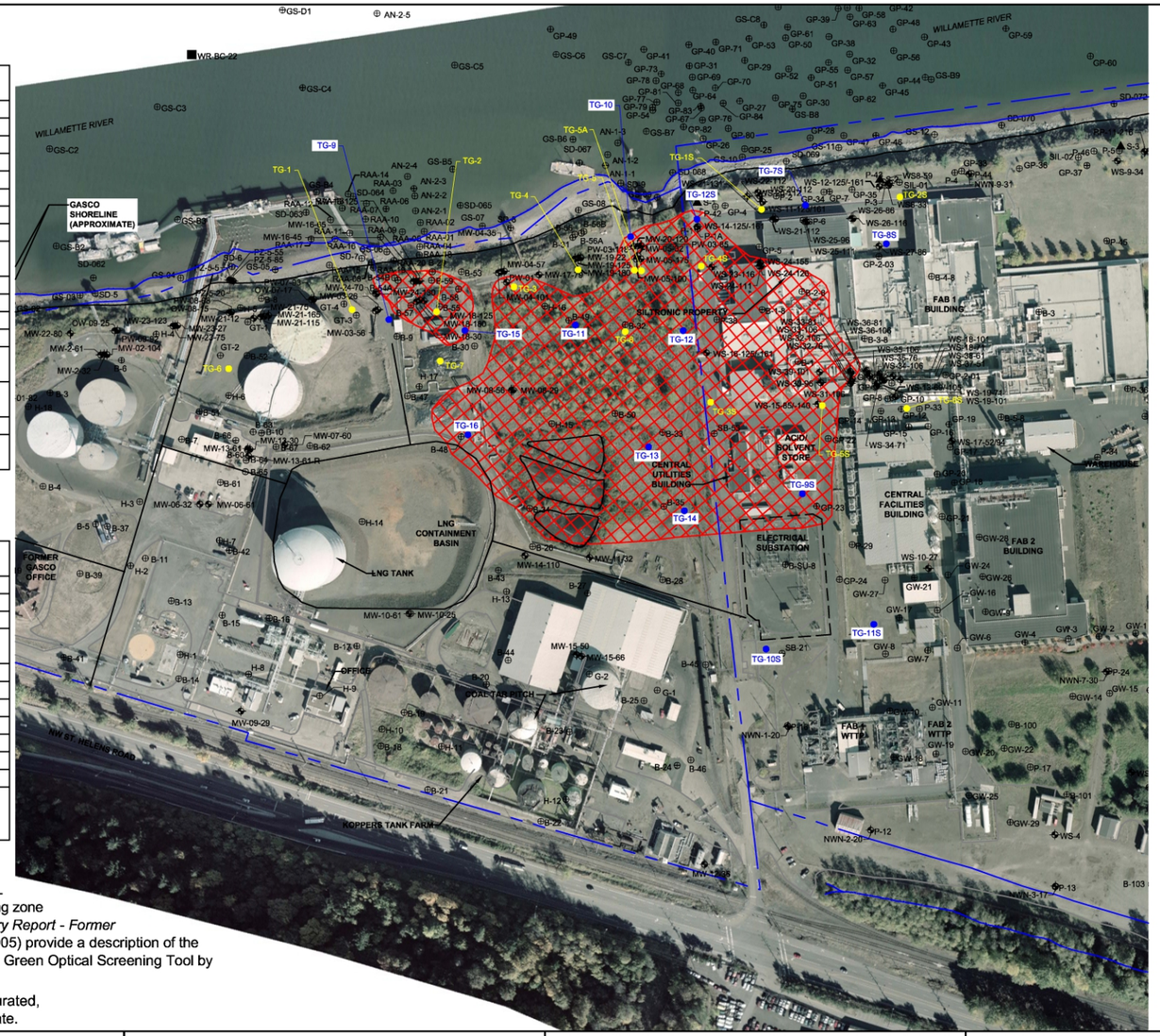
Figure 3-4a
Estimated Distribution of Tar and DNAPL within the Fill Zone
Draft Final Design Report
Gasco Groundwater Source Control

Table: TarGOST DNAPL Presence
Screening Results - Gasco Property

Boring ID	Boring Depth (ft bgs)	Depths of DNAPL Indication (Alluvial)
TG-1	150.1'	NONE
TG-2	150.3'	28.7'-30.6'
TG-3	150.3'	58.8'-60.6'
TG-4	150.0'	NONE
TG-5	99.1'	51.6'-53.3',57.8'-58.8',59.3'-63.2', 64.8'-65.1'
TG-5A	150.3'	51.3' ?
TG-6	125.5'	NONE
TG-7	150.4'	NONE
TG-8	150.2'	25'-39',41.4'-43.6',44.1'-45.3' 48.7'-48.9',51.5'-52.3',54.9'-61.1'
TG-9	148.2'	27.9'-28.8' (minor-upper silt)
TG-10	150.9'	75.4'-77.4',79.2'-88.2'
TG-11	150.2'	54.5'-56.1',112.3'? (plant/mineral interference?)
TG-12	149.5'	25'-36.8', 40.7'-48.8', 49.6'-49.9', 52.8'-53'
TG-13	101.7' (refusal)	26.5'-35.6' (minor), 35.6'-36.7', 36.7'-43.7' (minor), 43.7'-49.5', 55.3'-68.3'
TG-14	100.5' (refusal)	23'-27.9' (minor), 29.5'-30.8' (minor), 32.3'-32.4' (minor), 33.5'-39.8', 45.7'-46.3'
TG-15	149.4'	143.8'-143.9' (plant/mineral interference?)
TG-16	149.1'	26.5'-27.4', 41'-41.3', 42.5'-46.7', 52.2'-52.5', 57.9', 60.3'-61.2', 78.3'-83.9'

Table: TarGOST DNAPL Presence
Screening Results - Siltronic Property

Boring ID	Boring Depth (ft bgs)	Depths of DNAPL Indication (Alluvial)
TG-1S	151.3'	116.2-118.6'
TG-2S	151'	NONE
TG-3S	150.2'	34'-78' in multiple intervals
TG-4S	150.3'	36.7'-36.9', 62.8'-63.5', 63.8'-65.6', 67.3'-68.6', 79.0'-80.8', 91.8'-93.2', 93.9'-94.5', 98.6'-100'
TG-5S	150.6'	30'-38.6', 40.2'-41.5', 42.9'-44.2'
TG-6S	149.8'	NONE
TG-7S	150.0'	NONE
TG-8S	146.8'	NONE
TG-9S	101.3'	31.2'-48.7', 50.1'-50.5', 73.8'-74.4'
TG-10S	90.5'	NONE
TG-11S	78.5'	30.1'-30.3' (minor-upper silt)
TG-12S	156.0'	33.4'-35', 36.2', 37.2', 94.7'-97.8', 101.3'-101.7', 110.6'-111.6', 113.1'-119.6', 125.5'-127.5', 129.5'-131.4', 132.9'-136.7'



NOTES:
Borings within outlined areas identified the presence of DNAPL at some depth or depth interval within the Alluvial water-bearing zone at depths shallower than 100' bgs. Tables 2 and 3 of *Summary Report - Former MGP Operations and DNAPL Occurrence* (HAI, November 2005) provide a description of the DNAPL presence at each boring. TarGOST ™ = Tar-Specific Green Optical Screening Tool by Dakota Technologies.

Interpreted Extent of DNAPL (visually saturated, well entry, or TarGost ID), May 2011 update.

LEGEND
- Monitoring Well
- Soil Boring
- Property Line (Approximate)
- 2007 TarGost/CPT Boring Locations (TG-Series)
- 2008 TarGost/CPT Boring Locations (TG-Series)

HAHN AND ASSOCIATES, INC.
ENVIRONMENTAL CONSULTANTS
434 NW 6th AVENUE, SUITE 203
PORTLAND, OREGON 97209
503-796-0717

Scale: 1 inch = 250 feet
250 0 250 500
feet

Project No. 2708-5237 REV. MAY 2011

Figure 11
DNAPL Screening with TarGOST 2007 and 2008 Boring Locations Showing Estimated DNAPL within Alluvial - Above 100' BGS

NW Natural and Siltronic Properties
Portland, Oregon

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05/03/11 heriksen K:\Jobs\000029-GASCO\00002902\CorelDRAW figs\IDR\00002902-RP-005.cdr

SOURCE: Hahn and Associates, Inc.

ANCHOR QEA

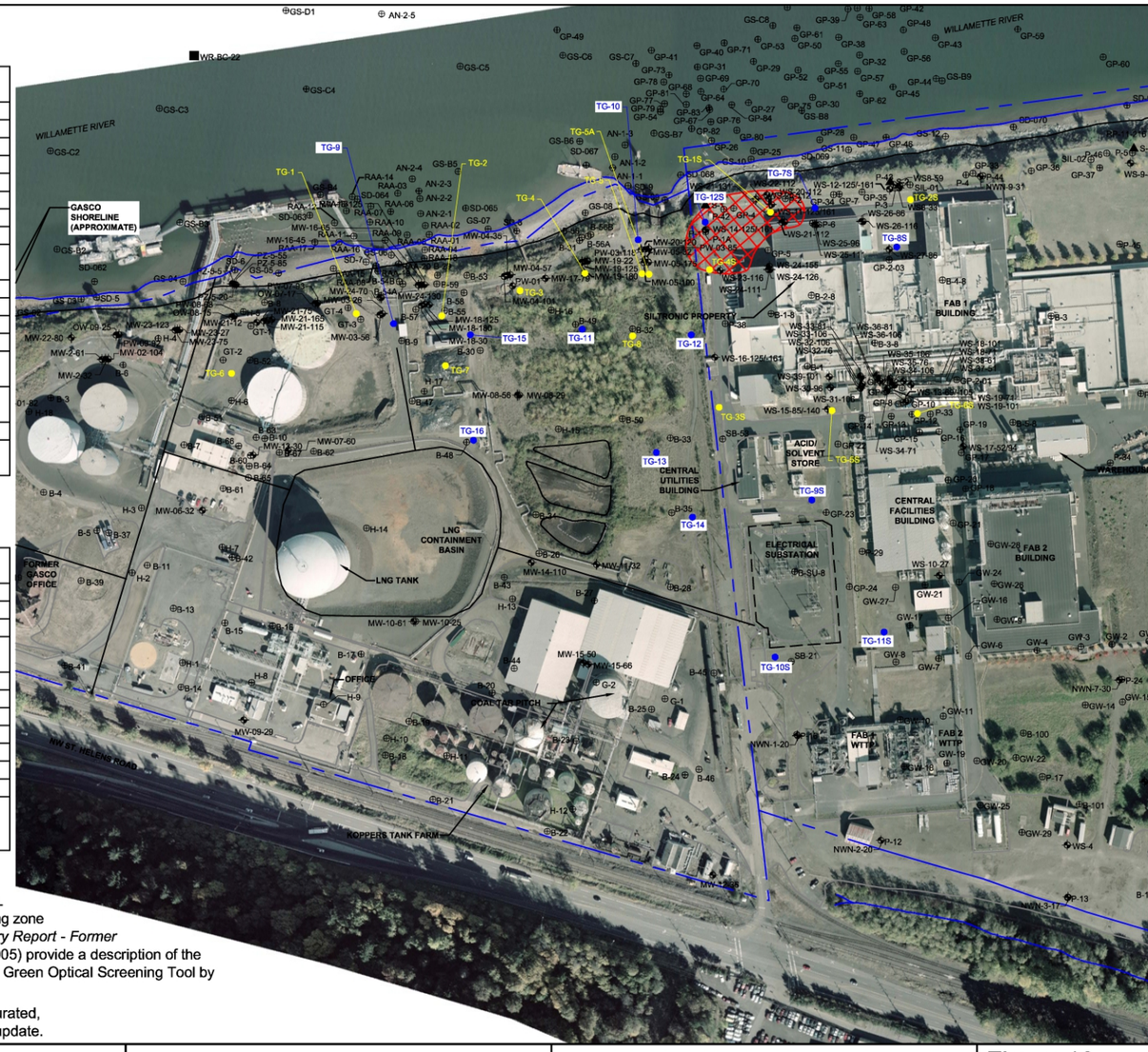
Figure 3-4b
DNAPL Screening with TarGOST 2007 and 2008 Boring Locations Showing Estimated DNAPL within Alluvial - Above 100' BGS
Draft Final Design Report
Gasco Groundwater Source Control

Table: TarGOST DNAPL Presence
Screening Results - Gasco Property

Boring ID	Boring Depth (ft bgs)	Depths of DNAPL Indication (Alluvial)
TG-1	150.1'	NONE
TG-2	150.3'	28.7'-30.6'
TG-3	150.3'	58.8'-60.6'
TG-4	150.0'	NONE
TG-5	99.1'	51.6'-53.3',57.8'-58.8',59.3'-63.2', 64.8'-65.1'
TG-5A	150.3'	51.3' ?
TG-6	125.5'	NONE
TG-7	150.4'	NONE
TG-8	150.2'	25'-39',41.4'-43.6',44.1'-45.3' 48.7'-48.9',51.5'-52.3',54.9'-61.1'
TG-9	148.2'	27.9'-28.8' (minor-upper silt)
TG-10	150.9'	75.4'-77.4',79.2'-88.2'
TG-11	150.2'	54.5'-56.1',112.3'? (plant/mineral interference?)
TG-12	149.5'	25'-36.8', 40.7'-48.8', 49.6'-49.9', 52.8'-53'
TG-13	101.7' (refusal)	26.5'-35.6' (minor), 35.6'-36.7', 36.7'-43.7' (minor), 43.7'-49.5', 55.3'-68.3'
TG-14	100.5' (refusal)	23'-27.9' (minor), 29.5'-30.8' (minor), 32.3'-32.4' (minor), 33.5'-39.8', 45.7'-46.3'
TG-15	149.4'	143.8'-143.9' (plant/mineral interference?)
TG-16	149.1'	26.5'-27.4', 41'-41.3', 42.5'-46.7', 52.2'-52.5', 57.9', 60.3'-61.2', 78.3'-83.9'

Table: TarGOST DNAPL Presence
Screening Results - Siltronic Property

Boring ID	Boring Depth (ft bgs)	Depths of DNAPL Indication (Alluvial)
TG-1S	151.3'	116.2-118.6'
TG-2S	151'	NONE
TG-3S	150.2'	34'-78' in multiple intervals
TG-4S	150.3'	36.7'-36.9', 62.8'-63.5', 63.8'-65.6', 67.3'-68.6', 79.0'-80.8', 91.8'-93.2', 93.9'-94.5', 98.6'-100'
TG-5S	150.6'	30'-38.6', 40.2'-41.5', 42.9'-44.2'
TG-6S	149.8'	NONE
TG-7S	150.0'	NONE
TG-8S	146.8'	NONE
TG-9S	101.3'	31.2'-48.7', 50.1'-50.5', 73.8'-74.4'
TG-10S	90.5'	NONE
TG-11S	78.5'	30.1'-30.3' (minor-upper silt)
TG-12S	156.0'	33.4'-35', 36.2', 37.2', 94.7'-97.8', 101.3'-101.7', 110.6'-111.6', 113.1'-119.6', 125.5'-127.5', 129.5'-131.4', 132.9'-136.7'



NOTES:
Borings within outlined areas identified the presence of DNAPL at some depth or depth interval within the Alluvial water-bearing zone at depths shallower than 100' bgs. Tables 2 and 3 of *Summary Report - Former MGP Operations and DNAPL Occurrence* (HAI, November 2005) provide a description of the DNAPL presence at each boring. TarGOST ™ = Tar-Specific Green Optical Screening Tool by Dakota Technologies.

Interpreted Extent of DNAPL (visually saturated, well entry, or TarGost ID), January 2011 update.

LEGEND
- Monitoring Well
- Soil Boring
- Property Line (Approximate)
- 2007 TarGost/CPT Boring Locations (TG-Series)
- 2008 TarGost/CPT Boring Locations (TG-Series)

HAHN AND ASSOCIATES, INC.
ENVIRONMENTAL CONSULTANTS
434 NW 6th AVENUE, SUITE 203
PORTLAND, OREGON 97209
503-796-0717

Scale: 1 inch = 250 feet
250 0 250 500
feet

Project No. 2708-5237 REV. JANUARY 2011

Figure 12
DNAPL Screening with TarGOST 2007 and 2008 Boring Locations Showing Estimated DNAPL within Alluvial - Below 100' BGS

NW Natural and Siltronic Properties
Portland, Oregon

SOURCE: Hahn and Associates, Inc.

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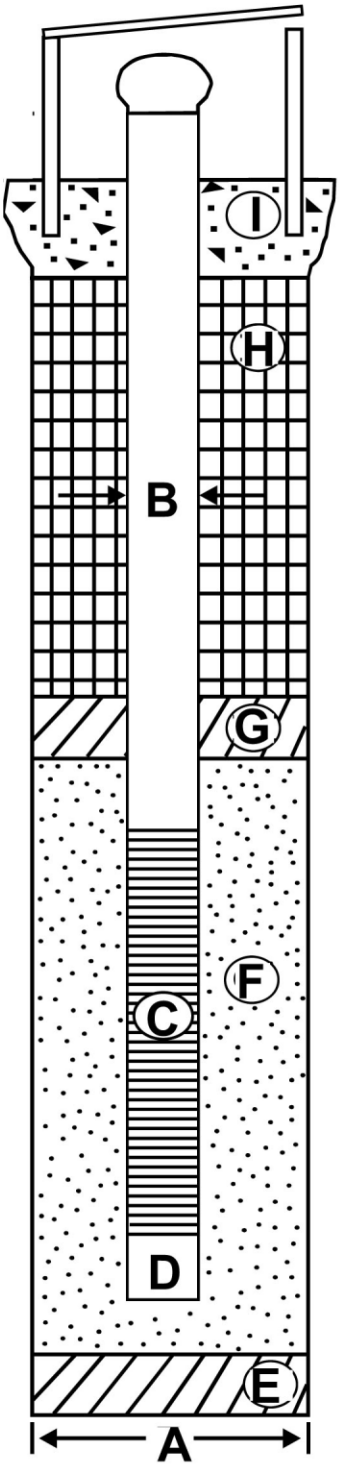
X:\Hahn\Gasco Site 2011\Siltronic Reporting\DNAPL\DNAPL Alluvial Deep-TarGOST.dwg 2/24/11

ANCHOR QEA

Figure 3-4c
DNAPL Screening with TarGOST 2007 and 2008 Boring Locations Showing Estimated DNAPL within Alluvial - Below 100' BGS
Draft Final Design Report
Gasco Groundwater Source Control



Boring Details

A: 12" diameter casing

Well Construction

B: 6" diameter Steel Riser Pipe

C: 6" diameter Stainless Steel 0.035 slot wire-wrap screen

D: 6" diameter, 3-foot-long steel sump

E:Bentonite Grout / Organoclay if NAPL is present

F: 10x20 Silica Sand Filter Pack

G:Bentonite Chip Filter Pack Seal

H:Bentonite Grout / Organoclay if NAPL is present

I: Cement Grout Surface Seal

5/06/20011 heriksenDRAW figs\IDR\00002902-RP-001.cdr

Figure 3-5
Extraction Well Construction Detail
Draft Final Design Report
Gasco Groundwater Source Control

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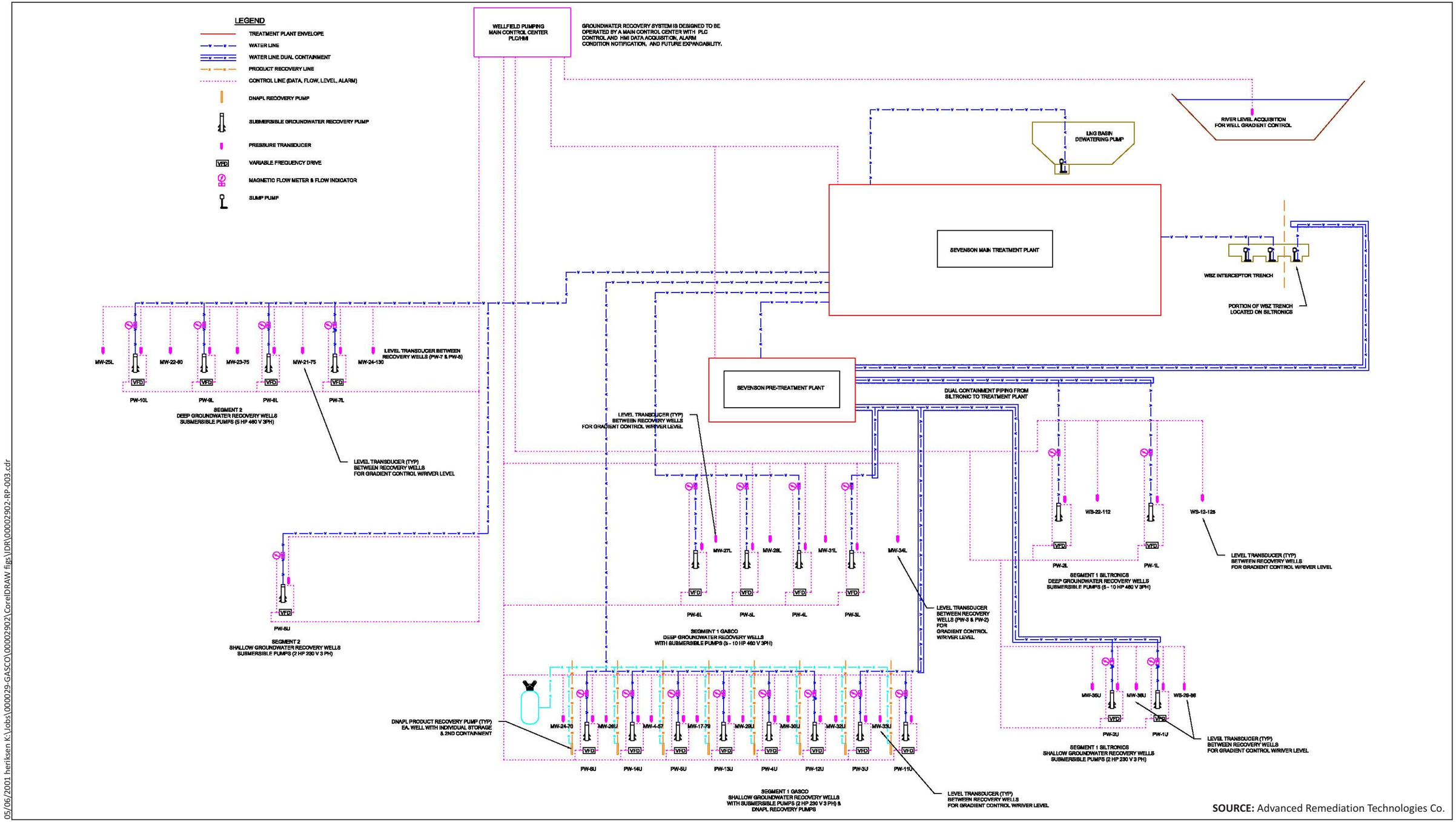

SOURCE: Advanced Remediation Technologies Co.

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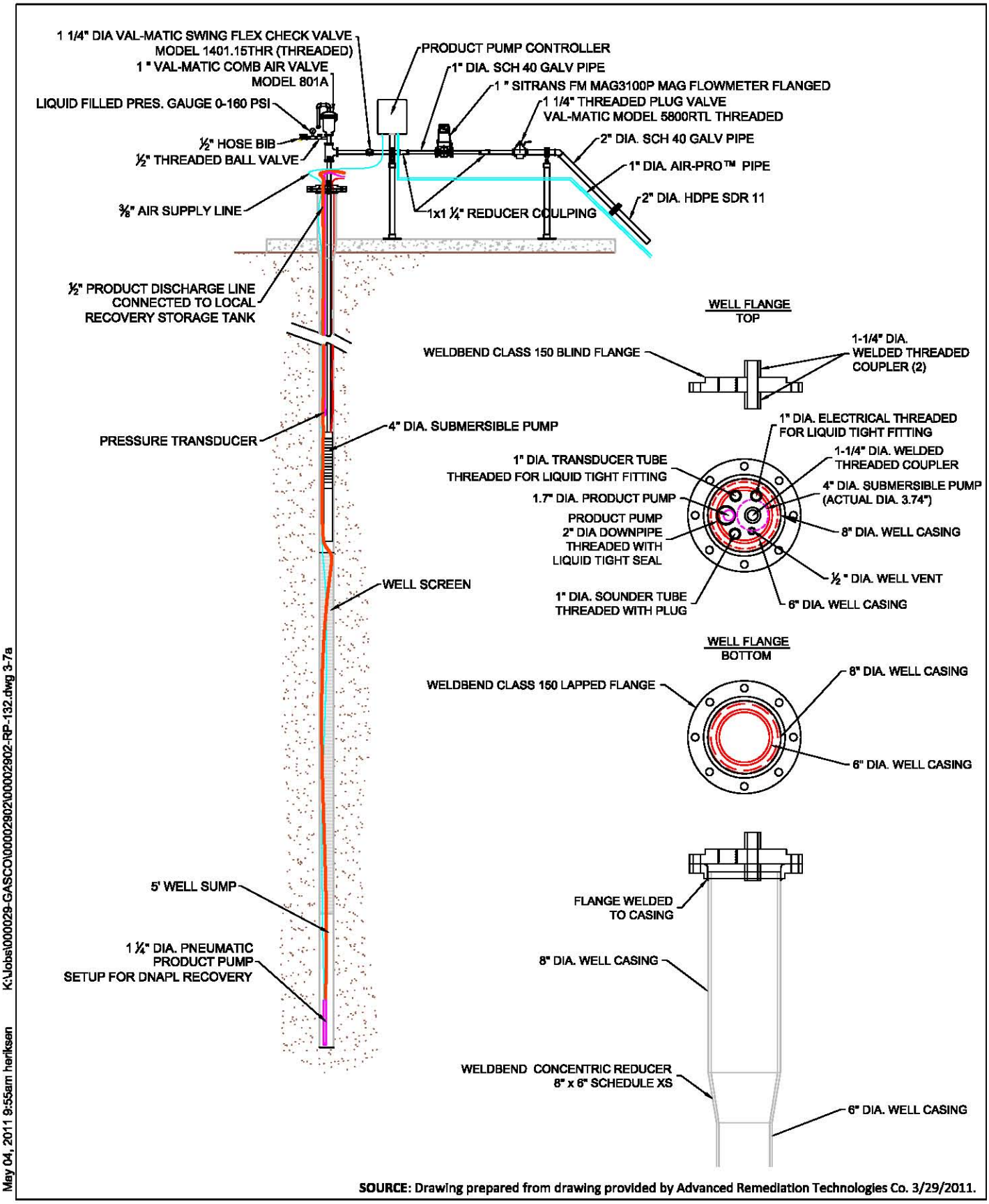
Figure 3-6
Well Field Controls and Piping
Draft Final Design Report
Gasco Groundwater Source Control



SOURCE: Drawing prepared from drawing provided by Advanced Remediation Technologies Co. 3/29/2011.

May 04, 2011 9:55am heriksen K:\Jobs\000029-GASCO\00002902\00002902-RP-132.dwg 3-7a

Figure 3-7a
Upper Alluvium Extraction Well with DNAPL Removal System Schematic
Draft Final Design Report
Gasco Groundwater Source Control

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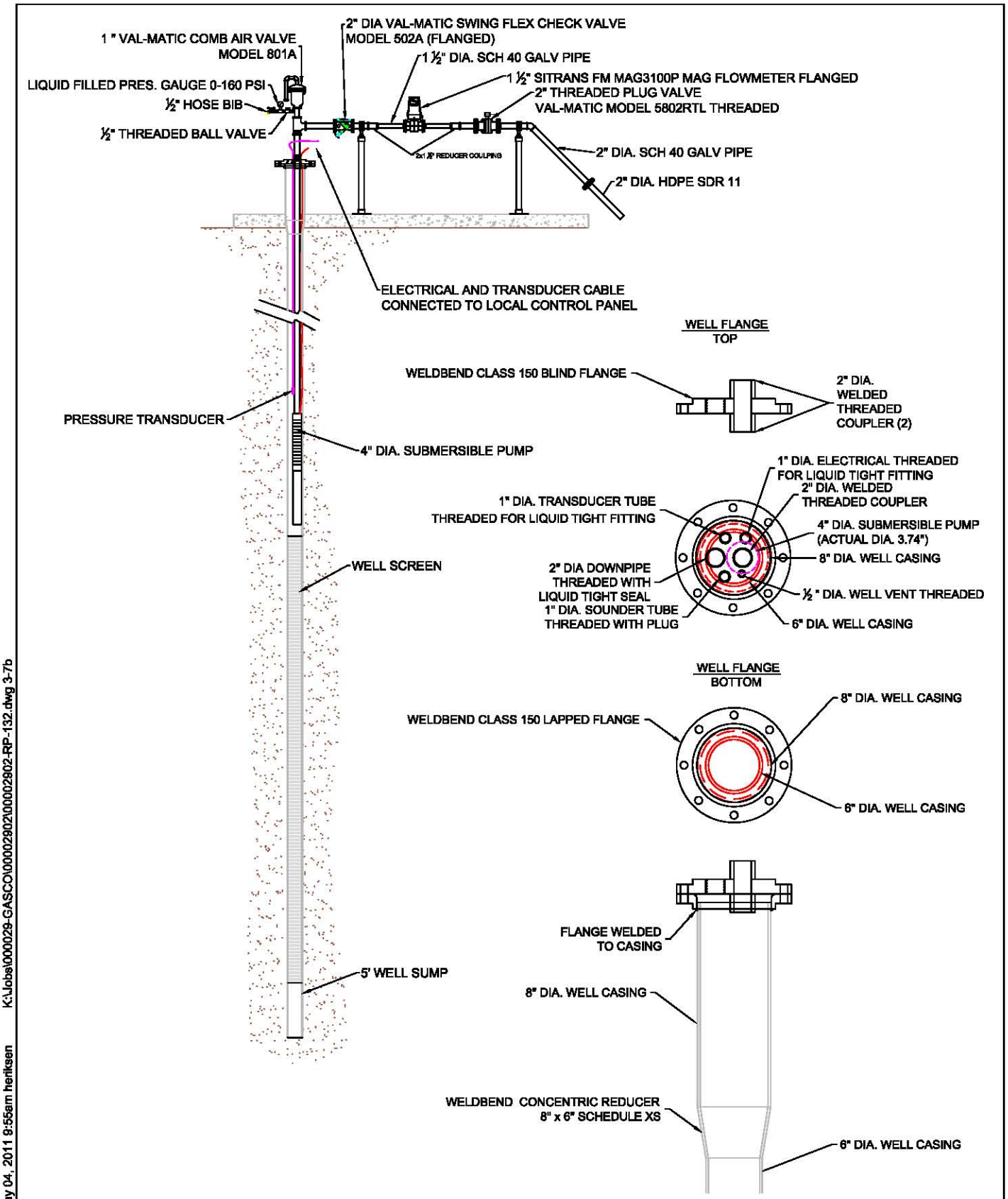

SOURCE: Drawing prepared from drawing provided by Advanced Remediation Technologies Co. 3/29/2011.

May 04, 2011 9:55am heriksen K:\Jobs\000029-GASCO\00002902\00002902-RP-132.dwg 3-7b

Figure 3-7b
Lower Alluvium Extraction Well Schematic
Draft Final Design Report
Gasco Groundwater Source Control

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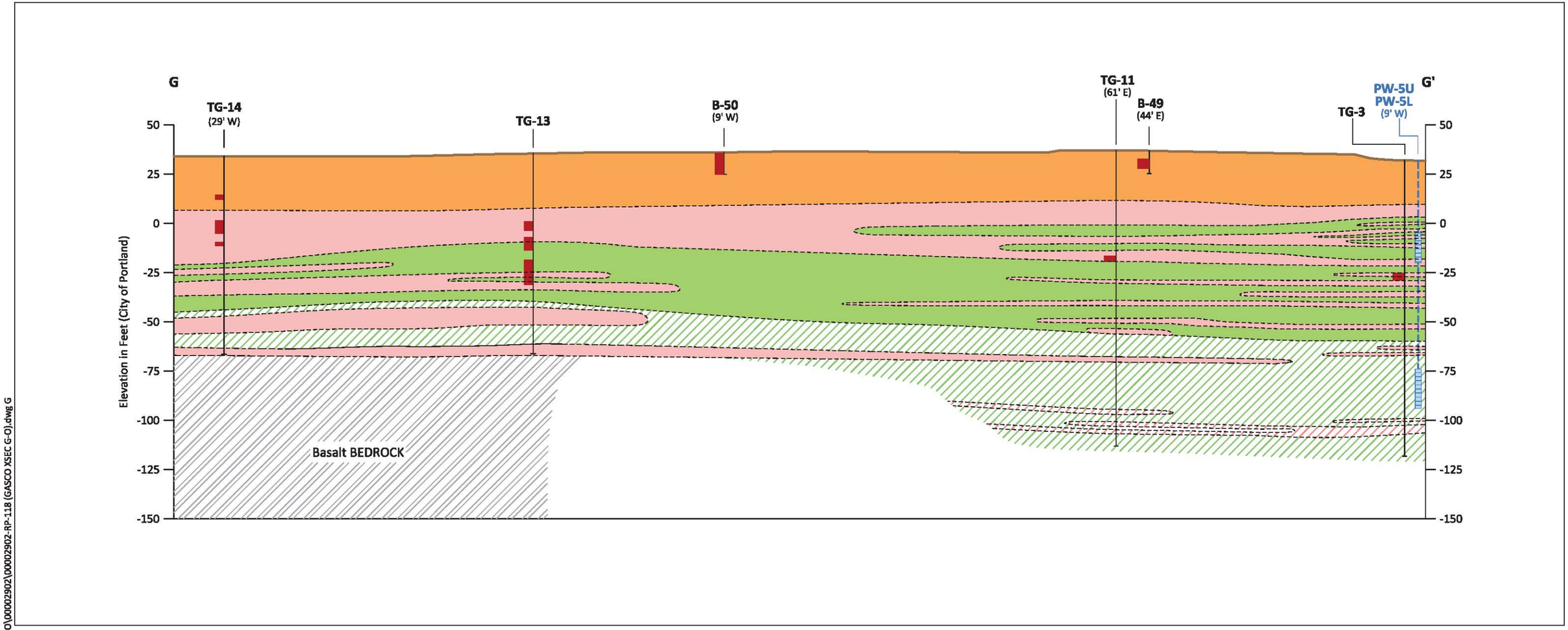


LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily fine to medium grained SAND and SILTY-SAND interbedded with thin silt and sandy-silt layers
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Existing Ground Surface
- TG-14 (29' W) — Boring ID — Offset Distance in Feet
- Proposed Extraction Well / Existing Well or Piezometer — NAPL and/or Tar Interval — Well Screen

0 50
Scale in Feet

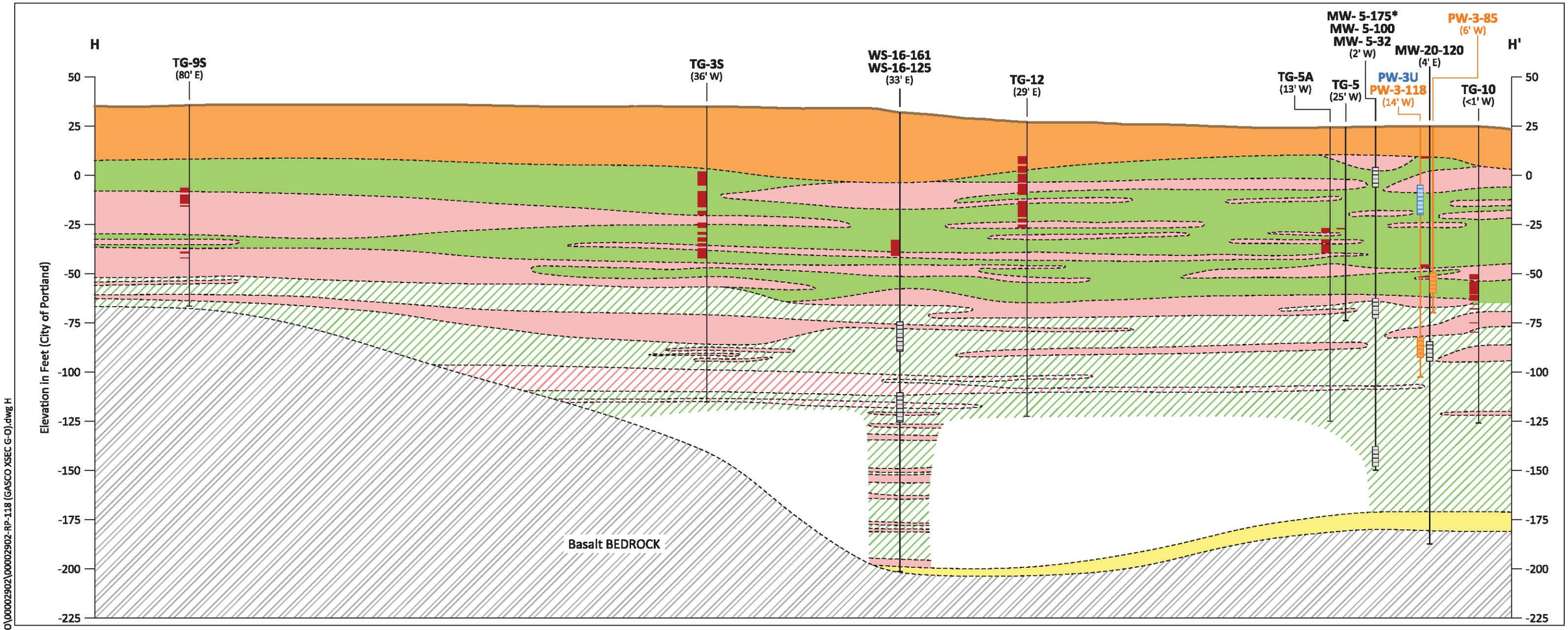
NOTE: Geologic contacts are inferred between borings.

K:\Jobs\000029-GASCO\00002902\00002902-RP-118 (GASCO XSEC G-O).dwg G

Apr 21, 2011 2:38pm heriksen

ANCHOR QEA

Figure 3-8
Geologic Cross Section G-G'
Draft Final Design Report
Gasco Groundwater Source Control



LEGEND:

- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily fine to medium grained SAND and SILTY-SAND interbedded with thin silt and sandy-silt layers
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK

Existing Ground Surface

TG-12 — Boring ID
(29' E) — Offset Distance in Feet

Existing Extraction Well
Proposed Extraction Well
Existing Well or Piezometer

— NAPL and/or Tar Interval

— Well Screen

0 50
Scale in Feet

NOTES:
Geologic contacts are inferred between borings.
* Lithology below 32 feet in depth at MW-5-175 not used for cross section interpretation.

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Apr 19, 2011 3:33pm heriksen

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Figure 3-9
Cross Section H-H'
Draft Final Design Report
Gasco Groundwater Source Control

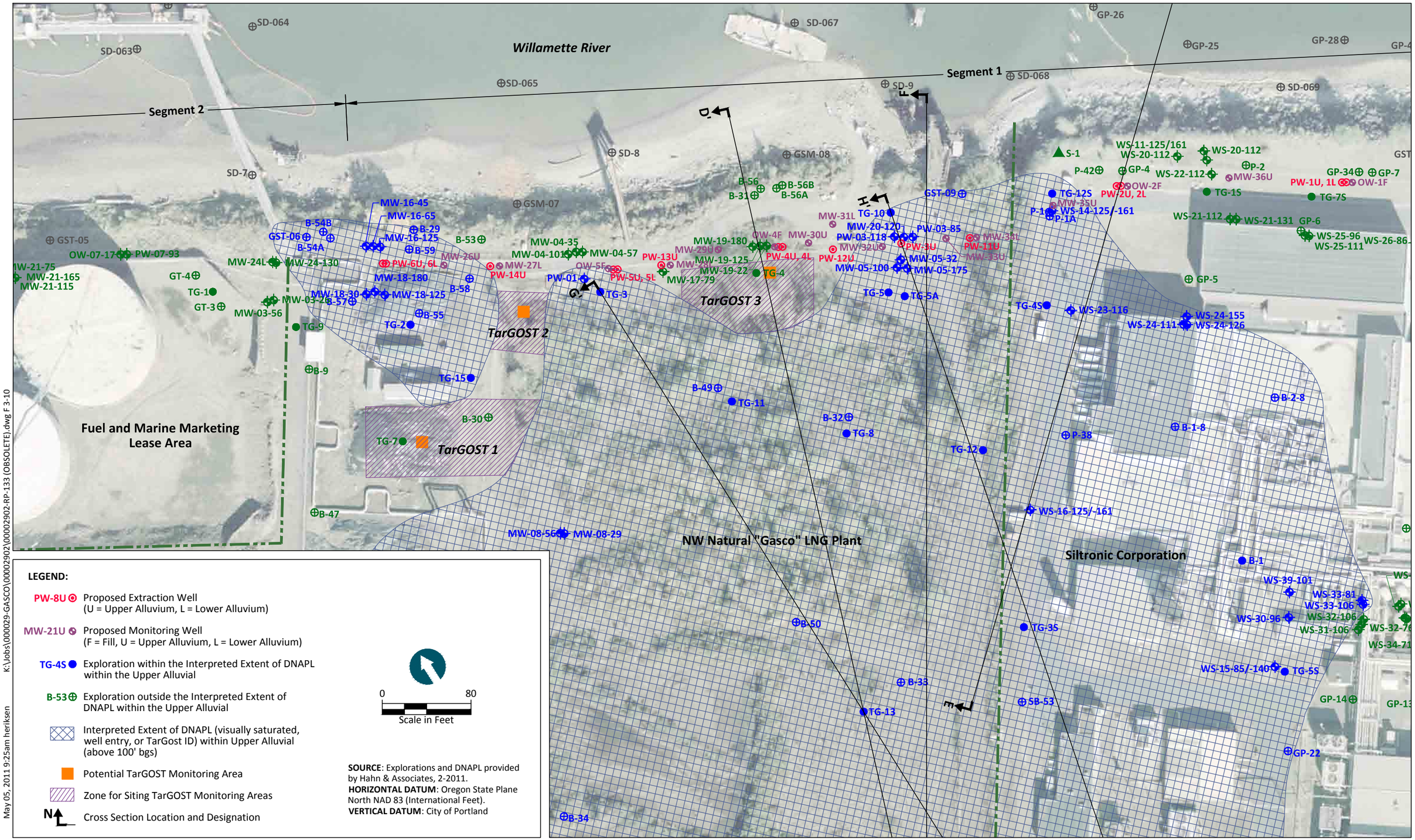

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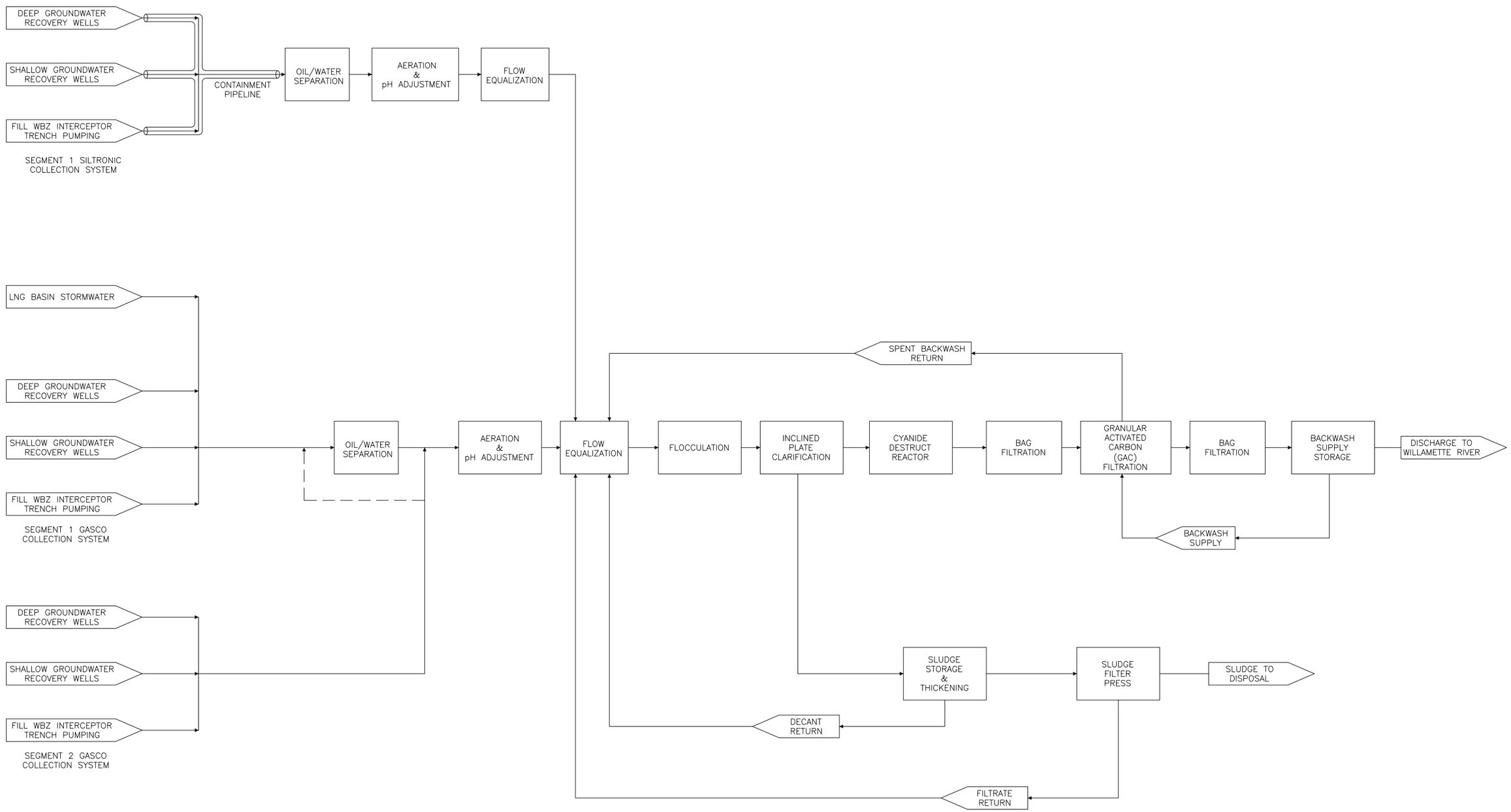
Figure 3-10
TarGOST Screening Locations
Draft Final Design Report
Gasco Groundwater Source Control



SOURCE: ADA, Inc.

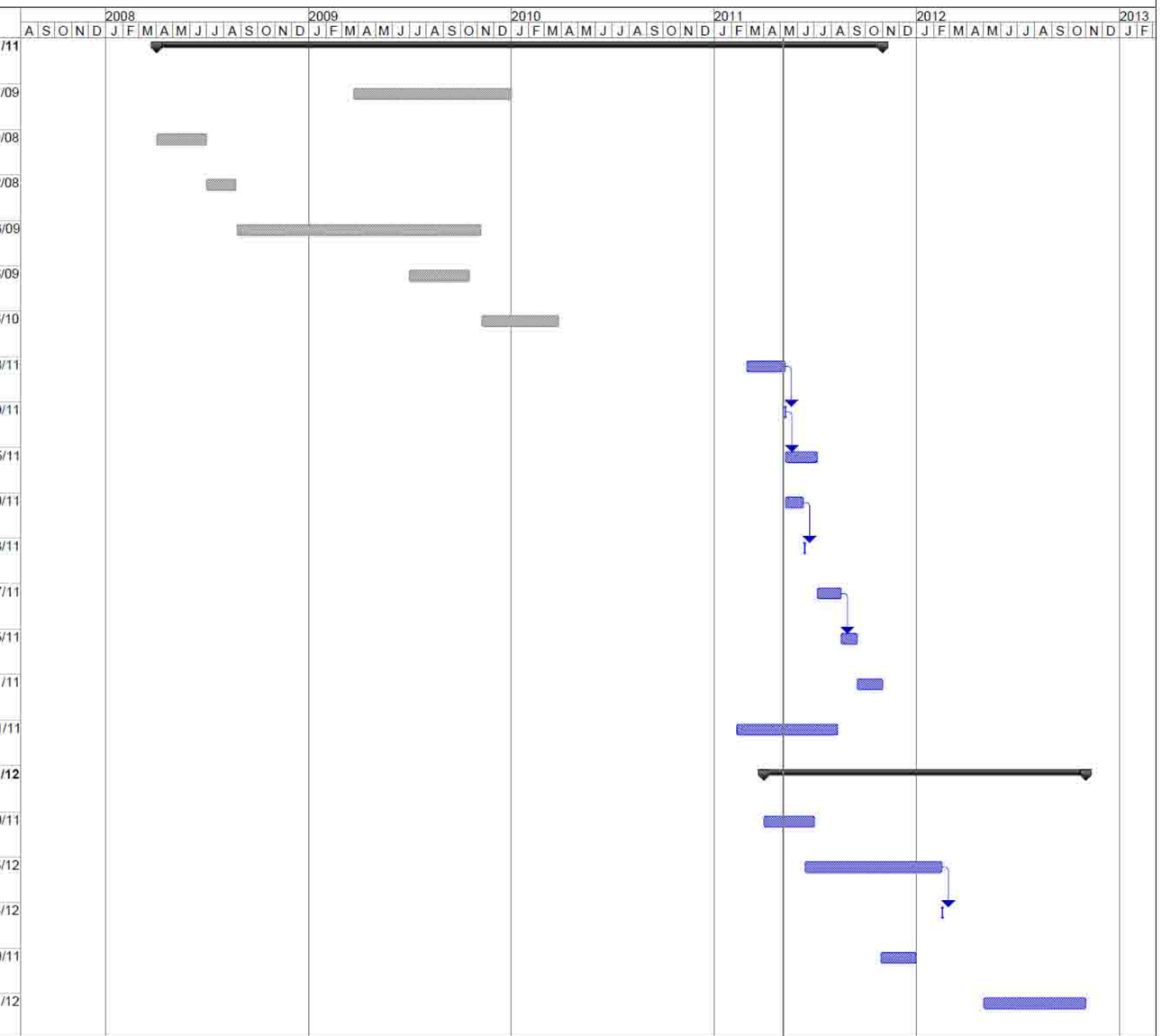
04/19/2011 heriksen K:\Jobs\000029-GASCO\00002902\CorelDRAW figs\IDR\00002902-RP-006.cdr

ANCHOR QEA

Figure 3-11
Groundwater Treatment System Process Flow Diagram
Draft Final Design Report
Gasco Groundwater Source Control

Gasco Source Control Planning Schedule

ID	Task Name	Duration	Start	Finish
1	**Groundwater/DNAPL Source Control Design**	**954 days?**	**Wed 4/2/08**	**Mon 10/31/11**
2	Conduct Design Level Studies	210 days	Mon 3/23/09	Thu 12/31/09
3	Prepare Preliminary Design	65 days?	Wed 4/2/08	Mon 6/30/08
4	DEQ/EPA Review Preliminary Design	39 days?	Tue 7/1/08	Fri 8/22/08
5	Prepare Interim Design	323 days	Mon 8/25/08	Fri 11/6/09
6	Treatment Pilot Test	80 days?	Wed 7/1/09	Fri 10/16/09
7	DEQ/EPA Review Interim Design	103 days	Mon 11/9/09	Fri 3/26/10
8	Prepare Draft Final Design Report	50 days?	Tue 3/1/11	Sun 5/8/11
9	Submit Draft Final Design to DEQ	1 day?	Mon 5/9/11	Mon 5/9/11
10	DEQ Review of Design Report	41 days?	Tue 5/10/11	Tue 7/5/11
11	DEQ Expedited Review of Treatment System Design	24 days?	Tue 5/10/11	Fri 6/10/11
12	DEQ Approve Treatment System Design	1 day?	Mon 6/13/11	Mon 6/13/11
13	Revise Final Design	31 days?	Wed 7/6/11	Wed 8/17/11
14	DEQ Review	21 days?	Thu 8/18/11	Thu 9/15/11
15	Public Notice and DEQ Staff Report	34 days?	Fri 9/16/11	Mon 10/31/11
16	NPDES Permit Process	131 days?	Fri 2/11/11	Thu 8/11/11
17	**Construction of Groundwater DNAPL Source Controls**	**418 days?**	**Fri 4/1/11**	**Wed 10/31/12**
18	Negotiate Contractor Contract	66 days	Fri 4/1/11	Thu 6/30/11
19	Order Treatment System Materials and Construct System	179 days?	Tue 6/14/11	Wed 2/15/12
20	Startup Treatment System	1 day?	Thu 2/16/12	Thu 2/16/12
21	Construct and Startup Extraction Well System	46 days?	Sat 10/29/11	Fri 12/30/11
22	DEQ Source Control Determination to EPA	133 days	Tue 5/1/12	Wed 10/31/12



Project: Gasco Source Control Planning Schedule
Date: Thu 5/5/11

Task	Rolled Up Progress	Inactive Task	Manual Summary Rollup	Deadline
Milestone	Split	Inactive Milestone	Manual Summary	
Summary	Completed Tasks	Inactive Summary	Start-only	
Rolled Up Task	Project Summary	Manual Task	Finish-only	
Rolled Up Milestone	Group By Summary	Duration-only	Progress	

ANCHOR QEA

Figure 5-1
Construction Schedule and Sequencing
Draft Final Design Report
Gasco Groundwater Source Control

APPENDIX A
DEQ COMMENTS ON INTERIM DESIGN REPORT

Oregon
Theodore 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

March 26, 2010

Also Sent Via E-mail

Mr. Robert J. Wyatt
NW Natural
220 N.W. Second Avenue
Portland, OR 97209

Re: Interim Design Report
Shoreline Segments 1 and 2, NW Natural Property and the Northern Portion of the Siltronic Corporation Property
Portland, Oregon
ECSI Nos. 84 and 183

Dear Mr. Wyatt:

The Department of Environmental Quality (DEQ) reviewed the "Interim Design Report – Groundwater Source Control, NW Natural Gasco Site" dated November 2009 and received November 10, 2009 (Interim Design Report). The Interim Design Report represents the first source control document to incorporate the findings and results of source control measures (SCMs) design support and feasibility studies. Anchor QEA, LLC (Anchor) prepared the Interim Design Report on behalf of NW Natural.

In addition to the Interim Design Report, DEQ reviewed the "NW Natural and Siltronic Groundwater Treatment Pilot Study Report" dated December 2009 and received January 21, 2010 (Pilot Study Report). The Pilot Study Report was prepared by Sevenson Environmental Services, Inc. for NW Natural. Comments to the Pilot Study Report are combined with the comments to Appendix C (Groundwater Treatment System Design) of the Interim Design Report for completeness.

The primary purpose of this letter is to inform NW Natural that DEQ:

- Accepts NW Natural's recommendation to evaluate the vertical barrier and dense non-aqueous phase liquid (DNAPL) removal SCMs in the uplands feasibility study (FS);
- Approves the locations, depths, and designs of the two northern-most extraction wells (i.e., PW-9 and PW-10);
- Provides conditional approval of the locations of four extraction wells (i.e., PW-1, PW-2, PW-7, and PW-8) subject to DEQ's review of additional information to be provided by NW Natural;
- Expects the need for an additional extraction well to be evaluated southeast (upstream) of the upstream-most extraction well (i.e., PW-1); and
- Does not approve extraction wells located along the vertical barrier alignment (i.e., PW-3 through PW-6) and will defer these installations to the uplands FS so hydraulic control and containment (HC&C) along this portion of Segment 1 can be evaluated in the context of DNAPL remedial action alternatives.

DEQ's comments in this letter regarding the vertical barrier and/or HC&C along the barrier alignment should be carried forward and addressed during the uplands FS.

BACKGROUND

DEQ determined the shoreline of property owned by NW Natural (NW Natural Property) and the northern portion of the property owned by Siltronic Corporation (Siltronic Property) are high priorities for source control. The portion of the shoreline identified as the highest priority for source control (Segment 1) extends from near the south side of the Fuel and Marine Marketing (FAMM) leasehold on the NW Natural Property, to upstream of the former "Gasco Facility" manufactured gas plant (MGP) effluent ponds on the Siltronic Property. Segment 1 coincides with the heaviest MGP-related impacts identified near the river, including DNAPLs, contaminated groundwater, and impacted riverbank soils. It also includes the portion of the Siltronic Property where releases of volatile organic compounds (VOCs) from Siltronic's former solvent underground storage tank system (Former UST System) have commingled with DNAPL and groundwater contamination resulting from the historic operations of the Gasco Facility.

The segment of NW Natural's shoreline extending north of Segment 1 to the downstream property line with US Moorings (Segment 2) is also considered a high priority for source control, primarily due to the presence and concentrations of MGP chemicals of interest (COI), particularly cyanide, in riverbank soils and groundwater. A third shoreline segment (Segment 3) extends from upstream of the former effluent ponds to the upstream Siltronic Property line. A source control evaluation of Segment 3 is ongoing.

SOURCE CONTROL MEASURES PLANNING AND DESIGN

NW Natural completed the Groundwater/DNAPL Focused Feasibility Study (FFS) for Segment 1 and Segment 2 in November 2007[1]. The Groundwater/DNAPL FFS presents the remedial action objectives (RAOs) for source control, which were jointly developed by NW Natural and DEQ including: 1) preventing DNAPL in the uplands from migrating to the Willamette River (RAO #1); and 2) hydraulic capture of upland groundwater discharging to the river. The Groundwater/DNAPL FFS also presents NW Natural's evaluation of source control measures (SCMs) alternatives and recommended SCMs to achieve RAOs. NW Natural's recommendation combines a HC&C system along shoreline segments 1 and 2 with a vertical barrier along the northern portion Segment 1 (i.e., the southern portion of the NW Natural Property). DEQ approved NW Natural's recommendation subject to conditions and comments detailed in a March 21, 2008 letter (March 21st Letter) which included, but are not limited to the following:

- Adding extraction wells above the bottom of the vertical barrier with the objective increasing horizontal and upward vertical gradients operating behind the barrier, and reducing the potential for DNAPL to migrate below and beyond the influence of deeper extraction wells.

[1] Anchor QEA, LLC, 2007, "Groundwater/DNAPL Source Control Focused Feasibility Study – NW Natural 'Gasco' Site," October 12 (amended November 9th), and report prepared for NW Natural.

- Constructing engineering controls in the fill water-bearing zone (WBZ) on the upland side of the barrier to prevent DNAPL and/or contaminated groundwater from moving over or around the vertical barrier.
- Including DNAPL removal as a SCM to the extent necessary to control and contain the potential movement of DNAPL from former effluent ponds on the NW Natural and Siltronic properties that could result from operation of the hydraulic control/containment system.

Subsequent to completion of the Groundwater/DNAPL FFS, NW Natural and DEQ participated in a series of meetings to work through the more substantive issues identified in the March 21st Letter and establish the SCMs planning and design process, including identifying and agreeing on "preliminary," "interim," and "final" design steps. Preliminary design steps included conducting studies to further assess the feasibility of constructing major elements of source control (e.g., vibration study in support of the vertical barrier; groundwater treatability study and treatment system pilot study to support evaluations of HC&C).

The Preliminary Design Report[2] prepared by NW Natural summarizes the status of SCMs planning and design based on the outcomes of the meetings. In addition, the document summarizes agreements reached by NW Natural and DEQ regarding SCMs design, the preliminary design for the principal source control elements, and those aspects of source control requiring further investigation so informed decisions could be made regarding sequencing SCMs implementation (e.g., DNAPL mobility evaluation). DEQ provided comments to the Preliminary Design Report in a letter dated August 22, 2008 (August 22nd Letter). DEQ's expectations regarding the content of the next SCMs planning document (the "Interim Design Report") are also communicated in the August 22nd Letter. The content of the Interim Design Report was further clarified by DEQ in a letter dated September 24, 2009 (September 24th Letter).

The Interim Design Report represents the first source control document to incorporate the findings and results of SCMs design support and feasibility studies. Based on the outcome of planning meetings and support studies, the Interim Design Report confirms the feasibility of NW Natural's SCMs alternatives recommendations made in the Groundwater/DNAPL FFS, and provides the interim design for a combination of SCMs, including a:

- Vertical barrier constructed of sheet piles extending from just north of the Siltronic property line to the south side of the FAMM leasehold; and
- HC&C system consisting of a series of ten extraction wells along shoreline segments 1 and 2, including a groundwater treatment system sized to treat up to 400 gallons per minute (gpm).

In addition, the Interim Design Report provides NW natural's recommendations for modifying SCMs implementation by:

- Constructing the HC&C system, including the groundwater treatment system as soon as practicable after finalizing the design and obtaining necessary permits; and
- Further evaluating the vertical barrier and DNAPL removal SCMs in the uplands FS.

[2] Anchor QEA, LLC, 2008, "Preliminary Design Report – Groundwater Source Control, NW Natural Gasco Site," June, a report prepared for NW Natural.

A copy of the Interim Design Report was provided to the U.S. Environmental Protection Agency (EPA) for review. DEQ comments regarding the Interim Design Report are provided below and incorporate EPA's comments.

GENERAL COMMENTS

Vertical Barrier and Uplands Feasibility Study. Several years ago DEQ prioritized source control over the upland RI/FS. The goal of source control was to identify high priority contaminant transport pathways to the river, and design and implement SCMs to control those pathways so in-water actions could proceed without the risk of recontamination. Completion of the site-wide RI/FS was to follow SCMs design. As such, source control planning and design was prioritized over the RI and Risk Assessment. NW Natural and DEQ have been working towards fully implementing source control. However, given the scale, magnitude of contamination, and complexity of the source control project, particularly with respect to DNAPL, timelines for designing and implementing SCMs have been extended and now reasonably overlap with the uplands FS and in-water sediment project. Given this information, DEQ concludes:

- Construction of the vertical barrier prior to initiating the uplands FS is not likely to occur; and
- Benefits associated with early implementation of the vertical barrier SCM would be much reduced.

DEQ further concludes completing the uplands RI/FS on a parallel track with the in-water sediment project will benefit uplands and in-water remediation overall and concurs with the reasons NW Natural lists in Section 3.3.1 of the Interim Design Report, including:

- The uplands FS could identify alternative technologies, or combinations of technologies, including DNAPL removal, soil removal, alternative configurations of vertical barriers, that would be more effective at achieving RAO #1 than the vertical barrier identified in the Interim Design Report;
- Evaluating the vertical barrier during the uplands FS will allow it to be considered in the context of a site-wide remedial action strategy; and
- Postponing the vertical barrier will facilitate development of more fully integrated upland and in-water sediment remedial actions.

Based on the information summarized above, DEQ approves NW Natural's proposal to defer evaluation of the vertical barrier and DNAPL removal SCMs to the uplands FS. Furthermore, NW Natural should postpone installation of extraction wells PW-3 through PW-6 to the uplands FS so HC&C along this portion of the shoreline can be evaluated in the context of DNAPL remedial action alternatives.

As discussed above, NW Natural and DEQ identified preventing migration of DNAPL from the uplands to the Willamette River to be an RAO for source control (RAO #1). Remedial alternatives to address source control RAOs, including RAO #1, were evaluated in the Groundwater/DNAPL FFS. Based on the work documented in the Groundwater/DNAPL FFS, NW Natural determined that of the SCM alternatives carried forward into detailed evaluation, the vertical barrier and HC&C combination scored highest overall. Notably the combination scored higher than HC&C alone in four of the five "Effectiveness" sub-categories, primarily because the vertical barrier physically blocks DNAPL

migrating towards the river. DEQ's March 21st Letter approved, subject to conditions and comments, NW Natural's recommendation for a SCMs alternative combining a vertical barrier along the northern portion Segment 1 (i.e., the southern portion of the NW Natural Property) with HC&C along shoreline segments 1 and 2.

NW Natural should be advised that source control RAO #1 will be an RAO in the uplands FS. DEQ's acceptance of NW Natural's recommendation to postpone final design and construction of the vertical barrier pending the outcome of the uplands FS is subject to the following conditions:

- A barrier must be carried forward into the detailed analysis of remedial action alternatives for RAO #1 in the uplands FS; and
- The vertical barrier carried forward into detailed analysis will be 625 feet long and constructed using sheet pile methods to a depth of -60 feet City of Portland datum (COP).

DEQ expects NW Natural to acknowledge these conditions in writing prior to moving forward with final design of the HC&C system discussed below. Construction feasibility and design support studies show pile driven vertical sheet pile barriers can be constructed to depths of up to 90 feet below ground surface (bgs). The studies not only show construction is feasible, but provide information to support design, including identifying barrier materials, construction methods and equipment, and approaches for monitoring field activities to reduce potential impacts to the adjoining Siltronic operation(s) during construction. Given DEQ's determination, NW Natural should carry any comments in this letter pertaining to the vertical barrier and/or HC&C along the barrier alignment forward into the FS.

Groundwater Modeling. NW Natural relies on groundwater modeling to develop conclusions regarding the influence of the HC&C system on the alluvial WBZ. The groundwater model was originally developed to assess groundwater flow beneath the site and support evaluations of SCMs alternatives in the Groundwater/DNAPL FFS, including HC&C and the groundwater treatment system. The model simplified subsurface conditions by simulating only the main elements of the site hydrogeology (i.e., fill unit, upper silt unit of the alluvium; and alluvial sands subdivided into an upper and lower based on hydraulic properties). Given the model encompasses an area much greater in size than the NW Natural and Siltronic properties, DEQ considered the model suitable for these purposes. The groundwater model was subsequently used at DEQ's request to assess the depth of the vertical barrier and the potential influence pumping extraction wells near the shoreline could have on DNAPL movement beneath the former effluent ponds.

Since the Groundwater/DNAPL FFS, NW Natural consistently indicates the HC&C system will capture groundwater over the full thickness of the alluvial WBZ across shoreline segments 1 and 2. Since completion of the focused feasibility study, interpretations of the alluvium stratigraphy have been refined. As shown in the geologic cross-sections presented in the Interim Design Report, the stratigraphy of the alluvial WBZ is predominantly fine and medium sand (upper alluvium) overlying medium sand (lower alluvium). A gravel unit occurs in the deepest portions of the alluvium in contact with Columbia River Basalt. Depending on location and depth, layers and lenses of fine-grained silt, sandy silt, and silty sand complicate the stratigraphy of the alluvium. In general, the proportion of fine-grained material is greatest in the upper alluvial sand where the greatest mass of contamination occurs. The amount of fine-grained material noticeably increases in the lower alluvium beneath the Siltronic

Property. The Interim Design Report presents for the first time NW Natural's interpretation of a silt unit in the lower alluvium between elevations of approximately -100 and -125 feet. The lower silt unit and packages of fine-grained layers beneath the northern portion of the Siltronic Property are interpreted by NW Natural to act as an aquitard in the lower alluvial WBZ that potentially restricts vertical migration of contaminated groundwater into deeper intervals of the alluvial WBZ.

Although the site stratigraphy has been refined with time, DEQ understands for the modeling NW Natural conducted for the Interim Design Report the only change made to the previous model is the addition of the lower silt unit. Based on this information, DEQ considers there to be much uncertainty associated with NW Natural's conclusions regarding the capability of the HC&C system to influence the full thickness of the alluvial WBZ within a reasonable timeframe. Uncertainties are primarily associated with the model's ability to account for the presence of fine-grained layers and lenses within, above, and below the screened intervals of many extraction wells. Many of these fine-grained layers project beyond the riverbank and out under the river. The potential for fine-grained material to influence and/or limit modeling predictions and/or the performance of the HC&C system is not discussed in the Interim Design Report. To address these uncertainties and reduce the influence of fine-grained layers on contaminated groundwater capture and contaminant mass removal, extraction wells should be located where the highest concentrations of MGP constituents and VOCs occur. The extraction wells affected by this comment are discussed further below under DEQ's "Hydraulic Control and Containment" comments.

NW Natural is currently in the process of conducting long-term variable rate pumping tests using three test extraction wells and multiple observation wells constructed in the fill WBZ and upper and lower alluvial WBZ. NW Natural indicates the primary purpose of the tests is to support planning of the in-water sediment project by assessing the influence pumping wells in the uplands has on groundwater levels beneath the river. As indicated on DEQ's letter dated January 10, 2010, NW Natural should use test data to assess the lateral and vertical influence of pumping test wells on the fill WBZ and alluvial WBZ. NW Natural's final data interpretations, conclusions, and analysis of the tests, including the results of any groundwater modeling, should be incorporated into the HC&C system final design document.

Hydraulic Control and Containment System. The Interim Design Report proposes implementing a HC&C system consisting of ten extraction wells located along shoreline Segment 1 and Segment 2. Based on review of the Interim Design Report and acceptance of NW Natural's recommendation to evaluate the vertical barrier in the uplands FS, DEQ has made the following determinations regarding the proposed HC&C system.

- The locations and depths of extraction wells PW-9 and PW-10 are approved.
- The locations and depths of extraction wells PW-1, PW-2, PW-7, and PW-8 are conditionally approved subject to NW Natural conducting additional evaluations per DEQ's comments below. The outcome of these evaluations should be presented in the final design document.
- An additional extraction well located upstream (i.e., southeast) of PW-1 may be warranted and should be evaluated in the final design document.
- Extraction wells PW-3 through PW-6 are not approved and should be further evaluated during the uplands FS in the context of DNAPL remedial action alternatives.

DEQ's rational for these determinations is provided below.

Extraction wells PW-1 PW-2, PW-7, and PW-8. There is insufficient information provided in the Interim Design Report to evaluate how the locations and depths of these four extraction wells correspond to dissolved phase MGP contamination (PW-7 and PW-8), and commingled MGP constituents and VOCs (PW-1 and PW-2). As discussed above, given the uncertainties of groundwater modeling the wells should be located within the highest concentration portions of groundwater plumes to maximize to the extent practicable, contaminant capture and mass removal. The only information provided in the Interim Design Report regarding contaminant distributions are shown for total and free cyanide (see figures 12a and 12b) which is inadequate for this purpose.

NW Natural should prepare figures for the final design document showing how the locations of these extraction wells relate to groundwater contamination as shown by data collected from uplands monitoring wells (not nearshore borings). The figures should show extraction wells with MGP and VOC COI along cross-section A-A'. The MGP and VOC COI shown in the figures should include, but not necessarily be limited to, benzene, naphthalene, total cyanide, and vinyl chloride, and the rational for selecting COI must be provided. In preparing the figures, NW Natural should use reconnaissance groundwater data as needed to fill data gaps. For example, the VOC Plume FFS[3] prepared by Siltronic provides cross-sectional views of VOCs, including trichloroethene, cis-1,2-dichloroethene, and vinyl chloride, that are useful for locating extraction wells PW-1 and PW-2 (see figures 1-3a, 1-3b, and 1-3c).

Additional Extraction Well. Figure 2-10 summarizes groundwater data for selected MGP COI collected from monitoring wells located in the upstream portion of shoreline Segment 2 and the length of Segment 1. Detected concentrations of total and free cyanide between approximately 0 and -80 feet in elevation exceed Joint Source Control Strategy[4] (JSCS) criteria upstream of the WS-8 and WS12 monitoring well clusters. This comment also applies to detected concentrations of VOCs. Furthermore, the capture zone for extraction well PW-1 shown by Figure 4-2 does not appear to extend far enough upstream to intercept groundwater contamination documented at the WS-8 and WS-12 monitoring clusters (i.e., groundwater in the alluvial WBZ contaminated by MGP and VOC COI could by-pass the HC&C system on the upstream side). Based on this information an additional extraction well may be warranted upstream of PW-1. The need for an additional extraction well should be fully evaluated in the final design document.

Extraction Wells PW-3 through PW-6. Extraction wells PW-3 through PW-6 are located along the most contaminated portion of shoreline Segment 1. Contamination includes MGP DNAPL, groundwater impacted by MGP constituents, and groundwater impacted by MGP constituents and VOCs. The four extraction wells proposed in the Interim Design Report are similar in number and depth as those NW Natural proposed in the Groundwater/DNAPL FFS. As indicated in the March 21st

[3] Maul Foster and Alongi, Inc., 2007, "Focused Feasibility Study - Siltronic Corporation, Portland, Oregon," October 23 (amended December 19, 2007), a report prepared for Siltronic Corporation.
[4] EPA and DEQ, 2005, "Portland Harbor Joint Source Control Strategy – Final," December (note Table 3-1 revised July 16, 2007), a guidance document prepared jointly by the US Environmental Protection Agency and Oregon Department of Environmental Quality.

Letter, DEQ concluded from drilling observations and TarGOST® work, extraction wells could potentially mobilize and spread DNAPL. DEQ also informed NW Natural that potential expansion of the distribution of DNAPL is a significant factor for SCMs planning and design. As such, DEQ did not approve NW Natural's recommendation in the focused feasibility study because:

- Extraction wells are placed below much of the DNAPL shown in cross-sections and pumping the wells will increase the potential for coalescence and downward vertical migration of DNAPL.
- Coalescence, pooling, and movement of DNAPL cannot be reliably predicted or monitored.

Since the Groundwater/DNAPL FFS was submitted, SCMs planning for this portion of Segment 1 has included a vertical barrier and "shallow" and "intermediate" depth extraction wells. The barrier and extraction wells were intended to operate in combination to physically block DNAPL migrating towards the river (vertical barrier); increase horizontal and upward vertical gradients operating behind the barrier ("shallow" depth extraction wells); and control and contain groundwater in the alluvial WBZ beneath the barrier ("intermediate" depth extraction wells). The Interim Design Report recommends deferring evaluation of the vertical barrier to the uplands FFS and removes shallow extraction wells from the proposed design.

Based on the information provided in the Interim Design Report, and consistent with determinations made previously, DEQ does not approve: 1) drilling and installation of extraction wells PW-4, PW-5, and PW-6; or 2) operation of PW-3-81 and PW-3-118. DEQ considers it likely HC&C will be carried forward into detailed analysis of remedial action alternatives in the uplands FS. For the most impacted portion of Segment 1, the uplands FS should evaluate the locations, depths, timing of construction, and operation of extraction wells with DNAPL remedial action alternatives.

SPECIFIC COMMENTS

Section 1.1. NW Natural indicates DEQ has not commented on two documents relevant to the Interim Design Report, including the Gradient Evaluation Report[5] and the DNAPL Mobilization Evaluation[6]. The two documents use groundwater modeling to:

- Assess changes in the horizontal and vertical hydraulic gradients in the alluvial WBZ associated with a variety of shoreline SCMs scenarios under reasonable worst-case combinations of groundwater flow and river channel configuration; and
- Perform preliminary assessments of DNAPL mobility and movement, including assessing the potential for the HC&C system to mobilize DNAPL beneath the former upland effluent ponds.

The content of the two documents was developed by NW Natural and DEQ during a series of meetings convened to work through the more substantive issues identified in DEQ's March 21st Letter. In addition, the documents respond to DEQ's August 22nd Letter.

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[5] Anchor QEA, LLC, 2008, "Groundwater Flow Model and DNAPL Evaluation Supplemental Report," October (supplemented with supporting figures on March 26, 2009), a report prepared for NW Natural.

[6] Anchor QEA, LLC, 20009, "Evaluation of Potential DNAPL Mobilization in Former Effluent Pond Area by Shoreline Source Control Extraction Wells, Gasco Site, Portland, Oregon," March 18, a technical memorandum prepared for NW Natural.

As indicated in the August 22nd Letter, DEQ expected the Gradient Evaluation Report to be performed, "...with the specific objective of assessing the depth of the vertical barrier proposed in the Preliminary Design Report (i.e., between -50 and -60 feet mean sea level [msl])." The DNAPL Mobilization Evaluation responded to DEQ's March 21st Letter and August 22nd Letter by supplying DEQ with a basis for considering NW Natural's proposal to implement uplands DNAPL removal after construction of the vertical barrier and HC&C SCM combination.

Although detailed review comments were not provided, via a June 5, 2009 letter DEQ informed NW Natural the two documents provide a technical basis for: 1) carrying -60 feet msl forward into the Interim Design Report as the design elevation for the bottom of the vertical barrier; and 2) moving forward with developing plans and schedules to implement uplands DNAPL removal after construction of the vertical barrier and HC&C SCMs.

Section 1.2. Although not mentioned here, the March 21st Letter points out the RAOs identified in the Groundwater/DNAPL FFS for Segment 1 did not address the fill WBZ. Certain conditions and general comments in the March 21st Letter informed NW Natural that:

- Controlling and containing groundwater in the fill WBZ should be included in planning and design of the vertical barrier (i.e., engineering controls on the upland side of the barrier to prevent DNAPL and/or contaminated groundwater from moving over or around the barrier); and
- Absent information, data, and/or analysis indicating the alluvial WBZ extraction wells will control/contain groundwater in the fill WBZ, DEQ expected evaluations of riverbank remedial alternatives to include this as an RAO.

The Interim Design Report does not include an approach for controlling and containing groundwater in the fill WBZ behind the vertical barrier. Without information regarding how groundwater in the fill WBZ will be addressed during design and construction of the vertical barrier, DEQ considers the interim design of the vertical barrier to be incomplete. For clarification, controlling groundwater flux in the fill WBZ must be achieved by NW Natural whether the barrier is constructed or not. Furthermore, NW Natural has not provided information, data, and/or analysis regarding the second item.

NW Natural is currently conducting an evaluation of the influence of pumping uplands test wells on groundwater levels beneath the river in Segment 2. These tests will provide information to preliminarily assess the capability of extraction wells in the alluvial WBZ to influence shallow groundwater in the fill WBZ. DEQ expects this information to be fully incorporated into the final SCMs design document.

Section 1.3. NW Natural uses the term "riverbank stabilization" throughout this section of the Interim Design Report. The term pre-supposes one type of riverbank remedial alternative and should be revised to reference "riverbank cleanup." NW Natural will also need to develop an approach for evaluating the effectiveness of the upland remedy against performance standards for COI. Groundwater in the fill WBZ represents a complete high priority contaminant transport pathway from the uplands into the in-water sediment project area. As such, measuring groundwater flux should also be included as a performance monitoring criterion for the remedy. For clarification, mitigating

groundwater flux to the river via the fill WBZ is an uplands source control RAO and is subject to DEQ oversight.

Section 1.4. Regarding the schedule NW Natural references here, as indicated in the March 21st Letter, DEQ prioritized source control over the upland RI/FS several years ago. The source control strategy involved implementation of source control as a removal action to cut-off DNAPL migration to the river and MGP and VOC contamination being transported from the uplands to the river via groundwater. The goal for implementing SCMs was to address high priority contaminant transport pathways to the river and allow in-water actions to proceed without the immediate risk of recontamination from an uncontrolled upland source. The second phase of the source control strategy, a site-wide RI/FS resulting in a comprehensive final remedy would follow SCMs implementation. The SCMs planning and design process is ongoing.

DEQ disagrees with two assertions made by NW Natural in the fourth paragraph of this section. NW Natural indicates that, "...upland DNAPL is not currently discharging to river sediment via subsurface pathways," and that, "...the distribution of upland DNAPL will not be significantly impacted by operation of the source control wells..." DEQ addresses these assertions in our comments to Section 2.1.3 (second paragraph), Section 4.2.1.4, and in the General Comments.

Section 2.1.1. For clarification, although work documented in the Offshore Investigation Report[7] was done under DEQ oversight, DEQ was primarily interested in investigations designed to assess potential ongoing uplands contaminant transport pathways (e.g., direct discharge, groundwater) as sources of contamination to the river. This data was incorporated into the Groundwater/DNAPL FFS and the SCMs planning and design process that followed. A significant amount of the work performed during the offshore investigation was intended to support the Portland Harbor in-water RI/FS being performed by the Lower Willamette Group under EPA's oversight. Furthermore, off-shore investigatory work supplied surface water, sediment, transition zone water, and shallow groundwater data to assist planning of the in-water sediment project also being overseen by EPA.

This section of the Interim Design Report references numerous geologic cross-sections. DEQ requests an additional cross-section be developed for the final design document which depicts the area of deeper DNAPL occurrence between borings TG-10 to B-4B shown on Figure 2-3b. This additional cross-section would be drawn between existing cross-sections D and E.

Section 2.1.1, 5th and 6th paragraphs. The Interim Design Report indicates, "The basalt is a no-flow boundary in the MODFLOW model that has been developed by SS Papadoulos (SSPA) for the site." This assertion is in error. The revised groundwater model report[8] indicates, "As described on page 22 of the model summary report, the basalt is not a no-flow boundary. The basalt contributes flow to the model through the upgradient specified head boundary." In addition, observations made during decommissioning of cathodic protection boreholes provide site-specific evidence the basalt recharges

[7] Anchor QEA, LLC, 2008, "Offshore Investigation Report - NW Natural 'Gasco' Site," February, a report prepared for NW Natural.
[8] Anchor QEA, LLC, 2008, "NW Natural Groundwater Model," April 25, a document prepared for NW Natural.

the alluvial WBZ. During decommissioning, water-bearing zones were observed in the basalt at approximately 80 feet bgs, and by downhole video surveys between 106 and 145 feet bgs. These zones occur at depth intervals that project horizontally into the alluvial WBZ. Based on the results of modeling and seepage meter data, groundwater flux through the alluvial WBZ into the river was estimated to be approximately 250 gpm.

Section 2.1.1, 6th paragraph. The Interim Design Report indicates, "Groundwater in the Fill WBZ recharges the underlying alluvium and discharges to the river." DEQ concurs with NW Natural's conclusions that where the upper silt unit is thin, absent, or penetrated by secondary porosity (e.g., root and/or rootlet voids) groundwater in the fill WBZ would tend to migrate vertically downward. Based on data collected on the NW Natural and Siltronic properties, vertical migration through the silt unit by DNAPL and contaminated groundwater has been observed and documented. Although vertical groundwater migration through the silt has been documented, based on available information, including from dewatering the LNG tank basin, DEQ interprets overall groundwater flux through the fill WBZ to be laterally directed towards the river. The magnitude and timing of groundwater flux through the fill WBZ represents an information need for uplands SCMs planning and design. When the results of the evaluation NW Natural is conducting to assess the influence of pumping test wells on groundwater levels under the river are available, SCMs alternatives for the fill WBZ will need to be identified in the final design document and further evaluated in the uplands FS.

Section 2.1.2. DEQ notes the silt unit directly underlying the surficial fill is not mentioned in this section of the report. The silt unit comprises the upper-most material of the alluvium. Not mentioning the upper silt unit appears to be an oversight as NW Natural and DEQ acknowledge it influences the nature and extent of contamination in the surficial fill, including the distribution of DNAPL. From a hydrogeologic standpoint the upper silt unit is considered the boundary between the fill WBZ and the alluvial WBZ. The configuration of the top of the upper silt unit, as well as its thickness and hydraulic properties influence the horizontal movement of MGP DNAPL and shallow groundwater in the fill WBZ, and the vertical migration of DNAPL and groundwater from the surficial fill WBZ into the alluvial WBZ. A description of the geology and hydrogeology of the upper silt unit should be included in the final design document for completeness.

Section 2.1.2.1. NW Natural's interpretation of the presence of a hydrogeologically significant silt unit is presented in this section of the Interim Design Report. DEQ understands NW Natural relied on observations made during drilling of the shoreline monitoring wells and TarGOST® logs in interpreting the depth, thickness, and lateral extent of the silt unit. DEQ provides preliminary concurrence with NW Natural's interpretations regarding "lower" silt unit based on drilling observations. However, DEQ is not aware of work done by NW Natural to correlate TarGOST® logging data to the subsurface geology of the site. This information should be provided as a supplement to Appendix H to document NW Natural's basis for interpreting silt unit occurrence and for completeness.

Section 2.1.3, 1st paragraph. This section of the Interim Design Report provides NW Natural's summary of offshore groundwater conditions. NW Natural indicates that because of low river levels, groundwater seepage data collected during late summer and fall are expected to be representative of seasonal maximums. NW Natural envisions the HC&C system operating over a long period of time.

As such, the system will need to accommodate a dynamic system influenced by seasonal changes in natural recharge, river stages and tidal influence. It is recommended NW Natural run the MODFLOW model in a transient state to verify the model's ability to simulate changing groundwater flux and hydraulic head conditions resulting from these influences. One method NW Natural should consider and which utilizes currently available tidal lag time data is to run and calibrate transient simulated head conditions (as needed) to observed heads changing over time due to actual tidal and river stage influences.

Regardless of seasonal variations in groundwater flux or the potential for additional sources of water to be added to the treatment process (e.g., fill WBZ, LNG tank basin), groundwater source control planning accommodated uncertainties through designing the treatment system for 400 gpm. NW Natural should confirm DEQ's understanding or provide clarifying information.

Section 2.1.3, 2nd paragraph. NW Natural summarizes their conclusions regarding the distribution and source of DNAPL observed during offshore investigations in this paragraph, asserting, "...DNAPL has not migrated from the upland alluvium into river sediments." NW Natural further indicates DNAPL in sediments, "...is sourced from direct discharge of MGP residuals from upland waste management areas into the river, not from DNAPL migration from the upland Alluvium WBZ." DEQ disagrees with NW Natural's conclusions about the distribution of MGP DNAPL in river sediment. As shown by figures 2-12a and 2-12b, the borings on which NW Natural bases its assertions are approximately 200 feet apart. In other words, there are too few borings spaced too widely apart to support NW Natural's assertions made in this section, Section 3.1, and Section 3.3.1. Furthermore, based on DEQ's review of the Offshore Investigation Report, evidence of MGP DNAPL having migrated from uplands source areas out under the river exists at one of the nearshore drilling locations. Field measurements made during drilling of Boring GS-09 detected DNAPL approximately 10 feet deeper than the bottom of MGP material reasonably interpreted as resulting from direct discharge/placement (i.e., approximately 10 feet deeper than –17 feet COP). Figures 2-12a and 2-12b of the Interim Design Report show the deeper occurrence of DNAPL measured at GS-09.

Section 2.2. DEQ notes the Army Corps of Engineers U.S. Moorings facility adjoins the NW Natural Property to the north.

Section 3.1, 2nd paragraph. NW Natural indicates DEQ's September 24th Letter required a vertical barrier be designed to block DNAPL migrating to the river. As discussed in the General Comments, inclusion of the vertical barrier as a SCM is an outcome of the Groundwater/DNAPL FFS completed by NW Natural. For clarification, the September 24th Letter directed NW Natural to complete the Interim Design Report that DEQ understood was going to provide the interim design for a combination of SCMs, including a:

- Vertical barrier constructed using either sheet-pile or slurry wall methods with dimensions of approximately 625 feet long by 90 feet deep, extending from just north of the Siltronic property line to the south side of the FAMM leasehold.
- Hydraulic control and containment system consisting of a series of "intermediate" depth extraction wells evenly spaced along segments 1 and 2, and "shallow" extraction wells located behind the vertical barrier.

- Water treatment system sized to treat 400 gpm.

The Interim Design Report was also to include a sequencing plan to integrate SCMs implementation, a performance monitoring program to assess the effectiveness of SCMs through monitoring groundwater levels and chemistry along segments 1 and 2, and a general approach and timeframe for implementing upland DNAPL removal in the area of the former effluent ponds.

Based on DEQ's review, the Interim Design Report is incomplete as engineering controls for the fill WBZ and shallow extraction wells located behind the vertical barrier are not included in the document. For clarification, DEQ is accepting the Interim Design Report due to our: 1) approval of NW Natural's proposal to defer the vertical barrier to the uplands FS, and 2) determination that HC&C behind the barrier should also be deferred to the FS and evaluated in the context of DNAPL remedial action alternatives. The status of evaluating source control of the fill WBZ and the information needed for source control planning are discussed in DEQ's General Comments and comments to sections 1.2, 1.3, and 2.1.1.

Section 3.1, 4th paragraph. DEQ's comments to the second paragraph of Section 2.1.3 apply here.

Section 3.2.1. According to NW Natural, the TarGOST® detector, "...is reliable for the detection of the presence of tar and oil, but cannot differentiate between tar and oil or determine if the material is mobile." In the next paragraph figures depicting the interpreted occurrence of "DNAPL (tar and oil)" in the fill and alluvium to depths greater than 100 feet bgs are referenced. Previously in Section 3.1, NW Natural indicates MGP tar does not migrate. Taken together it appears NW Natural is suggesting mixtures of immobile tar and mobile oil occur in the alluvium.

For clarification, DNAPL detected in the alluvium (i.e., below the top of the upper silt unit) must be mobile. According to information provided by NW Natural in a variety of documents, MGP waste management areas on the NW Natural and Siltronic properties occur entirely within the fill (i.e., above the top of the upper silt unit whether modified by historic site operations or not). For MGP DNAPL to be detected in the alluvium by the TarGOST® logging equipment, the material must have migrated to the location.

Section 3.2.2. DEQ's comments to sections 4.2.1.3 and 4.2.1.4 apply here.

Section 3.3.1. DEQ's General Comment regarding the vertical barrier and the uplands FS applies here.

Section 3.3.2. DEQ has numerous comments regarding this section of the Interim Design Report.

- NW Natural indicates in sections 3.2 and 3.3 that the location and depth of the vertical barrier were planned to block DNAPL migrating to the river navigation channel. The river channel occurs at an approximate elevation of -40 COP. As DEQ determined previously, a vertical barrier constructed to -40 feet COP is inadequate because this depth does not consider potential deepening of the channel during the in-water sediment project and/or navigation channel dredging (i.e, there are no safety factors incorporated into the -40 feet design depth). In addition, Figure 2-3b shows much of the DNAPL in the southern section of barrier occurs between elevations of -40 and -60 feet.

Furthermore, DEQ continues to consider ongoing migration of DNAPL from the uplands to areas beneath the river to be an unacceptable condition. Even absent direct discharge into the river, depending on the lateral and vertical depth of occurrence DNAPL represents an ongoing source of dissolved-phase recontamination to the river channel.

- NW Natural indicates in the second paragraph TarGOST® investigations did not result in changes to the depth or lateral extent of DNAPL such that modifications were made to the barrier locations shown in the Groundwater/DNAPL FFS and Preliminary Design Report. DEQ notes the bottom of the vertical barrier proposed in Groundwater/DNAPL FFS was -40 feet COP, while the Preliminary Design Report envisioned a barrier constructed to elevations between -50 and -60 feet COP.
- It appears the top of steel sheets are at elevation +20 feet, or approximately 5 to 15 feet bgs. NW Natural indicates the bottom of the clearing trench will be excavated to 20 feet bgs and backfilled prior to driving sheets. As such, it is not clear how the top of the sheet will be driven through the backfill to depth.
- DEQ considers the absence of groundwater controls on the fill WBZ to be a design deficiency which must be addressed if the vertical barrier is selected as a component of the final remedy for the uplands.

NW Natural should be advised that should the vertical barrier(s) be selected as a component of the final remedy, additional more detailed modeling work will be needed to support final design. For example, more detailed modeling could include reducing the grid spacing in the vicinity of the barrier and using the horizontal flow barrier package available in MODFLOW to develop more realistic representations of the vertical barrier in the simulations.

Section 3.3.3. Given consideration of subsurface conditions and the potential effects on the operating Siltronic facility, work completed by NW Natural and Siltronic confirms the feasibility of constructing the vertical barrier using sheet pile methodology. Based on this work, DEQ concurs with NW Natural's recommendation to construct the vertical barrier using sheet pile construction methods. DEQ defers to the NW Natural team's expertise in selecting steel sheets for the vertical barrier.

Section 3.3.3.1. DEQ concurs with NW Natural that no "substantial unresolved constructability issues" remain with regard to constructing the vertical barrier. Although DEQ identifies lack of provisions for controlling groundwater in the fill WBZ as a design deficiency, it is not considered a substantial issue. As discussed in our comments to Section 1.2, controlling groundwater flux in the fill must be achieved by NW Natural whether the barrier is constructed or not.

Section 3.3.3.2. Prior to initiating vertical barrier construction, DEQ will expect a work plan to be prepared detailing NW Natural's approach to temporarily by-passing and replacing the WR-107 outfall.

Section 3.3.3.3. As part of vertical barrier planning and design, DEQ required NW Natural to assess methods to minimize the potential for DNAPL to migrate vertically downward during construction. DEQ understands this design detail will be worked out further if a sheet pile barrier(s) is selected as a component of the final upland remedy.

Section 3.3.4. Contingencies should be discussed if the 4-foot bucket cannot remove debris encountered during pre-trenching (e.g., alternate equipment, trench re-alignment, etc.).

Section 3.3.6. NW Natural should provide additional information to clarify how joint sealing "prior to subsequent driving of a sheet pile pair" will be done. It is unclear how joint sealant remains in place while a new sheet is driven between an in-ground pair. It is also not clear how and to what extent joint sealant is forced into the joint void when the temporary sheet is removed.

Section 4.1.1. DEQ's comment to Section 1.2 regarding the fill WBZ zone applies here.

Section 4.1.2. DEQ's comments to Appendix C and the Pilot Study Report apply here.

Section 4.1.3. DEQ understands from reviewing this section of the Interim Design Report that:

- Maintenance of an individual extraction well, including replacing a pump, is expected to be completed within 24 hours.
- Power loss could reasonably shut-down the HC&C and groundwater treatment systems for up to 12 hours based on historic records from Portland General Electric.

Based on discussions with NW Natural during meetings, DEQ understood power losses up to between 24 to 36 hours could occur. NW Natural should check information provided in this section and explain the shorter timeframe, or confirm DEQ's understanding of the topic. In addition, given the uncertainty regarding the maintenance of extraction wells (see Section 4.2.2.3), NW Natural should evaluate a shut-down scenario involving extraction well replacement.

Besides extraction well shut-downs, the groundwater treatment system will be shut down for maintenance and in response to periodic high level/pressure shut-downs. NW Natural should provide additional information regarding the length of time associated with treatment system shut-downs (see also DEQ's comments to Appendix C).

NW Natural's approach to evaluating potential water quality impacts is also provided in this section of the report. The evaluation of the period of time the system could be shutdown before an unacceptable water quality impact in the river occurs appears to be more appropriate for planning an in-water capping project. As such, the approach pre-supposes implementation of in-water remedial action alternatives. Furthermore, the input parameters, model documentation, and results were not provided to DEQ for discussion or review prior to the Interim Design Report being submitted, and are not included in the document. For clarification, DEQ envisioned a simpler scenario being assessed. NW Natural should revise the response to estimate the time needed for contaminated groundwater to: 1) escape capture and bypass the HC&C system; and 2) migrate to the river in the event shut-down occurs. The estimated timeframes should then be compared to the shutdown times associated with power outages.

Section 4.2.1.1. DEQ's comment to Section 2.1.1 applies here. In the last paragraph, NW Natural indicates free cyanide was not detected in any surface water samples collected during the offshore investigation. It should be noted total cyanide was detected in three samples at concentrations ranging from 10 micrograms per liter (ug/L, or parts per billion) to 140 ug/L in surface water.

Section 4.2.1.3. DEQ acknowledges the Gradient Evaluation Report simulated reasonable worst-case scenarios for assessing groundwater flow rates to the river and sizing the groundwater treatment system. In general, NW Natural's interpretations regarding the results of groundwater modeling conducted near the shoreline focus on the effects extraction wells have on hydraulic gradients at or below the base of the vertical barrier, including interpretations #3, #4, and #6 listed in this section. However, information presented in the Interim Design Document continues to support DEQ's conclusion that locating extraction wells at or below the bottom of the vertical barrier increases vertical downward gradients behind the barrier and the potential for DNAPL to mobilize.

Figures 3-3a through 3-3c show model output for an extraction well screened between elevation -40 and -60 feet with the HC&C system pumping at a total discharge rate of 250 gpm, under three vertical barrier scenarios, including: 1) a barrier constructed to -40 feet (Figure 3-3a), 2) a barrier constructed to -60 feet (Figure 3-3b), and 3) no barrier (Figure 3-3c). Compared to ambient conditions (see Appendix I, Figure A-9), downward vertical gradients 15 to 20 feet above the top of the screen (elevation -20 to 25 feet) increase by factors between approximately 20 (no barrier) and 30 times (barrier constructed to elevation -60 feet). DEQ also notes that gaps in fine-grained material shown in cross-section (see Figure 2-3b) provide avenues for DNAPL to move downward in the alluvium. Furthermore, downward migration is further facilitated by the intermediate or neutral wettability of DNAPL occurring near the shoreline (i.e., capillary forces resisting movement are less).

Although pumping extraction wells cause hydraulic gradients to reverse from the river back towards the uplands, the information summarized above supports DEQ's conclusion that NW Natural's recommended approach to HC&C along the most impacted portion of Segment 1 has a high potential for inducing downward vertical migration of DNAPL.

Documentation for the groundwater model including general calibration, verification, and sensitivity, as well as specific recalibration of the model (referenced in the Interim Design Report) and the incorporation of the lower aquitard (presented for the first time in the Interim Design Report) is insufficient. For the final design document, NW Natural should provide more detailed documentation regarding numerical modeling, including its update and refinement for the Interim Design Report, as follows:

- A table describing hydrostratigraphic layers represented in the model and their dimensions compared to the characterization shown in cross-section using well log information.
- A water budget summary for the hydrostratigraphic layers represented in the model.
- Hydraulic properties assigned to the model layers including, but not limited to, calibrated vertical and horizontal hydraulic conductivities (Kv/Kh), specific storativity, and specific yield.
- Details on the numerical model boundaries.
- Additional calibration information demonstrating confidence in the model representing measured heads under various conditions. The available information[9] is insufficient to allow for a spatial evaluation, and modeled versus measured heads appear to be off calibration by up to four feet, or

[9] See Figure 4-5 NW Natural Gasco, Pump Test Analysis and MODFLOW Model Summary – October 2007

approximately 25% of the total average gradient across the site. Calibration plots should include a spatial plot of the head difference between modeled and measured values across the site to focus refinements to the hydraulic properties and model grid where needed. Additionally, time-series plots of seasonal water level data should be compared with transient modeled water levels trends to verify the model under measured seasonal variation.

- A sensitivity analysis to potential future land use changes (e.g. ditch/trench lining, removal, site paving) that could change the current recharge, gradient/flow conditions assumed by the numerical groundwater flow model.

NW Natural should be advised the existing model may have to be further modified to fully evaluate the performance and effectiveness of HC&C (e.g., vertical extent and timeframe of capture where fine-grained layers/lenses are present). Modifications may include but not be limited to, decreasing the grid spacing within selected portions of the model. Alternatively, project needs may indicate development of more detailed purpose specific models is warranted.

Section 4.2.1.4. NW Natural indicates that with regard to the modeling work done to assess the potential influence of pumping extraction wells on DNAPL movement that, "From this analysis, enhanced groundwater movement in the former effluent pond area due to shoreline extraction wells is minimal and would not substantially change DNAPL distribution over time." For clarification, DEQ understands the modeling work focused on assessing the additional component of DNAPL movement induced by extraction wells. Site investigations completed to date show that under unstressed conditions DNAPL in the alluvial WBZ has migrated laterally away from the former effluent ponds towards the river and vertically downward.

Based on information provided in the RI Report, the effluent ponds were used between 1941 and 1955. Using the midpoints of DNAPL occurrence shown in borings TG-8, B-4B, and GS-09; the distances between TG-8 and B-4B and TG-8 and GS-09; and the range of time bracketing pond use and submittal of the DNAPL mobility evaluation (i.e., 53 to 67 years); DEQ estimates horizontal and vertical DNAPL migration rates under non-pumping conditions range between 3.3 and 5.4 feet/year and 0.3 and 0.8 feet/year, respectively. Based on this information and literature[10] which indicates coal tar DNAPL can migrate for over 100 years before attaining a stable subsurface configuration, DEQ concludes DNAPL migration is ongoing. As such, the uplands FS should evaluate remedial action alternatives that mitigate DNAPL migration, including, but not necessarily limited to source reduction, removal, and stabilization.

Section 4.2.2.1.1. DEQ has a number of comments regarding this section of the Interim Design Report.

- For clarification, based on numerical simulations the final horizontal hydraulic conductivity of the upper and lower alluvial WBZs used for the MODFLOW model were 15 and 300 feet/day respectively.
- The vertical placements of extraction well screens are discussed in terms of their positions relative to the upper and lower alluvial WBZs. An additional significant factor for locating screened

[10] Gerhard, J.I.; Pang, T.; Kueper, B.H., 2007, "Time Scales of DNAPL Migration in Sandy Aquifers Examined via Numerical Simulation," Groundwater Vol. 45, No. 2, March–April 2007, pages 147–157.

intervals is the occurrence of DNAPL and dissolved phase contamination, neither of which is discussed here. NW Natural should provide additional information regarding the locations of the proposed extraction wells, screen depths, and the distribution of DNAPL and MGP and VOC contamination.

- NW Natural indicates extraction well PW-1 through PW-7 are planned to be screened in the upper alluvial WBZ. Within this group, the two PW-3 extraction wells are already constructed in the upper (PW-3-85) and lower (PW-3-118) alluvial WBZs. The vertical placement of PW-3-118 is inconsistent with NW Natural's location criteria described in this report section. The purpose and NW Natural's plans for operating PW-3-118 should be further explained.
- The vertical placement of the screen for extraction well PW-2 (elevation -25 to -45 feet) does not appear to coincide with the highest concentrations of total cyanide shown in Figure 2-12b. The location and vertical placements of the screens for extractions wells PW-1 and PW-2 should be compared to the distribution of MGP and VOC COI and adjusted as needed to intercept the highest concentrations of contaminants.
- Spacing of extraction wells decreases from approximately 200 feet to about 140 feet between PW-3-85/118, PW-4, and PW-5 behind the vertical barrier. The rational for tightening the spacing should be provided.

Section 4.2.2.4.1. This section outlines a proposed monitoring program to verify the performance of the HC&C system. The proposed network appears to be predicated on contemporaneous installation of the vertical barrier wall. Since DEQ accepted NW Natural's recommendation to defer the vertical barrier to the uplands FS, and HC&C along this section of Segment 1 is also going to be evaluated in the FS, NW Natural should revise the program for monitoring the performance of two groups of extraction wells, including 1) PW-1 and PW-2, and 2) PW-7 through PW-10. For example, piezometer cluster PZ7 should be relocated to monitor the influence of pumping extraction wells PW-1 and PW-2 on the Siltronic Property. DEQ notes between the MW-5 monitoring well cluster on the NW Natural Property and the WS-8/WS-12 cluster on the Siltronic Property there are no monitoring wells installed near the shoreline above 112 feet bgs. Additional monitoring wells should be installed to measure water levels and groundwater chemistry in closer proximity to extraction wells PW-1. The wells should be installed at depth intervals corresponding to the highest contaminant concentrations.

NW Natural indicates the goal of operating extraction wells is to maintain the average groundwater elevation below the average river elevation, initially on a running one-hour basis. However, the performance criterion for water level differences is not discussed and should be provided in NW Natural's response to this letter.

Section 6. DEQ acknowledges NW Natural's commitment to consider sequencing the vertical barrier early or first during upland remedial activities. DEQ would add that regardless of whether the vertical barrier is selected as a component of the final remedy, based on the magnitude of contamination and its proximity to the river, remedial action(s) in the southern portion of the NW Natural Property should be scheduled for early implementation.

Table 2-2. DEQ understands the lower aquitard occurs entirely within the lower alluvial WBZ. The title of the table implies the lower aquitard separates the upper alluvium from the "deep" alluvium. The title should be revised to indicate the table compares groundwater data collected above and below the lower aquitard.

Table 4-4. It is unclear why only four monitoring wells are shown for the Siltronic Property when there are eight that could be considered "shoreline" installations and a total of fourteen that should be considered for water level performance monitoring. NW Natural and Siltronic should select additional monitoring wells for purposes of monitoring water level data between and upgradient of extraction wells PW-1 and PW-2. The revised Table 4-4 should be included in the final design document.

Figures – General Comment. Inconsistencies between figures in the Interim Design Report make comparing, interpreting, and understanding related figures difficult. Examples are listed below.

- Certain figure reference the "NAVD 88," mean sea level, and City of Portland vertical datums. DEQ understands the datum in current general use is the COP datum. This should be made clear in the text and all relevant figures should be reviewed and revised as appropriate in the final design document.
- The vertical datum(s) used to prepare many figures is not referenced, including Figure 1-2, figures 2-2a through 2-2c; figures 2-3a through 2-3c; figures 2-5 through 2-7; and figures 2-12a, 2-12b, 2-13, 3-1, 3-4, 3-9, and 4-1. Furthermore, contours on Figure 3-4 are not labeled. NW Natural should review and revise any figure combining elevation information with site and/or investigatory information.
- The TarGOST® logging locations and geotechnical borings shown on Figure 2-1 are not included on figures 2-2a through 2-2c and should be added for reference and completeness. In addition, TG-4 is missing from Figure 2-3b.
- Geologic cross-sections reference shoreline source control segments 1 and 2 and show the locations of uplands installations, while subsurface profiles of free and total cyanide refer to the NW Natural and Siltronic property line and nearshore borings. Furthermore, monitoring wells, extraction wells, and geologic information are not provided on figures 2-12a and 2-12b. As such, evaluating the locations of the proposed extractions wells in the context of groundwater contamination, and the relationship between subsurface stratigraphy and contamination cannot be assessed.
- As shown by figures 2-3a through 2-3c, the vertical barrier and extraction wells are located in the uplands along or near a geologic cross-section containing uplands monitoring wells (see Figure 2-10). However, the subsurface distributions of free and total cyanide shown by figures 2-12a and 2-12b rely on interpretations of data collected from nearshore borings (GS-01 through GS-12) that are between 75 and 125 feet downgradient and under the river from where monitoring wells and extraction wells are located. These figures should be revised to show contaminant distributions interpreted from uplands monitoring wells in the final design document.
- The distribution of VOCs in groundwater is not shown in any figure in the Interim Design Report. Figures depicting the nature and extent of groundwater contamination are considered deficient lacking this information and should be revised accordingly.

The referenced figures should be reviewed and revised. Copies of the revised figures should be included in NW Natural's response to this letter and included in the final design document.

Figures 2-3a through 2-3c. DEQ notes water level information for the fill WBZ is representative of seasonal low values (i.e., conditions of low flux to the river). The figures should be revised to include a range of water levels for comparison purposes and completeness.

Figures 2-3b, 2-3c, and 2-5 through 2-7. These figures appear to rely on: 1) geologic observations made during the most recently completed geotechnical drilling and monitoring well installation work; and 2) DNAPL intervals identified during TarGOST® logging work. Regarding DNAPL occurrence at a number of monitoring well locations (e.g., WS-14), sheen observed during drilling preceded DNAPL entering the installation. As such, DEQ considers observations of sheen as being suggestive of the presence of DNAPL. The figures should be revised to include depths intervals where evidence of DNAPL (e.g., sheen, heavy sheen) was observed during all uplands drilling work completed in the areas shown in cross-section, including but not limited to borings B-29, B-55, B-57, B-58, B-59; boreholes at the MW-18, MW-19, WS-14, and WS-16 monitoring well clusters; and PW-01-80. Where DNAPL is shown for monitoring well locations, the depth of occurrence should also be checked. DEQ previously requested these figures be revised in the August 22nd Letter. The figures should be reviewed, revised, and resubmitted for the final design document.

Figure 2-10. Lacking groundwater data from monitoring wells, NW Natural should fill in the gap in groundwater data between the MW-5 and WS-8/WS-12 monitoring well clusters above elevation -75 feet with reconnaissance groundwater sampling data collected by either NW Natural and/or Siltronic. In addition, based on the detected concentrations of total and free cyanide between approximately 0 and -80 feet in elevation, the figure should have been extended beyond (i.e., upstream) of the WS-8/WS12 monitoring well clusters. Lastly, vinyl chloride should be added to the list of target analytes to provide information regarding the distribution of VOCs within the cross-section shown. The figure should be reviewed, revised, and resubmitted for the final design document.

Figure 3-2c. The title for the figure may be incorrect. DEQ understands the figure depicts the estimated extent of DNAPL "below" 100 feet bgs. The figure should be reviewed and revised as appropriate.

Appendix A – Sheet Pile Design Report

DEQ has a number of questions and comments regarding the wall design presented in this appendix as follows:

- General. The information presented presumes the vertical barrier is being constructed to elevation -40 feet. As indicated in DEQ's general comments the barrier carried forward into detailed analysis in the uplands FS should extend to elevation -60 feet. DEQ continues to understand this depth is feasible and the appendix could be revised by simply referencing the appropriate construction and materials depths (e.g., construct barrier to -60 feet; sheet pile lengths 80 feet long). NW Natural should confirm this understanding in the response to this letter.

- Pre-Trenching. NW Natural indicates the trench, "...will be dug to a depth not greater than the groundwater table or where the strata of oversized material and undisturbed natural material transition." DEQ considers it reasonable to plan for a scenario in which oversize material occurs below the water table, and wonders if dewatering has been, or should be considered during trenching.
- Groundwater. According to the Wall Depths section, the top of the barrier will be set at elevation +20 feet. Shallow groundwater is indicated as being at elevation +13 feet. As discussed above, DEQ considers the vertical barrier design to be incomplete without engineering controls to prevent groundwater in the fill WBZ from mounding behind and migrating around the barrier.
- Alignment. Additional information should be provided to clarify whether the stormwater pipe that needs to be reconnected is below the water table, acknowledge construction below the water table could require additional engineering controls during construction (e.g., dewatering; water storage, sampling, and management), and clarify whether the penetration through the wall needs to be sealed.
- Drawing SP1. Labels and text on the 11"x17" versions of the drawing are blacked out. The figure should be revised and resubmitted for insertion into the document copies. The ends of the vertical barrier shown in the drawing are either linear (north end) or exhibit a short-radius curvature towards the river (south end). NW Natural should discuss the need for typical landward facing end wingwalls to reduce the potential for dissolved phase constituents and/or NAPL from migrate around the ends of the barrier.

The report should include a section describing sheen monitoring in the river. The construction of SCMs or implementation of remedial action technologies (e.g., sheet-pile driving) could cause sheen bursts, blossoms, and/or outbreaks to occur in the river. As was done during the vibration study, a sorbent and containment boom system should be deployed to capture any sheen generated during uplands construction activities. Visual monitoring should be done throughout the work day and the boundaries of the boom system adjusted as needed to ensure sheen is captured.

Appendix C, Water Treatment/Treatment System Pilot Study

DEQ understands sludge and water produced during the treatment system pilot study were managed consistent with DEQ's March 27, 2008 letter regarding investigation derived waste. NW Natural should provide documentation regarding solids IDW management for DEQ's information and completeness. For the final design document, DEQ expects NW Natural to identify each waste-stream in the water treatment process and document the type of media (solid, liquid); regulatory status (solid waste, hazardous waste), basis for regulatory determination (e.g., regulatory citation, knowledge of process, sampling data), estimated annual volume, and anticipated management approach. Figures should be provided to clearly show the locations of waste-streams in the treatment process.

Comments regarding the water treatment system are listed below.

- The potential presence of unexpected DNAPL in the treatment system and the apparent reliance on manual draining of LNAPL from oil-water separators (OWSs) will require attention during operation. DEQ expects the schedule for OWS inspections and LNAPL/DNAPL removal criteria to be detailed in the final design document.

- Equalization storage volumes for the NW Natural and Siltronic treatment systems appear to underestimate capacity needs. Given DEQ's decision to defer installation of four extraction wells to the uplands FS and using a reasonable pumping rate of 25 gpm for each extraction well , influent into the Siltronic and NW Natural treatment systems is estimated to be 50 gpm and 100 gpm respectively. This translates into total daily influent volumes of 72,000 gallons (Siltronic) and 144,000 gallons (NW Natural). On an average daily basis equalization tank storage capacity represents between 7.5% and 15% of the total daily flow. NW Natural should check storage needs and provide additional information justifying equalization tank requirements in the context of this information. In addition, NW Natural should evaluate the length of time extraction wells can continually operate during treatment plant shut-downs.
- NW Natural should discuss the implications of specifying a 259 gpm clarifier feed pump given the overall treatment system is designed for maximum flow rates of 400 gpm.
- Page 10 of the appendix indicates the treatment system will use two GAC units in series, page 18 indicates a parallel arrangement, and sheet M-8 does not clearly depict the configuration. NW Natural should clarify.
- It does not appear DNAPL pumps (see Interim Design Report, Figure 4-4) are included in the extraction well design. Figures M-3 and M-4 do not identify this type of pump. NW Natural should clarify.

DEQ's review of the Pilot Study Report focused on final effluent data. DEQ understands analytical results collected from sampling locations NW-9 (Table 6) and NW-9S (Table 7) are representative of the final treated effluent data (i.e., data for treated effluent prior to discharge) from the NW Natural and Siltronic process streams respectively. Comments regarding the data compiled in tables 6 and 7 are provided below.

- DEQ's letter dated April 2, 2009 identified xylene as a monitoring parameter for the pilot study, however data for is reported as "m,p-xylene" and "o-xylene" in tables 6 and 7. NW Natural should explain these results further.
- The footnotes for tables 6 and 7 reference footnotes in attachments E and G. These references are confusing, especially for the chromium(VI) notes in Table 6. NW Natural should revise the tables to make the information more understandable and accessible, and resubmit them.
- Iron and manganese data are inconsistently reported in tables 6 and 7. NW Natural should clarify which iron and manganese data represent total or dissolved concentrations. NW Natural should also confirm concentration units. The tables in the Pilot Study Report should be reviewed and revised as appropriate.
- In addition to chromium(III) and chromium(VI), "chromium" is reported twice in Table 6 with different values. NW Natural should clarify chromium data and confirm concentration units. The tables should be reviewed and revised as appropriate.
- The maximum values for several parameters are elevated in Table 6. Certain parameters exceed the applicable water quality standard (WQS), including arsenic , copper, iron, lead, manganese, mercury, nickel, benzo(a)pyrene, benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, and tetrachloroethene. NW Natural should confirm DEQ's observations of the data and indicate how these results were considered in treatment system design.

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- Several parameters shown in Table 6 have quantitation limits greater than the values listed in DEQ's November 2007 technical memorandum[11], including cadmium, chromium(VI), tetrachloroethene, trichloroethene, toluene, and ethylbenzene. Except for toluene and ethylbenzene, the higher quantitation limits could impact reasonable potential. NW Natural should confirm DEQ's observations of the data and indicate how these results were considered in treatment system design.
- The maximum values for several parameters in Table 7 are elevated, including iron, mercury, and manganese. The value for iron exceeds the WQS. The maximum values for manganese and mercury are just below or at the WQS, respectively. NW Natural should confirm DEQ's observations of the data and indicate how these results were considered in treatment system design.
- Several parameters shown in Table 7 have quantitation limits greater than the values listed in DEQ's November 2007 memorandum, including cadmium and chromium(III). The higher quantitation limit for chromium (III) will likely not impact reasonable potential; however the limit shown for cadmium (1.00 ug/L) could have an impact.

NW Natural should address DEQ's comments regarding the treatment system and Pilot Study Report in the response to this letter. The clarifying information and revised versions of table 6 and 7 are needed before DEQ can proceed with updating the Reasonable Potential Analysis using the pilot study effluent data.

Appendix D, Geotechnical Boring Logs and Soil Data Tables

DEQ has the following specific comments regarding Figure A-1 (Key to Exploration Logs) and the geotechnical boring logs in the appendix.

- The date water levels were observed during drilling are not shown on the logs.
- The test symbol "GS" is not included on Figure A-1.

Table 1 includes a column for "Permeability" testing in which no values are provided. NW Natural should clarify whether testing results should be included in the column, or confirm all testing results are provided in Table 2 as "Hydraulic Conductivity" values.

Appendix E, Well Design

Consistent with work done previously, the plan specifies that pumping and observation wells be constructed with 0.035-inch V-shaped wire-wrapped screen. Graded 10-20 Colorado Silica sand will be used for the filter pack material around the well screens. The manufacturer's maximum recommended slot size opening for this gradation of filter pack material is 0.030. As such, the use of 0.035-inch slots may allow passage of some of the filter pack material. Well construction procedures should ensure that: 1) thorough surging of the well during filter pack placement is conducted, and 2) upon completion of surging the top of the filter pack be verified and brought back to the specified level prior to placement of the annular seal.

[11] DEQ, 2007, "Addendum to Reasonable Potential IMD to Revise Quantitation Limits," November 16, a document prepared by DEQ.

In the interest of reducing the potential influence of DNAPL, sheen, and/or contaminated groundwater on future observation or monitoring well construction, DEQ recommends NW Natural modify installation procedures as follows:

- Bailing contaminated fluids out of the upper casing (i.e., larger casing) used to double-case the borehole(s). Where subsurface require the use of double-case drilling methods, this step should be performed immediately after the upper casing is seated in the bentonite plug, and just before the secondary casing is placed downhole. DEQ acknowledges potable water may be needed to stabilize water levels in the casing, but considers this preferable to carrying contaminated fluids down the borehole.
- Using fine graded sand on top of the screen filter pack as pouring bentonite chips through heavy sheen or DNAPL could hinder hydration. Fine graded sand does not require hydration and can prevent migration of the bentonite and organoclay slurry into the filter pack.

These comments should be incorporated into the final design document. In addition, the final design document should provide details for managing investigation derived waste consistent with procedures currently in place and being used by NW Natural or Siltronic.

Appendix F, Sampling and Analysis Plan

If NW Natural has not already done so, comments made by EPA and DEQ to the Segment 2 Test Plan[12] should be fully incorporated into the appendix for the final design document.

Table F-1. DEQ has the following clarifying comments regarding the sampling parameters list provided in the table.

- Chemical monitoring should include, but is not limited to, analyzing groundwater samples from extraction wells and/or performance monitoring wells for:
  - Typical field measured water quality parameters;
  - NW Natural and Siltronic facility COI (e.g., polycyclic aromatic hydrocarbons; VOCs, metals);
  - All parameters on the groundwater treatment system discharge list, and any additional constituents that could influence extraction well and/or groundwater treatment system operation and performance.
- The analyte list should be revised to include 1,2,4-trimethylbenze and 1,3,5-trimethylbenzene under the appropriate suite of analyses.
- A performance objective of the HC&C system is to reverse groundwater gradients and induce movement of water from the river towards extraction wells. Inorganic indicator parameters of river water should be added to the analyte list to monitor progress towards meeting this objective, including, but not necessarily limited to, calcium, potassium, sodium, iron (total and dissolved), magnesium (total and dissolved), sulfate, chloride, bicarbonate, carbonate, and nitrate.

[12] Anchor QEA, LLC, 2009, "Capture Zone Field Test Plan – Gasco, Portland, Oregon," September, a work plan prepared for NW Natural.

NEXT STEPS

DEQ is not requiring the Interim Design Report to be revised and resubmitted. Within 30 days of receiving this letter, NW Natural should provide a written response to DEQ's comments and requests for information and/or clarifications. Copies of all revised figures should be submitted within 45 days of NW Natural's receipt of the letter. DEQ recommends a meeting be arranged as soon as practicable after NW Natural reviews this letter to discuss the scope, content, and schedule for the final source control design document.

Please feel free to contact me with questions regarding this letter.

Sincerely,

Dana Bayuk
Project Manager
Portland Harbor Section

Cc: Patty Dost, Pearl Legal Group
John Edwards, Anchor QEA
Carl Stivers, Anchor QEA
Rob Ede, Hahn & Associates
Myron Burr, Siltronic Corporation
Tom McCue, Siltronic Corporation
Alan Gladstone, Davis Rothwell Earle and Xochihua
James Peale, Maul Foster & Alongi, Inc.
Ted Wall, Maul Foster & Alongi, Inc.
Kristine Koch, EPA
Sean Sheldrake, EPA
Lance Peterson, CDM
Jim Anderson, NWR/PHS
Rob Burkhart, NWR/WQ
Tom Gainer, NWR/PHS
Henning Larsen, NWR/SRS
Matt McClincy, NWR/PHS
ECSI No. 84 File
ECSI No. 183 File

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Appendix A
Gasco Source Control Design Report
Table Documenting DEQ March 26, 2010 Comment Letter

DEQ Requests	Location Where DEQ Request is addressed in Draft Final Source Control Design Report
1 **Page 5, paragraph 2** NW Natural should be advised that source control RAO #1 will be an RAO in the uplands FS. DEQ's acceptance of NW Natural's recommendation to postpone final design and construction of the vertical barrier pending the outcome of the uplands FS is subject to the following conditions: • A barrier must be carried forward into the detailed analysis of remedial action alternatives for RAO #1 in the uplands FS; and • The vertical barrier carried forward into detailed analysis will be 625 feet long and constructed using sheet pile methods to a depth of -60 feet City of Portland datum (COP). DEQ expects NW Natural to acknowledge these conditions in writing prior to moving forward with final design of the HC&C system discussed below. Construction feasibility and design support studies show pile driven vertical sheet pile barriers can be constructed to depths of up to 90 feet below ground surface (bgs). The studies not only show construction is feasible, but provide information to support design, including identifying barrier materials, construction methods and equipment, and approaches for monitoring field activities to reduce potential impacts to the adjoining Siltronic operation(s) during construction. Given DEQ's determination, NW Natural should carry any comments in this letter	See Section 1.2, paragraph 3

	DEQ Requests	Location Where DEQ Request is addressed in Draft Final Source Control Design Report
	pertaining to the vertical barrier and/or HC&C along the barrier alignment forward into the FS.	
2	**Page 6, paragraph 2** To address these uncertainties and reduce the influence of fine-grained layers on contaminated groundwater capture and contaminant mass removal, extraction wells should be located where the highest concentrations of MGP constituents and VOCs occur.	See Section 3.2.2.2.1, paragraph 5
3	**Page 6 paragraph 3** NW Natural is currently in the process of conducting long-term variable rate pumping tests using three test extraction wells and multiple observation wells constructed in the fill WBZ and upper and lower alluvial WBZ. NW Natural indicates the primary purpose of the tests is to support planning of the in-water sediment project by assessing the influence pumping wells in the uplands has on groundwater levels beneath the river. As indicated on DEQ's letter dated January 10, 2010, NW Natural should use test data to assess the lateral and vertical influence of pumping test wells on the fill WBZ and alluvial WBZ. NW Natural's final data interpretations, conclusions, and analysis of the tests, including the results of any groundwater modeling, should be incorporated into the HC&C system final design document.	See Section 3.2.1.9
4	**Page 6, paragraph 4** • An additional extraction well located upstream (i.e.,	See Section 3.2.2.2.1, paragraph 6

DEQ Requests	Location Where DEQ Request is addressed in Draft Final Source Control Design Report
southeast) of PW-1 may be warranted and should be evaluated in the final design document.	
5 **Page 7, paragraph 2** NW Natural should prepare figures for the final design document showing how the locations of these extraction wells relate to groundwater contamination as shown by data collected from uplands monitoring wells (not nearshore borings). The figures should show extraction wells with MGP and VOC COI along cross-section A-A'. The MGP and VOC COI shown in the figures should include, but not necessarily be limited to, benzene, naphthalene, total cyanide, and vinyl chloride, and the rational for selecting COI must be provided. In preparing the figures, NW Natural should use reconnaissance groundwater data as needed to fill data gaps. For example, the VOC Plume FFS prepared by Siltronic provides cross-sectional views of VOCs, including trichloroethene, cis-1,2-dichloroethene, and vinyl chloride, that are useful for locating extraction wells PW-1 and PW-2 (see figures 1-3a, 1-3b, and 1-3c).	See Figures 2-11a,b,c Also see Section 3.2.2.2.1, paragraph 6
6 **Page 7, paragraph 3** **<u>Additional Extraction Well.</u>** Figure 2-10 summarizes groundwater data for selected MGP COI collected from monitoring wells located in the upstream portion of shoreline Segment 2 and the length of Segment 1. Detected concentrations of total and free cyanide between approximately 0 and -80 feet in elevation exceed Joint	See the Particle Track Capture Map on Figure 3-2 Also see Section 3.2.2.2.1, paragraph 6

	DEQ Requests	Location Where DEQ Request is addressed in Draft Final Source Control Design Report
	Source Control Strategy (JSCS) criteria upstream of the WS-8 and WS12 monitoring well clusters. This comment also applies to detected concentrations of VOCs. Furthermore, the capture zone for extraction well PW-1 shown by Figure 4-2 does not appear to extend far enough upstream to intercept groundwater contamination documented at the WS-8 and WS-12 monitoring clusters (i.e., groundwater in the alluvial WBZ contaminated by MGP and VOC COI could by-pass the HC&C system on the upstream side). Based on this information an additional extraction well may be warranted upstream of PW-1. The need for an additional extraction well should be fully evaluated in the final design document.	
7	**Page 9, paragraph 4** The Interim Design Report does not include an approach for controlling and containing groundwater in the fill WBZ behind the vertical barrier. Without information regarding how groundwater in the fill WBZ will be addressed during design and construction of the vertical barrier, DEQ considers the interim design of the vertical barrier to be incomplete. For clarification, controlling groundwater flux in the fill WBZ must be achieved by NW Natural whether the barrier is constructed or not. Furthermore, NW Natural has not provided information, data, and/or analysis regarding the second item.	See Section 3.2.2.1 Also see the Fill WBZ Interceptor Trench Design in Appendix J The request to use the Segment 2 test data is previously addressed in DEQ item 3.

	DEQ Requests	Location Where DEQ Request is addressed in Draft Final Source Control Design Report
	NW Natural is currently conducting an evaluation of the influence of pumping uplands test wells on groundwater levels beneath the river in Segment 2. These tests will provide information to preliminarily assess the capability of extraction wells in the alluvial WBZ to influence shallow groundwater in the fill WBZ. DEQ expects this information to be fully incorporated into the final SCMs design document.	
8	**Page 9, paragraph 6** NW Natural uses the term "riverbank stabilization" throughout this section of the Interim Design Report. The term pre-supposes one type of riverbank remedial alternative and should be revised to reference "riverbank cleanup."	See Section 1.2
9	**Page 10, paragraph 4** This section of the Interim Design Report references numerous geologic cross-sections. DEQ requests an additional cross-section be developed for the final design document which depicts the area of deeper DNAPL occurrence between borings TG-10 to B-4B shown on Figure 2-3b. This additional cross-section would be drawn between existing cross-sections D and E.	See new Section F-F' on Figure 2-8
10	**Page 10, paragraph 5, Section 2.1.1, 5th and 6th paragraphs.** The Interim Design Report indicates, "The basalt is a no-flow boundary in the MODFLOW model that has been developed by SS	See Section 3.2.1.4

	DEQ Requests	Location Where DEQ Request is addressed in Draft Final Source Control Design Report
	Papadoulos (SSPA) for the site." This assertion is in error. The revised groundwater model report indicates, "As described on page 22 of the model summary report, the basalt is not a no-flow boundary.	
11	**Page 11, paragraph 2** A description of the geology and hydrogeology of the upper silt unit should be included in the final design document for completeness.	See Section 2.1.3, paragraph 2
12	**Page 11, paragraph 3** However, DEQ is not aware of work done by NW Natural to correlate TarGOST® logging data to the subsurface geology of the site. This information should be provided as a supplement to Appendix H to document NW Natural's basis for interpreting silt unit occurrence and for completeness.	See Section 2.1.3.1, paragraph 2 and the memo in Appendix D
13	**Page 12, paragraph 1** As such, the system will need to accommodate a dynamic system influenced by seasonal changes in natural recharge, river stages and tidal influence. It is recommended NW Natural run the MODFLOW model in a transient state to verify the model's ability to simulate changing groundwater flux and hydraulic head conditions resulting from these influences.	See Section 3.2.1.4, final paragraph
14	**Page 12, paragraph 2** Regardless of seasonal variations in groundwater flux or the potential for additional sources of water to be added to the treatment	See Section 3.3 and the Treatment System Design Report in Appendix E

	DEQ Requests	Location Where DEQ Request is addressed in Draft Final Source Control Design Report
	process (e.g., fill WBZ, LNG tank basin), groundwater source control planning accommodated uncertainties through designing the treatment system for 400 gpm. NW Natural should confirm DEQ's understanding or provide clarifying information.	
15	DEQ included a number of requests in Section 3, the Vertical Barrier Design.	Since the vertical barrier is not a component of the source control final design, DEQ's requests related to the vertical barrier design are not addressed in this design report. However, DEQ's requests related to the vertical barrier design will be addressed in the upland FS, as they relate to issues in that document.
16	**Page 15, Section 4.1.1.** DEQ's comment to Section 1.2 regarding the fill WBZ zone applies here.	See Section 3.2.2.1 and Appendix J
17	**Page 15, Section 4.1.2.** DEQ's comments to Appendix C and the Pilot Study Report apply here.	See Section 3.3 and Appendix E
18	**Page 15, Section 4.1.3.** DEQ understands from reviewing this section of the Interim Design Report that: • Maintenance of an individual extraction well, including replacing a pump, is expected to be completed within 24 hours. • Power loss could reasonably shut-down the HC&C and	See Section 3.1.3.

DEQ Requests	Location Where DEQ Request is addressed in Draft Final Source Control Design Report
groundwater treatment systems for up to 12 hours based on historic records from Portland General Electric. Based on discussions with NW Natural during meetings, DEQ understood power losses up to between 24 to 36 hours could occur. NW Natural should check information provided in this section and explain the shorter timeframe, or confirm DEQ's understanding of the topic. In addition, given the uncertainty regarding the maintenance of extraction wells (see Section 4.2.2.3), NW Natural should evaluate a shut-down scenario involving extraction well replacement. Besides extraction well shut-downs, the groundwater treatment system will be shut down for maintenance and in response to periodic high level/pressure shut-downs. NW Natural should provide additional information regarding the length of time associated with treatment system shut-downs (see also DEQ's comments to Appendix C). NW Natural's approach to evaluating potential water quality impacts is also provided in this section of the report. The evaluation of the period of time the system could be shutdown before an unacceptable water quality impact in the river occurs appears to be	

DEQ Requests	Location Where DEQ Request is addressed in Draft Final Source Control Design Report
more appropriate for planning an in-water capping project. As such, the approach pre-supposes implementation of in-water remedial action alternatives. Furthermore, the input parameters, model documentation, and results were not provided to DEQ for discussion or review prior to the Interim Design Report being submitted, and are not included in the document. For clarification, DEQ envisioned a simpler scenario being assessed. NW Natural should revise the response to estimate the time needed for contaminated groundwater to: 1) escape capture and bypass the HC&C system; and 2) migrate to the river in the event shut-down occurs. The estimated timeframes should then be compared to the shutdown times associated with power outages.	
19 **Page 16** Documentation for the groundwater model including general calibration, verification, and sensitivity, as well as specific recalibration of the model (referenced in the Interim Design Report) and the incorporation of the lower aquitard (presented for the first time in the Interim Design Report) is insufficient. For the final design document, NW Natural should provide more detailed documentation regarding numerical modeling, including its update and refinement for the Interim Design Report, as follows: • A table describing hydrostratigraphic layers represented in	See Section 3.2.1.4

DEQ Requests	Location Where DEQ Request is addressed in Draft Final Source Control Design Report
the model and their dimensions compared to the characterization shown in cross-section using well log information. • A water budget summary for the hydrostratigraphic layers represented in the model. • Hydraulic properties assigned to the model layers including, but not limited to, calibrated vertical and horizontal hydraulic conductivities (Kv/Kh), specific storativity, and specific yield. • Details on the numerical model boundaries. • Additional calibration information demonstrating confidence in the model representing measured heads under various conditions. The available information is insufficient to allow for a spatial evaluation, and modeled versus measured heads appear to be off calibration by up to four feet, or approximately 25% of the total average gradient across the site. Calibration plots should include a spatial plot of the head difference between modeled and measured values across the site to focus refinements to the hydraulic properties and model grid where needed. Additionally, time-series plots of seasonal water level data should be compared with transient modeled water levels trends to verify the model under measured seasonal variation.	

	DEQ Requests	Location Where DEQ Request is addressed in Draft Final Source Control Design Report
	• A sensitivity analysis to potential future land use changes (e.g. ditch/trench lining, removal, site paving) that could change the current recharge, gradient/flow conditions assumed by the numerical groundwater flow model.	
20	**Page 17, paragraph 4** Based on this information and literature which indicates coal tar DNAPL can migrate for over 100 years before attaining a stable subsurface configuration, DEQ concludes DNAPL migration is ongoing. As such, the uplands FS should evaluate remedial action alternatives that mitigate DNAPL migration, including, but not necessarily limited to source reduction, removal, and stabilization.	NW Natural does not agree that there is conclusive evidence of current DNAPL migration; however, DNAPL remedial actions including these alternatives will be evaluated in the uplands FS.
21	**Page 17, paragraph 5** • For clarification, based on numerical simulations the final horizontal hydraulic conductivity of the upper and lower alluvial WBZs used for the MODFLOW model were 15 and 300 feet/day respectively.	See Section 3.2.1.3
22	**Page 17, last paragraph** The vertical placements of extraction well screens are discussed in terms of their positions relative to the upper and lower alluvial WBZs. An additional significant factor for locating screened intervals is the occurrence of DNAPL and dissolved phase contamination, neither of which is discussed here. NW Natural should provide additional information regarding the locations of the	See Section 3.2.2.2.1

DEQ Requests		Location Where DEQ Request is addressed in Draft Final Source Control Design Report
	proposed extraction wells, screen depths, and the distribution of DNAPL and MGP and VOC contamination.	
23	**Page 18, second bullet** The vertical placement of the screen for extraction well PW-2 (elevation -25 to -45 feet) does not appear to coincide with the highest concentrations of total cyanide shown in Figure 2-12b. The location and vertical placements of the screens for extractions wells PW-1 and PW-2 should be compared to the distribution of MGP and VOC COI and adjusted as needed to intercept the highest concentrations of contaminants.	See Section 3.2.2.2.1, paragraph 5
24	**Page 18, paragraph 1** DEQ notes between the MW-5 monitoring well cluster on the NW Natural Property and the WS-8/WS-12 cluster on the Siltronic Property there are no monitoring wells installed near the shoreline above 112 feet bgs. Additional monitoring wells should be installed to measure water levels and groundwater chemistry in closer proximity to extraction wells PW-1. The wells should be installed at depth intervals corresponding to the highest contaminant concentrations.	See Section 3.2.2.5.2, wells MW-35U and MW-36U are added on Siltronic property.
25	**Page 18, paragraph 2** NW Natural indicates the goal of operating extraction wells is to maintain the average groundwater elevation below the average river elevation, initially on a running one-hour basis. However, the	See Section 3.2.2.5.2, paragraphs 6 and 7

	DEQ Requests	Location Where DEQ Request is addressed in Draft Final Source Control Design Report
	performance criterion for water level differences is not discussed and should be provided in NW Natural's response to this letter.	
26	**Page 19, paragraph 1** **Table 2-2.** DEQ understands the lower aquitard occurs entirely within the lower alluvial WBZ. The title of the table implies the lower aquitard separates the upper alluvium from the "deep" alluvium. The title should be revised to indicate the table compares groundwater data collected above and below the lower aquitard.	See Table 2-2
27	**Page 19, paragraph 2** **Table 4-4.** It is unclear why only four monitoring wells are shown for the Siltronic Property when there are eight that could be considered "shoreline" installations and a total of fourteen that should be considered for water level performance monitoring. NW Natural and Siltronic should select additional monitoring wells for purposes of monitoring water level data between and upgradient of extraction wells PW-1 and PW-2. The revised Table 4-4 should be included in the final design document.	See Table 3-4
28	**Page 19, bullets 1 and 2** • Certain figure reference the "NAVD 88," mean sea level, and City of Portland vertical datums. DEQ understands the datum in current general use is the COP datum. This should be made clear in the text and all relevant figures should be reviewed and revised as appropriate in the final design	Figures revised

DEQ Requests	Location Where DEQ Request is addressed in Draft Final Source Control Design Report
document. • The vertical datum(s) used to prepare many figures is not referenced, including Figure 1-2, figures 2-2a through 2-2c; figures 2-3a through 2-3c; figures 2-5 through 2-7; and figures 2-12a, 2-12b, 2-13, 3-1, 3-4, 3-9, and 4-1. Furthermore, contours on Figure 3-4 are not labeled. NW Natural should review and revise any figure combining elevation information with site and/or investigatory information.	
29 **Page 19, bullet 3** • The TarGOST® logging locations and geotechnical borings shown on Figure 2-1 are not included on figures 2-2a through 2-2c and should be added for reference and completeness. In addition, TG-4 is missing from Figure 2-3b.	Figures revised
30 **Page 19, bullet 5** • As shown by figures 2-3a through 2-3c, the vertical barrier and extraction wells are located in the uplands along or near a geologic cross-section containing uplands monitoring wells (see Figure 2-10). However, the subsurface distributions of free and total cyanide shown by figures 2-12a and 2-12b rely on interpretations of data collected from nearshore borings (GS-01 through GS-12) that are between 75 and 125 feet downgradient and under the river from where monitoring wells and extraction wells are located. These figures should	It is not clear why DEQ wants data from upland monitoring wells placed on offshore cross sections. Further clarification is needed on this request.

DEQ Requests		Location Where DEQ Request is addressed in Draft Final Source Control Design Report
	be revised to show contaminant distributions interpreted from uplands monitoring wells in the final design document.	
31	**Page 19, bullet 6** • The distribution of VOCs in groundwater is not shown in any figure in the Interim Design Report. Figures depicting the nature and extent of groundwater contamination are considered deficient lacking this information and should be revised accordingly.	See Figure 2-11a,b,c
32	**Page 20, paragraph 2** **Figures 2-3a through 2-3c.** DEQ notes water level information for the fill WBZ is representative of seasonal low values (i.e., conditions of low flux to the river). The figures should be revised to include a range of water levels for comparison purposes and completeness.	Figures 2-3a,b,c revised
33	**Page 20, paragraph 3** **Figures 2-3b, 2-3c, and 2-5 through 2-7.** These figures appear to rely on: 1) geologic observations made during the most recently completed geotechnical drilling and monitoring well installation work; and 2) DNAPL intervals identified during TarGOST® logging work. Regarding DNAPL occurrence at a number of monitoring well locations (e.g., WS-14), sheen observed during drilling preceded DNAPL entering the installation. As such, DEQ considers observations of sheen as being suggestive of the presence of DNAPL. The figures should be revised to include depths intervals	See Section 3.2.1.6, paragraph 4

	DEQ Requests	Location Where DEQ Request is addressed in Draft Final Source Control Design Report
	where evidence of DNAPL (e.g., sheen, heavy sheen) was observed during all uplands drilling work completed in the areas shown in cross-section, including but not limited to borings B-29, B-55, B-57, B-58, B-59; boreholes at the MW-18, MW-19, WS-14, and WS-16 monitoring well clusters; and PW-01-80. Where DNAPL is shown for monitoring well locations, the depth of occurrence should also be checked. DEQ previously requested these figures be revised in the August 22nd Letter. The figures should be reviewed, revised, and resubmitted for the final design document.	
34	**Page 20, paragraph 4** **Figure 2-10.** Lacking groundwater data from monitoring wells, NW Natural should fill in the gap in groundwater data between the MW-5 and WS-8/WS-12 monitoring well clusters above elevation -75 feet with reconnaissance groundwater sampling data collected by either NW Natural and/or Siltronic. In addition, based on the detected concentrations of total and free cyanide between approximately 0 and -80 feet in elevation, the figure should have been extended beyond (i.e., upstream) of the WS-8/WS12 monitoring well clusters. Lastly, vinyl chloride should be added to the list of target analytes to provide information regarding the distribution of VOCs within the cross-section shown. The figure should be reviewed, revised, and resubmitted for the final design document.	See Figure 2-11a,b,c
35	**Page 20, paragraph 5**	See Figure 3-4c

	DEQ Requests	Location Where DEQ Request is addressed in Draft Final Source Control Design Report
	Figure 3-2c. The title for the figure may be incorrect. DEQ understands the figure depicts the estimated extent of DNAPL "below" 100 feet bgs. The figure should be reviewed and revised as appropriate.	
36	**Pages 21 through 23** Appendix C, Water Treatment System Pilot Study	For DEQ comments related to the groundwater treatment system design, please refer to Section 3.3 and Appendix E.
37	**Page 23** **Appendix D, Geotechnical Boring Logs and Soil Data Tables** DEQ has the following specific comments regarding Figure A-1 (Key to Exploration Logs) and the geotechnical boring logs in the appendix. • The date water levels were observed during drilling are not shown on the logs. • The test symbol "GS" is not included on Figure A-1. Table 1 includes a column for "Permeability" testing in which no values are provided. NW Natural should clarify whether testing results should be included in the column, or confirm all testing results are provided in Table 2 as "Hydraulic Conductivity" values.	This appendix is not included in the Final Design Report.
38	**Pages 23 and 24** **Appendix E, Well Design** Consistent with work done previously, the plan specifies that	Appendix K text has been modified to conform to DEQ requests.

DEQ Requests	Location Where DEQ Request is addressed in Draft Final Source Control Design Report
pumping and observation wells be constructed with 0.035-inch V-shaped wire-wrapped screen. Graded 10-20 Colorado Silica sand will be used for the filter pack material around the well screens. The manufacturer's maximum recommended slot size opening for this gradation of filter pack material is 0.030. As such, the use of 0.035-inch slots may allow passage of some of the filter pack material. Well construction procedures should ensure that: 1) thorough surging of the well during filter pack placement is conducted, and 2) upon completion of surging the top of the filter pack be verified and brought back to the specified level prior to placement of the annular seal. • Bailing contaminated fluids out of the upper casing (i.e., larger casing) used to double-case the borehole(s). Where subsurface require the use of double-case drilling methods, this step should be performed immediately after the upper casing is seated in the bentonite plug, and just before the secondary casing is placed downhole. DEQ acknowledges potable water may be needed to stabilize water levels in the casing, but considers this preferable to carrying contaminated fluids down the borehole. • Using fine graded sand on top of the screen filter pack as pouring bentonite chips through heavy sheen or DNAPL could hinder hydration. Fine graded sand does not require	

DEQ Requests		Location Where DEQ Request is addressed in Draft Final Source Control Design Report
	hydration and can prevent migration of the bentonite and organoclay slurry into the filter pack.	
39	**Page 24** **Appendix F, Sampling and Analysis Plan** If NW Natural has not already done so, comments made by EPA and DEQ to the Segment 2 Test Plan should be fully incorporated into the appendix for the final design document.	NW Natural requests further information including identification of the agency document that is referenced and identification of the comments.
40	**Page 24** **Table F-1.** DEQ has the following clarifying comments regarding the sampling parameters list provided in the table. • Chemical monitoring should include, but is not limited to, analyzing groundwater samples from extraction wells and/or performance monitoring wells for: – Typical field measured water quality parameters; – NW Natural and Siltronic facility COI (e.g., polycyclic aromatic hydrocarbons; VOCs, metals); – All parameters on the groundwater treatment system discharge list, and any additional constituents that could influence extraction well and/or groundwater treatment system operation and performance. • The analyte list should be revised to include 1,2,4-trimethylbenze and 1,3,5-trimethylbenzene under the appropriate suite of analyses.	See Section 3.2.2.5.4

Appendix A
Gasco Source Control Design Report
Table Documenting DEQ March 26, 2010 Comment Letter

DEQ Requests	Location Where DEQ Request is addressed in Draft Final Source Control Design Report
A performance objective of the HC&C system is to reverse groundwater gradients and induce movement of water from the river towards extraction wells. Inorganic indicator parameters of river water should be added to the analyte list to monitor progress towards meeting this objective, including, but not necessarily limited to, calcium, potassium, sodium, iron (total and dissolved), magnesium (total and dissolved), sulfate, chloride, bicarbonate, carbonate, and nitrate.	

APPENDIX B
SOURCE CONTROL DISPUTE DOCUMENTS

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July 20, 2010
Via Hand Delivery

James M. Anderson
Manager, DEQ Portland Harbor Section
Oregon Department of Environmental Quality
NW Region
2020 SW Fourth Ave Ste 400
Portland, OR 97201-4987

Re: Request for Formal Dispute Resolution
NW Natural Gasco Site
DEQ Voluntary Agreement No. WMCVC-NWR-94-13

Dear Jim:

Dana Bayuk's June 11, 2010 email[1] directs NW Natural to:

- Evaluate hydraulic control and containment (HC&C) with dense non-aqueous phase liquid (DNAPL) remedial action alternatives along the portion of Segment 1 corresponding to the vertical barrier alignment in the uplands feasibility study (FS).
- Complete additional evaluations of the locations and depths of extraction wells PW-2, PW-7, and PW-8, and create an additional extraction well southeast (upstream) of PW-1.
- Proceed with developing a final design for extraction wells PW-1 and PW-2 (and a possible additional well southeast of PW-1) on the Siltronic property, and extraction wells PW-7 through PW-10 along shoreline of Segment 2.

NW Natural disagrees with this direction for the reasons stated below and seeks formal dispute resolution as provided in Section II.M., of the Voluntary Agreement. DEQ's direction fails to address groundwater discharging to the river in the most highly contaminated area of the Gasco site and risks significantly delaying implementation of in-water remedies.

Dana's June 11 email also requested that NW Natural provide a written response to its March 26 comments on NW Natural's Interim Design Report (IDR)[2] on or before July 14. On July 14, I advised you by e-mail that NW Natural was invoking dispute resolution with respect to the source control direction in Dana's June 11 e-mail. On July 16, I received an e-mail from Dana Bayuk stating that our notice to invoke dispute "does not extend" to the response to DEQ's

[1] DEQ, 2010b. Email from Dana Bayuk, DEQ to Bob Wyatt, NW Natural. RE: Source Control Decision Along Vertical Barrier Alignment dated June 11, 2010
[2] Anchor QEA, 2009a. Groundwater Source Control Interim Design Report. Prepared for NW Natural. Prepared by Anchor QEA, LLC. November 2009.

March 26 letter and threatening to seek stipulated penalties if the response to comments is not submitted by July 30, 2010.

My July 14 e-mail to you states that NW Natural disputes "source control direction sent to us from DEQ via e-mail on June 11, 2010." NW Natural's intent was to seek dispute resolution of the June 11 e-mail as a whole, and we are unaware that Section II.S. of the Voluntary Agreement provides a basis for the assessment of penalties for failure to submit a written response to DEQ comments. However, NW Natural's response to DEQ's March 26, 2010 comments on the IDR is enclosed with this letter. NW Natural understands that the dispute process is the path DEQ and NW Natural will follow to resolve source control design requirements.

I. DEQ should allow NW Natural to proceed with final design of Segment 1 extraction wells PW-3 through PW-6.

NW Natural's IDR proposes a source control measure that uses shoreline extraction wells to establish hydraulic containment and thereby prevent groundwater and DNAPL from migrating to the river. Extraction wells will be installed at ten locations in Segments 1 and 2 on NW Natural and Siltronic property. The wells will pump an average total of approximately 260 gallons per minute, and the groundwater will be treated on site and discharged to the river under a National Pollutant Discharge Elimination System (NPDES) permit. DEQ's June 11 direction instructs NW Natural to defer planned Segment 1 extraction wells PW-3 through PW-6 pending further evaluation in the upland FS. DEQ should allow NW Natural to complete final design and construction of PW-3 through PW-6.[3]

A. *The source control measures developed in the Interim Design Report will effectively reduce risk from groundwater discharging in the most contaminated area of the site.*

The most significant groundwater contamination at the Gasco site is present between the former tar pond area and the river, within the area that NW Natural and DEQ refer to as Segment 1. NW Natural proposes to locate extraction wells PW-3 through PW-6 in this area. Based upon water quality and flow data found in the IDR, a significant mass of dissolved manufactured gas plant (MGP)-related contaminants discharges daily to the river in the area of proposed extraction wells PW-3 through PW-6. Figure 1 shows the range of concentrations of benzene, naphthalene, and total cyanide in shoreline monitoring wells. The map shows that the concentrations of these constituents are orders of magnitude higher in Segment 1, especially in the vicinity of PW-3 through PW-6, than in Segments 2 and 3.

Control of groundwater discharge to the river, both load and flux, is a source control action that is a critical precedent to implementation of the in-water remedy. The performance of the pilot cap constructed as part of the 2005 in-water removal action demonstrates that a cap cannot be effective under current conditions in at least some portions of the sediments site. This is due to the ongoing groundwater transport of chemicals, both dissolved in groundwater and historically deposited in sediments in the vicinity of Segment 1. Even if contaminated sediments

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[3] Final design of the shoreline extraction well system could include additional wells as described in Section 1.A., *infra*.

were removed by dredging, groundwater flux of upland sourced chemicals alone would create ongoing impacts to the river. The source control action described in the IDR will control groundwater discharge necessary to implement the in-water remedy.

As we understand it, DEQ has directed NW Natural to postpone operation of extraction wells PW-3 through PW-6 because it is concerned that operation of those wells may mobilize DNAPL, and the IDR does not propose specific DNAPL control measures. Multiple studies [4,5,6] performed by NW Natural at DEQ's request demonstrate that short-term operation of these four extraction wells will not create a significant risk of DNAPL migration to the river before DNAPL-specific controls could be evaluated in the upland feasibility study and selected and implemented as a final remedy. DEQ, based upon a crude extrapolation between an assumed release date and the current location of observed DNAPL, estimates that horizontal DNAPL migration rates under non-pumping conditions range between 3.3 and 5.4 feet/year.[7] This estimate ignores sophisticated modeling performed by NW Natural at DEQ's request,[8] which calculated potential DNAPL migration rates under the pumping conditions and extraction well depths identified in the IDR.[9] That evaluation used conservative model conditions, including the assumption that capillary forces that would resist DNAPL flow are zero. The site MODFLOW model shows that horizontal groundwater gradients in the former effluent pond area under the shallow extraction well configuration increase by 0.01 and 0.02 while groundwater gradients increased by only 0.001 to 0.002 with intermediate depth extraction wells. The model results show that the range in the groundwater gradient in the former effluent pond area due to shallow and intermediate depth extraction well pumping would cause maximum distances of potential DNAPL migration over a three year period to range between approximately 5.2 and 10.4 feet (or 1.7 and 3.5 feet/year) using shallow extraction wells, and 0.5 to 1.0 feet (or 0.17 and 0.33 feet/year) for intermediate depth extraction wells. DEQ has not commented on the DNAPL migration findings in the March 2009 report.

More recently, in an effort to further allay DEQ's concerns about vertical DNAPL migration, NW Natural developed a preliminary alternative design that further reduces the potential for DNAPL movement by installing eight shallow extraction wells that are spaced approximately 100 feet apart in the shoreline area of wells PW-3 to PW-6. These closely spaced shallow wells will be able to achieve groundwater capture by pumping at a much lower single well discharge rate of approximately 5 gallons per minute. The proposed closer well spacing and

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[4] Anchor Environmental, LLC and S.S. Papadopulos, Inc (SSPI), 2008. Groundwater Flow Model and DNAPL Evaluation Supplemental Report, NW Natural, Gasco Site, prepared for NW Natural. October 2008

[5] Anchor QEA, 2009b. Evaluation of Potential DNAPL Mobilization in Former Effluent Pond Area by Shoreline Source Control Extraction Wells, Gasco Site, Portland, Oregon. Prepared by Anchor QEA, LLC, and SS Papadopulos, Inc. March, 2009.

[6] Anchor QEA and S.S. Papadopulos, Inc (SSPI), 2009. Groundwater Flow Model DNAPL Evaluation Supplemental Figures, NW Natural, Gasco Site, prepared for NW Natural. March 2009

[7] DEQ 2010a. March 26, 2010 DEQ comments on the Interim Design Report, Shoreline Segments 1 and 2, NW Natural Property and the Northern Portion of the Siltronic Corporation Property, Portland, Oregon, ECSI Nos. 84 and 183, p. 17

[8] Anchor QEA, 2009b. Evaluation of Potential DNAPL Mobilization in Former Effluent Pond Area by Shoreline Source Control Extraction Wells, Gasco Site, Portland, Oregon. Prepared by Anchor QEA, LLC, and SS Papadopulos, Inc. March, 2009.

[9] Anchor QEA, 2009a. Groundwater Source Control Interim Design Report. Prepared for NW Natural. Prepared by Anchor QEA, LLC. November 2009..

reduced single well pumping rate will result in much lower horizontal groundwater gradients and the shallow wells will induce upward vertical gradients in the DNAPL zones; thereby helping to restrict downward migration of DNAPL. The well layout and concept for this revised source control design was presented to DEQ in a May 17 meeting. NW Natural anticipates that source control extraction wells that are screened in DNAPL zones in Segment 1 will remove DNAPL and will result in migration and capture of DNAPL immediately adjacent to the extraction wells. NW Natural views such DNAPL removal as beneficial to site cleanup and consistent with source control remedial action objectives (RAOs). In summary, the maximum potential DNAPL migration rates calculated using conservative model assumptions are very small, which means that the Segment 1 source control wells can be safely implemented without risk of significant migration of DNAPL prior to implementation of the upland cleanup.

We want to reiterate that all investigations to date show that subsurface migration of DNAPL to the river has not occurred.[10] Offshore investigations indicate that DNAPL detected in shallow nearshore river sediments is not the result of subsurface migration of DNAPL from the former effluent pond area into river sediments.[11] As described in Section 2.1 of the *Offshore Investigation Report*, the extensive offshore investigations completed in 2007 indicated that the only DNAPL present in shoreline sediments is very shallow and is not the result of subsurface migration of DNAPL from the former effluent pond area into river sediments. For example, shoreline borings GS-01 through GS-12 conclusively demonstrate that DNAPL is absent in deep sediments, thereby showing that DNAPL detected in upland nearshore alluvium has not migrated into nearshore sediments over a period of more than 50 years since the MGP operation ceased.

Implementation of source control in the shoreline area between PW-3 and PW-6 has been a key NW Natural priority since 2005. In 2005, NW Natural identified this area of the Gasco shoreline as the primary area for source control using extraction wells for hydraulic containment.[12] In the *Groundwater Source Control Pilot Plan*,[13] NW Natural proposed to design and implement a multi-well pump and treat system to contain groundwater and DNAPL in Segment 1 by the end of 2007. Per DEQ's recommendation, NW Natural installed pilot extraction wells at only one location and did not implement an extraction system in Segment 1. In the *Groundwater/DNAPL Source Control Focused Feasibility Study* (GWFFS),[14] NW Natural proposed to complete DEQ-recommended design studies and begin construction of a source control containment system by August 2008. In its March 21, 2008 comments to the GWFFS, DEQ requested additional design studies and modeling. The requested design studies included a DNAPL mobility assessment. The design study findings are reflected in the *Preliminary Design Report for Groundwater Source Control*,[15] which proposed to complete source control design

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[10] Anchor QEA, 2009a. Groundwater Source Control Interim Design Report. Prepared for NW Natural. Prepared by Anchor QEA, LLC. November 2009.

[11] Anchor, 2008a. Offshore Investigation Report. NW Natural "Gasco" Site. Prepared for NW Natural. Prepared by Anchor Environmental L.L.C. February.

[12] Anchor, 2005. Preliminary Identification of Technologies and Alternatives for Groundwater Source Control NW Natural Gasco Facility. Prepared for NW Natural. Portland, Oregon. December 2005.

[13] Anchor, 2006. Groundwater Source Control Pilot Plan. NW Natural Gasco Facility. Prepared for NW Natural. Portland, Oregon. April 2006.

[14] Anchor, 2007. Gasco/Siltronic Groundwater and DNAPL Source Control Focused Feasibility Study. Prepared for NW Natural. November 2007.

[15] Anchor, 2008b. Preliminary Design Report, Groundwater Source Control. NW Natural Gasco Site. Prepared for NW Natural. Prepared by Anchor Environmental, L.L.C. June 2008.

and have source control extraction wells in place by November, 2009. In August 22, 2008, comments to the Preliminary Design Report, DEQ requested additional design studies. The IDR[16] incorporated the findings of the additional DEQ-requested design studies.[17,18] The IDR described NW Natural's preferred alternative, which is to design and install the hydraulic containment wells by October 2010, and to further consider the vertical barrier with other potential DNAPL remedies in the upland FS. The decision to consider the vertical barrier in the upland FS was based on the findings of the DNAPL mobility evaluations required by DEQ, which indicated any DNAPL migration would be very slow and allow ample time for further evaluation of the wall.

In summary, NW Natural has been advocating source control in Segment 1 for almost five years and, in the three years since the GWFFS was submitted, has spent approximately $2.7 million to conduct additional design studies requested by DEQ and complete the interim design. The source control alternative developed in the IDR is supported by the findings of the design studies requested by DEQ. The IDR findings and recommendations show that the unlikely risk of minimal DNAPL migration resulting from operation of the source control extraction wells prior to selection of a DNAPL remedy is outweighed by the high priority of containing significant ongoing mass loading of dissolved contaminants to the river in the vicinity of the former tar ponds.

B. *If DEQ will allow NW Natural to proceed with PW-3 through PW-6, NW Natural is willing to accept conservative risk assumptions in order to expedite remedy selection and further minimize the risk of DNAPL migration.*

NW Natural received DEQ's comments on the December 2004 "Revised Baseline Ecological and Human Health Risk Assessment Report"[19] on March 10, 2010. NW Natural disagrees with many of these comments, including:[20]

- Use of tar/oil presence to determine unacceptable risk or hotspots either directly for ecological or as a surrogate for human health.
- Use of total concentrations (summed constituents) for use in hotspot determinations.
- Conducting the riverbank screening as part of the upland risk assessment, rather than under EPA's process.

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[16] Anchor QEA, 2009a. Groundwater Source Control Interim Design Report. Prepared for NW Natural. Prepared by Anchor QEA, LLC. November 2009.

[17] Anchor Environmental, LLC and S.S. Papadopulos, Inc (SSPI), 2008. Groundwater Flow Model and DNAPL Evaluation Supplemental Report, NW Natural, Gasco Site, prepared for NW Natural. October 2008.

[18] Anchor QEA and S.S. Papadopulos, Inc (SSPI), 2009. Groundwater Flow Model DNAPL Evaluation Supplemental Figures, NW Natural, Gasco Site, prepared for NW Natural. March 2009

[19] Anchor. 2004. Revised Baseline Level III Ecological and Human Health Risk Assessment Report. NW Natural Gasco Site. Prepared for Northwest Natural. Prepared by Anchor Environmental, L.L.C. December.

[20] None of these requested evaluations, except including riverbank samples in the upland risk assessment, were previously proposed by DEQ during 4 years of risk assessment development from 2001 to 2005 which included the following submittals as required by DEQ or in response to DEQ comments on the previous submittal: a Level II Human Health and Ecological Risk Assessment (RA) in February 21, 2001; a Draft Risk Assessment Receptor/Pathway Selection Interim Technical Memorandum in October of 2001; a Draft Baseline Level III Ecological and Human Health Risk Assessment Report in June of 2003; and a Revised Baseline Ecological and Human Health Risk Assessment Report on December 15, 2004.

- Conducting the requested data gaps analyses or collection of data to support completion of the risk assessment (applies globally to all parameters including total petroleum hydrocarbon [TPH] fractions).
- Conducting a risk evaluation of alluvial groundwater, because the DEQ-approved Beneficial Water Use Determination (BWUD) for the site found that there are no upland beneficial uses of alluvial groundwater, and DEQ has not identified new information that supports a revision to the BWUD consistent with DEQ rules or guidance.
- Developing cyanide soil screening level values (SLVs) for ecological screening.
- Developing cyanide mammalian or bird drinking water or soil no observed apparent effects levels (NOAELs) or lowest observed apparent effects levels (LOAELs) for the ecological screening.
- Evaluating stormwater ponding in the FAMM tank basin as part of the ecological risk screening of surface water. There is no significant water ponding in this area.
- Screening pond soil samples (located in the Former Tar Ponds Area) against sediment toxicity values.
- Delineation of wetlands within the tar ponds area.
- Including Siltronic data in Gasco screening for air volatilization risks.
- Screening total cyanide water data against free cyanide criteria.
- Using residential risk based calculations (RBCs) for human health screening.

Implementation of the risk assessment consistent with all DEQ comments would require several years to conduct, given that the March 10 DEQ letter requires new evaluations including: additional data collection and evaluation, gathering and assessment of non-standard toxicity values, inclusion of Siltronic groundwater data in the Gasco risk assessment, inclusion of additional chemicals, evaluation of the site for additional aquatic or semi-aquatic receptors, evaluation of deep groundwater exposures that do not reasonably exist at the site, evaluation of shallow groundwater as a surrogate for surface water exposures, and other additional screening steps. These requirements, together with DEQ's current direction on source control, mean that the upland FS will not start for several years, and the most seriously contaminated groundwater at the site will continue to discharge to the river for many more years.

In an effort to address DEQ's concerns about potential migration of DNAPL and reach agreement with DEQ on operation of the PW-3 through PW-6 wells, NW Natural has offered to compromise on some of the risk assessment methods by making extremely conservative assumptions.[21] For example, NW Natural has offered to assume that soil throughout the entire former tar pond area constitutes a "hot spot" of contamination, that all shallow groundwater poses unacceptable risk, and that seasonal ponds contain fish that will be consumed by humans. NW Natural is willing to complete the risk assessment on the basis of these conservative assumptions in order to expedite the upland FS and provide a shorter window of time between start up of the source control extraction wells and selection of a DNAPL remedy in the upland FS.

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[21] Anchor QEA, 2010. Memorandum Re: Gasco Upland – Proposal on Risk Methods. From Ben Hung and Amy Nelson, Anchor QEA to Dana Bayuk, Oregon Department of Environmental Quality. Dated June 21, 2010.

II. Alternatively, DEQ should select a different source control action that provides full source control across Segments 1 and 2 of the Gasco site.

For all of the reasons described above, NW Natural continues to believe that groundwater source control in the vicinity of the former tar pond area should be implemented as soon as possible. If DEQ will not accept the source control measures developed in the IDR, or as they may be modified in the final design (e.g. the preliminary alternative design discussed in Section I.A above), DEQ should select a different source control action that will attain full source control across the shoreline in Segments 1 and 2. The 2007 GWFFS is adequate to support DEQ selection of an alternative source control action. DEQ's June 2010 direction is not supported by the 2007 GWFFS or DEQ's comments on that document.

DEQ guidance recommends preparation of an engineering evaluation and cost analysis (EE/CA) "to provide sufficient information regarding the protectiveness and feasibility of removal action options."[22] In May 2005,[23] DEQ asked NW Natural to prepare an EE/CA "to identify and evaluate source control measures necessary to control the migration of contaminants in site groundwater (both dissolved and as nonaqueous phase liquids) to the Willamette River." In compliance with this directive, NW Natural prepared the 2007 GWFFS. The GWFFS was largely modeled on EPA EE/CA guidance,[24] which also assumes that the regulatory agency will "propose the removal action as a result of the EE/CA process."[25] DEQ conditionally approved the GWFFS in March 2008.[26]

DEQ did not ask NW Natural to evaluate the source control measure it is now directing as an alternative in the GWFFS, and the approved GWFFS does not do so. DEQ's comments on the IDR were the first time that a split system of extraction wells has been proposed as an alternative. As Figure 1 shows, extraction wells PW-1 and PW-2 are on Siltronic property, and wells PW-7, -8, -9, and -10 are hundreds of feet away on the north end of the NW Natural shoreline. By directing NW Natural to not install extraction wells PW-3, -4, -5, and -6, DEQ is creating a gap of approximately 900 feet between extraction wells PW-2 and PW-7. This large gap will result in two completely disconnected capture zones that were not evaluated in the GWFFS, the Preliminary Design Report, or the IDR and have not been modeled or studied. The groundwater capture pattern, groundwater flow direction, and contaminant migration that would result from operating two separate sets of extraction wells are unknown at this time. The DEQ-approved MODFLOW model would have to be revised, and complete redesign of the containment system would be required before such a system could be considered. Conducting a complete redesign of the source control system would put the source control project back to the Preliminary Design stage (i.e., 2 years ago). NW Natural estimates that it would take at least three years to implement the new wells consistent with DEQ's direction, including DEQ review and approval of the new preliminary, interim, and final design documents, obtaining permits, and construction of the new system.

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[22] Guidance for Conducting Feasibility Studies (DEQ 2008).

[23] NW Natural, 2005. May 24, 2005 letter from NW Natural to Matt McClincy, DEQ. Re: May 19, 2005 Meeting.

[24] DEQ has no regulation or guidance concerning EE/CA preparation or content.

[25] *Guidance on Conducting Non-Time Critical Removal Actions Under CERCLA*. EPA, August 1993.

[26] DEQ, 2008. March 21, 2008 letter from DEQ to NW Natural. Re: Groundwater/DNAPL Focused Feasibility Study Shoreline Segments 1 and 2, NW Natural Property and the Northern Portion of the Siltronic Corporation Property, Northwest Natural Gas Company, Portland OR, p. 3.

Oregon law generally requires an agency to follow its own stated positions and prior practice. *See, e.g.*, ORS 183.484(5)(b)(B). Five years into the established process for selecting a removal action, DEQ has discarded the GWFFS, as well as its own and EPA guidance for selection of a removal action without explanation. If DEQ will not accept the source control alternative recommended by NW Natural, it should select another alternative from the approved GWFFS.

III. <u>If DEQ rejects the NW Natural recommended source control alternative and related proposed compromises on risk assessment, DEQ and NW Natural will need to resolve many additional risk assessment issues.</u>

NW Natural has proposed conservative risk approaches that we do not technically agree with but are willing to accept solely because it allows us to expedite initiation of the FS to shorten the window of time between implementation of the hydraulic containment system it has proposed across Segments 1 and 2 and selection of a DNAPL remedy, thereby minimizing the risk of DNAPL migration.[27] If DEQ rejects NW Natural's recommended source control alternative, NW Natural will seek resolution of all of the issues listed in Section 1.B above in a technically sound manner consistent with applicable rules and guidance. Some of the issues we will need to resolve are:

- Defining hot spots within the tar ponds area. In the June 21 memo, NW Natural proposed to assume that the entire tar ponds area is a hotspot. Instead, we may propose identifying hot spots consistent with DEQ guidance including mapping of single chemicals (not summed or totaled chemicals) exceeding 10^{-4} cancer risk on a point by point basis to identify hot spot areas within the tar ponds area.
- Including additional contaminants of interest (COIs) in the risk screening. The June 21 memo describes a method of revising the COI list for future screening to include all past risk document COIs. Instead, we may propose determining the COI list based on the results of past screening efforts that have been previously reviewed by DEQ.
- Approach for incorporating TPH fractionation in the risk assessment. The June 21 memo proposes that any exceedance of an individual polycyclic aromatic hydrocarbon (PAH) screening level is assumed to be an exceedance of TPH criteria. We note that DEQ's comments on prior drafts of the risk assessment and related documents agreed that the data set for the human health risk assessment was complete and did not request the collection and evaluation of TPH fractionation data, even in comments issued after the guidance on TPH fractionation was issued.[28] Therefore, we strongly object to any requirement to collect TPH data.
- Approach for soils data screening. The June 21 memo proposes that soil data be screened using deeper soil data to represent shallower soil conditions (0 to 3.5-foot below ground surface [bgs] for ecological and 0 to 3-foot bgs for human health) where only 0 to 0.2-foot surface interval or no surface interval data are available in the same core. Instead, we may propose using the surface soil data set as available and used in previously DEQ reviewed documents for surface soil screening.

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[27] Anchor QEA, 2010. Memorandum Re: Gasco Upland – Proposal on Risk Methods. From Ben Hung and Amy Nelson, Anchor QEA to Dana Bayuk, Oregon Department of Environmental Quality. Dated June 21, 2010.
[28] *See, e.g.*, E. Blischke to Wyatt, March 15, 2002; McClincy to Wyatt, January 13, 2004 (comments on June 2003 draft risk assessment).

- Approach for evaluating groundwater risks. The June 21 memo proposes to assume unacceptable risk in shallow groundwater. Instead, we may propose screening shallow groundwater against risk based calculations (RBCs) for reasonably likely site use exposures consistent with DEQ guidance.
- Approach to risk assessment for LNG basin surface water screening. The June 21 memo proposes to screen shallow groundwater near the liquefied natural gas (LNG) basin as a surrogate for surface water screening. Instead, we may propose to screen only the existing surface water data set, given that groundwater is not likely to be representative of actual surface water exposures in the LNG basin.
- Approach to risk assessment for surface water screening. The June 21 memo proposes to use human health state and federal surface water quality criteria for surface water screening. Instead, we may propose, given these criteria are based on fish consumption and fish do not exist in these surface water features, that surface water should only be screened using readily available screening values that are consistent with site receptors and exposures.

It should be noted that the comments in DEQ's March 10, 2010 letter are extensive and the above list is not intended to capture all NW Natural proposals that may be retracted if NW Natural's preferred source control alternative is rejected by DEQ.

As a policy matter, NW Natural has worked cooperatively and collaboratively with DEQ on the Gasco site since 1996. At DEQ's direction, NW Natural has invested millions of dollars in the investigation of the site with the mutual goal of those studies being site remedy selection and construction. In 2005, NW Natural agreed with DEQ that source control at Gasco was a time critical remediation need, particularly in the zone related to the petroleum compound groundwater plume from the former MGP area. One primary reason for expediting a groundwater source control decision at Gasco was to have a significant contaminant transport pathway controlled in advance of EPA sediment remediation decisions. In recognition of this urgency, NW Natural agreed to produce a separate source control evaluation and design while concurrently working on the upland FS. At that time (2005), we also restated our concern that we had not yet received comments on the risk assessment, which prevented us from starting the upland FS, and we renewed our offer to pay for a DEQ consultant to review it. The offer of funding a DEQ consultant was again declined by DEQ, and today NW Natural remains unable to initiate the upland FS until the risk assessment issues are resolved.

NW Natural believes it has provided sufficient data, technical assessments and reports, models, supplemental information, and design studies for DEQ to make a source control decision

for the entire length of the Gasco shoreline and to allow the risk assessment to be finalized for use in developing the upland FS. NW Natural is ready to initiate clean up at the Gasco site.

Sincerely,

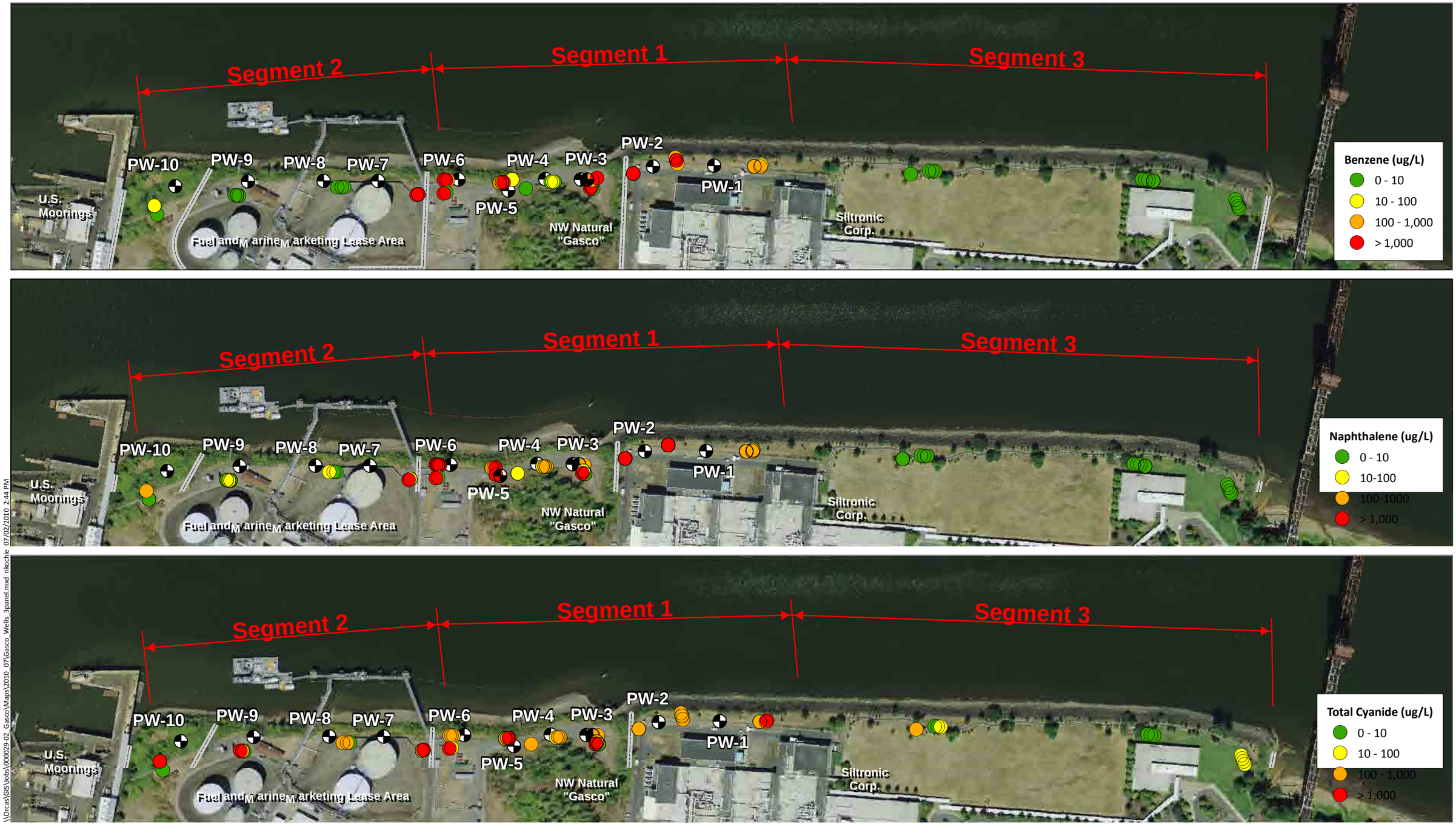
Robert J. Wyatt

cc: Margaret Kirkpatrick, NW Natural
Dana Bayuk, Oregon Department of Environmental Quality
Kurt Burkholder, Oregon Department of Justice
Patricia Dost, Pearl Legal Group

Attachments

Figure 1

NW Natural Response to Comments on IDR (Updated Figures Provided on CD)



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ANCHOR QEA

DRAFT

NOTES:
1. Data shown based on highest concentration from Equis database through 2009.
2. Aerial imagery from July 2007.

Proposed and Existing Extraction Well

Property Line

Feet
0 150 300 450 600

Figure 1
Gasco/Siltronic Monitoring Well Data

Response to DEQ March 26, 2010 Comments on Interim Design Report, dated November 2009, and Pilot Study Report, dated December 2009

DEQ Comment	NW Natural Response
General Comments - Interim Design Report	
1a. **Vertical Barrier and Uplands Feasibility Study.** Based on the information summarized above, DEQ approves NW Natural's proposal to defer evaluation of the vertical barrier and DNAPL removal SCMs to the uplands FS. Furthermore, NW Natural should postpone installation of extraction wells PW-3 through PW-6 to the uplands FS so HC&C along this portion of the shoreline can be evaluated in the context of DNAPL remedial action alternatives.	By moving these Segment 1 extraction wells to the Uplands FS, DEQ is essentially postponing the implementation of source control in that portion of Segment 1 for a period of at least 3 to 5 years. This forecasted time period for the Uplands FS, remedy design, permitting, and construction is based on the number of years needed to take the Gasco source control 2007 GWFFS to the current stage of source control design. For this reason, NW Natural does not accept DEQ's recommendation to postpone installation and operation of the extraction wells in the Gasco portion of Segment 1. Instead, NW Natural has proposed to revise the design of the extraction well system to further reduce the potential for migration of DNAPL. This proposal is explained in more detail later in these responses.
1b. NW Natural should be advised that source control RAO #1 will be an RAO in the uplands FS. DEQ's acceptance of NW Natural's recommendation to postpone final design and construction of the vertical barrier pending the outcome of the uplands FS is subject to the following conditions: • A barrier must be carried forward into the detailed analysis of remedial action alternatives for RAO #1 in the uplands FS; and • The vertical barrier carried forward into detailed analysis will be 625 feet long and constructed using sheet pile methods to a depth of -60 feet City of Portland datum (COP).	NW Natural agrees with carrying RAO No. 1 forward into the Uplands FS and the previously-described two conditions related to carrying forward the vertical barrier into the Uplands FS.
2. Groundwater Modeling. As indicated on DEQ's letter dated January 10, 2010, NW Natural should use test data	NW Natural agrees that data from the well tests will be considered in final design of the HC&C system.

DEQ Comment	NW Natural Response
to assess the lateral and vertical influence of pumping test wells on the fill WBZ and alluvial WBZ. NW Natural's final data interpretations, conclusions, and analysis of the tests, including the results of any groundwater modeling, should be incorporated into the HC&C system final design document.	
3a. **Hydraulic Control and Containment System.** Extraction wells PW-1 PW-2, PW-7, and PW-8. NW Natural should prepare figures for the final design document showing how the locations of these extraction wells relate to groundwater contamination as shown by data collected from uplands monitoring wells (not nearshore borings). The figures should show extraction wells with MGP and VOC COI along cross-section A-A'. The MGP and VOC COI shown in the figures should include, but not necessarily be limited to, benzene, naphthalene, total cyanide, and vinyl chloride, and the rational for selecting COI must be provided. In preparing the figures, NW Natural should use reconnaissance groundwater data as needed to fill data gaps. For example, the VOC Plume FFS1 prepared by Siltronic provides cross-sectional views of VOCs, including trichloroethene, cis-1,2-dichloroethene, and vinyl chloride, that are useful for locating extraction wells PW-1 and PW-2 (see figures 1-3a, 1-3b, and 1-3c).	Figure 2-10 in the Interim Design Report (IDR) shows the distribution of dissolved benzene, naphthalene, total cyanide, and free cyanide in monitoring wells along the shoreline. In response to DEQ comments, NW Natural has made some draft revisions to Figure 2-10, including extension of the profile to a portion of Segment 3, addition of data from reconnaissance borings, and vinyl chloride data. In coordination with DEQ we plan to add proposed extraction well screens to the diagram during the final design process. The draft Figure 2-10 is attached to this response document along with the other figures that have been revised at DEQ's request. The proposed extraction well screen elevations in the IDR were primarily selected based on MODFLOW evaluations to attain vertical capture. NW Natural would like to discuss with DEQ the concept and design basis for revising the screen elevations for this purpose.
3b. **Additional Extraction Well.** Figure 2-10 summarizes	This issue seems to be related to determining the boundary

[1] Maul Foster and Alongi, Inc., 2007. "Focused Feasibility Study - Siltronic Corporation, Portland, Oregon." October 23, 2007. Amended December 19, 2007. Prepared for Siltronic Corporation.

DEQ Comment	NW Natural Response
groundwater data for selected MGP COI collected from monitoring wells located in the upstream portion of shoreline Segment 2 and the length of Segment 1. Detected concentrations of total and free cyanide between approximately 0 and -80 feet in elevation exceed Joint Source Control Strategy2 (JSCS) criteria upstream of the WS-8 and WS12 monitoring well clusters. This comment also applies to detected concentrations of VOCs. Furthermore, the capture zone for extraction well PW-1 shown by Figure 4-2 does not appear to extend far enough upstream to intercept groundwater contamination documented at the WS-8 and WS-12 monitoring clusters (i.e., groundwater in the alluvial WBZ contaminated by MGP and VOC COI could by-pass the HC&C system on the upstream side). Based on this information an additional extraction well may be warranted upstream of PW-1. The need for an additional extraction well should be fully evaluated in the final design document.	between the Segment 1 and Segment 3 source control zones. NW Natural would like to discuss with DEQ the criteria that DEQ is using to determine the Segment 1 source control capture boundary and how that analysis relates to the Segment 3 Source Control Evaluation Report that was submitted to DEQ in February, 2009. NW Natural has not received comments from DEQ on that report. As described in NW Natural response 3a, NW Natural has prepared a draft revision of Figure 2-10 that extends the figure to include additional groundwater quality data on both sides of the boundary between Segments 1 and 3. The draft revision of Figure 2-10 is attached along with the other IDR figures that have been revised. If necessary, NW Natural could consider the two options of increasing the flow rate from extraction well PW-1 or adding an extraction well. Either of those options would result in increased groundwater flow to the treatment system.
3c. Based on the information provided in the Interim Design Report, and consistent with determinations made previously, DEQ does not approve: 1) drilling and installation of extraction wells PW-4, PW-5, and PW-6; or 2) operation of PW-3-81 and PW-3-118. DEQ considers it likely HC&C will be carried forward into detailed analysis of remedial action alternatives in the uplands FS.	NW Natural considers implementing containment of the dissolved groundwater plume as soon as possible throughout Segment 1 a very important goal. Deferring the Segment 1 extraction wells to the Uplands FS would likely mean that the Segment 1 wells would not be installed and operated before at least 2013 to 2015. This jeopardizes NW Natural's ability to implement control of the dissolved plume prior to the in-river

[2] EPA and DEQ, 2005, "Portland Harbor Joint Source Control Strategy – Final." December 2005. Revised July 16, 2007. Prepared by the U.S. Environmental Protection Agency (EPA) and DEQ.

DEQ Comment	NW Natural Response
For the most impacted portion of Segment 1, the uplands FS should evaluate the locations, depths, timing of construction, and operation of extraction wells with DNAPL remedial action alternatives.	sediment remedy. DEQ's recommendation to defer Segment 1 source control also allows the continued discharge of contaminated groundwater to the river for 3 to 5 years. Therefore, NW Natural proposes to work with DEQ to modify the design of the planned Segment 1 extraction wells. The basic components of the proposed revision were presented to DEQ at the May 17, 2010, meeting. The goal of the modifications would be to design a system that allows control of the dissolved groundwater plume to be implemented in a way that minimizes any potential for DNAPL migration. The redesigned system would include paired extraction wells, with both shallow and intermediate depth extraction wells in the alluvium. The effect of operating additional shallow extraction wells will also be evaluated. By reducing the lateral spacing between the shallow extraction wells, the required pumping rate from each well could be significantly reduced, thereby greatly reducing the vertical and horizontal groundwater gradients. The added shallow extraction wells would induce an upward vertical gradient in the DNAPL zones, thereby further reducing the potential for migration.
4. **Section 1.1.** Although detailed review comments were not provided, via a June 5, 2009 letter DEQ informed NW Natural the…[Gradient Evaluation Report3 and the DNAPL Mobilization Evaluation4] provide a technical	DEQ has not provided technical comments on those two DEQ-requested DNAPL evaluations. If DEQ had provided technical comments on the issues of extraction well depth, vertical gradients, and DEQ's concern about DNAPL migration, it is likely

[3] Anchor QEA, 2008. "Groundwater Flow Model and DNAPL Evaluation Supplemental Report." October 2008. Supplemented on March 26, 2009. Prepared for NW Natural.

[4] Anchor QEA, 2009. "Evaluation of Potential DNAPL Mobilization in Former Effluent Pond Area by Shoreline Source Control Extraction Wells, Gasco Site, Portland, Oregon." Technical Memorandum. March 18, 2009. Prepared for NW Natural.

DEQ Comment	NW Natural Response
basis for: 1) carrying -60 feet msl forward into the Interim Design Report as the design elevation for the bottom of the vertical barrier; and 2) moving forward with developing plans and schedules to implement uplands DNAPL removal after construction of the vertical barrier and HC&C SCMs.	that NW Natural would have considered those comments when developing the extraction well design presented in the IDR. In that case, an extraction well design that satisfies DEQ's concerns about DNAPL migration could have been developed and presented in the IDR. NW Natural believes that such a design can still be developed during the final design process.
5. **Section 1.2.** NW Natural is currently conducting an evaluation of the influence of pumping uplands test wells on groundwater levels beneath the river in Segment 2. These tests will provide information to preliminarily assess the capability of extraction wells in the alluvial WBZ to influence shallow groundwater in the fill WBZ. DEQ expects this information to be fully incorporated into the final SCMs design document.	Section 4.2.2.1.1 of the IDR describes the design concept for containment of groundwater in the Fill WBZ as follows. *"Containment of groundwater in the Fill WBZ is also a goal of source control. Table 4-4 and Figures 2-3a, b, and c in the IDR show that there will be multiple monitoring wells along the shoreline being used to assess the effect of the extraction wells on water levels in the Fill WBZ. Monitoring of these wells will show decline in groundwater levels in the Fill WBZ due to the increased downward hydraulic gradient caused by the extraction wells. It is likely that most of the upland area of the Site will be paved as part of upland cleanup and stormwater management actions. The paving should stop most of the infiltration recharge to the Fill WBZ, causing further decline in Fill WBZ groundwater levels. The current plan is to monitor the effect of the Alluvium WBZ extraction wells and the effect of future paving to evaluate the need for additional measures to control groundwater in the Fill WBZ. If sufficient decline in Fill WBZ groundwater levels is not observed, contingency measures for this WBZ would be implemented at that time."*
6. **Section 1.3.** NW Natural uses the term "riverbank	By using the term "riverbank stabilization," NW Natural did not

DEQ Comment	NW Natural Response
stabilization" throughout this section of the Interim Design Report. The term pre-supposes one type of riverbank remedial alternative and should be revised to reference "riverbank cleanup." NW Natural will also need to develop an approach for evaluating the effectiveness of the upland remedy against performance standards for COI. Groundwater in the fill WBZ represents a complete high priority contaminant transport pathway from the uplands into the in-water sediment project area. As such, measuring groundwater flux should also be included as a performance monitoring criterion for the remedy. For clarification, mitigating groundwater flux to the river via the fill WBZ is an uplands source control RAO and is subject to DEQ oversight.	intend to limit the remediation options that will be considered for this area and will now consider changing the terminology. NW Natural is not sure what DEQ means by the phrase "performance standards for COI" and requests clarification from DEQ. NW Natural's source control performance monitoring methodology is to use groundwater gradients to assess hydraulic containment of groundwater. If that is what DEQ is referring to by groundwater "flux," then NW Natural agrees.
7. **Section 1.4.** DEQ disagrees with two assertions made by NW Natural in the fourth paragraph of this section. NW Natural indicates that, "...upland DNAPL is not currently discharging to river sediment via subsurface pathways," and that, "...the distribution of upland DNAPL will not be significantly impacted by operation of the source control wells..." DEQ addresses these assertions in our comments to Section 2.1.3 (second paragraph), Section 4.2.1.4, and in the General Comments.	Regarding the issue of alleged subsurface DNAPL discharge to the river, please refer to NW Natural response 11b, on Section 2.1.3, 2nd paragraph. Regarding the issue of DNAPL being affected by operation of the source control wells, please refer to NW Natural's response 29, on Section 4.2.1.4.
8a. **Section 2.1.1.** This section of the Interim Design Report references numerous geologic cross-sections. DEQ requests an additional cross-section be developed for the final design document which depicts the area of deeper	We will prepare this cross-section after talking to DEQ to clarify the location of the section and which wells/borings should be used to prepare the section. These clarifications are needed because this requested cross-section is between adjacent sections

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DNAPL occurrence between borings TG-10 to B-4B shown on Figure 2-3b. This additional cross-section would be drawn between existing cross-sections D and E.	D-D′ (Figure 2-6) and E-E′(Figure 2-7) in the IDR, so we want to make sure we understand the details of this request.
8b. **Section 2.1.1, 5th and 6th paragraphs.** The Interim Design Report indicates, "The basalt is a no-flow boundary in the MODFLOW model that has been developed by SS Papadopulos (SSPA) for the site." This assertion is in error. The revised groundwater model report[5] indicates, "As described on page 22 of the model summary report, the basalt is not a no-flow boundary. The basalt contributes flow to the model through the upgradient specified head boundary." In addition, observations made during decommissioning of cathodic protection boreholes provide site-specific evidence the basalt recharges the alluvial WBZ. During decommissioning, water-bearing zones were observed in the basalt at approximately 80 feet bgs, and by downhole video surveys between 106 and 145 feet bgs. These zones occur at depth intervals that project horizontally into the alluvial WBZ. Based on the results of modeling and seepage meter data, groundwater flux through the alluvial WBZ into the river was estimated to be approximately 250 gpm.	The text will be changed to reflect the groundwater modeling report. With respect to data from decommissioning of cathodic protection boreholes, NW Natural will review available information to see if it affects the interpretation of the site hydrogeology and the model boundary conditions.
8c. **Section 2.1.1, 6th paragraph.** The Interim Design Report indicates, "Groundwater in the Fill WBZ recharges the underlying alluvium and discharges to the river." DEQ concurs with NW Natural's conclusions that where the	Refer to previous NW Natural's response 5 on Section 1.2. NW Natural expects to pave the site as part of site wide upland cleanup and future use of the property. This will facilitate

[5] Anchor QEA, 2008. "NW Natural Groundwater Model." April 25, 2008. Prepared for NW Natural.

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upper silt unit is thin, absent, or penetrated by secondary porosity (e.g., root and/or rootlet voids) groundwater in the fill WBZ would tend to migrate vertically downward. Based on data collected on the NW Natural and Siltronic properties, vertical migration through the silt unit by DNAPL and contaminated groundwater has been observed and documented. Although vertical groundwater migration through the silt has been documented, based on available information, including from dewatering the LNG tank basin, DEQ interprets overall groundwater flux through the fill WBZ to be laterally directed towards the river. The magnitude and timing of groundwater flux through the fill WBZ represents an information need for uplands SCMs planning and design. When the results of the evaluation NW Natural is conducting to assess the influence of pumping test wells on groundwater levels under the river are available, SCMs alternatives for the fill WBZ will need to be identified in the final design document and further evaluated in the uplands FS.	management of stormwater quality, prevent direct exposure of site workers to shallow site soils, and prevent recharge of the Fill WBZ from infiltration of precipitation. The combined effects of paving the site and operating the source control extraction wells will dry up the Fill WBZ, or at least greatly reduce the saturated thickness of the Fill WBZ. NW Natural will monitor water levels in the Fill WBZ during implementation of source control and the upland cleanup. If groundwater elevations in the Fill WBZ following source control and upland cleanup indicate that contaminated groundwater from the Fill WBZ is discharging to the river, then additional source control measures to contain those areas of Fill WBZ discharge will be implemented at that time. NW Natural cannot design an effective Fill WBZ source control measure until specific knowledge of the effect of source control and upland cleanup measures on the hydrology of the Fill WBZ is obtained. The source control final design will include an identification of potential Fill WBZ hydraulic containment measures that would be considered in the event that source control and upland cleanup measures do not provide full containment of the Fill WBZ along the river shoreline. NW Natural will consider the findings from the ongoing capture zone tests being conducted in Segment 2 extraction wells PW-7, PW-8, and PW-9, which may provide data to supplement the evaluation of source control alternatives for the Fill WBZ.
9. **Section 2.1.2.** DEQ notes the silt unit directly underlying the surficial fill is not mentioned in this section of the report. The silt unit comprises the upper-most material of the alluvium. Not mentioning the upper silt unit appears to be an oversight as NW Natural and DEQ	Agreed.

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acknowledge it influences the nature and extent of contamination in the surficial fill, including the distribution of DNAPL. From a hydrogeologic standpoint the upper silt unit is considered the boundary between the fill WBZ and the alluvial WBZ. The configuration of the top of the upper silt unit, as well as its thickness and hydraulic properties influence the horizontal movement of MGP DNAPL and shallow groundwater in the fill WBZ, and the vertical migration of DNAPL and groundwater from the surficial fill WBZ into the alluvial WBZ. A description of the geology and hydrogeology of the upper silt unit should be included in the final design document for completeness.	
10. **Section 2.1.2.1.** NW Natural's interpretation of the presence of a hydrogeologically significant silt unit is presented in this section of the Interim Design Report. DEQ understands NW Natural relied on observations made during drilling of the shoreline monitoring wells and TarGOST® logs in interpreting the depth, thickness, and lateral extent of the silt unit. DEQ provides preliminary concurrence with NW Natural's interpretations regarding "lower" silt unit based on drilling observations. However, DEQ is not aware of work done by NW Natural to correlate TarGOST® logging data to the subsurface geology of the site. This information should be provided as a supplement to Appendix H to document NW Natural's basis for interpreting silt unit occurrence and for completeness.	As part of the implementation of TarGost at the site, HAI made a comparison of initial TarGOST/CPT results to the geology logged in nearby borings that were advanced using traditional soil sampling methods. This work showed that the CPT method was a reliable indicator for differentiating sand and silt layers in the alluvium. The findings of those comparisons will be included in a supplement to the Final Design Report.
11a. **Section 2.1.3, 1st paragraph.** Regardless of seasonal	Groundwater modeling has been conducted in transient mode

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variations in groundwater flux or the potential for additional sources of water to be added to the treatment process (e.g., fill WBZ, LNG tank basin), groundwater source control planning accommodated uncertainties through designing the treatment system for 400 gpm. NW Natural should confirm DEQ's understanding or provide clarifying information.	and these results have been presented to DEQ. In a March 21, 2008 letter DEQ requested that NW Natural apply the groundwater model to the PW-4 pump test and show whether the model could simulate the drawdown at MW-5-175. The pump test extended over several tidal cycles. The model was applied over the duration of the pump test and included the tidal fluctuations over the duration of the test. The model results were presented to DEQ in the Additional Groundwater Flow Analysis memorandum, April 25, 2008. Further transient simulations are expected as part of the pump test analysis of PW-7, PW-8 and PW-9, which are in progress.
11b. **Section 2.1.3, 2nd paragraph.** NW Natural summarizes their conclusions regarding the distribution and source of DNAPL observed during offshore investigations in this paragraph, asserting, "...DNAPL has not migrated from the upland alluvium into river sediments." NW Natural further indicates DNAPL in sediments, "...is sourced from direct discharge of MGP residuals from upland waste management areas into the river, not from DNAPL migration from the upland Alluvium WBZ." DEQ disagrees with NW Natural's conclusions about the distribution of MGP DNAPL in river sediment. As shown by figures 2-12a and 2-12b, the borings on which NW Natural bases its assertions are approximately 200 feet apart. In other words, there are too few borings spaced too widely apart to support NW Natural's assertions made in this section, Section 3.1, and Section 3.3.1. Furthermore, based on DEQ's review of the Offshore Investigation Report, evidence of MGP DNAPL	The IDR is not the first document where NW Natural has stated that DNAPL in river sediments is the result of direct discharge from upland industrial operations to the river, not from subsurface migration of DNAPL to the river. The absence of connection between upland DNAPL and DNAPL in river sediments was demonstrated in the Offshore Investigation Report (Anchor QEA 2008) and in the DEQ-requested Evaluation of Potential DNAPL Mobilization in Former Effluent Pond Area by Shoreline Source Control Extraction Wells (Anchor QEA 2009). The somewhat deeper detection of DNAPL at GS-09 is likely due to two factors. Historic aerial photos show and the Gasco RI Report (HAI 2007) describe a drainage channel at the location of GS-09. The drainage channel carried upland runoff to the river, including industrial waste materials from MGP operations. The somewhat deeper detection of DNAPL at that location is likely due to the incised depth of the former drainage channel at that location. Furthermore, the GS-09 boring is adjacent to the dock structure that was used to moor ships and barges up until the late

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having migrated from uplands source areas out under the river exists at one of the nearshore drilling locations. Field measurements made during drilling of Boring GS-09 detected DNAPL approximately 10 feet deeper than the bottom of MGP material reasonably interpreted as resulting from direct discharge/placement (i.e., approximately 10 feet deeper than –17 feet COP). Figures 2-12a and 2-12b of the Interim Design Report show the deeper occurrence of DNAPL measured at GS-09.	1970s, as shown on a 1971 historic aerial photo in the 2007 RI Report. It is possible that the sediments adjacent to the dock were dredged to maintain the necessary depth for ship mooring. These two factors likely account for the deeper DNAPL detections at the GS-09 location and are consistent with the conceptual site model. Deeper upland DNAPL was not detected at GS-09, even though the boring is directly offshore from NW Natural and Siltronic upland borings where DNAPL was detected. Offshore boring GS-10 is directly offshore from upland Siltronic borings that detected deep DNAPL, but DNAPL was not detected in GS-10. Although DEQ states that the offshore boring locations are too far apart and that DNAPL could have migrated between the borings, NW Natural specifically designed the offshore boring locations to be directly offshore from deep DNAPL detected in the uplands. Although DEQ apparently feels that information from the offshore borings does not support NW Natural's conclusions, DEQ has not provided a technical basis for that opinion. NW Natural has not changed its conclusion derived from the offshore boring data that DNAPL has not migrated from subsurface sources to the river channel.
12. **Section 2.2.** DEQ notes the Army Corps of Engineers U.S. Moorings facility adjoins the NW Natural Property to the north.	Comment noted.
13a. **Section 3.1, 2nd paragraph**. Based on DEQ's review, the Interim Design Report is incomplete as engineering controls for the fill WBZ and shallow extraction wells located behind the vertical barrier are not included in the document. For clarification, DEQ is accepting the Interim	NW Natural's design concept for the Fill WBZ is presented in the IDR and is further clarified in NW Natural's response 5, on Section 1.2 and response 8c, on Section 2.1.1, 6th paragraph). As described in the NW Natural response 1a on DEQ's General Comment, it is NW Natural's intent to submit modifications to the

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	Design Report due to our: 1) approval of NW Natural's proposal to defer the vertical barrier to the uplands FS, and 2) determination that HC&C behind the barrier should also be deferred to the FS and evaluated in the context of DNAPL remedial action alternatives. The status of evaluating source control of the fill WBZ and the information needed for source control planning are discussed in DEQ's General Comments and comments to sections 1.2, 1.3, and 2.1.1.	Segment 1 extraction well design that will address DEQ's concern about DNAPL migration. NW Natural disagrees that the IDR is incomplete or in any way inconsistent with any prior DEQ direction.
13b.	**Section 3.1, 4th paragraph.** DEQ's comments to the second paragraph of Section 2.1.3 apply here.	See NW Natural's response 11b on Section 2.1.3, 2nd paragraph.
14.	**Section 3.2.1.** For clarification, DNAPL detected in the alluvium (i.e., below the top of the upper silt unit) must be mobile. According to information provided by NW Natural in a variety of documents, MGP waste management areas on the NW Natural and Siltronic properties occur entirely within the fill (i.e., above the top of the upper silt unit whether modified by historic site operations or not). For MGP DNAPL to be detected in the alluvium by the TarGOST® logging equipment, the material must have migrated to the location.	NW Natural is not clear what technical point DEQ is trying to make in this comment. . Review of the historic aerial photos in Appendix A of the 2007 RI Report clearly show that extensive liquid waste management, including wastewater ponds and runoff areas were present prior to the site filling with dredge spoils that occurred circa 1940. Even the 1940 fill activities were mostly restricted to the western part of the former MGP operations area, and a significant area in the eastern portion of the site did not have fill placed in 1940. That unfilled area had significant waste management activities on the former ground surface (i.e., alluvium) prior to subsequent filling operations. DEQ is oversimplifying the waste management history of the site with regard to interpreting the distribution of tar and oil in the subsurface.
15.	**Section 3.2.2.** DEQ's comments to sections 4.2.1.3 and 4.2.1.4 apply here.	Please refer to NW Natural response 28 on Section 4.2.1.3, and response 29 on Section 4.2.1.4.
16.	**Section 3.3.1.** DEQ's General Comment regarding the	Please refer to NW Natural's response 1a to DEQ's General

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vertical barrier and the uplands FS applies here.	Comment.
17a. **Section 3.3.2.** NW Natural indicates in sections 3.2 and 3.3 that the location and depth of the vertical barrier were planned to block DNAPL migrating to the river navigation channel. The river channel occurs at an approximate elevation of -40 COP. As DEQ determined previously, a vertical barrier constructed to -40 feet COP is inadequate because this depth does not consider potential deepening of the channel during the in-water sediment project and/or navigation channel dredging (i.e, there are no safety factors incorporated into the -40 feet design depth). In addition, Figure 2-3b shows much of the DNAPL in the southern section of barrier occurs between elevations of -40 and -60 feet. Furthermore, DEQ continues to consider ongoing migration of DNAPL from the uplands to areas beneath the river to be an unacceptable condition. Even absent direct discharge into the river, depending on the lateral and vertical depth of occurrence DNAPL represents an ongoing source of dissolved-phase recontamination to the river channel. NW Natural indicates in the second paragraph TarGOST® investigations did not result in changes to the depth or lateral extent of DNAPL such that modifications were made to the barrier locations shown in the Groundwater/DNAPL FFS and Preliminary Design Report. DEQ notes the bottom of the vertical barrier proposed in Groundwater/DNAPL FFS was -40 feet COP, while the Preliminary Design Report envisioned a barrier	The GWFFS selected a vertical barrier with a bottom elevation of -40 feet. In their March 21, 2008, comments to the GWFFS, DEQ recommended that a bottom barrier elevation of -60 feet be carried forward for planning purposes.

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constructed to elevations between -50 and -60 feet COP.	
17b. It appears the top of steel sheets are at elevation +20 feet, or approximately 5 to 15 feet bgs. NW Natural indicates the bottom of the clearing trench will be excavated to 20 feet bgs and backfilled prior to driving sheets. As such, it is not clear how the top of the sheet will be driven through the backfill to depth.	This issue will be addressed as needed in the upland FS and upland cleanup design process.
17c. DEQ considers the absence of groundwater controls on the fill WBZ to be a design deficiency which must be addressed if the vertical barrier is selected as a component of the final remedy for the uplands.	The plan for containment of groundwater in the Fill WBZ is addressed in NW Natural response 5 on Section 1.2, response 8c on Section 2.1.1, 6th paragraph, and response 13a on Section 3.1, 2nd paragraph.
17d. NW Natural should be advised that should the vertical barrier(s) be selected as a component of the final remedy, additional more detailed modeling work will be needed to support final design. For example, more detailed modeling could include reducing the grid spacing in the vicinity of the barrier and using the horizontal flow barrier package available in MODFLOW to develop more realistic representations of the vertical barrier in the simulations.	DEQ's request to reduce the grid spacing in the vicinity of the barrier and use the MODFLOW horizontal flow barrier (HFB) package is redundant. The HFB package was developed specifically to allow simulation of vertical hydraulic controls without going to a grid spacing refinement. The documentation of the HFB states that vertical flow barriers "can be simulated … by reducing grid spacing appropriately or by using variable grid spacing in the region of the feature to be modeled…. The Horizontal-Flow-Barrier (HFB) Package … allows these features to be modeled without increasing the number of model cells or using variable grid spacing…." (Hsieh and Freckleton, USGS Open-File Report 92-477). Implementing the HFB package is slightly more cumbersome than including the barrier wall as a low hydraulic conductivity feature, but NW Natural can easily implement the HFB package at DEQ's request. Both implementing the HFB Package and refining the model grid, though, is redundant and not necessary.

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	It should also be noted that, if contaminant transport analysis is requested by DEQ, the HFB package would only be applicable to sheetpile walls as the HFB does not allow for any sorption or attenuation of contaminants through a barrier wall. Sorption and attenuation are important processes in slurry walls and, consequently, the HFB package is not appropriate for simulation of contaminant transport through slurry walls.
18. **Section 3.3.3.** Given consideration of subsurface conditions and the potential effects on the operating Siltronic facility, work completed by NW Natural and Siltronic confirms the feasibility of constructing the vertical barrier using sheet pile methodology. Based on this work, DEQ concurs with NW Natural's recommendation to construct the vertical barrier using sheet pile construction methods. DEQ defers to the NW Natural team's expertise in selecting steel sheets for the vertical barrier.	Comment noted.
19. **Section 3.3.3.1.** DEQ concurs with NW Natural that no "substantial unresolved constructability issues" remain with regard to constructing the vertical barrier. Although DEQ identifies lack of provisions for controlling groundwater in the fill WBZ as a design deficiency, it is not considered a substantial issue. As discussed in our comments to Section 1.2, controlling groundwater flux in the fill must be achieved by NW Natural whether the barrier is constructed or not.	Agreed.
20. **Section 3.3.3.2.** Prior to initiating vertical barrier construction, DEQ will expect a work plan to be prepared	Design details associated with the outfall bypass would be a part of future vertical barrier design associated with the source control

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	detailing NW Natural's approach to temporarily by-passing and replacing the WR-107 outfall.	or site wide cleanup design.
21.	**Section 3.3.3.3.** As part of vertical barrier planning and design, DEQ required NW Natural to assess methods to minimize the potential for DNAPL to migrate vertically downward during construction. DEQ understands this design detail will be worked out further if a sheet pile barrier(s) is selected as a component of the final upland remedy.	The need for such contingencies would be considered as part of the construction planning for any vertical barrier associated with source control or site wide cleanup.
22.	**Section 3.3.4.** Contingencies should be discussed if the 4-foot bucket cannot remove debris encountered during pre-trenching (e.g., alternate equipment, trench re-alignment, etc.).	The need for such contingencies would be considered as part of the construction planning for any vertical barrier associated with source control or site wide cleanup.
23.	**Section 3.3.6.** NW Natural should provide additional information to clarify how joint sealing "prior to subsequent driving of a sheet pile pair" will be done. It is unclear how joint sealant remains in place while a new sheet is driven between an in-ground pair. It is also not clear how and to what extent joint sealant is forced into the joint void when the temporary sheet is removed.	Additional details associated with the methodology of sealing sheet pile joints would be included with the design of any vertical barrier associated with source control or site wide cleanup.
24.	**Section 4.1.1.** DEQ's comment to Section 1.2 regarding the fill WBZ zone applies here.	The plan for containment of groundwater in the Fill WBZ is addressed in NW Natural response 5 on Section 1.2, response 8c on Section 2.1.1, 6th paragraph, and response 13a on Section 3.1, 2nd paragraph.
25.	**Section 4.1.2.** DEQ's comments to Appendix C and the Pilot Study Report apply here.	Please refer to NW Natural responses 40, 41, and 42 to DEQ comments on Appendix C and the Pilot Study Report.
26a.	**Section 4.1.3.** Based on discussions with NW Natural during meetings, DEQ understood power losses up to	This issue will be further evaluated and potential solutions discussed with DEQ prior to completing the Final Design Report.

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between 24 to 36 hours could occur. NW Natural should check information provided in this section and explain the shorter timeframe, or confirm DEQ's understanding of the topic. In addition, given the uncertainty regarding the maintenance of extraction wells (see Section 4.2.2.3), NW Natural should evaluate a shut-down scenario involving extraction well replacement. Besides extraction well shut-downs, the groundwater treatment system will be shut down for maintenance and in response to periodic high level/pressure shut-downs. NW Natural should provide additional information regarding the length of time associated with treatment system shut-downs (see also DEQ's comments to Appendix C).	
26b. NW Natural's approach to evaluating potential water quality impacts is also provided in this section of the report. The evaluation of the period of time the system could be shutdown before an unacceptable water quality impact in the river occurs appears to be more appropriate for planning an in-water capping project. As such, the approach pre-supposes implementation of in-water remedial action alternatives. Furthermore, the input parameters, model documentation, and results were not provided to DEQ for discussion or review prior to the Interim Design Report being submitted, and are not included in the document. For clarification, DEQ envisioned a simpler scenario being assessed. NW Natural should revise the response to estimate the time	This issue will be further evaluated and potential solutions discussed with DEQ prior to completing the Final Design Report.

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	needed for contaminated groundwater to: 1) escape capture and bypass the HC&C system; and 2) migrate to the river in the event shut-down occurs. The estimated timeframes should then be compared to the shutdown times associated with power outages.	
27.	**Section 4.2.1.1.** DEQ's comment to Section 2.1.1 applies here. In the last paragraph, NW Natural indicates free cyanide was not detected in any surface water samples collected during the offshore investigation. It should be noted total cyanide was detected in three samples at concentrations ranging from 10 micrograms per liter (ug/L, or parts per billion) to 140 ug/L in surface water.	Comment noted.
28a.	**Section 4.2.1.3.** Figures 3-3a through 3-3c show model output for an extraction well screened between elevation -40 and -60 feet with the HC&C system pumping at a total discharge rate of 250 gpm, under three vertical barrier scenarios, including: 1) a barrier constructed to -40 feet (Figure 3-3a), 2) a barrier constructed to -60 feet (Figure 3-3b), and 3) no barrier (Figure 3-3c). Compared to ambient conditions (see Appendix I, Figure A-9), downward vertical gradients 15 to 20 feet above the top of the screen (elevation -20 to 25 feet) increase by factors between approximately 20 (no barrier) and 30 times (barrier constructed to elevation -60 feet). DEQ also notes that gaps in fine-grained material shown in cross-section (see Figure 2-3b) provide avenues for DNAPL to move downward in the alluvium. Furthermore, downward migration is further facilitated by the intermediate or neutral wettability of DNAPL occurring near the	As previously stated in NW Natural's response 1a to DEQ's General Comment on Extraction Wells PW-3 through 6, it is essential for groundwater source control to be implemented in all of Segment 1. By deferring the Segment 1 extraction wells to the Uplands FS, it is likely that the Segment 1 wells would not be installed and operated before at least 2013 to 2015. This jeopardizes NW Natural's ability to implement control of the dissolved plume prior to the in-river sediment remedy. DEQ's recommendation to defer Segment 1 source control also allows the continued discharge of contaminated groundwater to the river for 3 to 5 years. Therefore, NW Natural proposes to work with DEQ to modify the design of the planned Segment 1 extraction wells. The basic components of the proposed revision were presented to DEQ in the May 17, 2010, meeting. The goal of the modifications would be to design a system that allows control of the dissolved

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shoreline (i.e., capillary forces resisting movement are less). Although pumping extraction wells cause hydraulic gradients to reverse from the river back towards the uplands, the information summarized above supports DEQ's conclusion that NW Natural's recommended approach to HC&C along the most impacted portion of Segment 1 has a high potential for inducing downward vertical migration of DNAPL.	groundwater plume to be implemented in a way that minimizes any potential for DNAPL migration. The redesigned system would include paired extraction wells, with both shallow and intermediate depth extraction wells in the alluvium. The effect of operating additional shallow extraction wells will also be evaluated. By reducing the lateral spacing between the shallow extraction wells, the required pumping rate from each well could be significantly reduced, thereby greatly reducing the vertical and horizontal groundwater gradients. The shallow extraction wells would induce an upward vertical gradient in the DNAPL zones, thereby further reducing the potential for migration.
28b. Documentation for the groundwater model including general calibration, verification, and sensitivity, as well as specific recalibration of the model (referenced in the Interim Design Report) and the incorporation of the lower aquitard (presented for the first time in the Interim Design Report) is insufficient. For the final design document, NW Natural should provide more detailed documentation regarding numerical modeling, including its update and refinement for the Interim Design Report, as follows: • A table describing hydrostratigraphic layers represented in the model and their dimensions compared to the characterization shown in cross-section using well log information. • A water budget summary for the hydrostratigraphic layers represented in the model. • Hydraulic properties assigned to the model layers	Model documentation has been provided in consultation with DEQ through a series of memorandums, which have been revised at DEQ's request over time. For instance, the October 2007 document referenced by DEQ was revised and re-submitted to DEQ and dated April 25, 2008. DEQ did not question the adequacy of the model calibration at that time. DEQ now questions the adequacy of the calibration based on model-to-data comparison at a single point of "up to four feet". The maximum single point discrepancy is actually 3.4 feet. The range in data is from 26.9 to 7.6 and the 25 percent discrepancy stated by DEQ is actually less than 20 percent. Single point discrepancies are only one method of evaluating model performance and probably the least robust since the comparison is potentially affected by variability in the data rather than model performance. The model-data comparison referenced by DEQ produces a regression with a slope close to 1, intercept close to zero and a correlation coefficient (r2) greater than 0.9.

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including, but not limited to, calibrated vertical and horizontal hydraulic conductivities (Kv/Kh), specific storativity, and specific yield. • Details on the numerical model boundaries. • Additional calibration information demonstrating confidence in the model representing measured heads under various conditions. The available information[6] is insufficient to allow for a spatial evaluation, and modeled versus measured heads appear to be off calibration by up to four feet, or approximately 25% of the total average gradient across the site. Calibration plots should include a spatial plot of the head difference between modeled and measured values across the site to focus refinements to the hydraulic properties and model grid where needed. Additionally, time-series plots of seasonal water level data should be compared with transient modeled water levels trends to verify the model under measured seasonal variation. • A sensitivity analysis to potential future land use changes (e.g. ditch/trench lining, removal, site paving) that could change the current recharge, gradient/flow conditions assumed by the numerical groundwater flow model. NW Natural should be advised the existing model may	The r2 value means the model explains over 90% of the variability in the data. Consequently, the model is a very good simulator of groundwater levels at the site. Following calibration, DEQ requested several changes to the model to make it more conservative. These changes included extending the high hydraulic conductivity zone in the lower alluvium upgradient to the basalt boundary and using the March 2000 high gradient condition for all predictive simulations. These changes, and in particular the use of a very conservative condition for all predictive simulations, makes a sensitivity analysis unnecessary. Overall, NW Natural is disappointed to see a comment of this nature and scope after all the efforts made to address DEQ's concerns through meetings and documentation over the last three years. Although a more comprehensive model documentation document can be prepared, NW Natural does not think it is necessary and it should not delay implementation of the interim design system.

[6] See Figure 4-5 of NW Natural Gasco, Pump Test Analysis and MODFLOW Model Summary (October 2007).

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have to be further modified to fully evaluate the performance and effectiveness of HC&C (e.g., vertical extent and timeframe of capture where fine-grained layers/lenses are present). Modifications may include but not be limited to, decreasing the grid spacing within selected portions of the model. Alternatively, project needs may indicate development of more detailed purpose specific models is warranted.	
29. **Section 4.2.1.4**. Based on information provided in the RI Report, the effluent ponds were used between 1941 and 1955. Using the midpoints of DNAPL occurrence shown in borings TG-8, B-4B, and GS-09; the distances between TG-8 and B-4B and TG-8 and GS-09; and the range of time bracketing pond use and submittal of the DNAPL mobility evaluation (i.e., 53 to 67 years); DEQ estimates horizontal and vertical DNAPL migration rates under non-pumping conditions range between 3.3 and 5.4 feet/year and 0.3 and 0.8 feet/year, respectively. Based on this information and literature7 which indicates coal tar DNAPL can migrate for over 100 years before attaining a stable subsurface configuration, DEQ concludes DNAPL migration is ongoing. As such, the uplands FS should evaluate remedial action alternatives that mitigate DNAPL migration, including, but not necessarily limited to source reduction, removal, and stabilization.	DEQ's analysis of potential lateral DNAPL migration rates assumes a simplistic and apparently incorrect history of wastewater management in the area between borings TG-8, B-4B, and GS-09. Firstly, NW Natural strongly disagrees that the DNAPL detected in offshore boring GS-09 is present because of subsurface transport from the uplands. NW Natural has concluded in past reports that DNAPL in the river sediments is derived from direct discharge of wastewater to the river. The reasons for that conclusion are reiterated in NW Natural's response to DEQ's Comment 11b (on Section 2.1.3, 2nd paragraph). Because the DNAPL in GS-09 is not due to subsurface migration from the uplands, it is not technically correct to use the presence of DNAPL at that location in DEQ's calculation of DNAPL migration rate. Secondly, DEQ's analysis assumes that the only source of DNAPL at the location of boring B4-B is lateral subsurface migration from the area of boring TG-8. The presence of shallow DNAPL (just

[7] Gerhard, J.I.; Pang, T.; Kueper, B.H., 2007. "Time Scales of DNAPL Migration in Sandy Aquifers Examined via Numerical Simulation," *Groundwater* Vol. 45, No. 2. March–April 2007. Pp. 147–157.

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	below the surficial fill) at the B4-B location indicates NAPL sources to the alluvial unit that are much more proximate to B4-B than the TG-8 location. For example, a review of historic aerial photos in Appendix A of the 2007 RI Report shows that liquid overflowed from the former tar ponds across the area where boring B4-B was drilled, thereby resulting in a NAPL source for the alluvial unit in this area. A 1975 aerial photo in Appendix A shows that plant process water and stormwater were later stored in surface ponds that extended near the former shoreline immediately adjacent to Boring B-4B. Based on this evidence, DEQ's use of the distance between boring TG-8 and B-4B to calculate DNAPL migration rates is an oversimplification that does not consider the site's complex DNAPL distribution and waste management history. DEQ's estimate also ignores sophisticated modeling performed by NW Natural at DEQ's request (Anchor QEA, 2009, Evaluation of Potential DNAPL Mobilization in Former Effluent Pond Area by Shoreline Source Control Extraction Wells), which calculated potential DNAPL migration rates under the pumping conditions and extraction well depths identified in the IDR. DEQ's analysis also does not acknowledge that the DNAPL subsurface migration rate was much higher when the ponds were active and sources were being replenished, resulting in a higher DNAPL head to drive migration. Since the ponds were decommissioned in the 1970s, the DNAPL head that drives migration has greatly declined. Calculation of DNAPL migration rate should conclude that the current DNAPL migration rate, if it is moving at all, is much lower than would have occurred during

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		plant operations. Therefore, even if NW Natural accepts DEQ's flawed calculation method, it is not useful for determining current DNAPL migration rates under ambient conditions, because it does not account for the decline in DNAPL head as explained previously.
30a.	**Section 4.2.2.1.1.** For clarification, based on numerical simulations the final horizontal hydraulic conductivity of the upper and lower alluvial WBZs used for the MODFLOW model were 15 and 300 feet/day respectively.	Hydraulic conductivity values used in the model are 10 ft/day in the upper alluvium and 300 feet per day in the lower alluvium. The typo on the hydraulic conductivity of the lower alluvium will be corrected.
30b.	The vertical placements of extraction well screens are discussed in terms of their positions relative to the upper and lower alluvial WBZs. An additional significant factor for locating screened intervals is the occurrence of DNAPL and dissolved phase contamination, neither of which is discussed here. NW Natural should provide additional information regarding the locations of the proposed extraction wells, screen depths, and the distribution of DNAPL and MGP and VOC contamination. The vertical placement of the screen for extraction well PW-2 (elevation -25 to -45 feet) does not appear to coincide with the highest concentrations of total cyanide shown in Figure 2-12b. The location and vertical placements of the screens for extractions wells PW-1 and PW-2 should be compared to the distribution of MGP and VOC COI and adjusted as needed to intercept the highest concentrations of contaminants.	The RAO for the extraction system is full containment of groundwater at the river shoreline. Consequently, there is no need for extraction well screen intervals to coincide with the zones of highest contaminant concentration. This would provide higher initial mass removal, but is inconsequential over long-term system operation.
30c.	NW Natural indicates extraction well PW-1 through PW-	PW-3 consists of two wells screened at different intervals. If DEQ

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	7 are planned to be screened in the upper alluvial WBZ. Within this group, the two PW-3 extraction wells are already constructed in the upper (PW-3-85) and lower (PW-3-118) alluvial WBZs. The vertical placement of PW-3-118 is inconsistent with NW Natural's location criteria described in this report section. The purpose and NW Natural's plans for operating PW-3-118 should be further explained.	requires rigid adherence to the criteria for well screen elevation, NW Natural would only pump the well at PW-3-85; however, this approach would need to be evaluated for the effect on hydraulic gradients.
30d.	Spacing of extraction wells decreases from approximately 200 feet to about 140 feet between PW-3-85/118, PW-4, and PW-5 behind the vertical barrier. The rational for tightening the spacing should be provided.	The lateral spacing of wells is affected by the present location of the PW-3 wells, resulting in tighter spacing between wells PW-3, PW-4 and PW-5. Tighter spacing of wells in this region with the highest contamination should not be considered a problem, but a means of better controlling groundwater in this area.
31a.	**Section 4.2.2.4.1.** This section outlines a proposed monitoring program to verify the performance of the HC&C system. The proposed network appears to be predicated on contemporaneous installation of the vertical barrier wall. Since DEQ accepted NW Natural's recommendation to defer the vertical barrier to the uplands FS, and HC&C along this section of Segment 1 is also going to be evaluated in the FS, NW Natural should revise the program for monitoring the performance of two groups of extraction wells, including 1) PW-1 and PW-2, and 2) PW-7 through PW-10. For example, piezometer cluster PZ7 should be relocated to monitor the influence of pumping extraction wells PW-1 and PW-2 on the Siltronic Property. DEQ notes between the MW-5 monitoring well cluster on the NW Natural Property and the WS-8/WS-12 cluster on the Siltronic Property	NW Natural acknowledges that the selection of monitoring wells to be used for performance monitoring could change depending upon which extraction wells are operated in Segment 1. This issue will be further evaluated in the process of source control final design.

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there are no monitoring wells installed near the shoreline above 112 feet bgs. Additional monitoring wells should be installed to measure water levels and groundwater chemistry in closer proximity to extraction wells PW-1. The wells should be installed at depth intervals corresponding to the highest contaminant concentrations.	
31b. NW Natural indicates the goal of operating extraction wells is to maintain the average groundwater elevation below the average river elevation, initially on a running one-hour basis. However, the performance criterion for water level differences is not discussed and should be provided in NW Natural's response to this letter.	The performance criteria for water level differences is to maintain an inward gradient between the river and the wells located midway between the extraction wells. The inward gradient will be computed on a 3-day moving average based on the method presented by Serfes (Groundwater, v. 29, 1991). An inward gradient will be defined as attaining 3-day moving average water levels at these wells being below the 3-day moving average river stage. Inward gradients at wells midway between extraction wells mean that groundwater upgradient of the line of extraction wells is not passing between the extraction wells and reaching the river.
32. **Section 6.** DEQ acknowledges NW Natural's commitment to consider sequencing the vertical barrier early or first during upland remedial activities. DEQ would add that regardless of whether the vertical barrier is selected as a component of the final remedy, based on the magnitude of contamination and its proximity to the river, remedial action(s) in the southern portion of the NW Natural Property should be scheduled for early implementation.	As stated in previously, it is NW Natural's intent to implement groundwater source control throughout Segment 1 and not defer groundwater source control to the Uplands FS and site-wide cleanup.
33. **Table 2-2.** DEQ understands the lower aquitard occurs entirely within the lower alluvial WBZ. The title of the table implies the lower aquitard separates the upper	Agreed.

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	alluvium from the "deep" alluvium. The title should be revised to indicate the table compares groundwater data collected above and below the lower aquitard.	
34.	**Table 4-4.** It is unclear why only four monitoring wells are shown for the Siltronic Property when there are eight that could be considered "shoreline" installations and a total of fourteen that should be considered for water level performance monitoring. NW Natural and Siltronic should select additional monitoring wells for purposes of monitoring water level data between and upgradient of extraction wells PW-1 and PW-2. The revised Table 4-4 should be included in the final design document.	DEQ's comments on the selection of performance monitoring wells to be used on Siltronic property will be addressed in the Source Control Final Design Report.
35a.	**Figures – General Comment.** Certain figure reference the "NAVD 88," mean sea level, and City of Portland vertical datums. DEQ understands the datum in current general use is the COP datum. This should be made clear in the text and all relevant figures should be reviewed and revised as appropriate in the final design document.	The relevant figures have been modified and are attached.
35b.	The vertical datum(s) used to prepare many figures is not referenced, including Figure 1-2, figures 2-2a through 2-2c; figures 2-3a through 2-3c; figures 2-5 through 2-7; and figures 2-12a, 2-12b, 2-13, 3-1, 3-4, 3-9, and 4-1. Furthermore, contours on Figure 3-4 are not labeled. NW Natural should review and revise any figure combining elevation information with site and/or investigatory information.	The referenced figures have been modified and are attached.
35c.	The TarGOST® logging locations and geotechnical borings shown on Figure 2-1 are not included on figures 2-2a through 2-2c and should be added for reference and	The TarGOST borings have been added to Figures 2-2a through 2-2c; the figures are attached. NW Natural reviewed the issue of adding TG-4 to Figure 2-3b and concluded that, because there are

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completeness. In addition, TG-4 is missing from Figure 2-3b.	already a large number of borings in the vicinity of TG-4, adding TG-4 does not substantially change the subsurface geology. Plus, there is simply not enough room to show the TG-4 boring information without crowding the other boring symbols on the figure. Therefore, NW Natural has not added TG-4 to the section. If DEQ still wants TG-4 added, NW Natural can discuss the technical reasons and reconsider this decision.
35d. Geologic cross-sections reference shoreline source control segments 1 and 2 and show the locations of uplands installations, while subsurface profiles of free and total cyanide refer to the NW Natural and Siltronic property line and nearshore borings. Furthermore, monitoring wells, extraction wells, and geologic information are not provided on figures 2-12a and 2-12b. As such, evaluating the locations of the proposed extractions wells in the context of groundwater contamination, and the relationship between subsurface stratigraphy and contamination cannot be assessed.	Figure 2-10 in the IDR shows site geology and representative concentrations of dissolved COIs in groundwater from monitoring well data. For the Final Design Report, a similar figure will be prepared that also shows the planned extraction well screen elevations. The revision of Figure 2-10 is in progress. Per DEQ's request, NW Natural has added the groundwater quality data from reconnaissance borings. NW Natural has also extended the Section to include a portion of Segment 3. NW Natural provides a draft version of Figure 2-10 attached to this document for DEQ review. NW Natural plans to discuss with DEQ potential revisions to extraction well screen intervals during final design.
35e. As shown by figures 2-3a through 2-3c, the vertical barrier and extraction wells are located in the uplands along or near a geologic cross-section containing uplands monitoring wells (see Figure 2-10). However, the subsurface distributions of free and total cyanide shown by figures 2-12a and 2-12b rely on interpretations of data collected from nearshore borings (GS-01 through GS-12) that are between 75 and 125 feet downgradient and under the river from where monitoring wells and extraction wells are located. These figures should be revised to	NW Natural is not clear on the rationale behind DEQ's request and requires further explanation. Why would NW Natural transpose groundwater quality data from upland monitoring wells onto an offshore subsurface profile?

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show contaminant distributions interpreted from uplands monitoring wells in the final design document.	
35f. The distribution of VOCs in groundwater is not shown in any figure in the Interim Design Report. Figures depicting the nature and extent of groundwater contamination are considered deficient lacking this information and should be revised accordingly.	The lateral extent of the CVOC plume at the river shoreline is shown on Figure 2-13. The width of the CVOC plume shown on Figure 2-13 was provided by Siltronic. If DEQ requires more information than is shown on Figure 2-13, NW Natural will request Siltronic to provide the additional figures, since Siltronic has the most up-to-date information on the nature and extent of CVOC contamination. NW Natural would then incorporate the Siltronic figure(s) into the Source Control Final Design Report. The draft revised version of Figure 2-10 (attached) now includes vinyl chloride concentrations.
35g. The referenced figures should be reviewed and revised. Copies of the revised figures should be included in NW Natural's response to this letter and included in the final design document.	It is not clear why DEQ is requesting that the revised and new figures be provided to DEQ prior to submittal of the Source Control Final Design Report. This comment applies to all of DEQ's requests for revised and new figures in this document. As stated previously in these responses, NW Natural has attached draft revisions of many of the figures in response to DEQ comments but has not completed all of the DEQ-requested revisions because further explanation from DEQ on some of the requests is needed. NW Natural would like to have further discussion with DEQ to clarify which figures the agency needs to see prior to the submittal of the Final Design Report.
36. **Figures 2-3a through 2-3c.** DEQ notes water level information for the fill WBZ is representative of seasonal low values (i.e., conditions of low flux to the river). The figures should be revised to include a range of water levels for comparison purposes and completeness.	The referenced figures have been revised per DEQ request and are attached.
37. **Figure 2-10.** Lacking groundwater data from monitoring	Figure 2-10 has been revised as previously described and a draft

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wells, NW Natural should fill in the gap in groundwater data between the MW-5 and WS-8/WS-12 monitoring well clusters above elevation -75 feet with reconnaissance groundwater sampling data collected by either NW Natural and/or Siltronic. In addition, based on the detected concentrations of total and free cyanide between approximately 0 and -80 feet in elevation, the figure should have been extended beyond (i.e., upstream) of the WS-8/WS12 monitoring well clusters. Lastly, vinyl chloride should be added to the list of target analytes to provide information regarding the distribution of VOCs within the cross-section shown. The figure should be reviewed, revised, and resubmitted for the final design document.	version is attached.
38. **Figure 3-2c.** The title for the figure may be incorrect. DEQ understands the figure depicts the estimated extent of DNAPL "below" 100 feet bgs. The figure should be reviewed and revised as appropriate.	The figure has been revised and is attached.
39a. **Appendix A – Sheet Pile Design Report. General.** The information presented presumes the vertical barrier is being constructed to elevation -40 feet. As indicated in DEQ's general comments the barrier carried forward into detailed analysis in the uplands FS should extend to elevation -60 feet. DEQ continues to understand this depth is feasible and the appendix could be revised by simply referencing the appropriate construction and materials depths (e.g., construct barrier to -60 feet; sheet pile lengths 80 feet long). NW Natural should confirm this understanding in the response to this letter.	DEQ's comment will be evaluated and applied as appropriate for preparation of any additional text or drawings related to the vertical barrier.

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39b. **Pre-Trenching.** NW Natural indicates the trench, "...will be dug to a depth not greater than the groundwater table or where the strata of oversized material and undisturbed natural material transition." DEQ considers it reasonable to plan for a scenario in which oversize material occurs below the water table, and wonders if dewatering has been, or should be considered during trenching.	Based on existing information from site borings and from the findings of the pretrenches dug during sheet pile pilot testing, it does not appear that dewatering will be necessary to facilitate removal of oversized material from the trenches. Sevenson Environmental Services will be consulted on this issue prior to finalization of vertical barrier construction plans.
39c. **Groundwater.** According to the Wall Depths section, the top of the barrier will be set at elevation +20 feet. Shallow groundwater is indicated as being at elevation +13 feet. As discussed above, DEQ considers the vertical barrier design to be incomplete without engineering controls to prevent groundwater in the fill WBZ from mounding behind and migrating around the barrier.	As explained previously, NW Natural plans to pave the site as part of the final upland cleanup. If a barrier is installed in Segment 1, the combined effects of paving the site and operating the source control extraction wells will likely prevent groundwater in the Fill WBZ from mounding and migrating around a vertical barrier. In the event that mounding and lateral bypass of the barrier occurs, engineering measures would be installed to prevent discharge to the river.
39d. **Alignment.** Additional information should be provided to clarify whether the stormwater pipe that needs to be reconnected is below the water table, acknowledge construction below the water table could require additional engineering controls during construction (e.g., dewatering; water storage, sampling, and management), and clarify whether the penetration through the wall needs to be sealed.	In the event that a vertical barrier is installed in Segment 1 and a stormwater pipe is below the watertable, the final design will account for either sealing the pipe penetration through the barrier, or rerouting the stormwater pipe around the barrier.
39e. **Drawing SP1.** Labels and text on the 11"x17" versions of the drawing are blacked out. The figure should be revised and resubmitted for insertion into the document copies. The ends of the vertical barrier shown in the drawing are either linear (north end) or exhibit a short-radius curvature towards the river (south end). NW	The blacked out sections of the figure will be corrected for the Final Design Report. The need for adding wing walls to the barrier will be considered. Since extraction wells will be operating beyond the ends of the barrier, the wing walls may not have much utility in enhancing groundwater containment. The value of wing walls for containing DNAPL will be further evaluated.

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	Natural should discuss the need for typical landward facing end wingwalls to reduce the potential for dissolved phase constituents and/or NAPL from migrate around the ends of the barrier.	
39f.	The report should include a section describing sheen monitoring in the river. The construction of SCMs or implementation of remedial action technologies (e.g., sheet-pile driving) could cause sheen bursts, blossoms, and/or outbreaks to occur in the river. As was done during the vibration study, a sorbent and containment boom system should be deployed to capture any sheen generated during uplands construction activities. Visual monitoring should be done throughout the work day and the boundaries of the boom system adjusted as needed to ensure sheen is captured.	A containment boom system is already in place along a significant portion of the shoreline adjacent to where the barrier could be installed. DEQ has recently approved (in a July 2, 2010, e-mail) NW Natural's proposal to expand the existing boom system in the Segment 1 area of the shoreline. It is anticipated that the extent of the boom system could be adjusted to account for sheet pile installation activities. Such a boom system would be included in the final construction plans for a vertical barrier system.
40.	**Appendix C, Water Treatment/Treatment System Pilot Study.** General DEQ understands sludge and water produced during the treatment system pilot study were managed consistent with DEQ's March 27, 2008 letter regarding investigation derived waste. NW Natural should provide documentation regarding solids IDW management for DEQ's information and completeness. For the final design document, DEQ expects NW Natural to identify each waste-stream in the water treatment process and document the type of media (solid, liquid); regulatory status (solid waste, hazardous waste), basis for regulatory determination (e.g., regulatory citation, knowledge of process, sampling data), estimated annual volume, and anticipated management approach. Figures	These revised figures will be provided.

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	should be provided to clearly show the locations of waste-streams in the treatment process.	
41a	**Appendix C, Water Treatment/Treatment System Pilot Study. Water Treatment System** The potential presence of unexpected DNAPL in the treatment system and the apparent reliance on manual draining of LNAPL from oil-water separators (OWSs) will require attention during operation. DEQ expects the schedule for OWS inspections and LNAPL/DNAPL removal criteria to be detailed in the final design document.	The design includes installation of separate DNAPL recovery well pumps in the each of the sumps of those wells known to contain DNAPL, namely PW-3, 4, 5, and 6. The proposed pumping scheme is as shown in Figure 4-5 in the IDR. These pumps discharge to a separate DNAPL collection tank. As a result, DNAPL is not expected to be a major problem in the OWS. Also, LNAPL has not been detected during NAPL monitoring in site wells; however, the OWS will be closely monitored for evidence of either DNAPL or LNAPL, which will be removed accordingly. The final design document will contain a tentative schedule for pumping, to be determined by operational experience.
41b.	Equalization storage volumes for the NW Natural and Siltronic treatment systems appear to underestimate capacity needs. Given DEQ's decision to defer installation of four extraction wells to the uplands FS and using a reasonable pumping rate of 25 gpm for each extraction well, influent into the Siltronic and NW Natural treatment systems is estimated to be 50 gpm and 100 gpm respectively. This translates into total daily influent volumes of 72,000 gallons (Siltronic) and 144,000 gallons (NW Natural). On an average daily basis equalization tank storage capacity represents between 7.5% and 15% of the total daily flow. NW Natural should check storage needs and provide additional information justifying equalization tank requirements in the context of this information. In addition, NW Natural should evaluate the length of time extraction wells can	DEQ appears to have misunderstood the design intent of the equalization tanks. It is not NW Natural's intent to operate on a fill-and-draw system. The tanks are an on-line flow equalization system, designed to operate on a flow routing principle: flow will enter the tank at varying rates, be stored, and be pumped from the tank to the treatment plant at a constant rate. Required equalization tank storage has been calculated, based upon a varying influent flow rate and the selected constant flow rate (total of NW Natural and Siltronic) of 259 gpm. These calculations are shown on Routing Analysis Appendices for both NW Natural and Siltronic flows.

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	continually operate during treatment plant shut-downs.	
41c.	NW Natural should discuss the implications of specifying a 259 gpm clarifier feed pump given the overall treatment system is designed for maximum flow rates of 400 gpm.	The 259-gpm rate is the equalized flow rate to the treatment plant, which was the basis for calculating the equalization tank storage volume requirements.
41d.	Page 10 of the appendix indicates the treatment system will use two GAC units in series, page 18 indicates a parallel arrangement, and sheet M-8 does not clearly depict the configuration. NW Natural should clarify.	Two parallel trains of two GAC units in series will be provided, for four vessels.
41e.	It does not appear DNAPL pumps (see Interim Design Report, Figure 4-4) are included in the extraction well design. Figures M-3 and M-4 do not identify this type of pump. NW Natural should clarify.	As previously outlined, four DNAPL submersible pumps will be provided in the sumps of those wells containing DNAPL. These pumps will pump DNAPL to a separate holding tank for reuse or disposal.
42a.	**Appendix C, Water Treatment/Treatment System Pilot Study. Pilot Study Report, Tables 6 and 7.** DEQ's letter dated April 2, 2009 identified xylene as a monitoring parameter for the pilot study, however data for is reported as "m,p-xylene" and "o-xylene" in tables 6 and 7. NW Natural should explain these results further.	The monitoring parameter specified by DEQ is total xylenes. The values shown in the tables are separate xylene isomers, which are added to generate total xylene.
42b.	The footnotes for tables 6 and 7 reference footnotes in attachments E and G. These references are confusing, especially for the chromium (VI) notes in Table 6. NW Natural should revise the tables to make the information more understandable and accessible, and resubmit them.	Tables 6 and 7 will be revised and re-submitted.
42c.	Iron and manganese data are inconsistently reported in tables 6 and 7. NW Natural should clarify which iron and manganese data represent total or dissolved concentrations. NW Natural should also confirm concentration units. The tables in the Pilot Study Report	Tables 6 and 7 will be revised and re-submitted.

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should be reviewed and revised as appropriate.	
42d. In addition to chromium (III) and chromium(VI), "chromium" is reported twice in Table 6 with different values. NW Natural should clarify chromium data and confirm concentration units. The tables should be reviewed and revised as appropriate.	Tables 6 and 7 will be revised and re-submitted.
42e. The maximum values for several parameters are elevated in Table 6. Certain parameters exceed the applicable water quality standard (WQS), including arsenic , copper, iron, lead, manganese, mercury, nickel, benzo(a)pyrene, benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, and tetrachloroethene. NW Natural should confirm DEQ's observations of the data and indicate how these results were considered in treatment system design.	NW Natural recognizes and has reported that several values were exceeded, as noted by DEQ; however, it should be clear that the primary purpose of the pilot testing program was to optimize the final design of the treatment plant for full-scale operation. In order to achieve this goal, certain parameters such as pH and chemical dosages were adjusted daily to optimize the ultimate system, which may have lead to the occasional exceedance. In addition, because the pilot was not operated on a continuous 24-hour, 7-day period, it is likely that the startup and shutdown period created process instability. The equalization tanks were not operated as such: they were used as only holding tanks, being filled and emptied each day, making the tanks merely holding tanks, and not allowing for load equalization that would happen under full-scale operation. While NW Natural attempted to meet all parameters specified by the DEQ for final discharge during every run, a very few were exceeded. The final design of the system will include additional process backups and flexibility that couldn't be implemented or utilized during pilot testing. As already mentioned, DNAPL will be largely removed ahead of the process by dedicated pumps in the

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	sumps of extraction wells known to be high in DNAPL. In addition, oil-water separators will be provided to further remove DNAPL and LNAPL. There will be more chemical dosage points to adjust the process as necessitated by observation of the influent water. Also, full-scale operation will incorporate effluent bag filters downstream of the GAC vessels to catch any carbon fines (with adsorbed organics) that might escape. While these bag filters were also provided in the pilot tests, the actual sampling point was from the Effluent Storage Tank upstream of the filters. Thus, NW Natural believes that the actual effluent quality (downstream of the pilot bag filters) was better than measured as final effluent.
42f. Several parameters shown in Table 6 have quantitation limits greater than the values listed in DEQ's November 2007 technical memorandum8, including cadmium, chromium (VI), tetrachloroethene, trichloroethene, toluene, and ethylbenzene. Except for toluene and ethylbenzene, the higher quantitation limits could impact reasonable potential. NW Natural should confirm DEQ's observations of the data and indicate how these results were considered in treatment system design.	The quantitation limits were based upon the specific parameters contained in the March 31, 2009, memo from Dana Bayuk to Rob Burkhart, as shown in Table 2 of the Pilot Plant Report. These limits and this approach were previously approved by DEQ in Sevenson' June 2009 Revised Pilot Plant Testing Plan, page 17, to wit: "Influent and effluent samples will be taken in accordance with the March 31, 2009 'Discharge Limitations and Monitoring Requirements for the NW Natural/Gasco Site' from Oregon Department of Environmental Quality (DEQ)." However, with specific regard to cadmium and chromium VI, the quantitation limit was 1 ug/L, vs. 10 ug/L limit cited by DEQ. The pilot plant quantitation limits for the organics cited was 0.5 ug/L, which is at the practical limit for removal by a Best Available Technology process for removal of volatile organics: granular activated carbon.

[8] DEQ, 2007. "Addendum to Reasonable Potential IMD to Revise Quantitation Limits," November 16, 2007. Prepared by DEQ.

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42g.	The maximum values for several parameters in Table 7 are elevated, including iron, mercury, and manganese. The value for iron exceeds the WQS. The maximum values for manganese and mercury are just below or at the WQS, respectively. NW Natural should confirm DEQ's observations of the data and indicate how these results were considered in treatment system design.	See the previous response regarding the goals of the pilot test program and the variability of operations, including startup and shutdown of operations, varying pH levels, and the final sampling point ahead of the final bag filter in the pilot plant. All of these factors are believed to have contributed to the occasional exceedances of iron, manganese and mercury. These factors have all been addressed in the full-scale design of the treatment plant.
42h.	Several parameters shown in Table 7 have quantitation limits greater than the values listed in DEQ's November 2007 memorandum, including cadmium and chromium (III). The higher quantitation limit for chromium (III) will likely not impact reasonable potential; however the limit shown for cadmium (1.00 ug/L) could have an impact.	As indicated earlier, the March 31, 2009, DEQ memo was used for quantitation limits; however, the cadmium quantitation limit shown in Table 7 shows the quantitation limit was 1 μg/L, vs. 10 μg/L limit cited by DEQ.
42i.	NW Natural should address DEQ's comments regarding the treatment system and Pilot Study Report in the response to this letter. The clarifying information and revised versions of table 6 and 7 are needed before DEQ can proceed with updating the Reasonable Potential Analysis using the pilot study effluent data.	Revised versions of Tables 6 and 7 will be submitted.
43a.	**Appendix D, Geotechnical Boring Logs and Soil Data Tables Figure A-1** The date water levels were observed during drilling are not shown on the logs.	Comment noted.
43b.	The test symbol "GS" is not included on Figure A-1.	Comment noted.
44.	**Appendix D, Geotechnical Boring Logs and Soil Data Tables Table 1** Table 1 includes a column for "Permeability" testing in which no values are provided. NW Natural should clarify whether testing results should be included in the column, or confirm all testing results are provided in Table 2 as "Hydraulic Conductivity"	All permeability test results are provided in Table 2.

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values.	
45. **Appendix E, Well Design.** In the interest of reducing the potential influence of DNAPL, sheen, and/or contaminated groundwater on future observation or monitoring well construction, DEQ recommends NW Natural modify installation procedures as follows: Bailing contaminated fluids out of the upper casing (i.e., larger casing) used to double-case the borehole(s). Where subsurface require the use of double-case drilling methods, this step should be performed immediately after the upper casing is seated in the bentonite plug, and just before the secondary casing is placed downhole. DEQ acknowledges potable water may be needed to stabilize water levels in the casing, but considers this preferable to carrying contaminated fluids down the borehole. Using fine graded sand on top of the screen filter pack as pouring bentonite chips through heavy sheen or DNAPL could hinder hydration. Fine graded sand does not require hydration and can prevent migration of the bentonite and organoclay slurry into the filter pack.	NW Natural agrees that double casing drilling methods should be used in areas of Segment 1 where the wells will be screened within or below a DNAPL zone. For example, wells to be screened below the upper alluvium in Segment 1 would be double cased if they are to be drilled through known or suspected DNAPL zones. NW Natural plans to review with DEQ the construction plans for extraction wells that would be screened in the upper alluvium to determine if double casing is needed. NW Natural also agrees with using fine sand as suggested by DEQ, and this method was used during construction of extraction wells PW-7, 8, and 9.
46. **Appendix F, Sampling and Analysis Plan General** If NW Natural has not already done so, comments made by EPA and DEQ to the Segment 2 Test Plan[9] should be fully incorporated into the appendix for the final design document.	NW Natural will review the comments made by the agencies on the Segment 2 Test Plan and incorporate them where they are relevant to source control design and implementation.
47a. **Appendix F, Sampling and Analysis Plan Table F-1**	NW Natural will evaluate these recommendations for inclusion in

[9] Anchor QEA, 2009. "Capture Zone Field Test Plan – Gasco, Portland, Oregon," September 2009. Prepared for NW Natural.

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DEQ has the following clarifying comments regarding the sampling parameters list provided in the table. • Chemical monitoring should include, but is not limited to, analyzing groundwater samples from extraction wells and/or performance monitoring wells for: ▪ Typical field measured water quality parameters; ▪ NW Natural and Siltronic facility COI (e.g., polycyclic aromatic hydrocarbons; VOCs, metals); ▪ All parameters on the groundwater treatment system discharge list, and any additional constituents that could influence extraction well and/or groundwater treatment system operation and performance. The analyte list should be revised to include 1,2,4-trimethylbenze and 1,3,5-trimethylbenzene under the appropriate suite of analyses.	the performance monitoring plan.
47b. A performance objective of the HC&C system is to reverse groundwater gradients and induce movement of water from the river towards extraction wells. Inorganic indicator parameters of river water should be added to the analyte list to monitor progress towards meeting this objective, including, but not necessarily limited to, calcium, potassium, sodium, iron (total and dissolved), magnesium (total and dissolved), sulfate, chloride, bicarbonate, carbonate, and nitrate.	NW Natural will evaluate this recommendation for inclusion in the performance monitoring plan.

DEQ Comment	NW Natural Response
48. **Next Steps.** DEQ is not requiring the Interim Design Report to be revised and resubmitted. Within 30 days of receiving this letter, NW Natural should provide a written response to DEQ's comments and requests for information and/or clarifications. Copies of all revised figures should be submitted within 45 days of NW Natural's receipt of the letter. DEQ recommends a meeting be arranged as soon as practicable after NW Natural reviews this letter to discuss the scope, content, and schedule for the final source control design document.	Please refer to NW Natural's response to DEQ's General Comments on Figures. With this response NW Natural has attached draft revised figures that respond to most of DEQ's requested revisions. The attachment of revised figures also includes a table that lists the figures that have been revised, a description of the revision, and which DEQ request applies. However, NW Natural has not completed these revisions because further clarifications from DEQ on some of the requested changes is needed. NW Natural requests further discussion with DEQ on the requested figure revisions and on DEQ's requested schedule for submitting the revised figures.

John Edwards

From: BAYUK Dana [BAYUK.Dana@deq.state.or.us]
Sent: Friday, June 11, 2010 4:57 PM
To: Bob Wyatt
Cc: Patty Dost; John Edwards; Carl Stivers; robe@hahnenv.com; McCue, Tom; Gladstone, Alan; jpeale@maulfoster.com; ANDERSON Jim M; GAINER Tom; LARSEN Henning
Subject: NW Natural, Source Control Decision Along Vertical Barrier Alignment

Hello Bob.

DEQ is reviewing the "Gasco Upland: DEQ Meeting Summary – Monday May 17, 2010" sent via e-mail on May 21, 2010 (Meeting Summary). The Meeting Summary provides NW Natural's understanding of agreements made and action items identified for source control and the risk assessment during our meeting on May 17th. Anchor QEA, LLC prepared the Meeting Summary for NW Natural. DEQ will provide comments on the risk assessment portion of the Meeting Summary early next week.

The purpose of this e-mail is to provide you with an important project decision regarding upland source control. During the May 17th meeting NW Natural presented a proposed approach for re-designing source control measures (SCMs) in the alluvial water-bearing zone (alluvial WBZ) along the portion of Segment 1 corresponding to the vertical barrier alignment. DEQ understands the approach relies on hydraulic control and containment (HC&C) using extraction wells placed at two different depth intervals (eight "shallow" and four "intermediate" depth wells) in the alluvial WBZ. DEQ further understands the numbers, locations, and depths of the wells are intended to reduce the potential for DNAPL migration during operation.

DEQ has considered the proposal and meeting discussions, and acknowledges NW Natural's desire and commitment to implementing groundwater SCMs. However, for the reasons provided in our March 26th comments letter to the Interim Design Report and as discussed during meetings, DEQ continues to maintain remedial action alternatives for addressing groundwater contamination and DNAPL in this portion of the site warrant evaluation in the uplands FS.

The basis for DEQ's position is provided in our March 26th letter commenting on the Interim Design Report which should be referred to for additional information. In summary, since DEQ commented on the Groundwater/DNAPL FFS, the principal elements of SCMs planning for the alluvial WBZ along this portion of Segment 1 have included a vertical barrier and "shallow" and "intermediate" depth extraction wells. The barrier and extraction wells were intended to operate in combination to physically block DNAPL migrating towards the river (vertical barrier); increase horizontal and upward vertical gradients operating behind the barrier; and control and contain groundwater in the alluvial WBZ beneath the barrier. In the Interim Design Report NW Natural recommended implementing HC&C as soon as practicable after finalizing the design and obtaining necessary permits; and further evaluating the vertical barrier and DNAPL removal SCMs in the uplands FS.

DEQ accepted NW Natural's recommendation for the vertical barrier, in part for the reasons listed in Section 3.3.1 of the Interim Design Report. However, because SCMs design was based on a vertical barrier and HC&C combination, DEQ determined HC&C for this portion of Segment 1 should also be evaluated in the uplands FS along with DNAPL remedial action alternatives.

Additional topics have been discussed during meetings, including the May 17th meeting, which DEQ concludes could require substantial time and effort to resolve, including but not limited to:

- Characterizing the distribution of DNAPL sufficiently to support the proposed SCM re-design;

- Developing an effective approach for monitoring the horizontal and vertical movement of DNAPL caused by pumping extraction wells; and

- Identifying performance criteria so the re-designed HC&C system could be operated to minimize the potential for DNAPL migration, or be shut-down based on DNAPL movement.

DEQ remains concerned the potential for mobilizing DNAPL exceeds the benefits of operating the HC&C system without the vertical barrier. Given the bulk of the mass of contamination resides in DNAPL, the properties of the DNAPL, and subsurface geologic conditions, DEQ concludes the short-term benefit of implementing HC&C alone, does not justify the risk of exacerbating DNAPL distribution, not evaluating HC&C in the context of DNAPL remedial action alternatives in the FS, not evaluating other options to achieve the overall project objectives (e.g., an overall project schedule which accommodates the uplands FS), and/or potentially delaying the uplands FS.

Based on the information summarized above and consistent with the March 26th letter, DEQ directs NW Natural to:

- Evaluate HC&C with DNAPL remedial action alternatives along the portion of Segment 1 corresponding to the vertical barrier alignment in the uplands FS;

- Complete additional evaluations of the locations and depths of extraction wells PW-1, PW-2, PW-7, and PW-8, and the need for an additional extraction well southeast (upstream) of PW-1; and

- Proceed with developing a final design for extraction wells PW-1 and PW-2 (and a possible additional well southeast of PW-1) on the Siltronic property, and extraction wells PW-7 through PW-10 along shoreline Segment 2.

DEQ would consider the following alternative to the preceding direction:

- Incorporating the principal design elements ("shallow" and "intermediate" depth sets of extraction wells) and performance objectives of the May 17th HC&C re-design into the interim design with a vertical barrier constructed to -60 feet bottom elevation (i.e., complete the design for the vertical barrier/HC&C combination);

- Completing the additional evaluations of the locations and depths of extraction wells PW-1, PW-2, PW-7, and PW-8; and the need for an additional extraction well southeast of PW-1; and

- Proceed with developing a final design which includes a vertical barrier in the southern portion of the NW Natural property and HC&C along segments 1 and 2, including shallow and intermediate depth sets of extraction wells behind the vertical barrier, extraction wells PW-1 and PW-2 (and a possible additional well southeast of PW-1) on the Siltronic property, and extraction wells PW-7 through PW-10 along shoreline Segment 2.

In either case, NW Natural should provide a written response to DEQ's March 26th comments and requests for information and/or clarifications, including revised figures, on or before July 14, 2010. NW Natural should also begin preparing the final source control design document.

Please feel free to contact me with questions regarding this e-mail.

Mr. Dana Bayuk, Project Manager

Cleanup & Portland Harbor Section

Oregon Department of Environmental Quality

2020 SW 4th Avenue, Suite 400

Portland, OR 97201

E-mail: bayuk.dana@deq.state.or.us

Phone: 503-229-5543

FAX: 503-229-6899

Please visit our website at http://www.oregon.gov/DEQ/

John Edwards

Subject: FW: Gasco Source Control Decision Dispute

From: Wyatt, Robert
To: 'ANDERSON.Jim@deq.state.or.us' <ANDERSON.Jim@deq.state.or.us>
Cc: Kirkpatrick, Margaret; 'BAYUK.Dana@deq.state.or.us' <BAYUK.Dana@deq.state.or.us>; 'pdost@pearllegalgroup.com' <pdost@pearllegalgroup.com>
Sent: Wed Jul 14 11:57:02 2010
Subject: Gasco Source Control Decision Dispute

Hi Jim,

This email provides DEQ with notice that NW Natural is invoking dispute resolution for the DEQ source control direction sent to us from DEQ via email on June 11, 2010. NW Natural will provide a written position document for the dispute to DEQ next week.

Thank you,

Bob

Robert J. Wyatt
NW Natural
503-226-4211

John Edwards

Subject: FW: Gasco Source Control Decision Dispute

From: ANDERSON Jim M <ANDERSON.Jim@deq.state.or.us>
To: Wyatt, Robert
Cc: Kirkpatrick, Margaret; BAYUK Dana <BAYUK.Dana@deq.state.or.us>; pdost@pearllegalgroup.com <pdost@pearllegalgroup.com>; BURKHOLDER Kurt <Kurt.BURKHOLDER@state.or.us>; PEDERSEN Dick <PEDERSEN.Dick@deq.state.or.us>
Sent: Tue Jul 20 11:34:08 2010
Subject: RE: Gasco Source Control Decision Dispute

Bob,

I want to describe how I recommend the dispute process should proceed. I reviewed the DEQ/NWN 12/22/93 Voluntary Cleanup Agreement (WMCVC-NWR-94-13) & 7/19/06 1st Addendum, & believe my recommendation is basically in-line with the Agreement & Addendum. I see 5 steps in the process. I welcome & will definitely consider any of your suggested changes or alternatives to my recommendation, but believe we should agree on the dispute resolution process before going much farther.

1) Step 1- Establish the structure & schedule for resolving the dispute- My suggestion for the structure of the dispute resolution is laid out in this e-mail. I recommend we establish the following schedule:

-7/27/10- Complete Step 1

-8/2/10- Complete Step 2

-8/9/10- Complete Step 3

-8/20/10- Complete Step 4 (I'll be in Indiana at a conference 8/10 thru 8/13/10)

-8/24/10- Begin step 5, if necessary

2) Step 2- Define the issue(s) in dispute- I think you & I should agree in writing on a precise definition of the issue. My recommendation of the definition of the disputed issue is contained in Dana B's 6/11/10 e-mail to you & summarized in my 6/18/10 e-mail to you in which I said…, "DEQ directed NWN to defer NWN's proposed HC&C source control in the portion of Segment 1 corresponding to the vertical barrier alignment (essentially the former tar ponds are) to the upland FS."

3) Step 3- Define respective positions on the issue in writing- I understand you are preparing NWN's position on the issue & dispute. I'll hold off preparing DEQ's position until we define the issue (Step 2).

4) Step 4- Negotiate on respective positions- I recommend you & I meet to make a strong, good-faith effort to try to resolve the dispute at our line-manager level before elevating the issue to senior managers.

5) Step 5- Elevate dispute resolution to senior managers, if necessary- I understand the senior managers will be Dick Pedersen & Margaret Kirkpatrick.

Jim Anderson

Manager, DEQ Portland Harbor Section

ph: 503.229.6825

fax: 503.229.6899

cell: 971.563.1434

-----Original Message-----
From: Wyatt, Robert [mailto:rjw@nwnatural.com]
Sent: Wednesday, July 14, 2010 11:57 AM
To: ANDERSON Jim M
Cc: Kirkpatrick, Margaret; BAYUK Dana; 'pdost@pearllegalgroup.com'
Subject: Gasco Source Control Decision Dispute

Hi Jim,

This email provides DEQ with notice that NW Natural is invoking dispute resolution for the DEQ source control direction sent to us from DEQ via email on June 11, 2010. NW Natural will provide a written position document for the dispute to DEQ next week.

Thank you,

Bob

Robert J. Wyatt

NW Natural

503-226-4211

NW Natural®
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November 29, 2010
Via Email and US Mail

James M. Anderson
Manager, DEQ Portland Harbor Section
Oregon Department of Environmental Quality
NW Region
2020 SW Fourth Ave Ste 400
Portland, OR 97201-4987

Re: Response to DEQ's August 9, 2010 Letter related to the Shoreline Segment 1 Source Control Dispute; Southern Portion of the NW Natural Property
NW Natural Gasco Site
DEQ Voluntary Agreement No. WMCVC-NWR-94-13

Dear Jim:

This letter transmits NW Natural's response to DEQ's August 9, 2010 comments as discussed at our August 25 meeting and according to the agreed dispute resolution process. NW Natural's *Responses to DEQ August 9, 2010 Statements on the Shoreline Segment 1 Source Control Dispute Letter of July 14, 2010* are provided as Attachment A. The response document also references the *Projected Process and Timeline for Source Control Using the DEQ Directed Approach* and the *Projected Process and Timeline for Source Control Using the NW Natural Proposed Approach,* which are provided as Attachments B and C to this letter, respectively.

In summary, NW Natural continues to believe that DEQ should allow NW Natural to proceed with final design of Segment 1 extraction wells PW-3 through PW-6, because the source control measures developed in the Interim Design Report will effectively reduce risk from groundwater discharging in the most contaminated area of the site. Alternatively, DEQ should select a different source control action, consistent with the DEQ approved GWFFS, that provides full source control across Segments 1 and 2 of the Gasco site. The partial source control alternative directed by DEQ on June 11, 2010 was not evaluated in the GWFFS and has not been evaluated in any other technical document.

DEQ should carefully consider the policy implications of directing NW Natural to implement a very expensive removal action that (1) without question will do nothing to achieve groundwater source control in the most contaminated area of the Gasco site by the time that EPA expects construction of the in-water sediment remedy to begin; and (2) has never been subject to scientific or engineering analysis, despite more than five years of sophisticated groundwater and DNAPL migration modeling, pilot tests, feasibility studies, and engineering design.

NW Natural understands that DEQ's primary concern about operation of the hydraulic containment system proposed in NW Natural's November 2009 Interim Design Report is that operation of PW-3 through PW-6 may mobilize DNAPL in the subsurface . The modeling DEQ

required NW Natural to perform concludes that such mobilization is highly unlikely.[1] Even so, NW Natural has proposed revisions to the design of the extraction wells to address DEQ's concern, including the installation of eight additional shallow extraction wells. This design revision reduces individual well pumping rates and will minimize the effect of the system on horizontal groundwater gradients and induce upward vertical gradients in the DNAPL zones. Further, NW Natural has offered to accept very conservative assumptions to finalize the upland risk assessments in order to expedite the upland feasibility study and upland remedy selection. As you can see from the attached schedules, NW Natural believes that this compromise approach achieves the following objectives:

1. Appropriate project sequencing. This sequence of remedial implementation was developed jointly by NW Natural, EPA and DEQ and begins with complete groundwater source control, followed by upland remedy and then construction of the Gasco sediment remedy. As you know, EPA believes the Gasco sediments should be among the first in line for cleanup in the Harbor. Remedial design for the sediment cleanup is at this point moving much more quickly than groundwater source control implementation. If we are not ready to move forward with the sediment cleanup by the time EPA issues a ROD for the site, NW Natural will be in the unacceptable position of needing to perform a final cleanup subject to immediate recontamination or being unable to implement EPA remedy selection consistent with appropriate harborwide construction sequencing. This would be an extraordinarily disappointing outcome of five years of source control work with DEQ.

2. Minimize the amount of time between operation of the extraction wells and selection and implementation of a final DNAPL remedy (which should mitigate DEQ's concerns about DNAPL migration during the interim).

3. Implementation of final upland remedies more than a year earlier than DEQ's approach.

4. Implementation of EPA's in-water remedy for sediments adjacent to Gasco more than two years earlier than DEQ's approach.

Finally, NW Natural understands that it remains responsible for DNAPL present at Gasco in the event that migration related to operation of the extraction wells does occur.

There will never be a perfect dataset for any technical problem, and therefore some level of uncertainty will always remain. NW Natural has worked for several years to provide all of the sampling, analysis, modeling and reporting requested by DEQ, and believes the extensive dataset available is comprehensive enough for DEQ to make a groundwater source control decision. As

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[1] "NW Natural investigations required by DEQ have shown that the operation of source control wells would not significantly impact the distribution of upland DNAPL (Anchor and SSPA 2008; Anchor QEA 2009b) and would cause little if any increased rate of DNAPL migration. Thus, near term source control actions do not need to include a vertical barrier to block DNAPL migration to the river. Because the extraction wells will cause a reversal of the groundwater gradient, operation of the extraction wells will reduce the potential for DNAPL in the shoreline area to migrate to the river." *Interim Design Report, Gasco Groundwater Source Control* (AnchorQEA, November 2009).

the agency charged with environmental risk management in Oregon, DEQ must balance the risk of making decisions even though some uncertainty remains against the risk of doing nothing at all. In this case, we think the balance clearly tips toward: (1) turning off the flow of the most significantly impacted groundwater to the river sooner rather than later, and (2) enabling the cleanup to move forward expeditiously and in proper sequence.

Please contact me at your earliest convenience to schedule the next meeting.[2]

Sincerely,

Bob Wyatt

cc: Dana Bayuk, Oregon Department of Environmental Quality
Kurt Burkholder, Oregon Department of Justice
Margaret Kirkpatrick, NW Natural
Patty Dost, Pearl Legal Group
Carl Stivers, AnchorQEA
John Edwards, AnchorQEA
Ben Hung, AnchorQEA

Attachments

A. Responses to DEQ August 9, 2010 Statements on the Shoreline Shoreline Segment 1 Source Control Dispute Letter of July 2010
B. Projected Process and Timeline for Source Control Using the DEQ Directed Approach
C. Projected Process and Timeline for Source Control Using the NW Natural Proposed Approach.

[2] NW Natural is in receipt of DEQ's October 27, 2010 letter, which contains several new technical opinions. NW Natural disagrees with the new technical opinions expressed in the October 27 letter and will be prepared to discuss them at our meeting.

Attachment A - Responses to DEQ August 9, 2010 Statements on the Shoreline Segment 1 Source Control Dispute Letter of July 14, 2010

DEQ Statements		NW Natural Talking Points/Responses
1	In an e-mail dated July 14, 2010, NW Natural informed DEQ of its intent to invoke dispute resolution regarding DEQ's June 11, 2010 direction for NW Natural to: • Evaluate hydraulic control and containment (HC&C) with dense non-aqueous phase liquid (DNAPL) remedial action alternatives along the portion of Segment 1 corresponding to the vertical barrier alignment in the uplands feasibility study (FS); • Complete additional evaluations of the locations and depths of extraction wells PW-1, PW-2, PW-7, and PW-8, and the need for an additional extraction well southeast (upstream) of PW-1; and • Proceed with developing a final design for extraction wells PW-1 and PW-2 (and a possible additional well southeast of PW-1) on the Siltronic property, and extraction wells PW-7 through PW-10 along shoreline Segment 2.	Statements noted. On July 20, 2010 NW Natural submitted to DEQ its rationale for requesting formal dispute resolution and its Response to DEQ's March 26, 2010 Comments on Interim Design Report.
2	In a July 20, 2010 e-mail to NW Natural, DEQ presented a recommendation for a 5-step process and schedule leading us through dispute resolution. Those five steps are: • Step 1- Establish the structure and schedule for resolving the dispute • Step-2- Define the issue(s) in dispute • Step 3- Define respective positions on the issue in writing • Step 4- Negotiate at our level on the respective positions • Step 5- Elevate dispute resolution to senior managers, if necessary	Statements noted.
3	In a July 29, 2010 e-mail reply, NW Natural indicated DEQ's proposed process and schedule were fine. With NW Natural's July 29th concurrence, DEQ considers Step 1 complete. Regarding Step 2,	DEQ has yet to provide NW Natural with any valid technical justification for the determination that NW Natural's proposal to install extraction wells without

DEQ Statements	NW Natural Talking Points/Responses
DEQ defined our understanding of the disputed issue in e-mails sent June 18, July 20, and July 30, 2010 as: "DEQ directed NW Natural to defer NW Natural's proposed HC&C source control in the portion of Segment 1 corresponding to the vertical barrier alignment (essentially the former tar ponds area) to the upland FS." Subsequently, in an August 2, 2010 e-mail NW Natural indicated that the dispute was not DEQ's direction to NW Natural to defer the proposed HC&C source control to the upland FS. Rather, the primary issue NW Natural states it is disputing is DEQ's decision that source control in Segment 1 is no longer a priority, and therefore DEQ intends to defer any source control decision for that Segment to the final remedy. That statement is incorrect. DEQ still considers the former tar pond area to be perhaps the most contaminated portion of the site and a high priority for source control. Indeed, DEQ's greatest concern with NW Natural's proposal to install extraction wells without also constructing a vertical barrier is that it will likely mobilize existing DNAPL and exacerbate existing conditions. Our source control direction is not a change of priorities; it is a determination that NW Natural's proposal to install HC&C and defer the vertical barrier along the NWN Portion of Segment 1 will likely exacerbate contamination.	also constructing a vertical barrier will likely mobilize existing DNAPL and exacerbate existing conditions. At DEQ's request, and specifically to address DEQ's concern, NW Natural has completed numerous field studies and technical analyses and has provided reports related to potential effects of hydraulic containment on DNAPL. The most recent report was the Evaluation of Potential DNAPL Mobilization in Former Effluent Pond Area by Shoreline Source Control Extraction Wells (Anchor QEA; March, 2009). DEQ has not provided technical comments on the findings of that report. The results of the field studies and analysis to date uniformly indicate that minor DNAPL mobilization that could result from hydraulic control and containment would not exacerbate existing conditions. Therefore, NW Natural believes that the results of the DNAPL evaluation studies address DEQ's concern about potential DNAPL migration. It is important to note that the conclusions Anchor QEA reached on DNAPL mobility are based on the results of the DEQ-requested DNAPL assessments. DEQ has not provided the basis for its continued concern, the technical rationale for its alternate conclusion, nor has it provided comments on the DNAPL mobilization report. NW Natural requests that DEQ provide a technical basis for its concern, and comments on the requested DNAPL assessment report.

DEQ Statements	NW Natural Talking Points/Responses
	Regardless, to address DEQ's continued technical concern, NW Natural has proposed a comprehensive plan for implementing source control and moving forward quickly on the RA and FS in parallel. Implementation of this comprehensive plan will allow installation and operation of HC&C across all of Segments 1 and 2 as soon as possible, and further evaluation (and implementation, as needed) of DNAPL controls will occur within a very short time frame. As a policy matter, DEQ directed NW Natural to prioritize source control evaluation and design, over the upland FS, years ago. Since that time, NW Natural has spent millions of dollars to conduct DEQ requested studies and designs to meet that objective. During that period of years, DEQ placed review of the upland risk assessments on hold. The DEQ decision to now postpone selection of complete Segment 1 source control and defer it to the upland FS, which has been on hold, was unexpected and inconsistent with the intent of prioritization. NW Natural believes the swiftest, most efficient way to achieve source control is to make any adjustments DEQ requires to the existing design, which can be rapidly finalized and constructed. NW Natural still believes implementing source control along all of Segment 1 is a priority and that it should be

DEQ Statements		NW Natural Talking Points/Responses
		constructed as soon as possible. Shoreline wide source control should be constructed in advance of the overall upland remedy as originally agreed. There is no way that an upland FS can be completed and a subsequent source control measure selected and then designed as quickly as simply finalizing the design DEQ currently has in hand, especially since the recent DEQ comments on the 2005 risk assessment require substantial revision before the FS can be developed.
4	Although DEQ and NW Natural do not precisely agree on the definition of the disputed issue (i.e., Step 2), our respective definitions are sufficiently close to move into Step 3 and define our respective positions in writing. DEQ understands NW Natural's position is presented in the July 20, 2010 letter. This letter presents DEQ's position on the issue and summarizes decisions regarding source control communicated to NW Natural in our March 26, 2010 letter commenting on the Interim Design Report[1] and during subsequent meetings on April 7, April 19, April 27, and May 17, 2010.	NW Natural believes the definition of the dispute has been recently verbally clarified between Bob Wyatt and Jim Anderson.
5	DEQ determined the shoreline of property owned by NW Natural (NW Natural Property) and the northern portion of the property owned by Siltronic Corporation (Siltronic Property) are high priorities for source control. Shoreline Segment 1 extends from near the south side of the Fuel and Marine Marketing (FAMM) leasehold on the NW Natural Property, to upstream of the former "Gasco Facility" manufactured gas plant (MGP) effluent ponds on the	Statements noted.

[1] Anchor QEA, LLC, 2009, "Interim Design Report – Groundwater Source Control, NW Natural Gasco Site," November (received November 10th), a report prepared for NW Natural.

DEQ Statements		NW Natural Talking Points/Responses
	Siltronic Property. Segment 1 coincides with the heaviest MGP-related impacts identified near the river, including DNAPLs, contaminated groundwater, and impacted riverbank soils. Releases of volatile organic compounds (VOCs) from Siltronic's former solvent underground storage tank system (Former UST System) have commingled with DNAPL and groundwater contamination resulting from the historic operations of the Gasco Facility in Segment 1. The most heavily impacted portion of Segment 1 occurs in the southern portion of the NW Natural Property where the bulk of DNAPLs along or near the shoreline occur. This portion of Segment 1 extends from near the south side of the FAMM leasehold to near the property line between the NW Natural and Siltronic properties, and is referred to as the "NWN Portion of Segment 1" in this letter. This letter focuses on DEQ's position regarding source control for the NWN Portion of Segment 1.	
6	Several years ago DEQ prioritized source control over the upland remedial investigation (RI) and FS. The goal of source control was to identify high priority contaminant transport pathways to the river, and design and implement source control measures (SCMs) to control those pathways so in-water actions could proceed without the risk of recontamination. Completion of the site-wide upland RI/FS was to follow SCMs design. As such, source control planning and design was prioritized over the uplands RI/FS. NW Natural completed the Groundwater/DNAPL Focused Feasibility Study[2] (FFS) for Segment 1 and Segment 2 in November 2007. In the	DEQ prioritization of source control over the upland RI and FS was a DEQ decision solely. Later in DEQ's letter it is characterized as a DEQ *and* NW Natural decision. NW Natural agrees that source control in the upland is a priority. NW Natural was and is prepared to complete the upland RI/FS on a parallel track; it was DEQ's decision to devote few DEQ resources to the upland RI/FS. NW Natural continues to believe source control in the area of primary groundwater contaminant flux is time critical and that DEQ should

[2] Anchor QEA, LLC, 2007, "Groundwater/DNAPL Source Control Focused Feasibility Study – NW Natural „Gasco" Site," October 12 (amended November 9th), and report prepared for NW Natural.

DEQ Statements	NW Natural Talking Points/Responses
Groundwater/DNAPL FFS, NW Natural evaluated SCMs alternatives and recommended SCMs to achieve source control remedial action objectives (i.e., prevent DNAPL in the uplands from migrating to the Willamette River [remedial action objective {RAO} #1]; achieve hydraulic capture of upland groundwater discharging to the river [RAO #2]). NW Natural's recommended SCMs combine a well-based HC&C system along shoreline segments 1 and 2 with a vertical barrier along the NWN Portion of Segment 1. DEQ approved NW Natural's recommendation subject to conditions and comments detailed in a March 21, 2008 letter, which included, but were not limited to the following: • Adding extraction wells above the bottom of the vertical barrier with the objective increasing horizontal and upward vertical gradients operating behind the barrier, and reducing the potential for DNAPL to migrate below and beyond the influence of deeper extraction wells. • Constructing engineering controls in the fill water-bearing zone (WBZ) on the upland side of the barrier to prevent DNAPL and/or contaminated groundwater from moving over or around the vertical barrier. • Including DNAPL removal as a SCM to the extent necessary to control and contain the potential movement of DNAPL from former effluent ponds on the NW Natural and Siltronic properties that could result from operation of the hydraulic control/containment system.	provide direction for finalizing and implementing the source control design.
7 Since DEQ commented on the Groundwater/DNAPL FFS, NW Natural and DEQ have been working towards implementing source control along segments 1 and 2. The source control planning and design process has involved source control design support and feasibility studies. The largest, most time-consuming, resource	Statements noted.

DEQ Statements		NW Natural Talking Points/Responses
	intensive and costly source control studies were the vibration study[3] and groundwater treatability[4] and treatment system pilot[5] studies. These studies were essential for evaluating the feasibility and design of NW Natural's recommended SCMs, especially given the potential for vertical barrier construction to negatively impact Siltronic's operating microelectronics facility located immediately south of the NWN Portion of Segment 1. As indicated in DEQ's August 22, 2008 letter commenting on the Preliminary Design Report, other studies including the Gradient Evaluation Report[6] and the DNAPL Mobilization Evaluation[7] were required by DEQ to support source control planning, but also so NW Natural would complete work recommended years prior.	
8	Through preliminary design planning, the principal elements of source control along the NWN Portion of Segment 1 have included DNAPL removal in the former tar ponds areas, and a vertical barrier and "shallow" and "intermediate" depth extraction wells. These SCMs were intended to work as integrated elements to: 1) reduce DNAPL "head" and mobility in the uplands source areas (DNAPL removal in former tar ponds areas), 2) physically block DNAPL migrating towards the river (vertical barrier); and 3) control and	Statements noted.

[3] Anchor QEA, LLC, 2009, "Vibration Study Data Report, Gasco Siltronic Construction," May 2009 (received June 3, 2009), a report prepared on behalf of NW Natural.
[4] Anchor QEA, LLC, "2008, "Groundwater Source Control Treatability Testing, NW Natural Gasco Site," December (received December 8, 2008), a report prepared for NW Natural.
[5] Anchor QEA, LLC, "NW Natural and Siltronic, Groundwater Treatment System Pilot Plant Report," December (received January 21, 2010), a report prepared on behalf of NW Natural.
[6] Anchor QEA, LLC, 2008, "Groundwater Flow Model and DNAPL Evaluation Supplemental Report," October (supplemented with supporting figures on March 26, 2009), a report prepared for NW Natural.
[7] Anchor QEA, LLC, 2009, "Evaluation of Potential DNAPL Mobilization in Former Effluent Pond Area by Shoreline Source Control Extraction Wells, Gasco Site, Portland, Oregon," March 18, a technical memorandum prepared for NW Natural.

DEQ Statements		NW Natural Talking Points/Responses
	contain groundwater in the fill WBZ and behind and beneath the barrier in the alluvial WBZ; in a manner that minimizes DNAPL mobilization. Developing a SCMs design that maximizes control of DNAPL and minimizes its mobilization is and has been a high priority for DEQ as the DNAPL represents a highly concentrated, toxic and persistent source of contamination. Additionally, mobilizing DNAPL, or allowing it to migrate reduces the feasibility and effectiveness of future remedial alternatives intended to control or remove the contamination. Based on review of the DNAPL Mobilization Evaluation, DEQ approved in a June 5, 2009 letter NW Natural's proposal to sequence DNAPL removal SCMs after the vertical barrier and HC&C combination were implemented.	
9	As discussed previously in this letter, NW Natural and DEQ prioritized source control over the uplands RI/FS with the intent of selecting and constructing SCMs that effectively cut-off significant contaminant migration pathways to the river. Our joint intent was to construct the SCMs early so the in-river sediment clean-up could proceed. Once the contaminant migration pathways to the river were cut-off, additional source control/reduction efforts would be considered upgradient of the SCMs (e.g., source reduction, removal, treatment, stabilization).	These statements are inaccurate. DEQ unilaterally prioritized source control over the uplands RI/FS. Project correspondence from DEQ repeatedly states that DEQ prioritized source control over the uplands RI/FS (e.g., the March 21, 2008 comments on the Groundwater/DNAPL Focused Feasibility Study and the March 10, 2010 comments on the RI and RA). NW Natural has frequently asked about the status of DEQ review and comments on the risk assessment (RA). Our past project schedules show our continued understanding that the final draft RA was under final review by DEQ. The project schedules show our initial anticipated target date for RA comments from DEQ was 2006, followed by 2007, then 2008 and finally 2009, with comments actually received in 2010. These schedules were requested by and provided to DEQ, but DEQ never advised NW Natural that it was not

DEQ Statements	NW Natural Talking Points/Responses
	reviewing and not planning to review the RA. NW Natural also has meeting notes that document DEQ statements at multiple meetings over the last two years or so in which the RA comments were promised at various delivery points. Further, NW Natural offered to provide funding for a DEQ contractor to expedite the review of the RA but those offers were rejected by DEQ. DEQ did not review the RA according to the project schedules and verbal deadlines provided during project meetings and this letter's statements do not accurately portray the project history.
10 During review of the source control Interim Design Report it became clear to DEQ that given the current timeline for designing and constructing the vertical barrier along the NWN Portion of Segment 1, the schedule for source control functionally overlaps with the uplands FS and planning for the in-water sediment project overseen by EPA. Based on our concern with exacerbating existing conditions (i.e., DNAPL mobilization) and this overlap in projects, and because the source control planning and design process was based on combining SCMs to mitigate DNAPL and contaminated groundwater migration, DEQ determined that completing the evaluation of the vertical barrier and HC&C combination in the uplands FS would be the most comprehensive and efficient process for coordinating cleanup efforts at the facility.	This "functional" overlap is unlikely even under the most optimistic process scenarios NW Natural can envision that include the DEQ requested RA revisions and subsequent Uplands FS. Given the project history, current regulatory challenges, and additional complexity of an upland FS addressing multiple media (not just groundwater) it is very unlikely that source control will be implemented anytime in the near future if it is pushed into the overall upland FS process. As previously noted, there is no way that an upland FS can be completed and a subsequent source control measure selected and then designed as quickly as simply finalizing the design DEQ currently has in hand, especially since the recent DEQ comments on the 2005 risk assessment require substantial revision before the FS can be developed. Please refer to the attached conceptual schedule entitled *Projected Process and Timeline for Source Control Using the DEQ Directed*

DEQ Statements		NW Natural Talking Points/Responses
		Approach which depicts the project timeline anticipated by NW Natural based on DEQ's direction.
11	DEQ's source control decision was also influenced by the HC&C system NW Natural proposed along the NWN Portion of Segment 1in the Interim Design Report. The numbers, locations, and depths of extraction wells were essentially the same as those NW Natural recommended in the Groundwater/DNAPL FFS, which DEQ rejected for the following reasons: • Placing and pumping extraction wells below DNAPL will increase the potential for coalescence and downward vertical migration of DNAPL; and • Coalescence, pooling, and movement of DNAPL cannot be reliably predicted or monitored.	The statement, "Placing and pumping extraction wells below DNAPL will increase the potential for coalescence and downward vertical migration of DNAPL," is overly simplified. DEQ did not provide comments on the DNAPL migration model results in Anchor QEA's March 18, 2009 modeling report. If DEQ had commented on that report prior to submittal of the referenced November 2009 IDR, NW Natural would have considered modification of our well design accordingly.
12	DEQ has consistently maintained throughout the source control planning process that potential exacerbation of the distribution of DNAPL is a significant factor in SCMs planning and design. Deferring HC&C for the NWN Portion of Segment 1 so the locations, numbers, and vertical placement of extraction wells can be considered in the context of uplands DNAPL remedial alternatives is consistent with DEQ's overall source control planning approach taken since before the Groundwater/DNAPL FFS was submitted.	NW Natural strongly disagrees that deferring HC&C in the NWN Portion of Segment 1 is consistent with DEQ's source control planning approach since before the GWFFS was submitted. It is inconsistent with DEQ rules, guidance and prior agency practice for DEQ to select a source control action not evaluated in the approved Groundwater Focused Feasibility Study. Deferring HC&C to the upland FS was not proposed to NW Natural until the March 26, 2010 DEQ comments to the Interim Design Report.
13	In Section 3.3.1 of the Interim Design Report, NW Natural recommends HC&C for the NWN Portion of Segment 1 be implemented as soon as practicable and the vertical barrier and DNAPL removal alternatives be further evaluated in the uplands	Statements noted.

DEQ Statements		NW Natural Talking Points/Responses
	FS. The advantages of further evaluating SCMs in the uplands FS is acknowledged by NW Natural for the vertical barrier in Section 3.3.1, many of which DEQ concurred with including the following: • The uplands FS could identify alternative technologies, or combinations of technologies, including DNAPL removal, soil removal, and alternative configurations of vertical barriers, that would be more effective at achieving RAO #1 than the vertical barrier identified in the Interim Design Report; • Evaluating the vertical barrier during the uplands FS would allow it to be considered in the context of a site-wide remedial action strategy; and • Postponing the vertical barrier would facilitate development of more fully integrated upland and in-water sediment remedial actions.	
14	DEQ believes the same considerations apply to the HC&C system along the NWN Portion of Segment 1 and warrant completion of its evaluation in the uplands FS.	The shoreline source control extraction wells can be designed to operate successfully in the interim period prior to the upland cleanup without the vertical barrier. During final design of the extraction wells, we would design the screen depths and well spacing to accommodate the later addition of a vertical barrier, if selected in the Upland FS. Therefore, delaying the HC&C well design to the Upland FS does not have the same benefit for the shoreline extraction wells that it does for the vertical barrier.
15	DEQ considers it likely HC&C will be carried forward into detailed analysis of remedial action alternatives in the uplands FS. However, the uplands FS will subject HC&C, as well as DNAPL removal and	NW Natural believes that future evaluations of DNAPL remedial alternatives in the upland FS will be more effective if they are informed by monitoring data

DEQ Statements		NW Natural Talking Points/Responses
	the vertical barrier along the NWN Portion of Segment 1, to more thorough and rigorous evaluations in the context of a broader range of remedial technologies and/or combinations of remedial technologies. The FS will result in a more comprehensive integrated uplands remedial action strategy for the tar ponds area, which should be effective at addressing DNAPL and contaminated soil and groundwater, and minimizing exacerbation of DNAPL distributions in upland areas and along the shoreline near the river.	resulting from implementation of shoreline HC&C extraction wells in all of Segments 1 and 2. Offshore groundwater capture data obtained from monitoring the operation of the shoreline extraction wells in Segments 1 and 2 are also needed for fully evaluating remedial alternatives and designing the in-water sediment remedy.
16	Besides determining the vertical barrier, DNAPL removal, and HC&C SCMs along the NWN Portion of Segment 1 should be deferred to the uplands FS; DEQ's March 26, 2010 letter approved NW Natural moving forward with groundwater source control along approximately 400 to 450 feet of Segment 1 (i.e., the portion on the Siltronic Property) and all of Segment 2. In other words, DEQ's source control decision approved or conditionally approved groundwater source control along approximately 1250-1350 feet of shoreline segments 1 and 2, which together represent about 2,000 feet of shoreline.	However, the agency direction did not approve source control along approximately 900 feet of shoreline (i.e., the NW Natural portion of Segment 1) where the majority of the combined Segment 1 and 2 dissolved contaminant mass flux occurs.
17	While, NW Natural appears to have accepted DEQ's source control decisions regarding DNAPL removal, the vertical barrier, and groundwater source control along the Siltronic portion of Segment 1 and Segment 2, NW Natural disputes DEQ's direction to defer HC&C for the NWN Portion of Segment 1 to the uplands FS.	This statement is inaccurate. As DEQ notes in the first paragraph of this letter, NW Natural disputes DEQ's source control decision as set out in Dana Bayuk's June 11 email in its entirety. As discussed in the NW Natural dispute letter, it is inconsistent with DEQ rules, guidance and prior agency practice for DEQ to select a source control action not evaluated in the approved Groundwater Focused Feasibility Study. NW Natural has agreed to defer consideration of the vertical barrier and DNAPL removal to the upland FS. Also, NW Natural will agree to implement HC&C in

DEQ Statements	NW Natural Talking Points/Responses
	Segment 2 and in the Siltronic portion of Segment 1 only if DEQ direction is to move forward with HC&C in all of Segment 1 and Segment 2.
18 NW Natural and DEQ met to discuss the issue on April 7, April 19, April 27, and May 17, 2010. During the meeting on May 17, 2010, NW Natural presented a proposal for re-designing the HC&C system along the NWN Portion of Segment 1. NW Natural for the first time recommended an HC&C approach that would incorporate the general design elements and performance objectives identified in DEQ's March 2008 comments to the Groundwater/DNAPL FFS (i.e., extraction wells placed at two different depth intervals [eight "shallow" and four "intermediate" depth wells]) in the alluvial WBZ.	The shallow and intermediate depth well scenario was modeled by Anchor QEA (March 18, 2009 report, Evaluation of Potential DNAPL Mobilization in Former Effluent Pond Area by Shoreline Source Control Extraction Wells). The issue of DEQ not commenting on this report was also pointed out in NW Natural's response to item 4 of DEQ's IDR comments. The following conclusion was provided in the Summary Discussion and Conclusions section of the March 2009 report. "From this analysis, enhanced groundwater movement in the former effluent pond area due to shoreline extraction wells is minimal and would not substantially change DNAPL distribution over time. These calculations are conservative approximations of the potential distances that DNAPL could travel and the true estimate would be less if the capillary term were factored into the calculation. The analysis also shows that pumping from the intermediate wells produces significantly smaller potential distances of travel. Therefore it is unlikely that that shallow extraction wells will be selected for design of the shoreline extraction system." Until the March 26, 2010 letter, DEQ had not provided any technical comments on this report or commented

DEQ Statements		NW Natural Talking Points/Responses
		on this conclusion. DEQ did not provide technical comments on this March 2009 report prior to submittal of the November 2009 IDR, even though this evaluation was requested by DEQ. Therefore, NW Natural did not include shallow extraction wells in the IDR design. If DEQ had commented on this conclusion, NW Natural would have been able to consider modifications to the design of the extraction system as NW Natural is currently proposing to do.
19	DEQ understands the numbers, locations, and depths of the wells are intended to control dissolved phase contaminant migration to the river and reduce the potential for DNAPL migration during operation. DEQ anticipated seeing something similar in the Interim Design Report combined with the vertical barrier.	See above response. DEQ would likely have seen such a design if DEQ had commented on Anchor QEA's March 2009 model report.
20a	That said, DEQ's maintains the position that HC&C alone, including NW Natural's May 17th approach, does not represent a viable short-term SCM alternative. There are many outstanding design issues associated with designing and implementing a stand-alone HC&C alternative along the NWN Portion of Segment 1 because of the presence of DNAPL. NW Natural would have to show that: • Characterization of the nature and extent of DNAPL is sufficient to support the proposed SCM re-design;	DEQ does not state here why DNAPL characterization is insufficient if a barrier is not installed, but is simultaneously sufficient if a barrier wall would be installed. The dataset is extensive. NW Natural has spent over two years collecting additional data and conducting additional analyses consecutively required by DEQ since its conditional approval of source control in March 2008. NW Natural believes that sufficient characterization data has been provided for DEQ to select source control measures.
20b	• The environmental benefits of operating the wells justifies the risk of implementation (e.g., operation of the HC&C system to control dissolved phase migration justifies the risk of exacerbating the subsurface distribution of DNAPL	NW Natural's July 20 letter provides this justification.

DEQ Statements		NW Natural Talking Points/Responses
	compared to pre-pumping conditions);	
20c	• The horizontal and vertical movement of DNAPL caused by pumping can be effectively and reliably monitored;	The same technologies that would be evaluated in the FS to effectively and reliably monitor DNAPL movement could be evaluated in a technical memo now or as part of final source control design. NW Natural sees no reason to wait to perform this evaluation until the Upland FS because the technologies evaluated will be exactly the same.
20d	• Performance criteria can be developed so the system can be operated to minimize the potential for DNAPL migration, or be shut-down based on DNAPL movement;	We can develop performance criteria either in an interim technical memo or in the final design.
20e	• There is a clear benefit to operating the wells before the uplands FS is completed instead of evaluating HC&C in the context of DNAPL remedial technologies in the FS, and/or other non-technical approaches (e.g., develop an overall integrated schedule for the uplands and in-water sediment remediation projects).	NW Natural understood there was an overall integrated schedule. This integrated schedule was even provided to EPA as part of the Gasco sediment remedy design Order. Please refer to the attached conceptual schedule entitled *Projected Process and Timeline for Source Control Using the NW Natural Proposed Approach*. This schedule depicts the integrated approach previously provided to EPA, which has been updated based on the current project status. In addition, detail has been added to provide greater understanding of the sub-tasks associated with the principle project components. It was our understanding that DEQ would select a source control measure for all of Segment 1 and Segment 2 which NW Natural would construct first. The in-water sediment remedial design and upland feasibility study would then be completed using empirical data from the operation of the source control

DEQ Statements	NW Natural Talking Points/Responses
	system. The upland remedy would be constructed second, followed by the sediment remedy after all potential sources of recontamination of sediments from the uplands are controlled. Given the timing and scope of the DEQ comments on the RA, and the recent DEQ source control decision, that integrated sequence is jeopardized. Please refer to the schedule entitled *Projected Process and Timeline for Source Control Using the DEQ Directed Approach*. This conceptual schedule shows that by following DEQ's current direction the in-water cleanup action would be delayed by years. It is not clear how the upland FS, upland remedy design, and upland remedial construction process can be completed before the in-water design is approved unless DEQ makes a source control decision for all of Segments 1 and 2 now, and is willing to expedite the upland FS as recommended by NW Natural. In addition, with NW Natural's proposed approach, the primary source area of dissolved phase contaminant mass discharge to the river would be stopped soon, rather than several years from now. These points are already made in the dispute document and NW Natural's response to comments on the IDR. NW Natural's July 20 letter also provides this justification.
21 DEQ believes that resolving these issues could require substantial time and effort, especially given the nature, movement, and extent of DNAPL has not been fully characterized in the area of influence of the proposed extraction wells. DEQ understands from NW Natural's perspective that the source control decision pushes implementation	We believe DEQ overestimates the time that finalizing the existing HC&C design would take, while underestimating the time the revisions requested for the RA and completion of the Upland FS, design, etc. could take. NW Natural proposes to work with DEQ

DEQ Statements	NW Natural Talking Points/Responses
of source control along the NWN Portion of Segment 1 out to completion of the uplands FS. In the agendas prepared for the April 27th and May 17th meetings, NW Natural indicates, "The window of GW pumping without specific additional DNAPL control remedy is 2-3 years." DEQ considers this projection to be an overestimate because NW Natural does not factor in the time necessary to complete source control final design, including treatment system permitting and HC&C construction. This would reduce the time of HC&C operation before the uplands FS is complete and supports DEQ's contention that any benefits associated with HC&C along the NWN Portion of Segment 1 would be short-term.	to modify the design of the planned Segment 1 extraction wells to further reduce the potential for migration of DNAPL, provide technical memos for monitoring and performance criteria, complete the final source control design, and install and begin operation of HC&C as soon as possible. As shown on the attached *Projected Process and Timeline for Source Control Using the NW Natural Proposed Approach* schedule, completion of the final source control design and installation of HC&C can thus be accomplished within a year or less considering that most of the source control design elements are already in the Interim Design Report. By deferring installation and operation of the Segment 1 extraction wells to the Uplands FS, DEQ is essentially postponing the implementation of source control in that portion of Segment 1 for about 3 years. This forecasted time period for the Uplands FS, remedy design, permitting, and construction is based on 1) recognition that the Upland FS will involve numerous additional remedy evaluations for upland groundwater, soils, and stormwater 2) DEQ is currently requesting additional data collection and another complete revision of the RA before even starting the Upland FS and 3) the number of years needed to take the Gasco source control 2007 GWFFS to the current stage of source control design. The probable effects of these factors on the project schedule are shown on the attached schedule entitled *Projected Process and Timeline for Source Control Using the DEQ Directed Approach*.

DEQ Statements	NW Natural Talking Points/Responses
22a NW Natural has estimated completion of the uplands FS by the end of 2011 with upland final remedy selection and implementation in 2012. NW Natural asserts that deferring HC&C along the NWN Portion of Segment 1 to the uplands FS could mean source control is not achieved in time to support the in-water sediment project. DEQ understands that NW Natural believes HC&C must be put into operation as soon as practicable to show dissolved phase migration is being controlled (i.e., recontamination via the groundwater pathway will not occur) and the in-water sediment project can be implemented. DEQ disagrees with this assertion for a number of reasons including: • The in-water sediment project is in the early planning stages and the schedule is subject to change.	DEQ is assuming that EPA lead projects (Gasco Sediments and Portland Harbor) will see significant delays while the DEQ projects (Upland FS) will move quickly and smoothly to completion. This seems unlikely given that DEQ and NW Natural have been working on the risk assessment since 2001 (the 2004 draft of which was under review by DEQ for more than 5 years) and that an "expedited" groundwater source control effort was underway for over 3 years before DEQ directed NW Natural to implement a source control alternative not evaluated in the GWFFS or subsequent design studies. In addition, the recent DEQ requests for additional data and analysis for the upland risk assessment, which NW Natural disagrees with, would result in an extended schedule before the Upland FS can even be started. Although the Portland Harbor project has had significant delays, it is in the final project phase with an EPA approved final data set, and EPA has recently publicly confirmed its commitment to issue the ROD in 2012. The same cannot be said for the Upland FS or the source control effort if it is pushed into the Upland FS, especially when additional data collection and analysis is being required first to complete the RA. The two previously referenced schedules illustrate the effect of DEQ's current direction to defer source control in Segment 1 to the Upland FS.
22b • Implementation of the in-water sediment work will occur sometime after the Portland Harbor Record of Decision is	As noted above, on July 27, 2010, EPA advised Portland Harbor General Notice Letter recipients that

DEQ Statements		NW Natural Talking Points/Responses
	finalized (projected for the end of 2012 or later), and must consider the schedules for, and sequencing of other in-water projects in this section of the Portland Harbor (e.g., the upstream Arkema sediment project).	it intends to issue the ROD in 2012.
22c	• Early implementation of HC&C appears to contradict NW Natural's recommendation to postpone source control of groundwater in the fill WBZ until after the uplands final remedy is implemented.	NW Natural disagrees with this statement. See NW Natural's response to item 5 in the IDR response to DEQ comments. The IDR described that the control of groundwater in the Fill WBZ will begin with operation of the shoreline extraction wells. If the Fill WBZ is not fully controlled by the shoreline extraction wells, then paving of the site as part of the upland cleanup should cut off recharge and help contain the Fill WBZ. Therefore, control of the Fill WBZ will begin with implementation of the shoreline extraction wells and NW Natural will not know how effective those wells are at controlling the Fill WBZ until they are in operation and the monitoring data are evaluated. Based on the extensive work done on this project, the groundwater in the fill WBZ is anticipated to be fully controlled with the proposed HC&C design. In the event it is not, contingencies will be implemented as part of the Upland FS.
22d	• The primary purpose of the HC&C system is to hydraulically control migration of dissolved phase contamination to the river by reversing gradients from the river towards the uplands. Although mass removal will occur as a consequence of pumping extraction wells, the system will not be operated for this purpose. NW Natural has indicated on numerous occasions that hydraulic control will be achieved within a	NW Natural disagrees with DEQ's conclusion. If the barrier is not present, the extraction wells will have a more direct hydraulic connection to the alluvial layers from the surface to the bottom of the barrier. Therefore, the dissolved mass of contamination in that zone between the wells and river channel will be removed more quickly without the barrier present. In

DEQ Statements	NW Natural Talking Points/Responses
very short time after HC&C system start-up (e.g., less than a week). As such, there is not a compelling reason for early implementation of HC&C along the NWN Portion of Segment 1 as NW Natural contends.	its January 7, 2010 comments to the IDR EPA stated that "Delay of the barrier construction has the additional benefit of allowing the extraction wells to reverse groundwater flow and back-flush contaminated groundwater toward the pumping wells."
23a NW Natural has also asserted the risk of exacerbating DNAPL movement is low. DEQ understands NW Natural uses the results of the Gradient Evaluation Report and DNAPL Mobilization Evaluation to support this assertion. However, the modeling results presented in these documents assess conditions beneath the former tar ponds areas which are approximately 200 feet from the shoreline. DEQ continues to maintain the potential for DNAPL movement, coalescence, and vertical movement due the HC&C system is greatest in the vicinity of extraction wells, not under the former tar ponds. As indicated in DEQ's March 26th Letter, based on review of the Gradient Evaluation Report and the Interim Design Report downward vertical gradients caused by pumping wells located at depth increase by factors of between approximately 20 and 30 times. DEQ also concluded geologic factors (gaps in fine-grained material) and the properties of DNAPL (intermediate or neutral wettability with corresponding reductions in capillary forces resisting movement) along the line of extraction wells increase the potential for vertical downward movement of DNAPL. Furthermore, given the estimated timeframe for releases to have occurred, the properties of DNAPL could facilitate movement for decades more.	NW Natural agrees that there is potential for DNAPL movement in the vicinity of extraction wells, but as stated in the dispute letter, NW Natural believes that movement and capture of DNAPL in the immediate vicinity of the extraction wells is beneficial to source control, not harmful. NW Natural has provided a thorough understanding of the nature and extent of DNAPL in the former tar pond and shoreline areas based upon extensive DEQ-requested investigations. Therefore, NW Natural believes that we have an accurate CSM in this portion of the site that supports the DNAPL migration evaluations submitted to DEQ in support of the IDR. As presented to DEQ in the May 17 meeting and the July 20 NW Natural response to DEQ IDR comments, adjustments to the extraction well spacing, depth, and pumping rates can easily be made to mitigate the potential for vertical gradients to mobilize DNAPL. Although we don't fully understand the last sentence of this paragraph and request clarification from DEQ, we maintain that DNAPL mobility at the site has been characterized sufficiently for DEQ to select a shoreline wide source control measure across Segments 1 and 2.

DEQ Statements	NW Natural Talking Points/Responses
	Our proposal further provides a process for quickly developing a comprehensive upland DNAPL management evaluation in the expedited upland FS. This proposed method is intended to expedite the design and construction of upland DNAPL management as soon as possible after shoreline source control is built.
23b NW Natural's May 17th re-design is intended to respond to these concerns, however the proposal has not been fully developed or presented. As such, it is premature to make conclusions as to the performance and/or effectiveness of the re-designed HC&C system with regard to reducing DNAPL migration potential.	DEQ has refused to fully evaluate the proposed May 17th re-design and stated in technical meetings that its decision has already been made. Based on that feedback, it is our understanding that no technical justification, however valid, even though intended to directly address DEQ concerns, would have any bearing on DEQ's decision.
23c As discussed above, it could take a substantial amount of time to complete a HC&C re-design given the issues needing resolution. .	As stated previously, the March 26, 2010 letter is the first time that DEQ has provided any technical comments on the findings of the March 2009 DNAPL Mobilization Evaluation. If DEQ had commented on that report prior to submittal of the IDR, NW Natural likely would have been able to evaluate alternative extraction well designs in the IDR. NW Natural also disagrees with the general statement. Re-design and submittal with the final design and implementation would take substantially less time than putting off HC&C until implementation of the Upland FS remedy as discussed in previous responses.
24 NW Natural also asserts lateral migration of DNAPL to the river has	Boring GS-09 is in the river directly in front of the

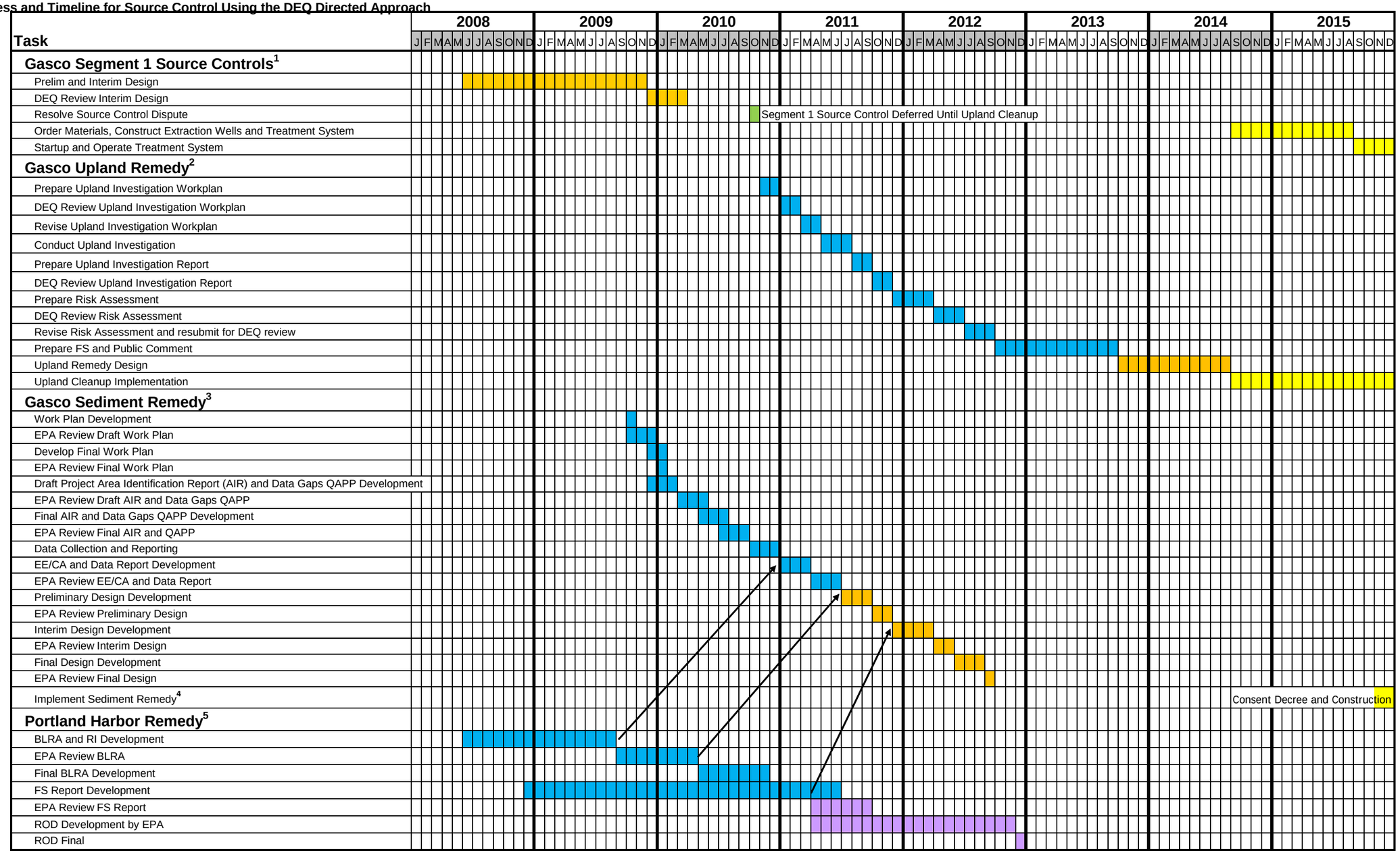
DEQ Statements		NW Natural Talking Points/Responses
	not and will not occur. The twelve borings on which NW Natural bases its assertions are spaced approximately 200 feet apart. DEQ considers there to be too few borings spaced too widely apart to support NW Natural's conclusive statements. Furthermore, based on information provided in the Offshore Investigation Report[8], Preliminary Design Report, DNAPL Mobilization Evaluation, and Interim Design Report, evidence of MGP DNAPL migration from the uplands out under the river exists at one of the nearshore drilling locations. Field measurements made during drilling in the river at Boring GS-09 detected DNAPL approximately 10 feet deeper than the bottom of MGP material reasonably interpreted as resulting from direct discharge/placement. To date, NW Natural has not addressed DEQ's comments regarding DNAPL occurrence at Boring GS-09.	historic drainage swale from the tar ponds area. Therefore, the presence of DNAPL at this location is much more likely the result of direct discharge rather than lateral migration in groundwater. This technical issue is discussed in detail in the response to DEQ comment 11b on the IDR.
25	For the reasons set forth in this letter, DEQ continues to maintain the potential for mobilizing DNAPL exceeds the short-term benefits of operating the HC&C system without additional remedial measures such as the vertical barrier. Given the bulk of the mass of contamination resides in DNAPL, the properties of the DNAPL, and subsurface geologic conditions near the shoreline, DEQ concludes the short-term benefit of controlling dissolved phase contaminant migration to the river, does not justify the risk of exacerbating DNAPL distribution. Although, NW Natural considers the risk of DNAPL migration to be low, an approach for reliably predicting and/or monitoring DNAPL movement has not been developed. Furthermore, DEQ does not consider NW Natural's assertions regarding potential impacts to the in-water sediment project schedule to be justification for implementing HC&C alone as the in-water project is in the early planning stages, the timeframe for	The approach for predicting and/or monitoring DNAPL movement could be proposed now in a technical memorandum or provided in the final design during the period shown on the attached schedule entitled *Projected Process and Timeline for Source Control Using the NW Natural Proposed Approach*. Regarding potential impacts to the in-water sediment project schedule, both NW Natural and USEPA agree that HC&C is needed prior to implementation of the in-water sediment remedy which is being conducted under USEPA authority. NW Natural does not understand why DEQ does not also agree with this fundamental point and notes that DEQ has not provided rationale for their continued disagreement.

[8] Anchor QEA, LLC, 2008, "Offshore Investigation Report - NW Natural „Gasco" Site," February, a report prepared for NW Natural

DEQ Statements		NW Natural Talking Points/Responses
	implementation is uncertain, early implementation is not warranted based on the operational objective of the HC&C system, and NW Natural has not entered into discussions with DEQ and/or EPA regarding a project schedule which fully integrates the uplands FS with the in-water project planning and design process.	In addition, whether or not the in-water sediment work timeframe for implementation is uncertain has no bearing on the on the fact that HC&C is needed prior to implementation of the sediment remedy. Furthermore, DEQ was fully aware of the in-water sediment project schedule, which was attached to the AOC for the in-water sediment work. This schedule was developed based on full source control (including HC&C) *and* the upland remedy being in place prior to the in-water sediment remedy being implemented. This project schedule fully integrated the uplands FS with the in-water planning and design process. HC&C across the entire shoreline of Gasco is needed prior to completing the design and construction of the in-water sediment remedy. As a result , the current direction from DEQ will result in significant impact to the in-water sediment remedy.
26	Based on the information summarized above and consistent with the March 26th Letter, NW Natural should follow DEQ's June 11, 2010 source control direction. DEQ's June 11th e-mail also provided NW Natural with an alternative source control direction, which incorporates the principal design elements ("shallow" and "intermediate" depth sets of extraction wells) and performance objectives of the May 17th HC&C re-design into the interim design with a vertical barrier constructed to -60 feet bottom elevation (i.e., complete the design for the vertical barrier/HC&C combination). The alternative also includes the same requirements for completing final design of extraction wells in the Siltronic portion of Segment 1 (i.e., PW-1 and PW-2) and in the southern portion of Segment 2 (i.e., PW-7 and PW-8).	This "alternative source control direction" is not direction from DEQ. It is worded as an option or choice. In fact, Dana Bayuk's email says only that DEQ would consider that option, not even that it approves the action. It is DEQ's responsibility to select the specific source control action required for the site, consistent with the approved groundwater focused feasibility study.

DEQ Statements		NW Natural Talking Points/Responses
27	**NEXT STEPS.** NW Natural and DEQ should proceed with Step 4 of the dispute resolution process and arrange a meeting to discuss each other's positions, clarify key issues central to the dispute, and resolve the key issues so uplands final source control design and the FS can move forward in a timely manner.	Statements noted.

Attachment B
Integrated Schedule of Major Gasco Deliverables
Projected Process and Timeline for Source Control Using the DEQ Directed Approach



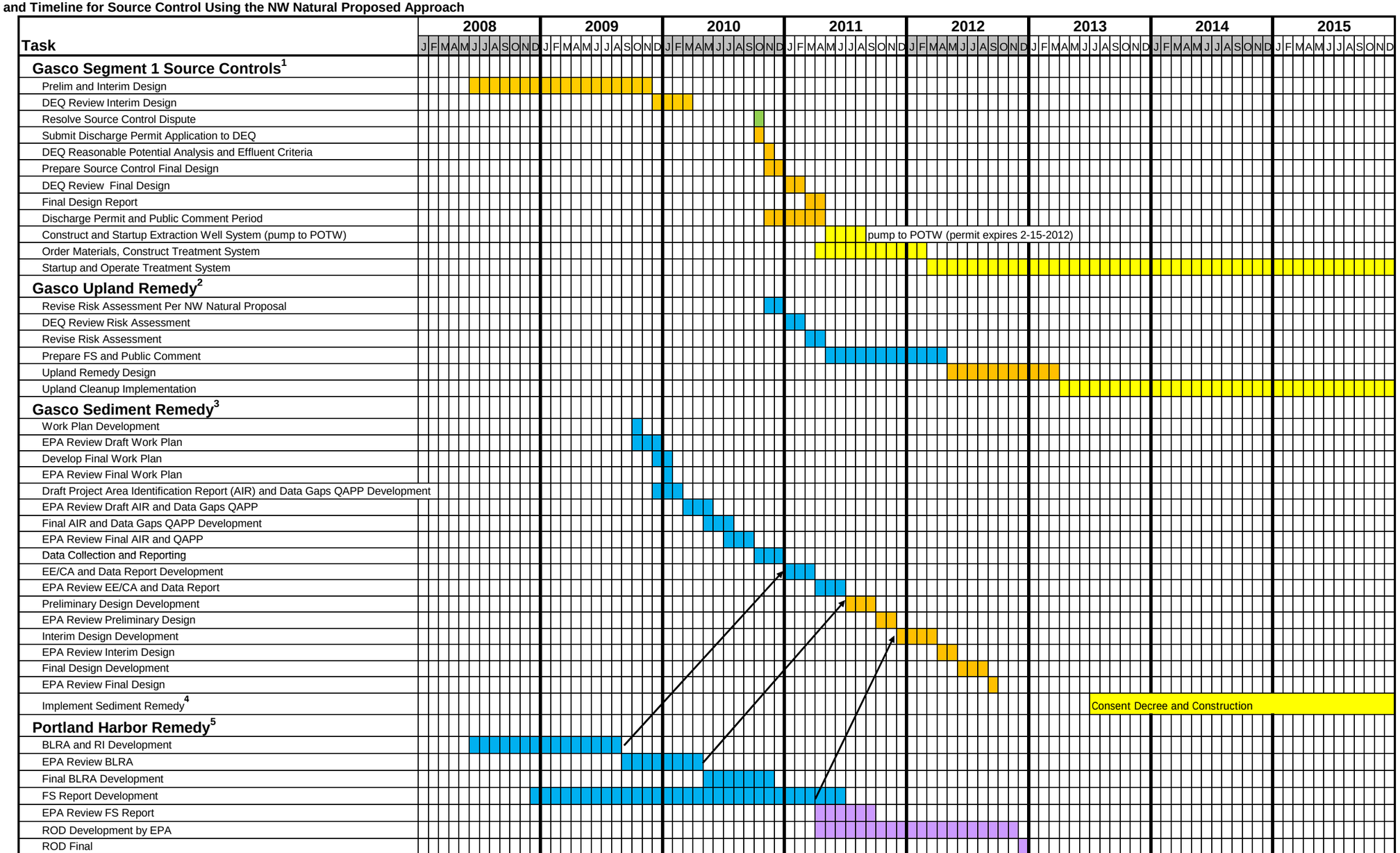
Footnotes:
The Gasco Source Control, Gasco Upland Remedy, and Portland Harbor Remedy schedule elements are for illustrative purposes only and are not enforceable schedules under the Gasco Sediment Remedy Administrative Settlement.

- Data Collection and FS Phase
- Design Phase
- Construction Phase
- EPA FS Review, Proposed Plan, and ROD

1 Gasco source controls are being evaluated and implemented by NW Natural through an Order with Oregon DEQ. The noted timeline is estimated and dependent upon the timeliness and content of DEQ comments, over which NW Natural has no control.
2 The Gasco upland remedy is being evaluated and implemented by NW Natural through an Order with Oregon DEQ. The noted timeline is estimated and dependent upon the timeliness and content of DEQ comments, over which NW Natural has no control.
3 The noted timeline is dependent upon the timeliness of the EPA comments, over which NW Natural has no control.
4 The Portland Harbor remedy is being evaluated through an RI/FS conducted by the Lower Willamette Group (LWG), which is under Order with EPA Region 10. EPA is solely responsible for FS Review, the Harbor Proposed Plan, and the Harbor Record of Decision (ROD). The noted timeline is estimated and dependent upon the ability of the LWG to meet the RI/FS submittal timeline, the timeliness and content of EPA comments on the RI/FS, as well as EPA's timing for developing the Proposed Plan and ROD. NW Natural has no control over any of these factors.

5 Construction of the sediment remedy is contingent upon a Portland Harbor ROD, a sediment remedy consent decree with EPA, and implementation of groundwater source control.

Attachment C
Integrated Schedule of Major Gasco Deliverables
Projected Process and Timeline for Source Control Using the NW Natural Proposed Approach



Footnotes:
The Gasco Source Control, Gasco Upland Remedy, and Portland Harbor Remedy schedule elements are for illustrative purposes only and are not enforceable schedules under the Gasco Sediment Remedy Administrative Settlement.

- Data Collection and FS Phase
- Design Phase
- Construction Phase
- EPA FS Review, Proposed Plan, and ROD

1 Gasco source controls are being evaluated and implemented by NW Natural through an Order with Oregon DEQ. The noted timeline is estimated and dependent upon the timeliness and content of DEQ comments, over which NW Natural has no control.
2 The Gasco upland remedy is being evaluated and implemented by NW Natural through an Order with Oregon DEQ. The noted timeline is estimated and dependent upon the timeliness and content of DEQ comments, over which NW Natural has no control.
3 The noted timeline is dependent upon the timeliness of the EPA comments, over which NW Natural has no control.
4 The Portland Harbor remedy is being evaluated through an RI/FS conducted by the Lower Willamette Group (LWG), which is under Order with EPA Region 10. EPA is solely responsible for FS Review, the Harbor Proposed Plan, and the Harbor Record of Decision (ROD). The noted timeline is estimated and dependent upon the ability of the LWG to meet the RI/FS submittal timeline, the timeliness and content of EPA comments on the RI/FS, as well as EPA's timing for developing the Proposed Plan and ROD. NW Natural has no control over any of these factors.

5 Construction of the sediment remedy is contingent upon a Portland Harbor ROD, a sediment remedy consent decree with EPA, and implementation of groundwater source control.

John Edwards

Subject: FW: 12/13/10 Gasco Dispute Mtg

From: ANDERSON Jim M [ANDERSON.Jim@deq.state.or.us]
Sent: Wednesday, December 15, 2010 4:21 PM
To: Wyatt, Robert
Cc: BAYUK Dana; DECONCINI Nina; PEDERSEN Dick
Subject: 12/13/10 Gasco Dispute Mtg

Bob,
Thanks for meeting with me Monday morning. The purpose of this e-mail is to summarize DEQ's proposal regarding HC&C & capture the important agreements we reached during our 12/13/10 meeting. I understand you discussed our meeting with Margaret K, & she was..., at least initially..., supportive of our agreements. During our meeting, I indicated DEQ is willing consider modifying our direction to NWN (made 6/11/10 by e-mail) which defers evaluation HC&C along the portion of shoreline Segment 1 where DNAPL occurs to the uplands FS. To us, this is the central issue being disputed. As an alternative to DEQ's 6/11 direction, I proposed that NWN incorporate HC&C along the disputed section of shoreline Segment 1 into the final groundwater source control design document. In other words, in addition to completing the design of HC&C along the southern portion of Segment 1 on the Siltronic property & all of the shoreline Segment 2 on the Gasco site..., NWN would have the opportunity to include the disputed portion of Segment 1 in the final source control design documents (i.e., not defer evaluation of HC&C along the disputed portion of shoreline Segment 1 to the uplands FS.
I presented 3 conditions for my proposal:
1) Technical issues with HC&C along the disputed portion of shoreline Segment 1 must be addressed during final design.
2) NWN must agree to a scope & schedule for completing the Gasco site risk assessments & move into the uplands FS as soon as practicable.
3) The uplands FS must fully evaluate remedial action alternatives for DNAPL associated with former tar ponds area(s), including actions such as barrier walls, removal, solidification/stabilization, etc.
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Regarding Step 3, as I indicated during our 12/13 meeting, in addition to allowing NWN to evaluate uplands DNAPL removal & the vertical barrier in the uplands FS, DEQ believes we are making another significant concession by allowing NW to include HC&C along the disputed section of shoreline Segment 1 in the source control final design document. Although I understand your concerns regarding DEQ's approach to completing the risk assessments (e.g., collecting samples for TPH fractions analyses) & whether it will help us make better cleanup decisions..., we expect NWN to be open to accepting DEQ's recommendations made in the interest of finishing a complete risk assessment that supports the upland FS.
Jim Anderson

Manager, DEQ Portland Harbor Section
ph: 503.229.6825
fax: 503.229.6899
cell: 971.563.1434

John Edwards

Subject: FW: 12/13/10 Gasco Dispute Mtg

From: Wyatt, Robert
Sent: Friday, December 17, 2010 11:54 AM
To: ANDERSON Jim M
Cc: BAYUK Dana; DECONCINI Nina; PEDERSEN Dick; Kirkpatrick, Margaret
Subject: RE: 12/13/10 Gasco Dispute Mtg

Hi Jim,

Thanks very much for the meeting summary and outline of the DEQ proposed path forward. I appreciate the time and thought that clearly went into your proposal. As you know, NW Natural is interested in reaching final resolution on the dispute. Based on our telephone conversation this morning I am providing the following re-statement of the key points from our meeting on Monday that NW Natural agrees would represent that resolution. I think it is consistent with your proposal, but if there are differences please give me a call so we can discuss them further.

NW Natural agrees that the following path forward provides a good resolution for the dispute, with the understanding that all of the conditions and next steps must be completed successfully.

NW Natural understands that we will develop and submit a final design for the HC&C system along the entire length of both Segments 1 and 2. Prior to submittal of that final design the following conditions must be met:

1. Resolution of remaining design details related specifically to the HC&C system raised during DEQ review of the interim design report.
2. Agreement on a monitoring program for the HC&C system that will be used to determine system effectiveness and include criteria for monitoring DNAPL movement. NW Natural has proposed a monitoring program to DEQ for this purpose and understands that DEQ will provide specific revisions to supplement or modify that program. NW Natural understands that if significant DNAPL migration is observed that DEQ may require additional interim action. If significant DNAPL migration is not observed NW Natural understands that DNAPL management will be fully addressed in the upland FS.
3. NW Natural and DEQ will develop a path forward to complete the Risk Assessment. It is a mutual goal of both NW Natural and DEQ to complete the Risk Assessment in order to expedite the development of the upland FS. This objective will minimize the amount of time the HC&C system operates prior to construction of final remedy, including DNAPL management. NW Natural also strongly believes expediting the upland FS is critical for overall project sequencing required in the broader context of Portland Harbor and the Gasco Sediment Remedy.

NW Natural agrees that technical meetings in January 2011 are crucial for getting the conditions resolved and completing the final design. I also appreciate your acknowledgement of our concerns regarding the current DEQ preference for additional data collection prior to completing the risk assessment. In addition to the technical issues you noted we also are concerned that it has schedule implications that affect the amount of time the HC&C system will operate before the upland FS can be prepared. Having said that, NW Natural agrees to be open to the DEQ request for additional data collection and the attendant schedule impacts, with the understanding that DEQ will consider our concerns before making a final decision.

If I have captured the concept we discussed accurately NW Natural is prepared to moved forward with this resolution to the dispute. If you think we should further discuss and clarify any of the elements of the agreement before finalizing the process please let me know.

Jim, I appreciate your efforts on this challenging issue and am looking forward to collaboratively reaching the major milestone of implementing source control at Gasco.

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Jim Anderson
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ph: 503.229.6825
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John Edwards

Subject: FW: 12/13/10 Gasco Dispute Mtg

From: ANDERSON Jim M [mailto:ANDERSON.Jim@deq.state.or.us]
Sent: Wednesday, December 22, 2010 10:32 AM
To: Wyatt, Robert
Cc: BAYUK Dana <BAYUK.Dana@deq.state.or.us>
Subject: RE: 12/13/10 Gasco Dispute Mtg

Bob,
I read your 12/17/10 e-mail. I appreciate NWN's decision to accept DEQ's proposal which will allow the source control project to move out of dispute resolution & back into project planning & design. Your 12/17 e-mail communicates NWN's perspective on certain aspects of DEQ's proposal..., several of which I want to clarify & present as expectations before we meet in January 2011. I believe the 2 meetings we're contemplating in 1/11 represent the best forum for identifying , discussing, & most importantly resolving technical issues associated with HC&C & the risk assessment. My clarifications are embedded in your 12/17 e-mail below & are presented in *red italic* font.

I hope this e-mail closes our formal dispute. Let's plan on talking after you return from holiday travels to arrange meeting dates & times &..., along with the technical leads..., begin to develop central meeting topics. I look forward to productive project planning meetings & getting to important source control & cleanup..., as I know you do too.

Hope you & yours have a safe, happy holiday.

Jim Anderson
Manager, DEQ Portland Harbor Section
ph: 503.229.6825
fax: 503.229.6899
cell: 971.563.1434

From: Wyatt, Robert [mailto:rjw@nwnatural.com]
Sent: Friday, December 17, 2010 11:54 AM
To: ANDERSON Jim M
Cc: BAYUK Dana; DECONCINI Nina; PEDERSEN Dick; Kirkpatrick, Margaret
Subject: RE: 12/13/10 Gasco Dispute Mtg

Hi Jim,

Thanks very much for the meeting summary and outline of the DEQ proposed path forward. I appreciate the time and thought that clearly went into your proposal. As you know, NW Natural is interested in reaching final resolution on the dispute. Based on our telephone conversation this morning I am providing the following re-statement of the key points from our meeting on Monday that NW Natural agrees would represent that resolution. I think it is consistent with your proposal, but if there are differences please give me a call so we can discuss them further.

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1. Resolution of remaining design details related specifically to the HC&C system raised during DEQ review of the interim design report. *DEQ will want to include discussion/concerns we have with NWN's revised HC&C proposal presented to us in a 5/17/10 technical meeting..., & not only our 3/26/10 comments on NWN's 11/09 Interim*

Design Report. I suggest the 1/11 meeting we're planning focus on technical issues to be resolved to evaluate, plan, & design HC&C along the disputed portion of Segment 1.

2. Agreement on a monitoring program for the HC&C system that will be used to determine system effectiveness and include criteria for monitoring DNAPL movement. NW Natural has proposed a monitoring program to DEQ for this purpose and understands that DEQ will provide specific revisions to supplement or modify that program. NW Natural understands that if significant DNAPL migration is observed that DEQ may require additional interim action. If significant DNAPL migration is not observed NW Natural understands that DNAPL management will be fully addressed in the upland FS. *DEQ agrees with NWN that an essential element of designing the HC&C along the disputed portion of Segment 1 is a monitoring program which evaluates the system performance & effectiveness..., including assessing DNAPL movement over time. NWN indicates a monitoring program proposal has already been submitted to DEQ for this purpose & understands DEQ will provide specific revisions to supplement or modify that program. DEQ believes this item should be one of central topics discussed during the 1/11 meeting. The only monitoring program DEQ is aware of NWN having submitted is included in the Interim Design Report, which did not contemplate the 5/17/10 HC&C re-design concept. Given the current status of the HC&C interim design, DEQ anticipates NWN will update the groundwater source control interim design with the 5/17 re-design concept. The update will include evaluating the performance & effectiveness of HC&C through monitoring the system's hydraulic influence, trends in groundwater data, & DNAPL movement.*
3. NW Natural and DEQ will develop a path forward to complete the Risk Assessment. It is a mutual goal of both NW Natural and DEQ to complete the Risk Assessment in order to expedite the development of the upland FS. This objective will minimize the amount of time the HC&C system operates prior to construction of final remedy, including DNAPL management. NW Natural also strongly believes expediting the upland FS is critical for overall project sequencing required in the broader context of Portland Harbor and the Gasco Sediment Remedy.

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APPENDIX C
SLUG TEST REPORT

6650 SW Redwood Lane, Suite 333
Portland, Oregon 97224
Phone 503.670.1108
Fax 503.670.1128
www.anchorqea.com

MEMORANDUM

To:	John Edwards, Anchor QEA	**Date:**	February 17, 2011
From:	Matthew Wilson, Anchor QEA	**Project:**	000029-02
Cc:	Mike Riley, Anchor QEA		
Re:	Hydraulic Conductivity Testing at NW Natural Gasco Site		

OVERVIEW

In January 2011, Anchor QEA performed slug tests for hydraulic conductivity analysis in 24 wells at the NW Natural Gasco site in Portland, Oregon. Slug tests were performed in nine wells screened in the fill water bearing zone and 15 wells screened in the upper section of the alluvial water bearing zone. These tests were conducted to provide supplemental groundwater data for source control design.

SLUG TEST PROCEDURE

Before slug testing activities began, pressure transducers were cleaned and then installed in the wells to be tested. The pressure transducers were calibrated before each test and programmed to collect data points in one second intervals. Dedicated PVC slugs were constructed for each well to eliminate the need for decontamination of the slugs and possible cross-contamination between wells. Both slug-in and slug-out tests were conducted at each well. Testing procedures generally consisted of performing a falling-head test (slug-in test) followed by a rising-head test (slug-out test) after the water level had returned to the pre-test static water level. Multiple iterations of this testing procedure were performed at each well as time constraints allowed. At least three slug tests were conducted at each well.

Upon completion of slug testing activities, data was downloaded from the pressure transducers, and the hydraulic conductivity was calculated for each well with the Bouwer-Rice slug test analysis method utilizing AquiferTest Pro software. A table listing the wells that were analyzed and the preliminary results of the hydraulic conductivity testing is attached. The water level data plots for the slug tests are also attached.

Attachments: Table of Hydraulic Conductivity Results
Data Plots of Slug Test Results

Slug Test Hydraulic Conductivity Preliminary Results
Fill and Upper Alluvium Wells
NW Natural Gasco Site

Well	Test 1 K (ft/day)	Test 2 K (ft/day)	Test 3 K (ft/day)	Test 4 K (ft/day)	Test 5 K (ft/day)	Test 6 K (ft/day)	Test 7 K (ft/day)	Test 8 K (ft/day)	Average K (ft/day)
Fill Wells									
MW-1-22	0.0272	0.0240	0.0428	0.0195					0.0313
MW-2-32	0.365	0.322	0.599	0.271					0.4287
MW-3-26	0.0112	0.0540	0.00817	0.1400					0.0245
MW-19-22	0.896	0.896	1.030	0.896	1.210	1.210			0.9856
MW-21-12	0.896	0.665	0.665	0.665					0.7228
MW-23-27	0.110	0.105	0.074	0.0795					0.0921
OW-7-17	NA[1]	9.83	9.83	9.83	9.83				9.8300
OW-8-15	NA[1]	0.365	0.493	0.674	0.829				0.5903
OW-9-25	0.8140	0.493	0.665						0.6573
Upper Alluvium Wells									
MW-1-55	17.9	17.9	13.3	17.9					16.3667
MW-2-61	4.98	16.5	85.3	30.4	155.0	96.6			58.4360
MW-3-56	3.46	1.99	9.99	11.4					6.7100
MW-4-57	2.93	2.30	2.20	2.20					2.4075
MW-5-32	0.896	0.665	0.650	0.650					0.7153
MW-16-65	0.374	0.254	0.328						0.3187
MW-24-70	2.45	4.03	3.07	2.48					3.0075
OW-8-28	0.271	0.264	0.303	0.365	0.365				0.3136
PZ1-20	0.201	0.365	0.201	0.365					0.2830
PZ2-20	4.00	4.00	4.40	4.98					4.3450
PZ4-12	4.06	4.06	4.06	4.06					4.0600
PZ5-20	0.0125	0.0278	0.0247						0.0217
PW-1-80	4.92	5.40	7.00	6.00	6.10	6.20	6.50	6.00	6.0171
PW-3-85	17.9	16.0	17.6	16.0					16.8750
PW-8-39	1.00	1.21	1.10						1.1033

Notes:
K = Hydraulic Conductivity
[1] Anomalous and questionable data - omitted from analysis

ANCHOR QEA
City, State/Province
Address
Contact Info
Company Name
6650 SW Redwood Lane, Suite 333
6650 SW Redwood Lane, Suite 333
Portland, Oregon 97224
Portland, Oregon 97224
Phone 503.670.1108
Phone 503.670.1108
Fax 503.670.1128
Fax 503.670.1128

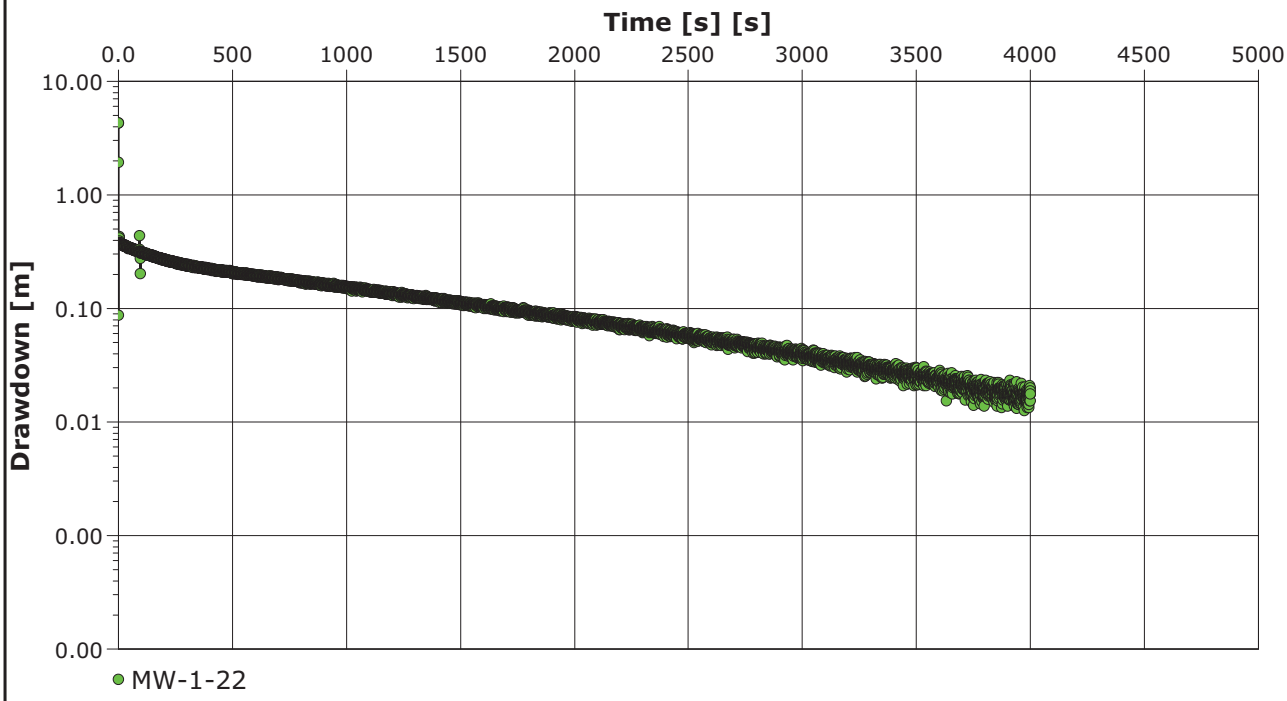
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-1-22 Test 1	Test Well: MW-1-22
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/17/2011
Aquifer Thickness: 11.71 ft		



ANCHOR QEA City, State/Province Address Contact Info Company Name 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

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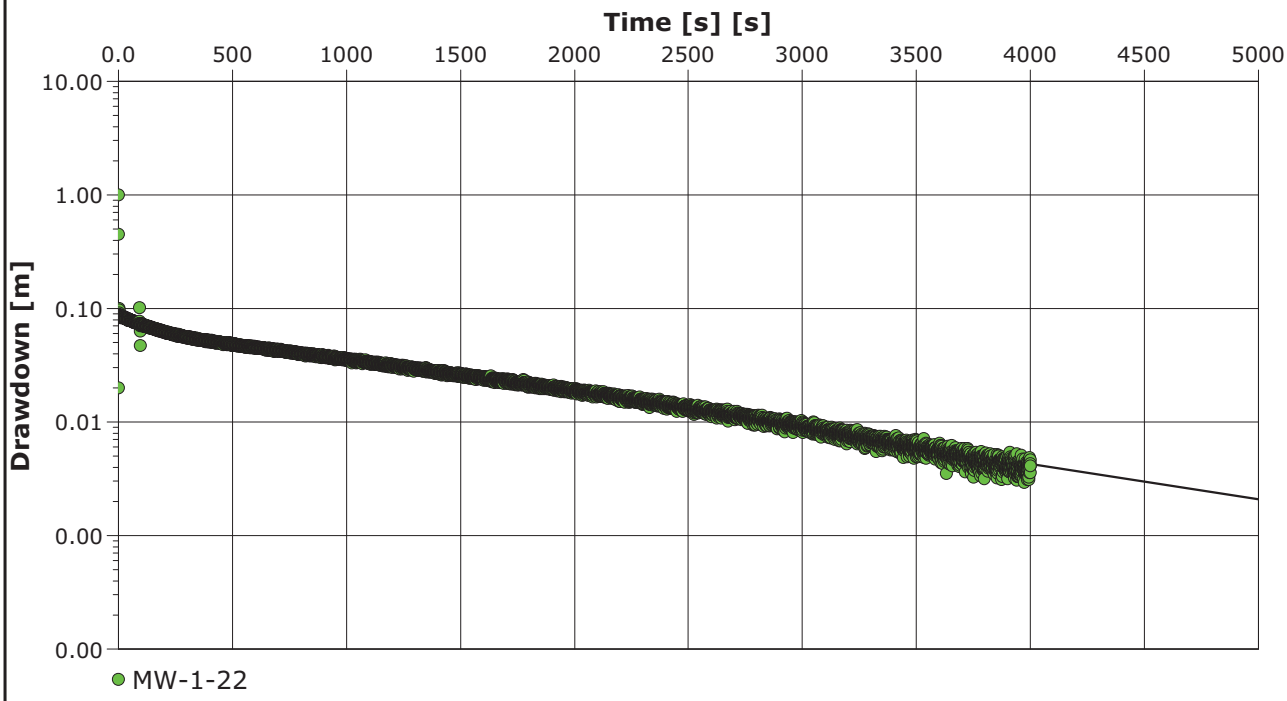

Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-1-22	2.28×10^{-2}	

ANCHOR QEA
City, State/Province
Address 6650 SW Redwood Lane, Suite 333
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Contact Info Phone 503.670.1108
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Company Name

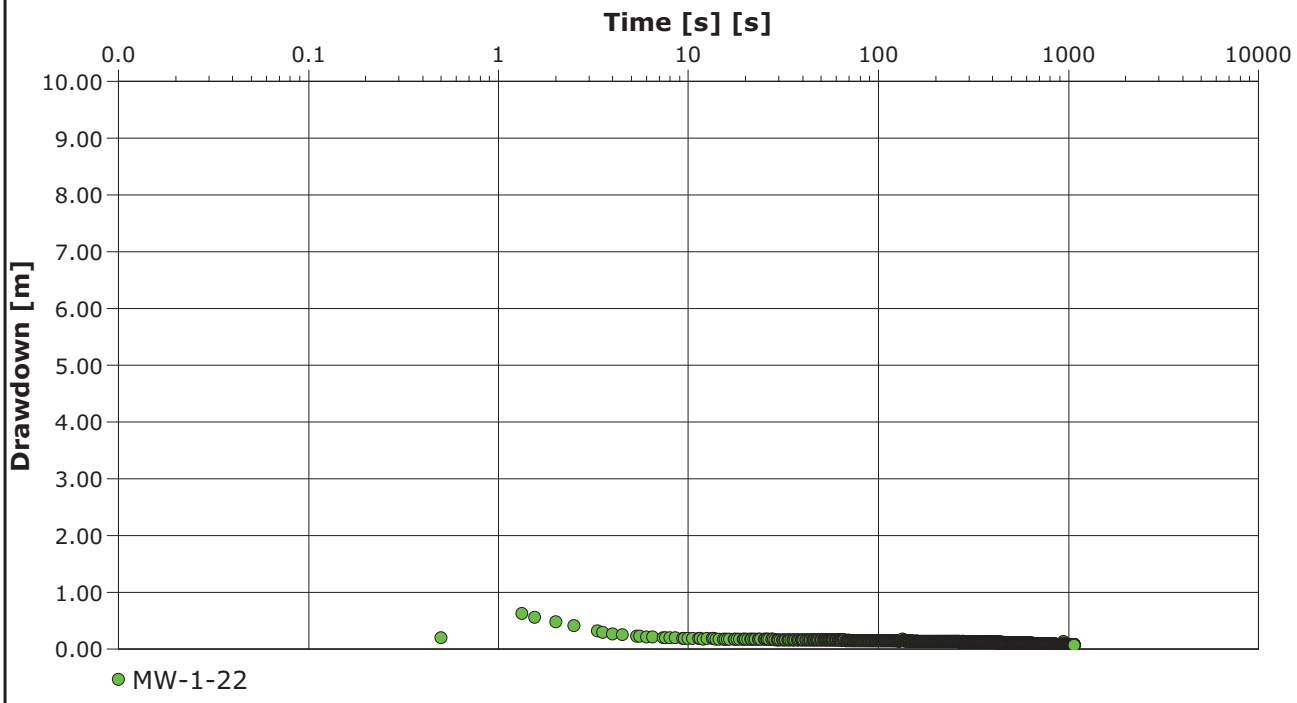
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-1-22 Test 2	Test Well: MW-1-22
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 11.71 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-1-22	2.40×10^{-2}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

Slug Test Analysis Report	
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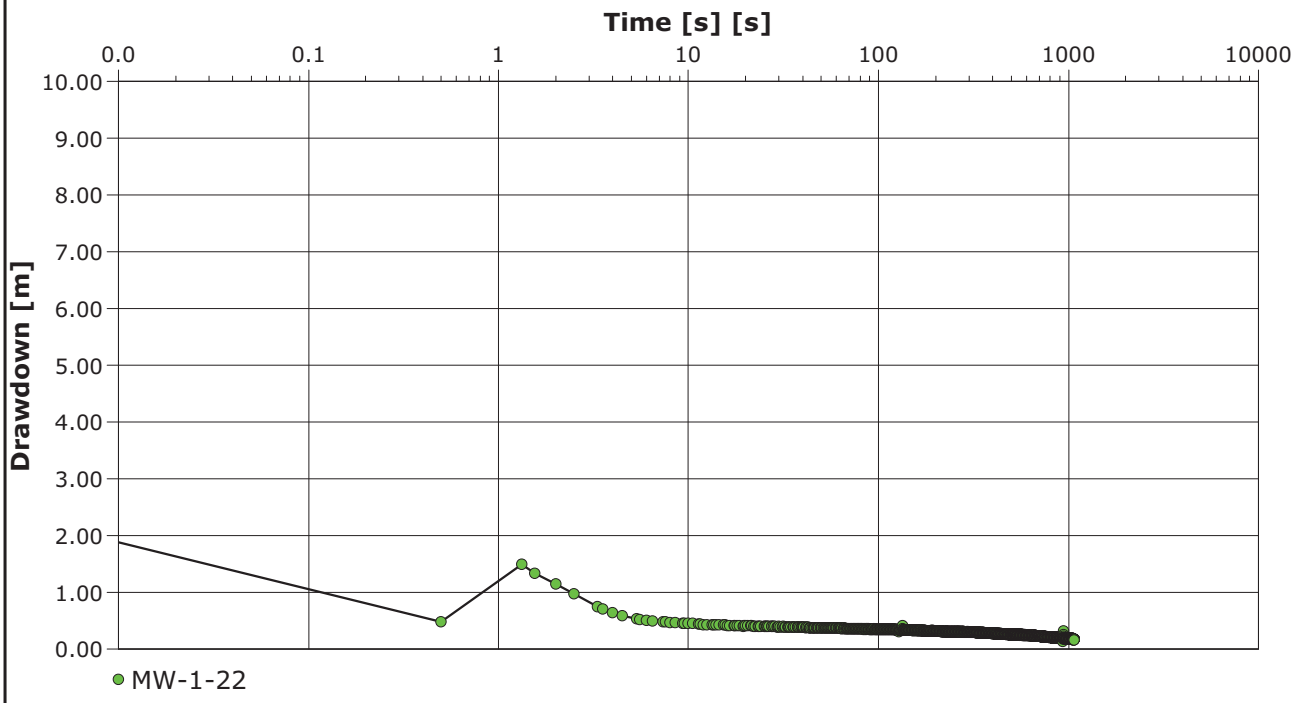
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/17/2011
Aquifer Thickness: 6.17 ft		



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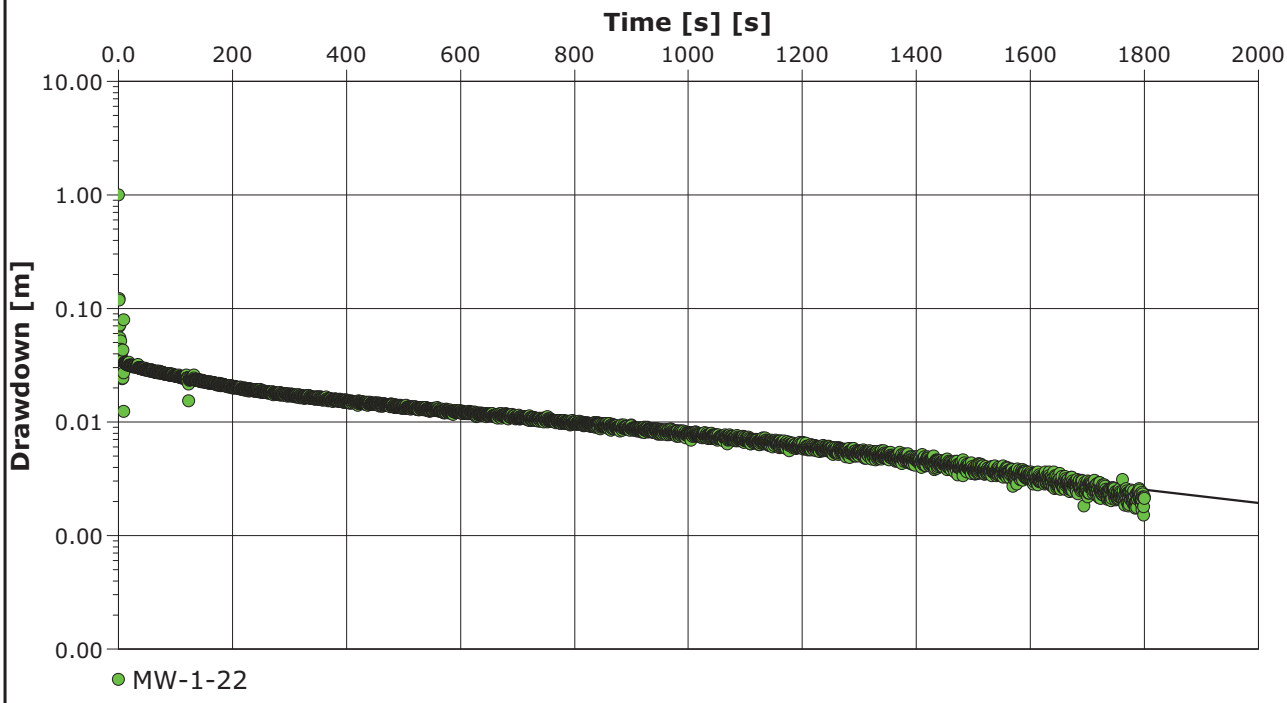


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-1-22	4.28×10^{-2}	

ANCHOR QEA
City, State/Province
Address 6650 SW Redwood Lane, Suite 333
Portland, Oregon 97224
Contact Info Phone 503.670.1108
Fax 503.670.1128
Company Name

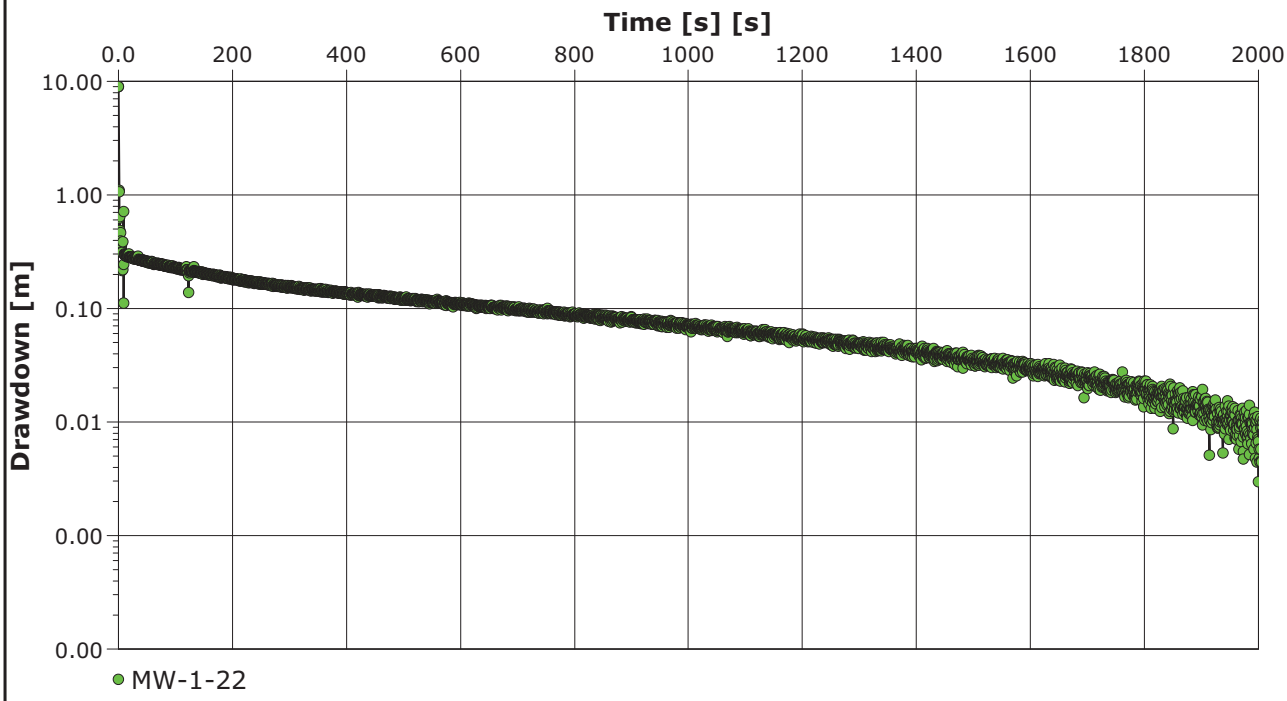
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

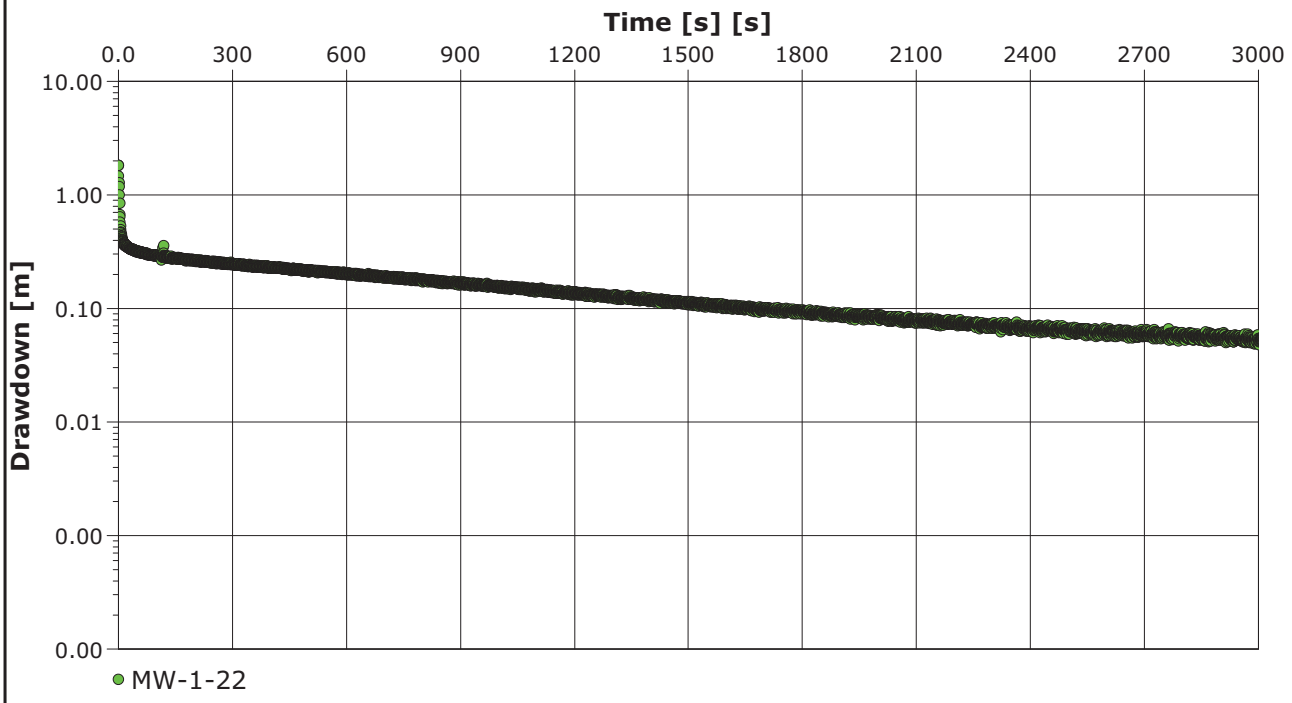
Location: Portland, Oregon	Slug Test: MW-1-22 Test 3	Test Well: MW-1-22
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/17/2011
Aquifer Thickness: 11.71 ft		



City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

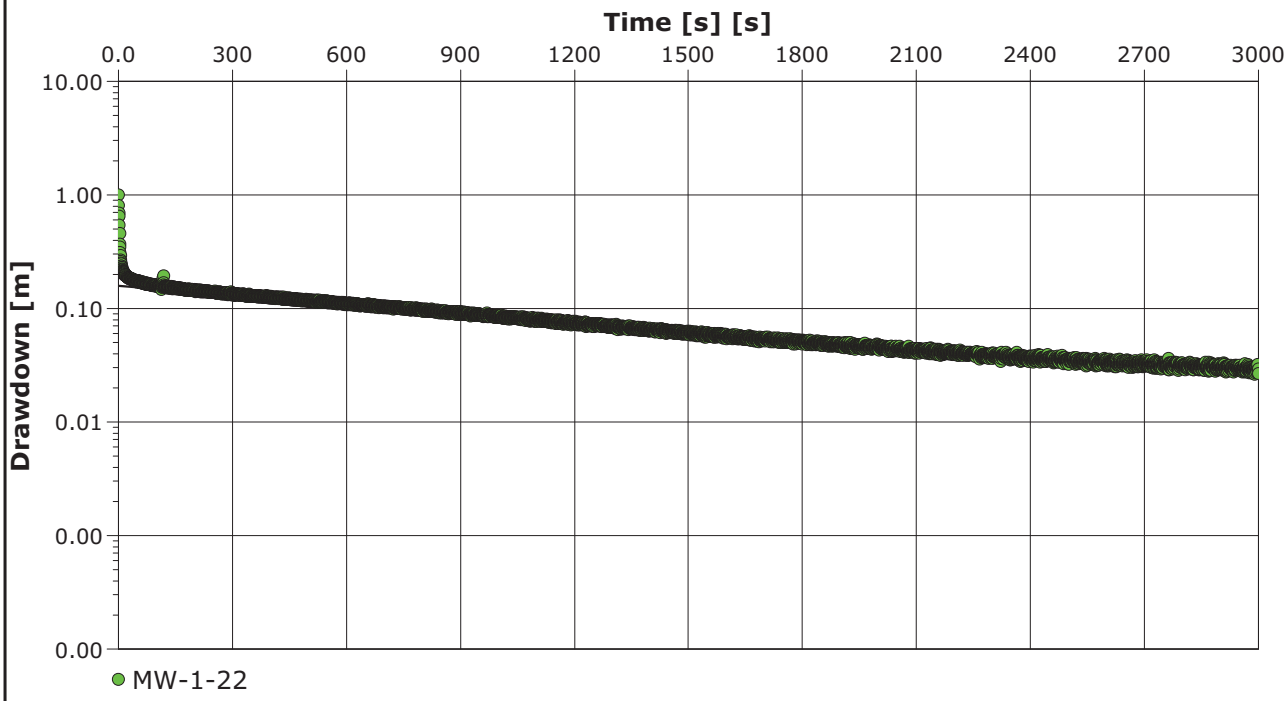
Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: MW-1-22 Test 4	Test Well: MW-1-22
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/17/2011
Aquifer Thickness: 11.71 ft		



City, State/Province **Address** **Contact Info** **Company Name**	**Slug Test Analysis Report**
ANCHOR QEA 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	Project: Gasco Ground Water Source Control
	Number: 000029-02.28 task 3A
	Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-1-22 Test 4	Test Well: MW-1-22
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 11.71 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-1-22	1.95×10^{-2}	

ANCHOR QEA
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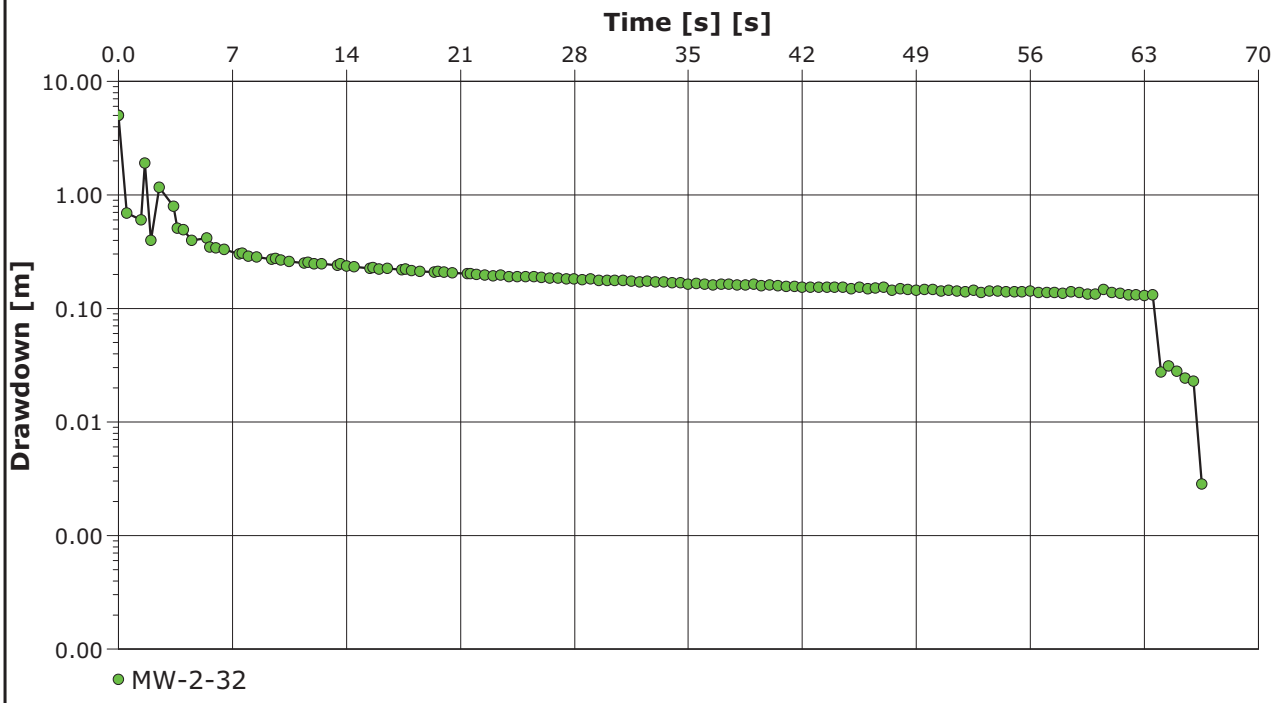
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-2-32 Test 1	Test Well: MW-2-32
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/17/2011
Aquifer Thickness: 10.24 ft		



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Slug Test Analysis Report

Project: Gasco Ground Water Source Control

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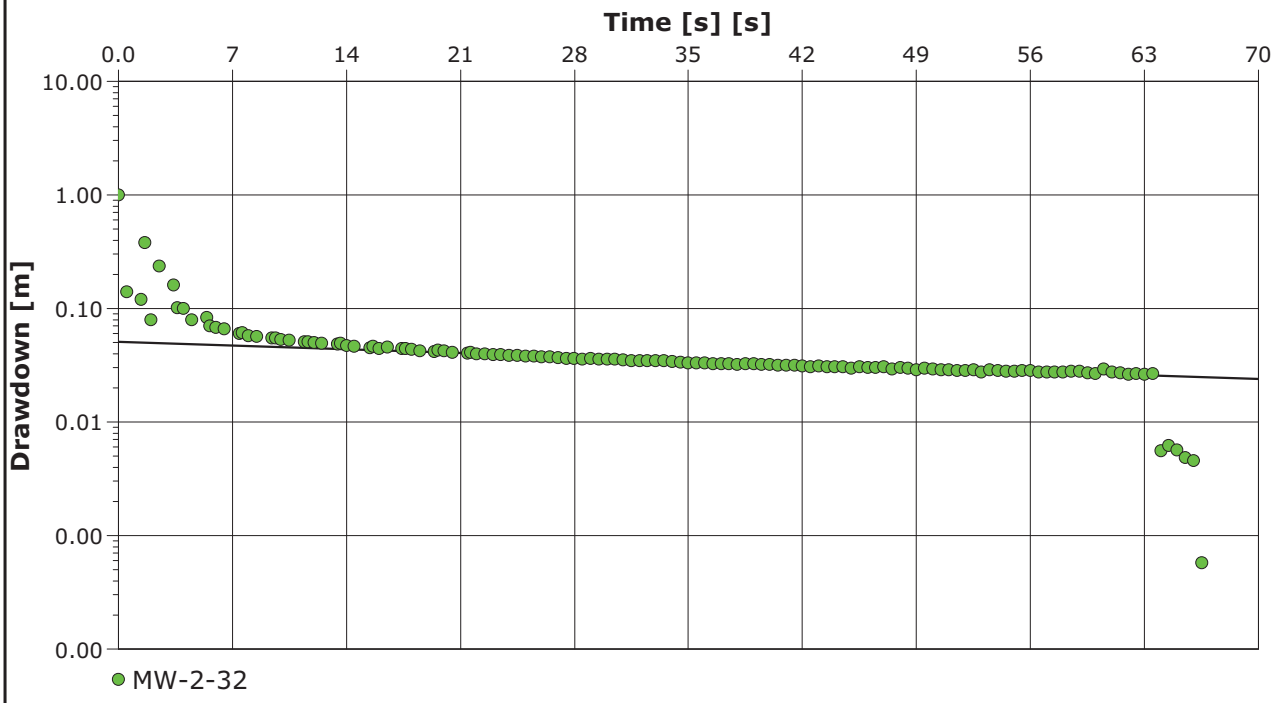
Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-2-32 Test 1	Test Well: MW-2-32
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 10.24 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-2-32	3.65×10^{-1}	

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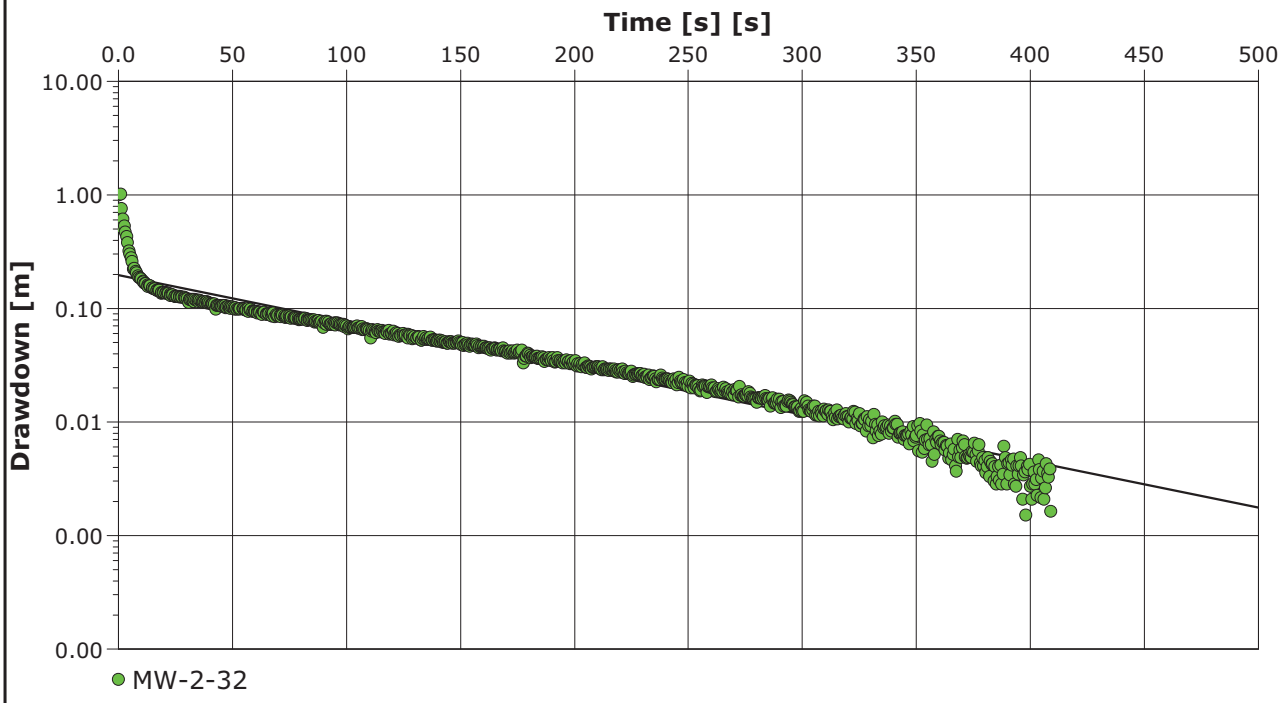
Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: MW-2-32 Test 2	Test Well: MW-2-32
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 10.24 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-2-32	3.22×10^{-1}	

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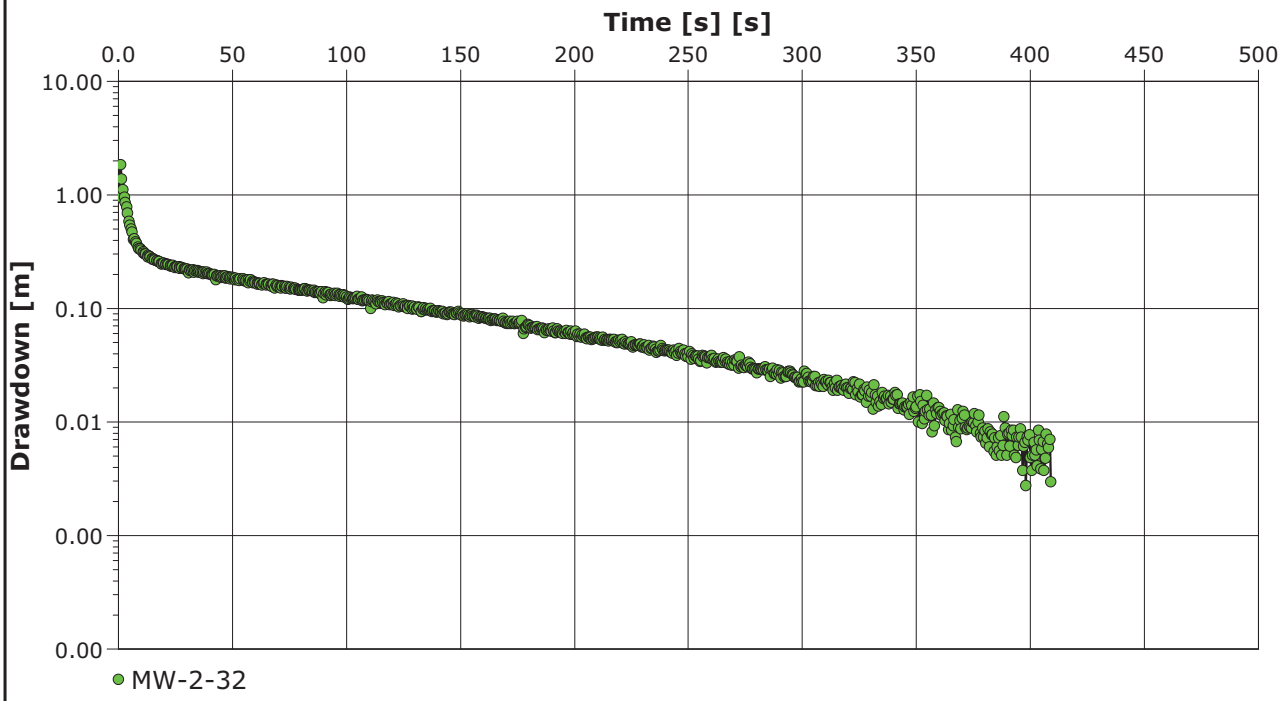
Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: MW-2-32 Test 2	Test Well: MW-2-32
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/17/2011
Aquifer Thickness: 10.24 ft		



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Slug Test Analysis Report

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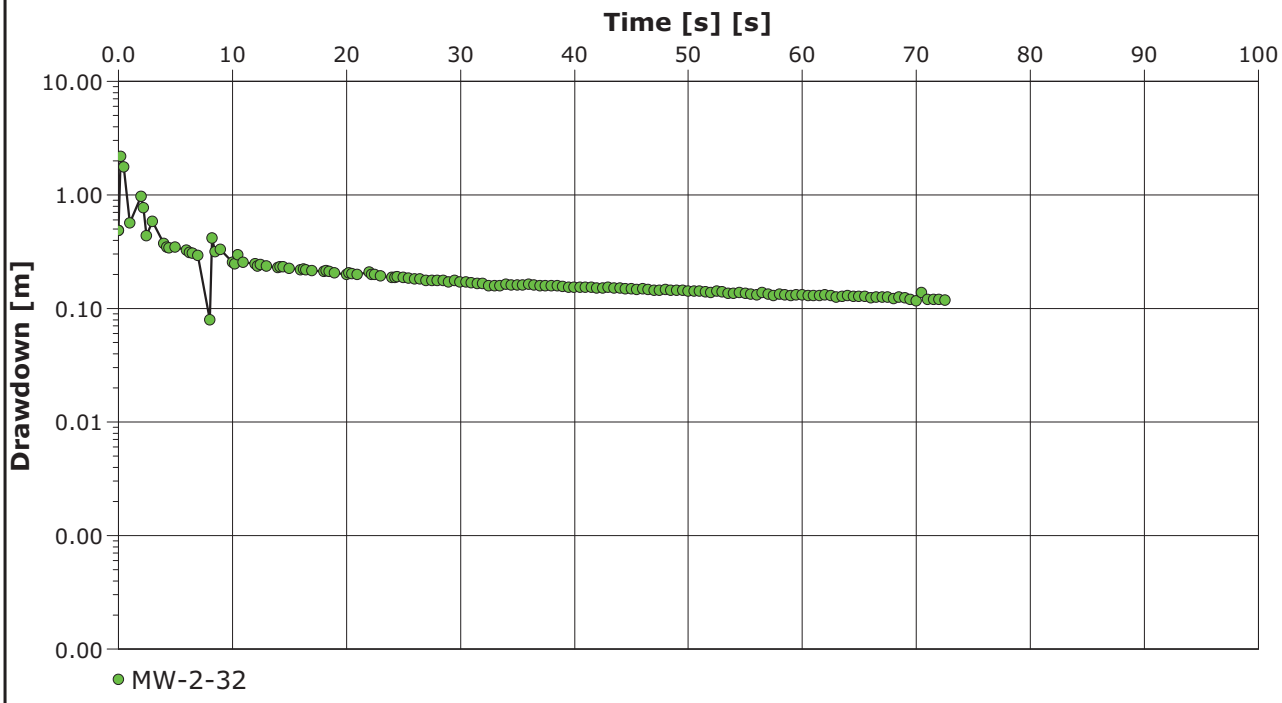

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Slug Test Analysis Report

Project: Gasco Ground Water Source Control

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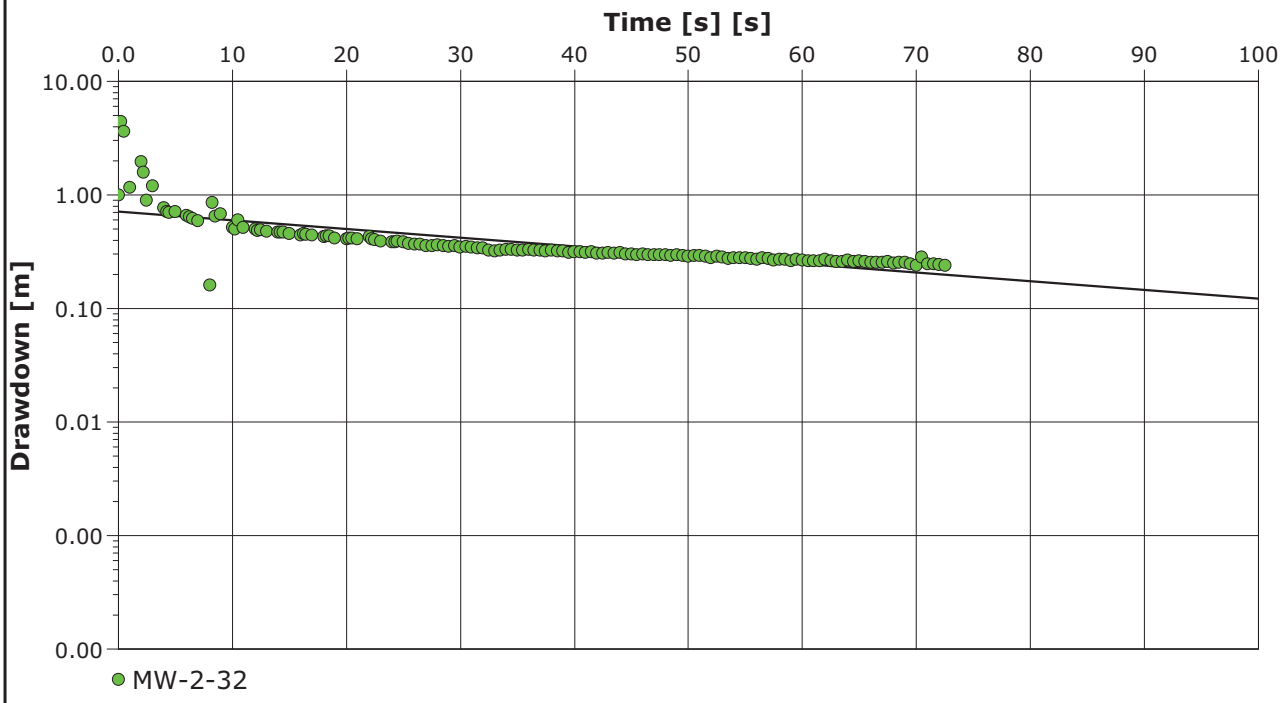
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 10.24 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-2-32	5.99×10^{-1}	

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Slug Test Analysis Report

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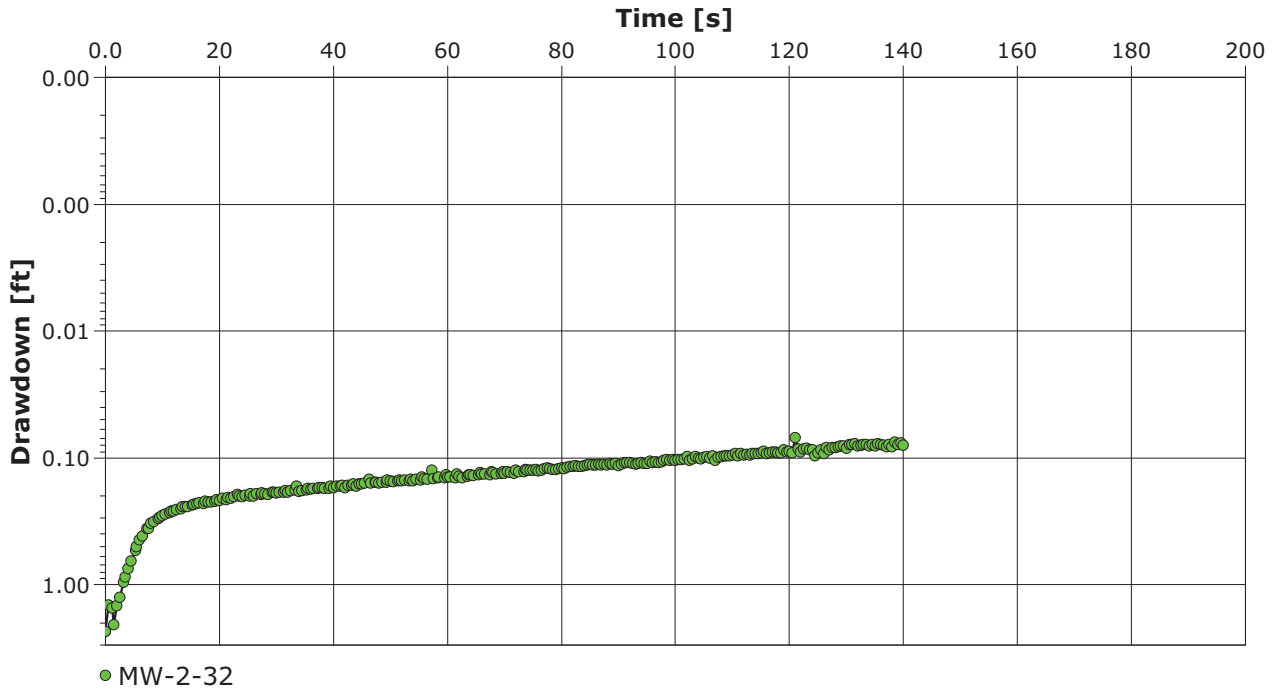
Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-2-32 Test 4	Test Well: MW-2-32
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/17/2011
Aquifer Thickness: 10.24 ft		



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Slug Test Analysis Report

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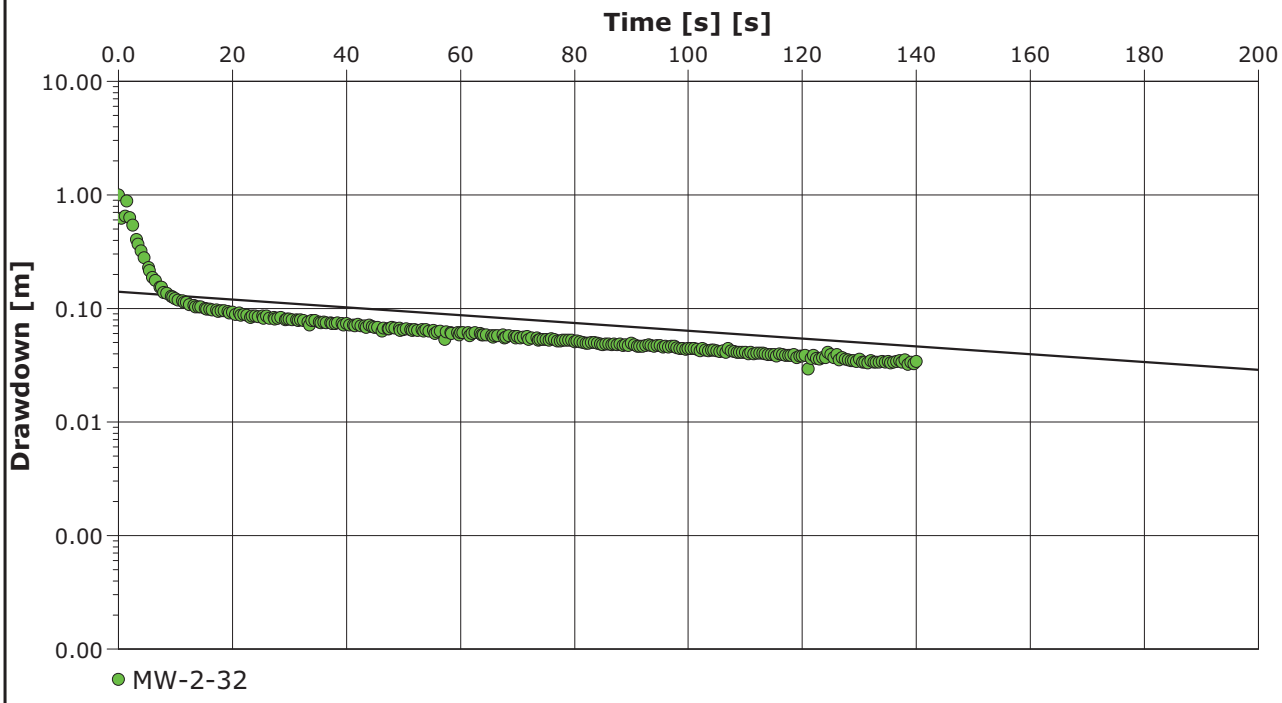
Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-2-32 Test 4	Test Well: MW-2-32
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 10.24 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-2-32	2.71×10^{-1}	

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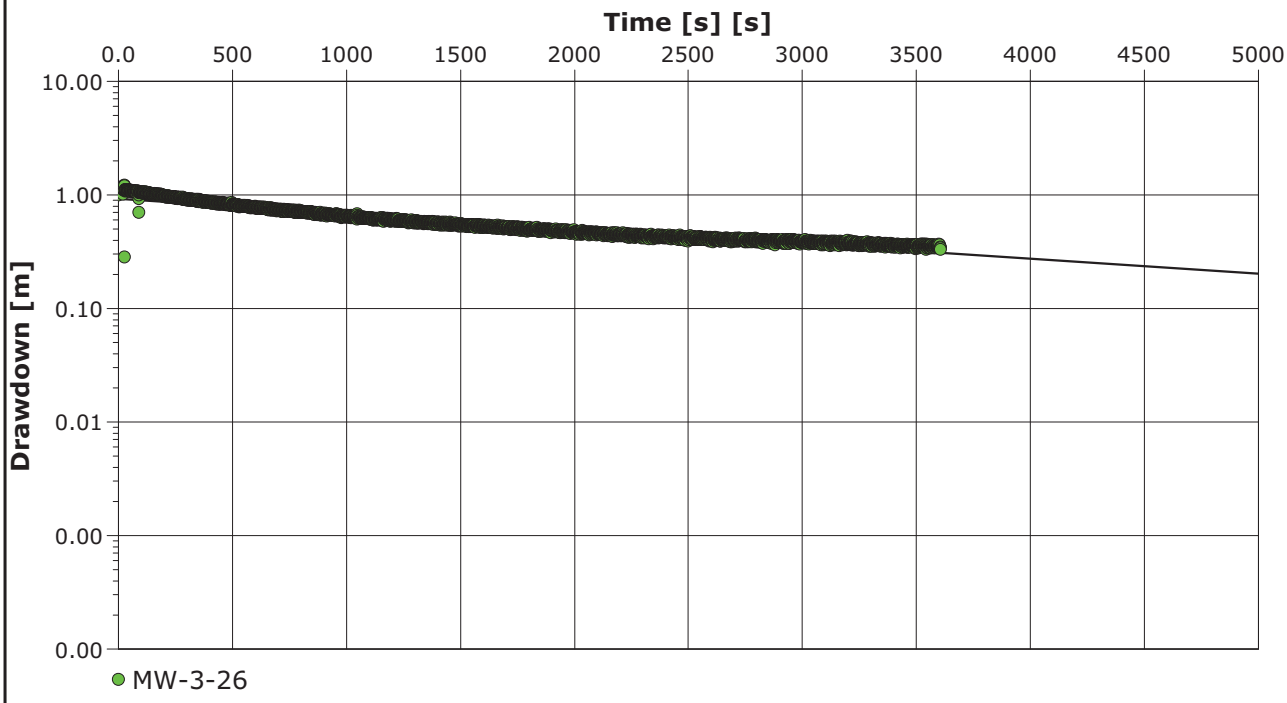
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-3-26 Test 1	Test Well: MW-3-26
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 8.82 ft		

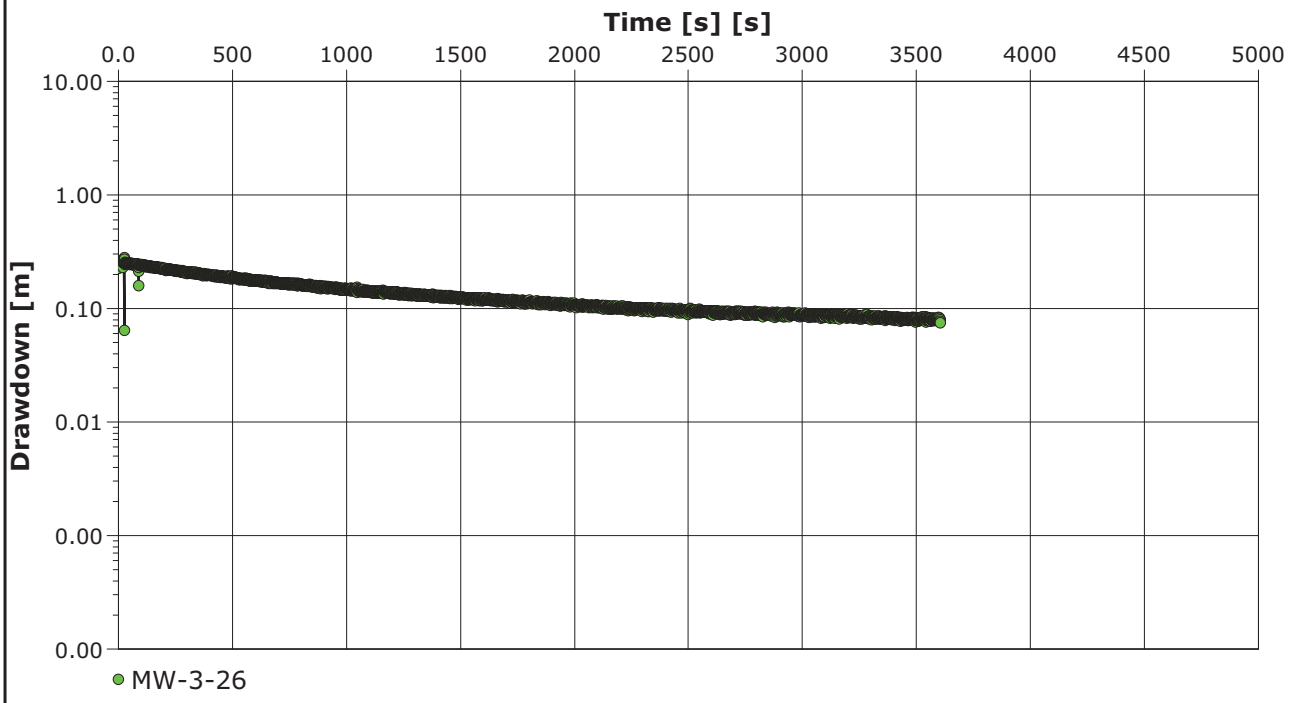


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-3-26	1.12×10^{-2}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-3-26 Test 1	Test Well: MW-3-26
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/17/2011
Aquifer Thickness: 8.82 ft		



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Company Name

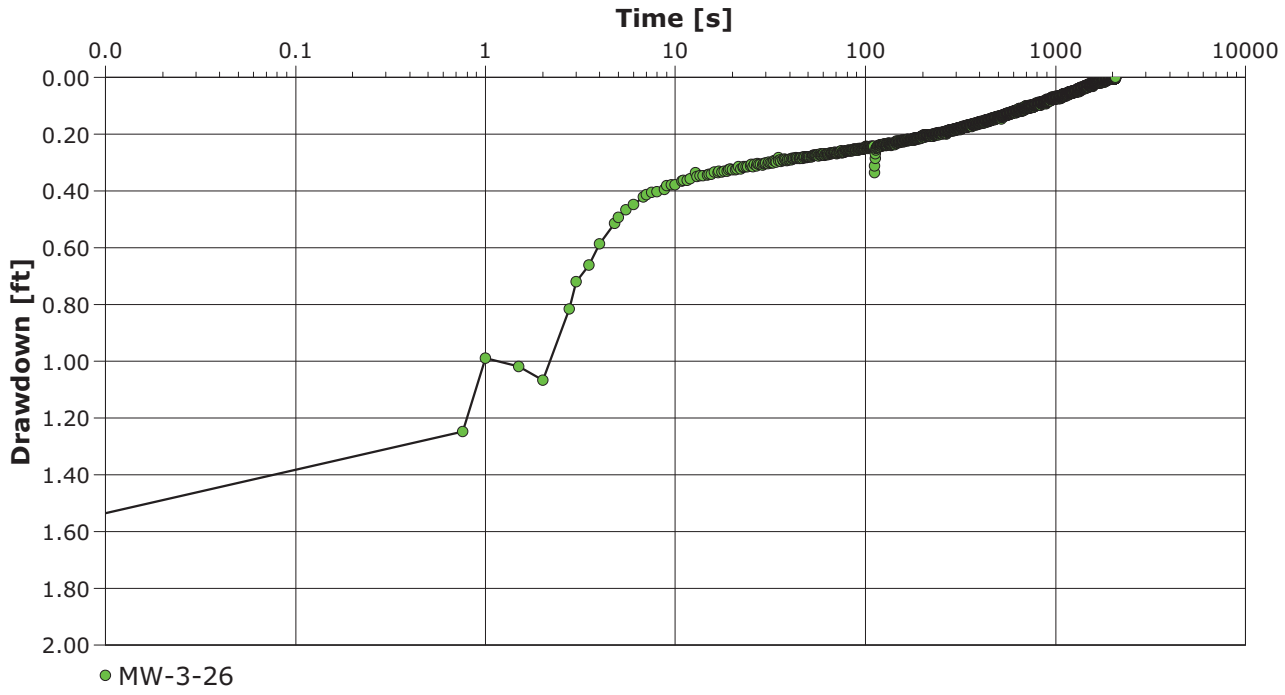
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

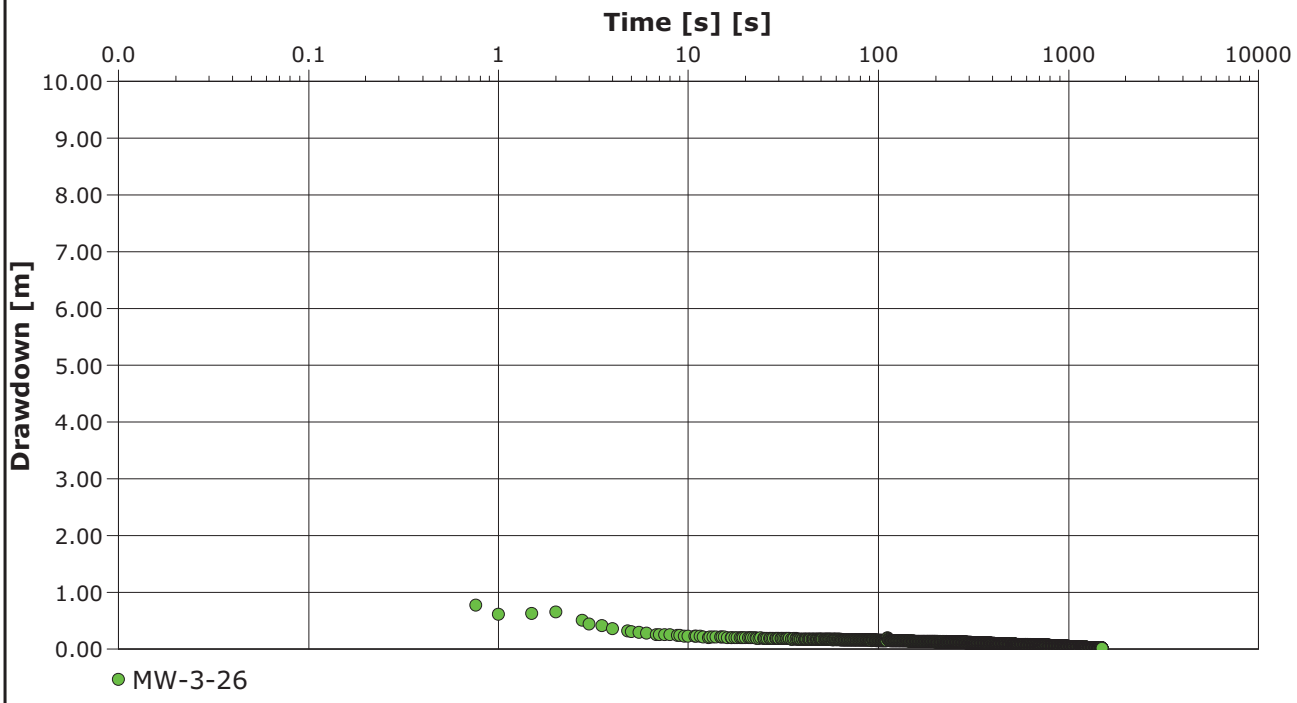
Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-3-26 Test 2	Test Well: MW-3-26
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/17/2011
Aquifer Thickness: 8.82 ft		



City, State/Province **Address** **Contact Info** **Company Name** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-3-26 Test 2	Test Well: MW-3-26
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 8.82 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-3-26	5.40×10^{-2}	

ANCHOR QEA
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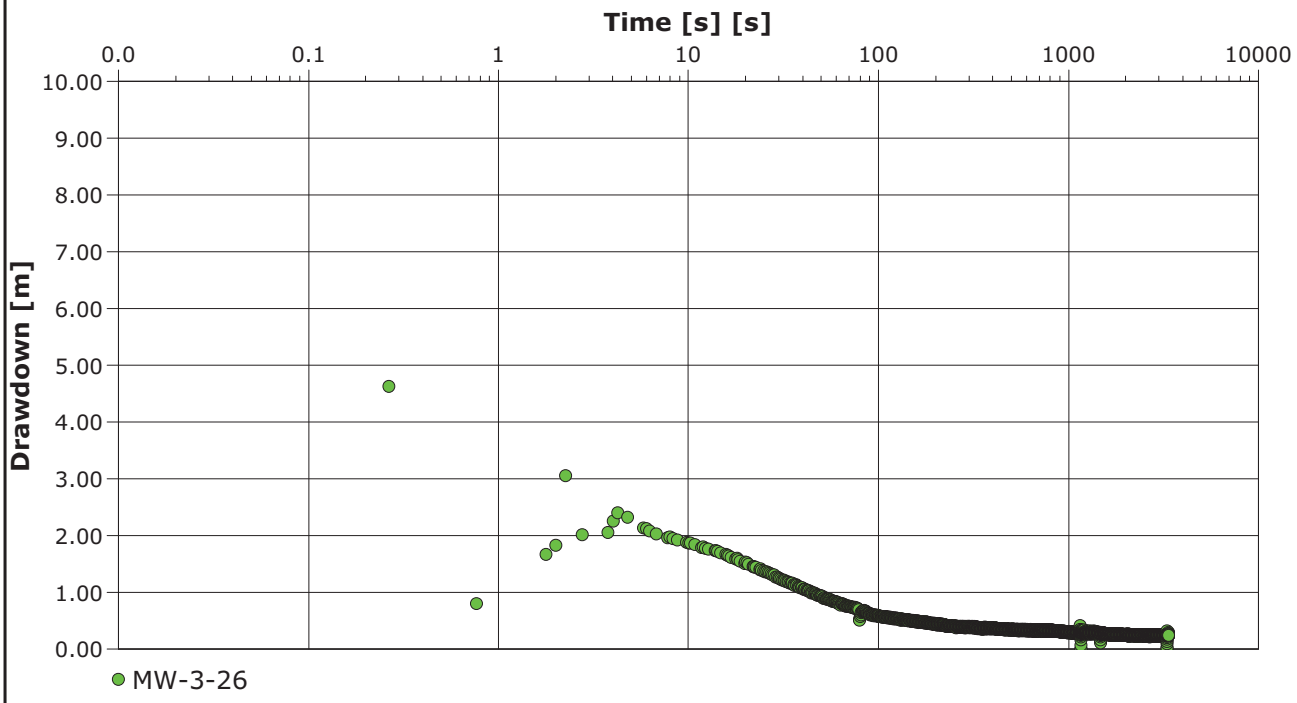
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-3-26 Test 3	Test Well: MW-3-26
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 8.82 ft		

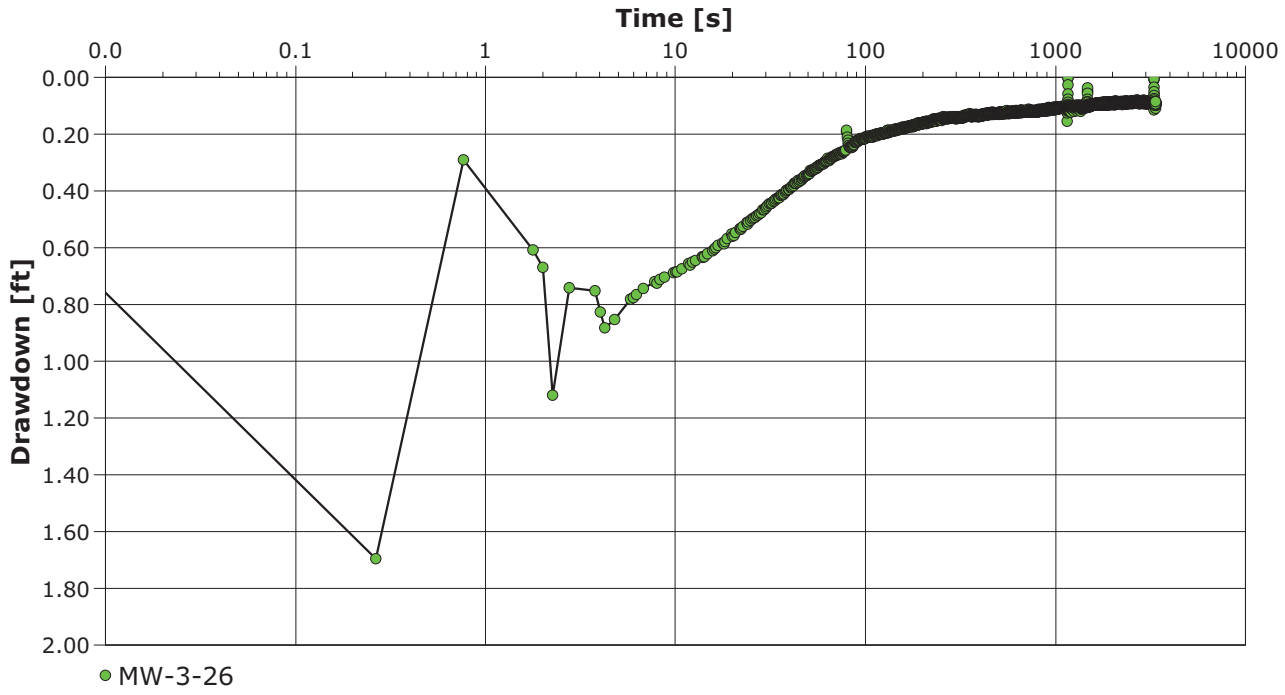


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-3-26	8.17×10^{-3}	

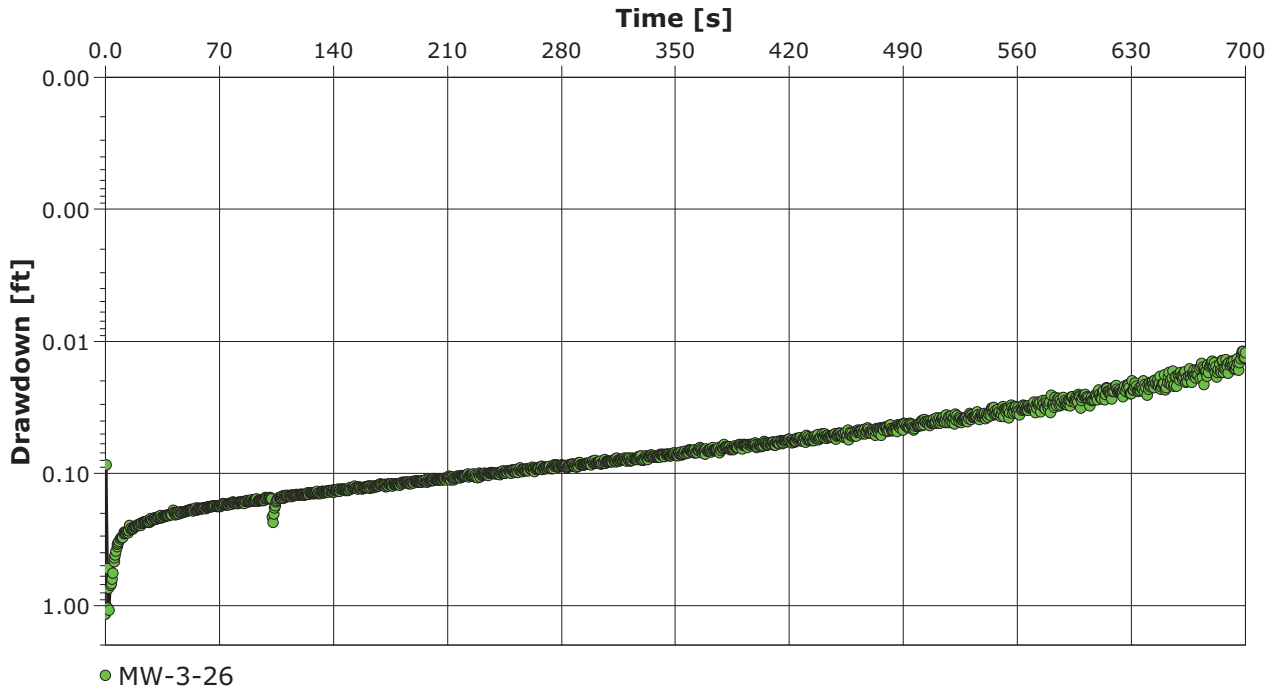
ANCHOR QEA City, State/Province Address Contact Info Company Name 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-3-26 Test 3	Test Well: MW-3-26
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/17/2011
Aquifer Thickness: 8.82 ft		



ANCHOR QEA **City, State/Province** **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

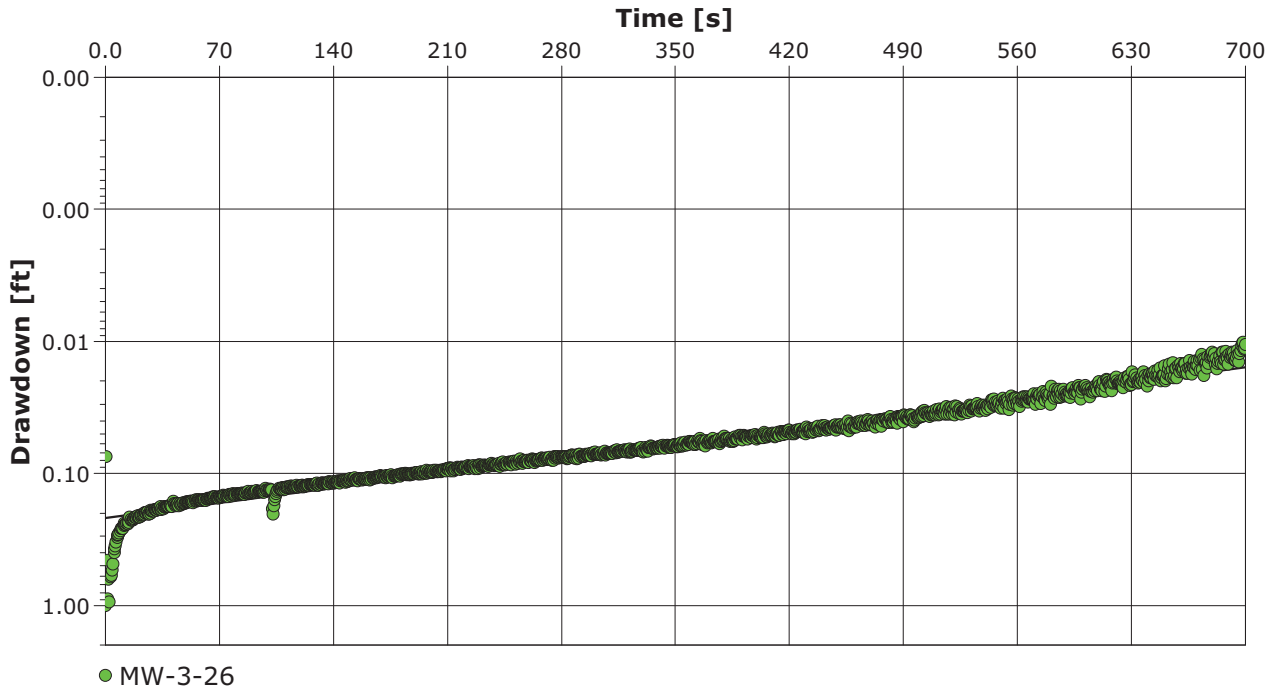
Location: Portland, Oregon	Slug Test: MW-3-26 Test 4	Test Well: MW-3-26
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/17/2011
Aquifer Thickness: 8.82 ft		



ANCHOR QEA	City, State/Province Address Contact Info Company Name	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: MW-3-26 Test 4	Test Well: MW-3-26
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 8.82 ft		



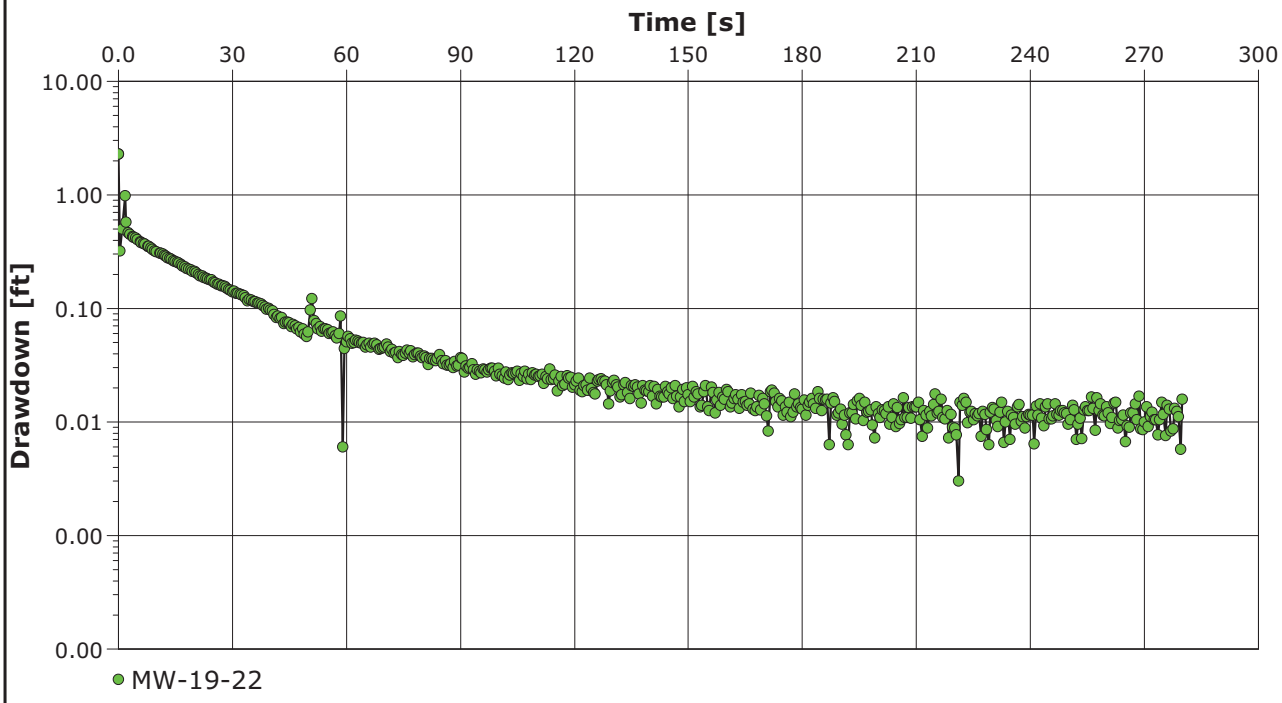
Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-3-26	1.40×10^{-1}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: MW-19-22 Test 1	Test Well: MW-19-22
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 5.35 ft		



ANCHOR QEA **City, State/Province** **Address** **Contact Info** **Company Name** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-19-22 Test 1	Test Well: MW-19-22
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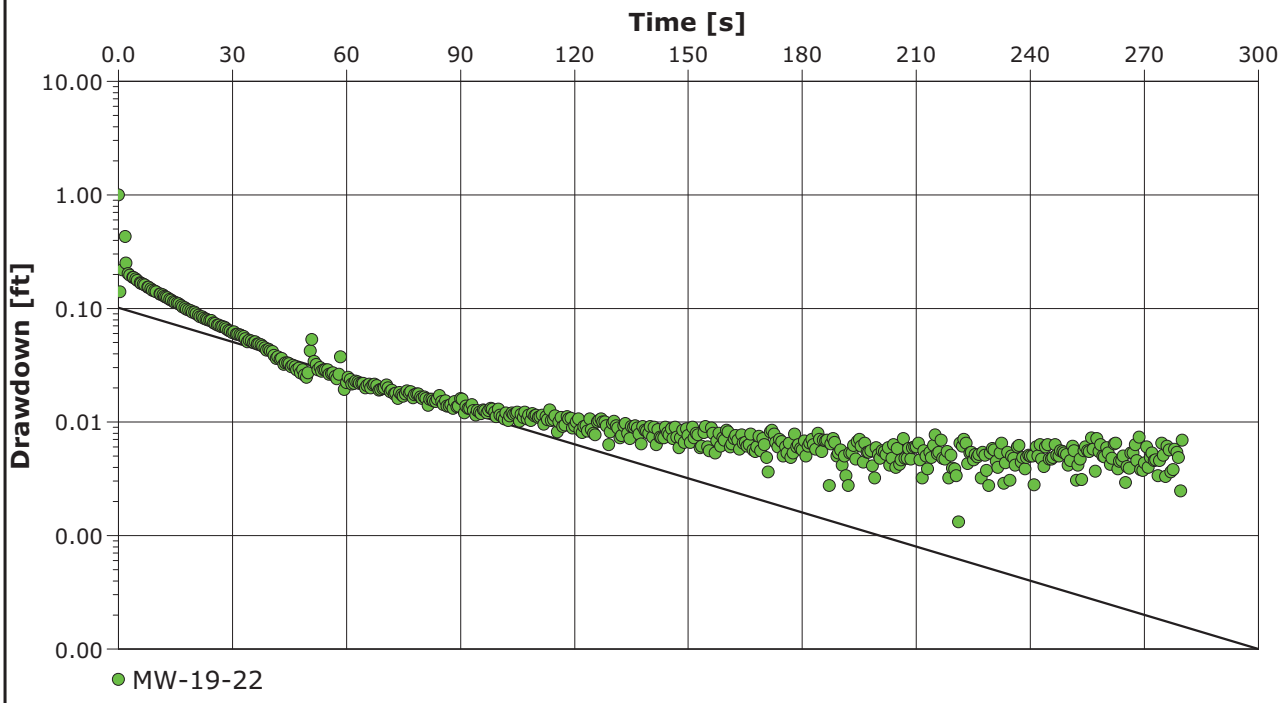
Aquifer Thickness: 5.35 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-19-22	8.96×10^{-1}	

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Slug Test Analysis Report

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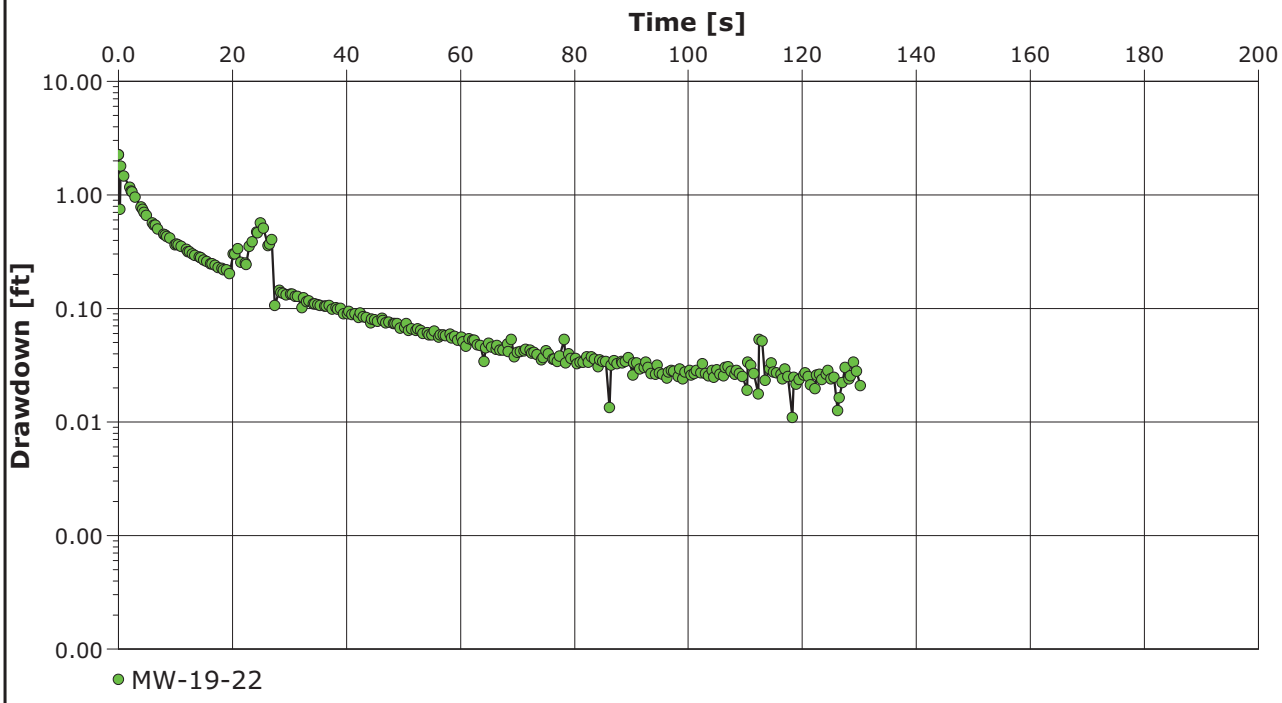

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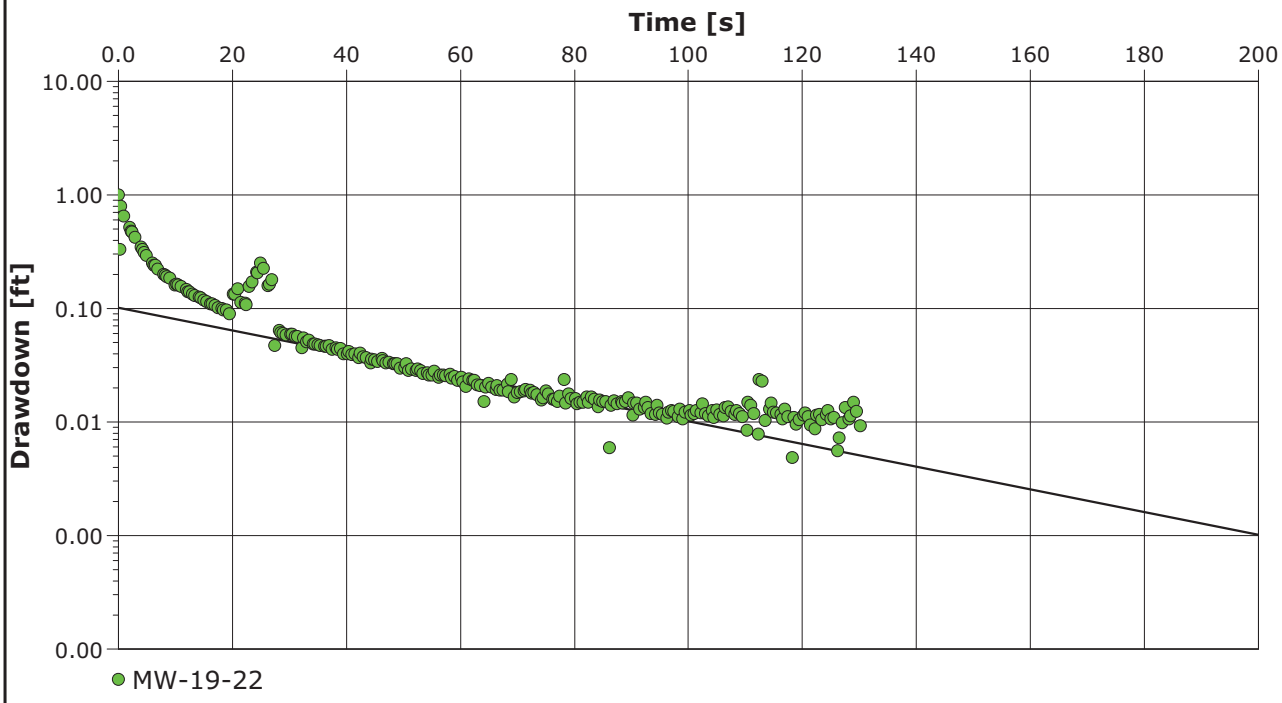

Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-19-22	8.96×10^{-1}	

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Slug Test Analysis Report

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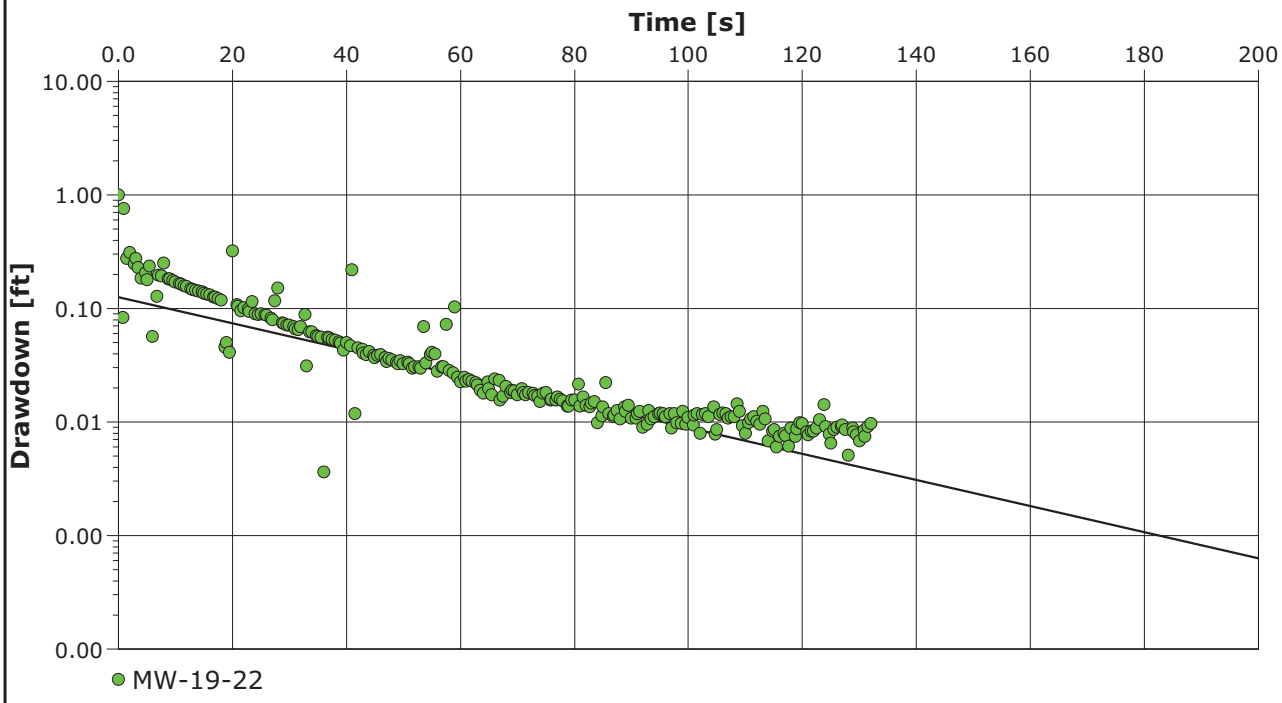
Aquifer Thickness: 5.35 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-19-22	1.03×10^{0}	

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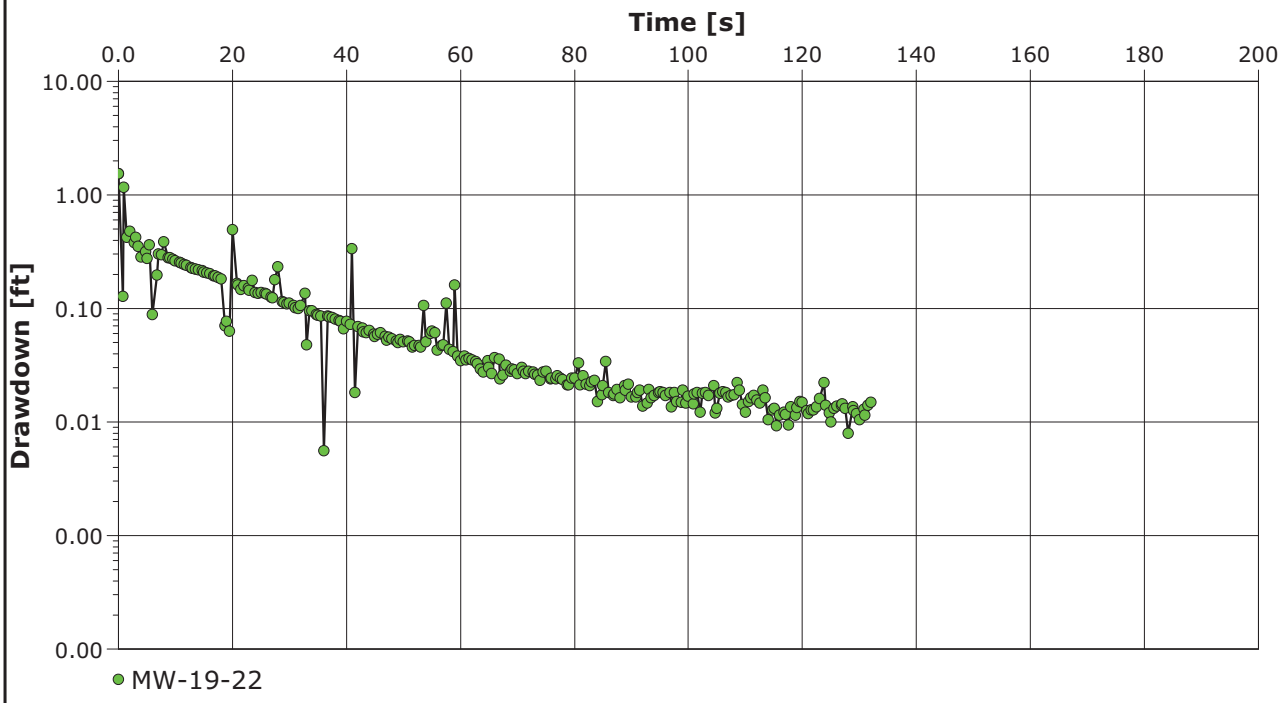
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 5.35 ft		



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Slug Test Analysis Report

Project: Gasco Ground Water Source Control

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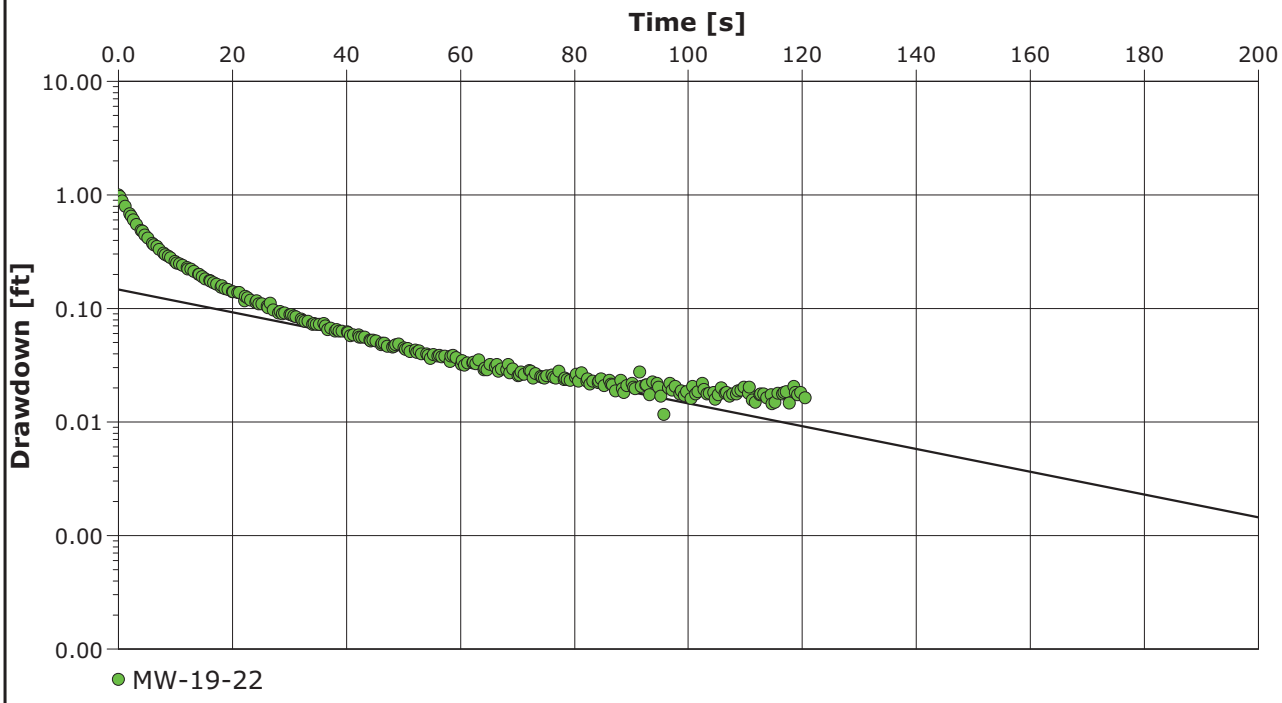
Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-19-22 Test 4	Test Well: MW-19-22
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 5.35 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-19-22	8.96×10^{-1}	

ANCHOR QEA
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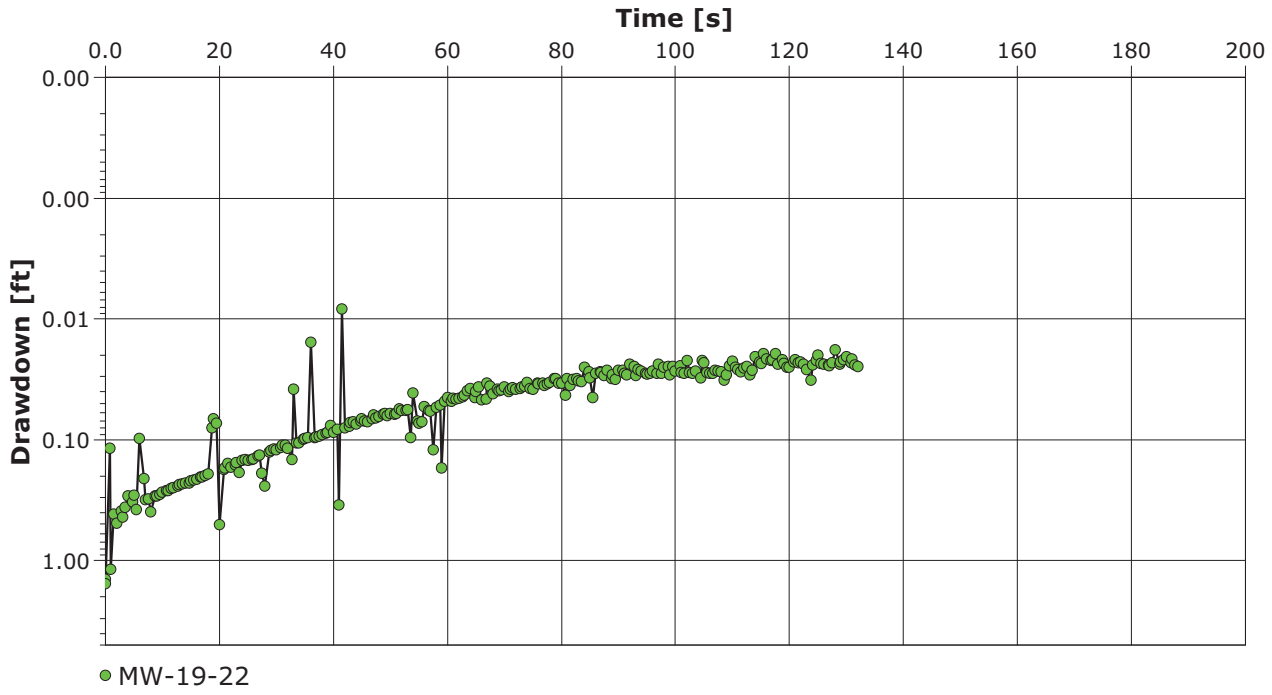
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

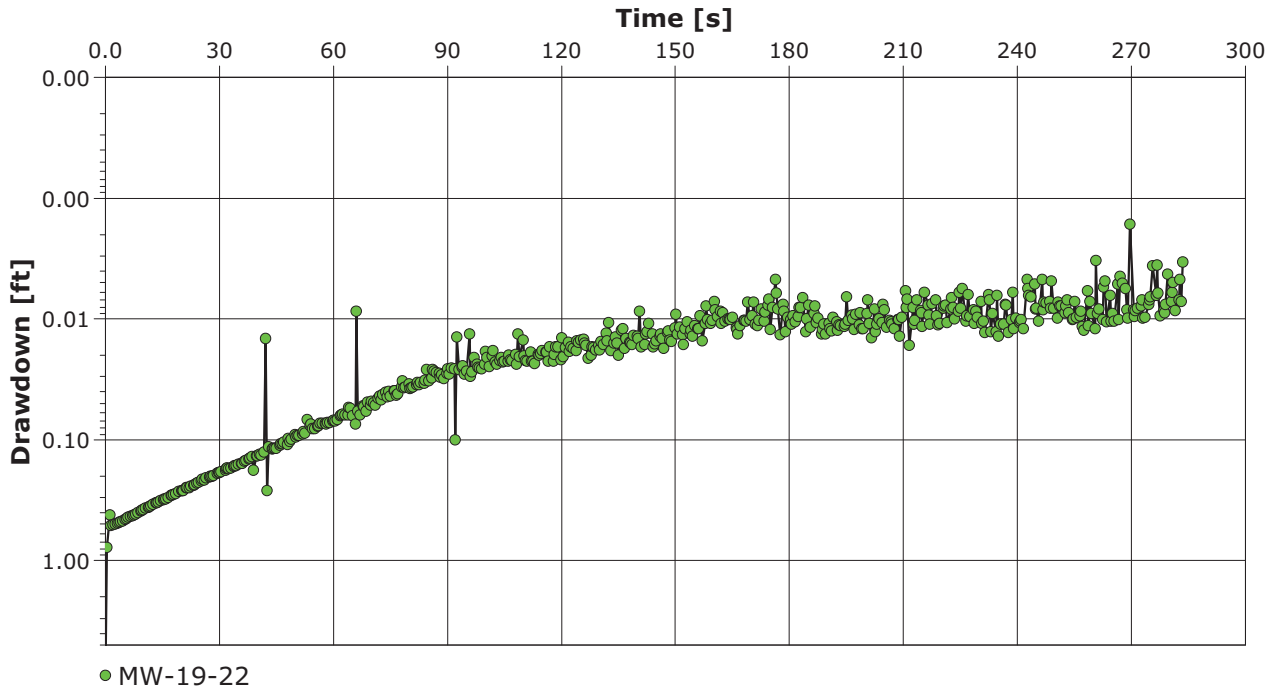
Location: Portland, Oregon	Slug Test: MW-19-22 Test 4	Test Well: MW-19-22
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 5.35 ft		



City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: MW-19-22 Test 5	Test Well: MW-19-22
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 5.35 ft		



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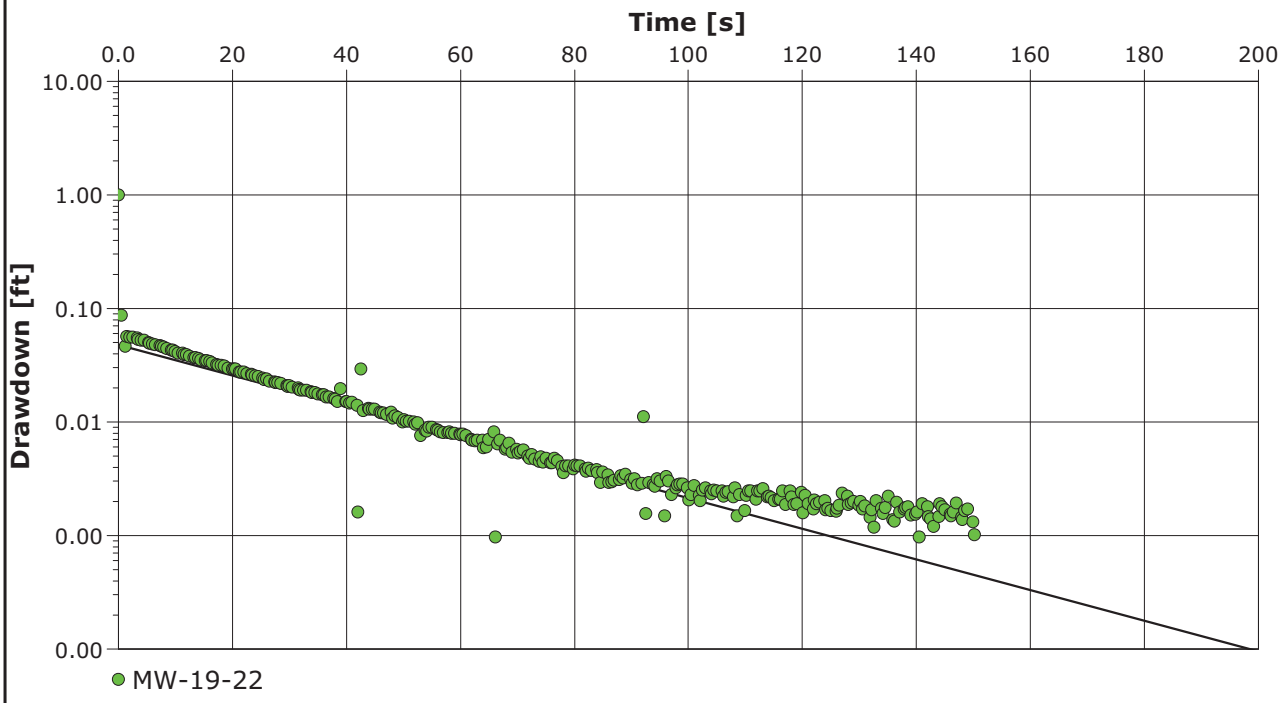
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-19-22 Test 5	Test Well: MW-19-22
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 5.35 ft		

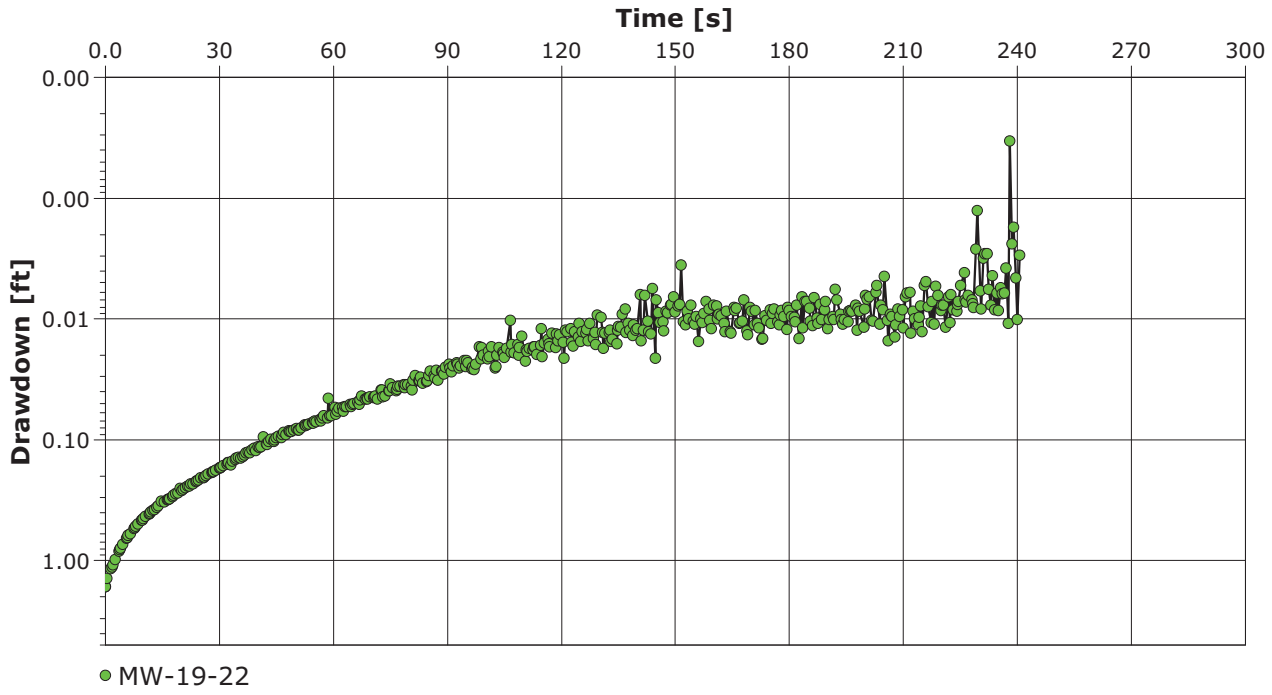


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-19-22	1.21×10^{0}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

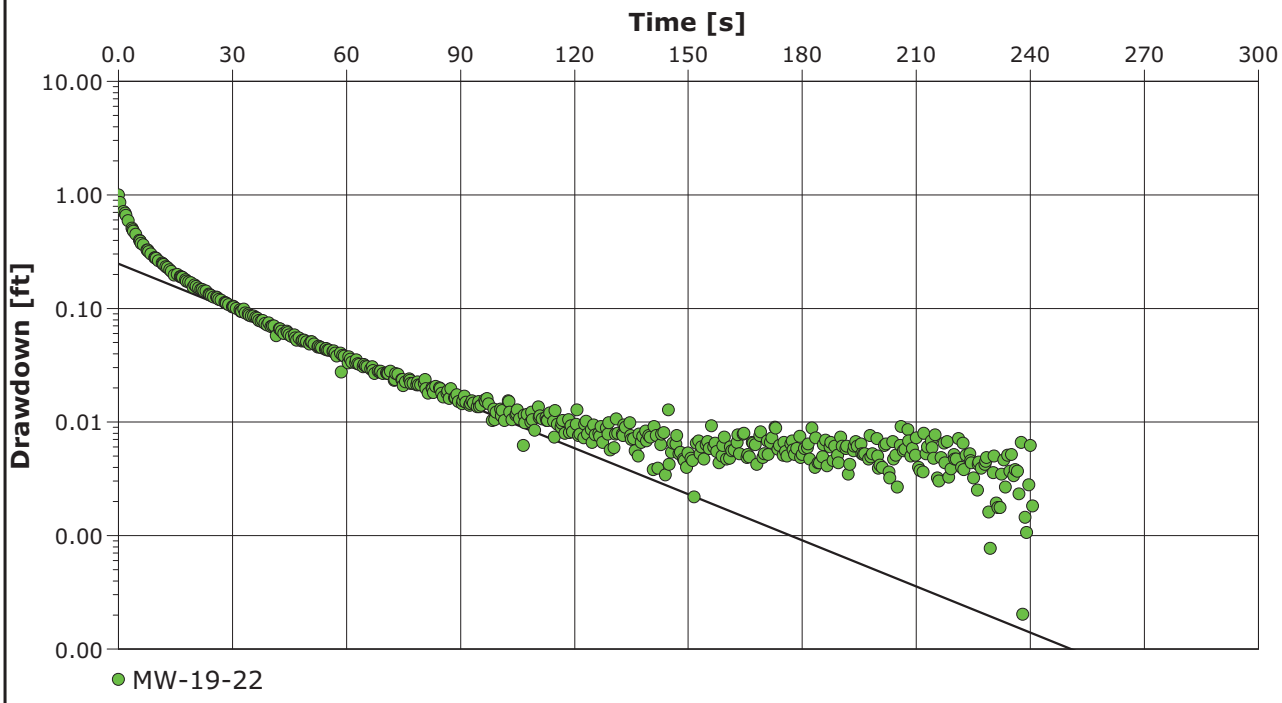
Location: Portland, Oregon	Slug Test: MW-19-22 Test 6	Test Well: MW-19-22
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 5.35 ft		



City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: MW-19-22 Test 6	Test Well: MW-19-22
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 5.35 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-19-22	1.21×10^{0}	

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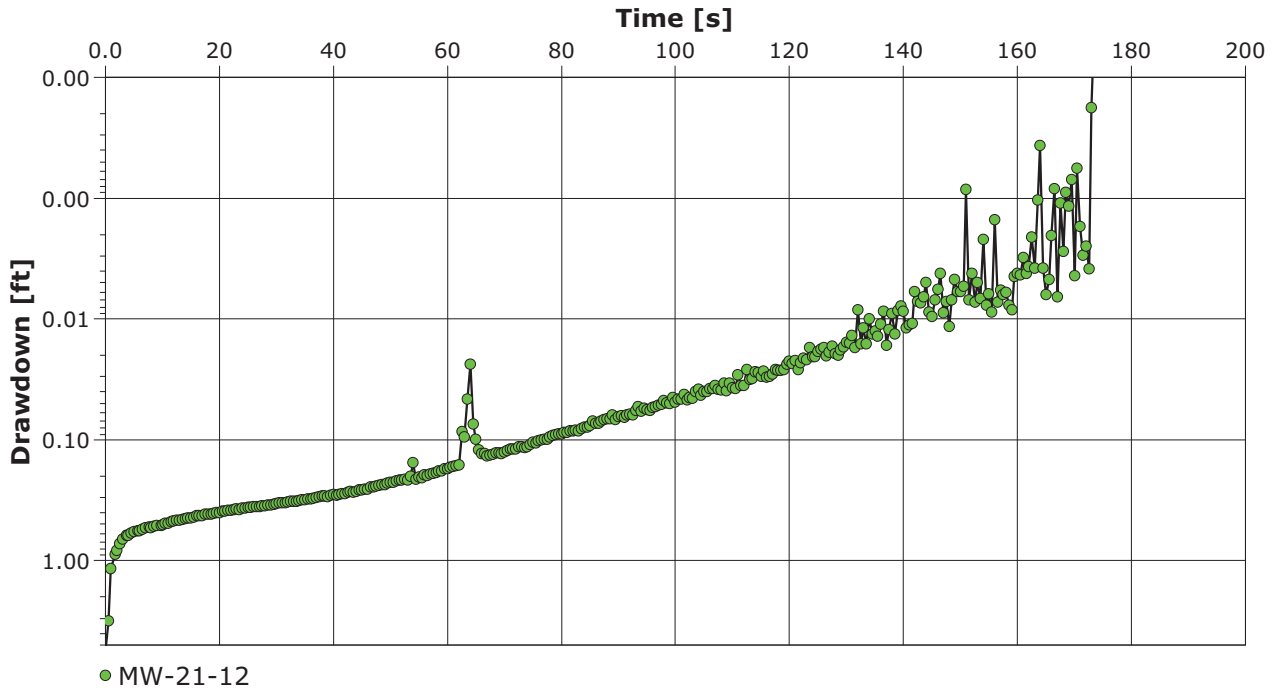
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-21-12 Test 1	Test Well: MW-21-12
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 11.55 ft		



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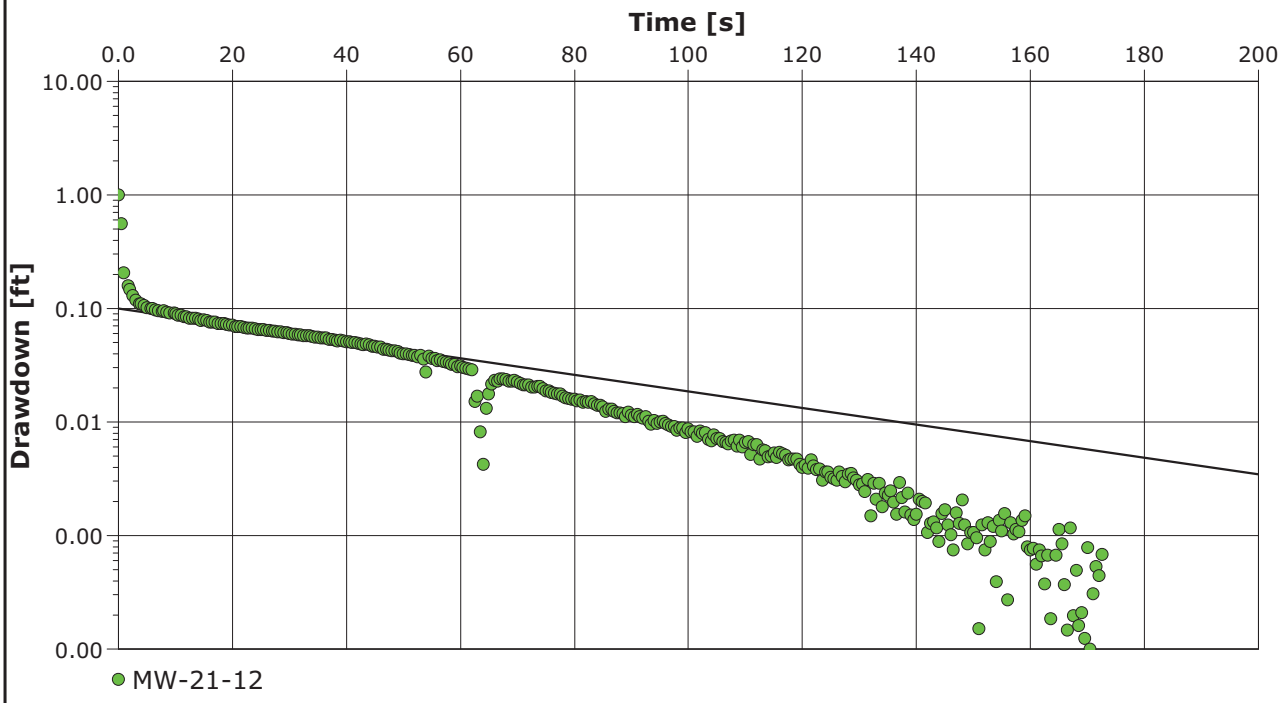
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-21-12 Test 1	Test Well: MW-21-12
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 11.55 ft		

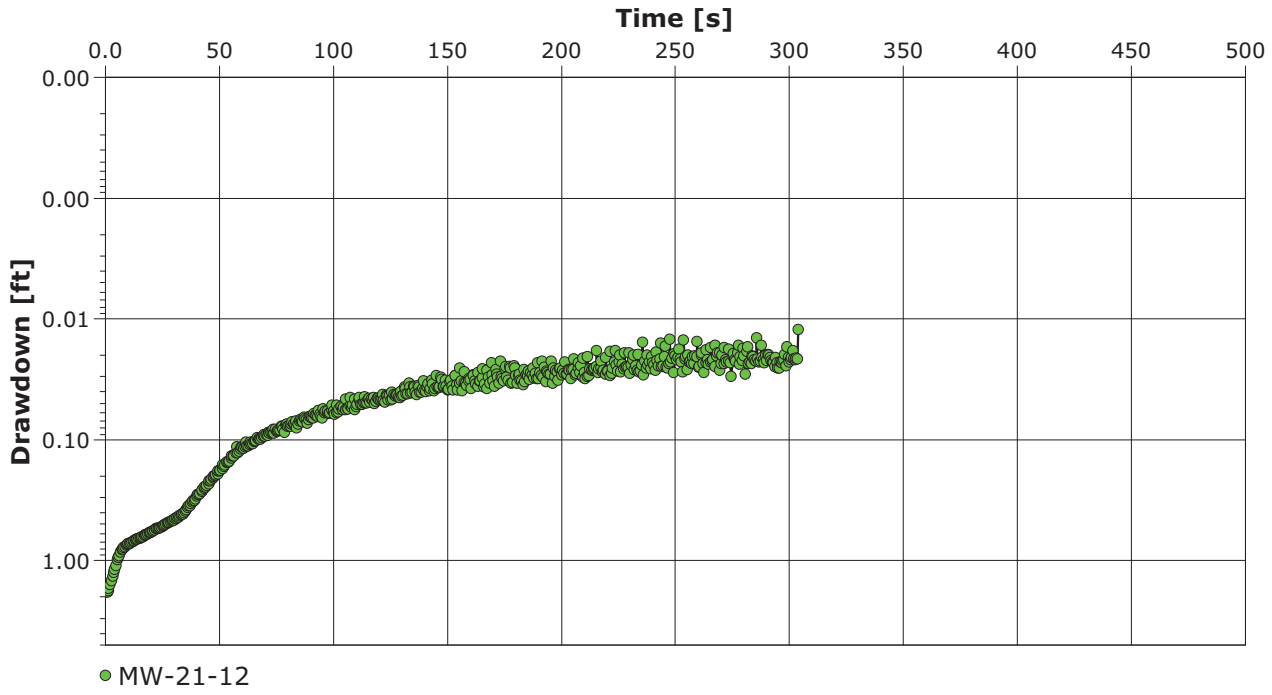


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-21-12	8.96×10^{-1}	

City, State/Province **Address** **Contact Info** **Company Name** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-21-12 Test 2	Test Well: MW-21-12
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 11.55 ft		



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Slug Test Analysis Report

Project: Gasco Ground Water Source Control

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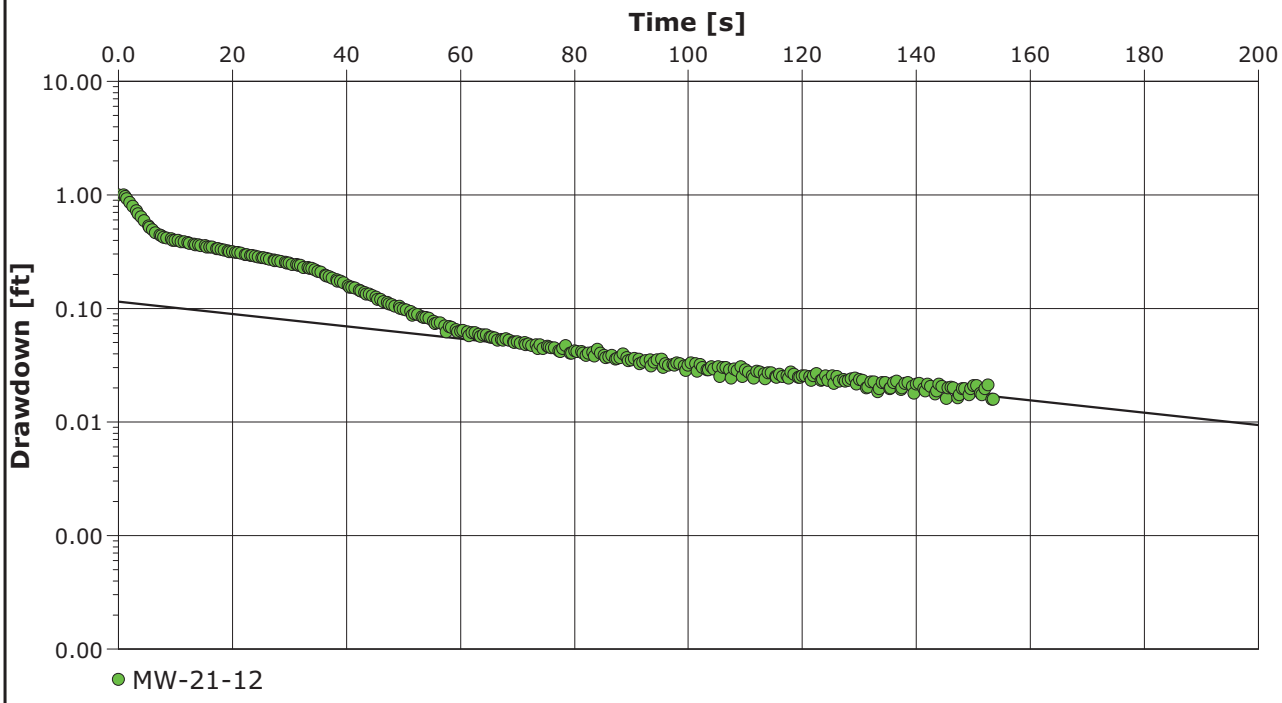
Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-21-12 Test 2	Test Well: MW-21-12
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 11.55 ft		

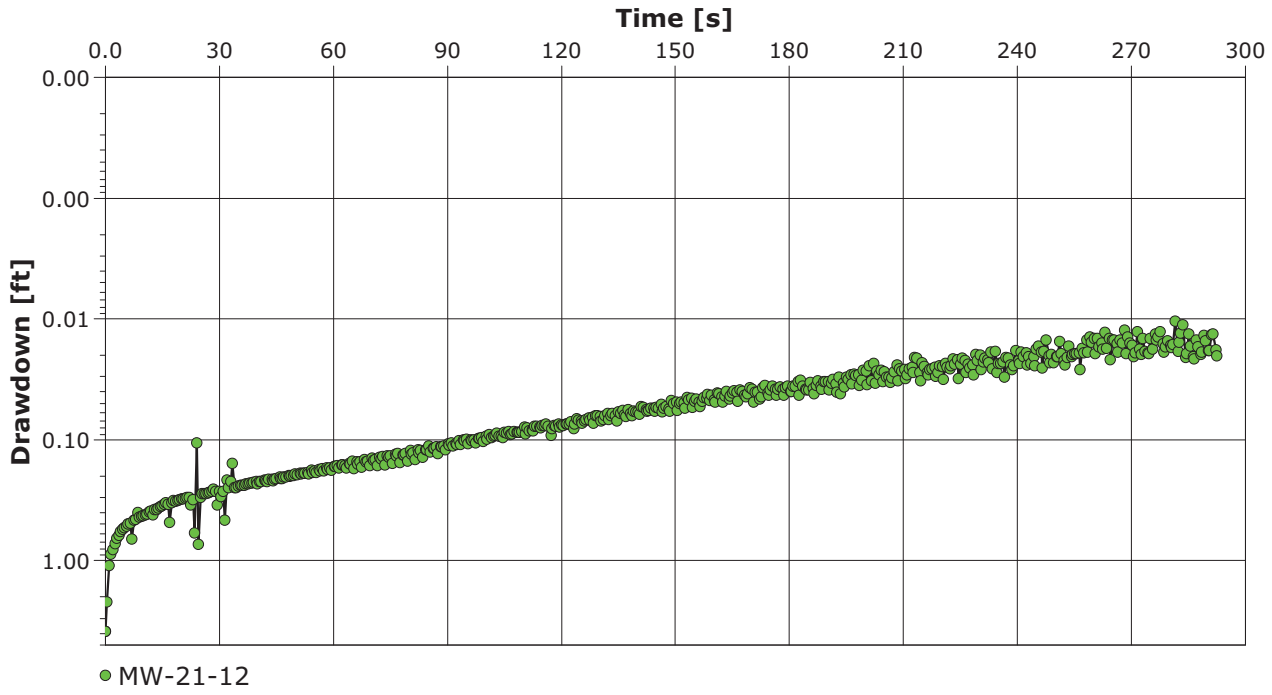


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-21-12	6.65×10^{-1}	

ANCHOR QEA City, State/Province Address Contact Info Company Name 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report**
	Project: Gasco Ground Water Source Control
	Number: 000029-02.28 task 3A
	Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-21-12 Test 3	Test Well: MW-21-12
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 11.55 ft		



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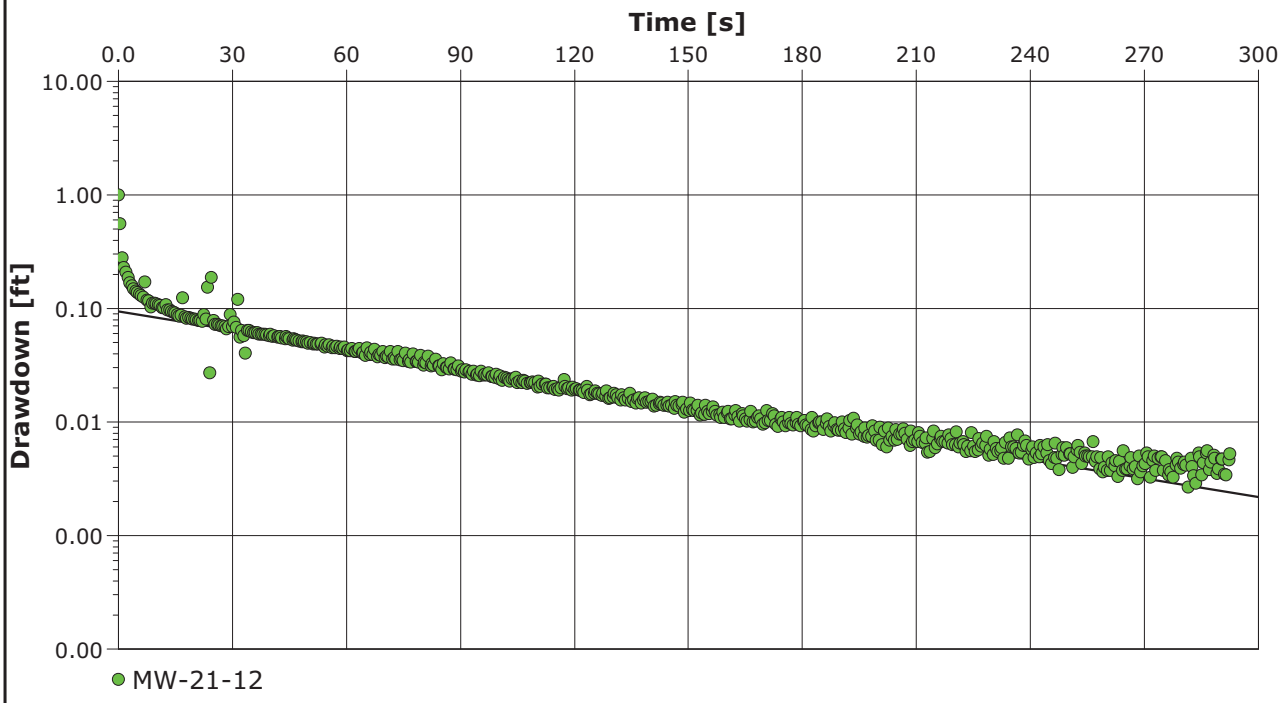
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 11.55 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-21-12	6.65×10^{-1}	

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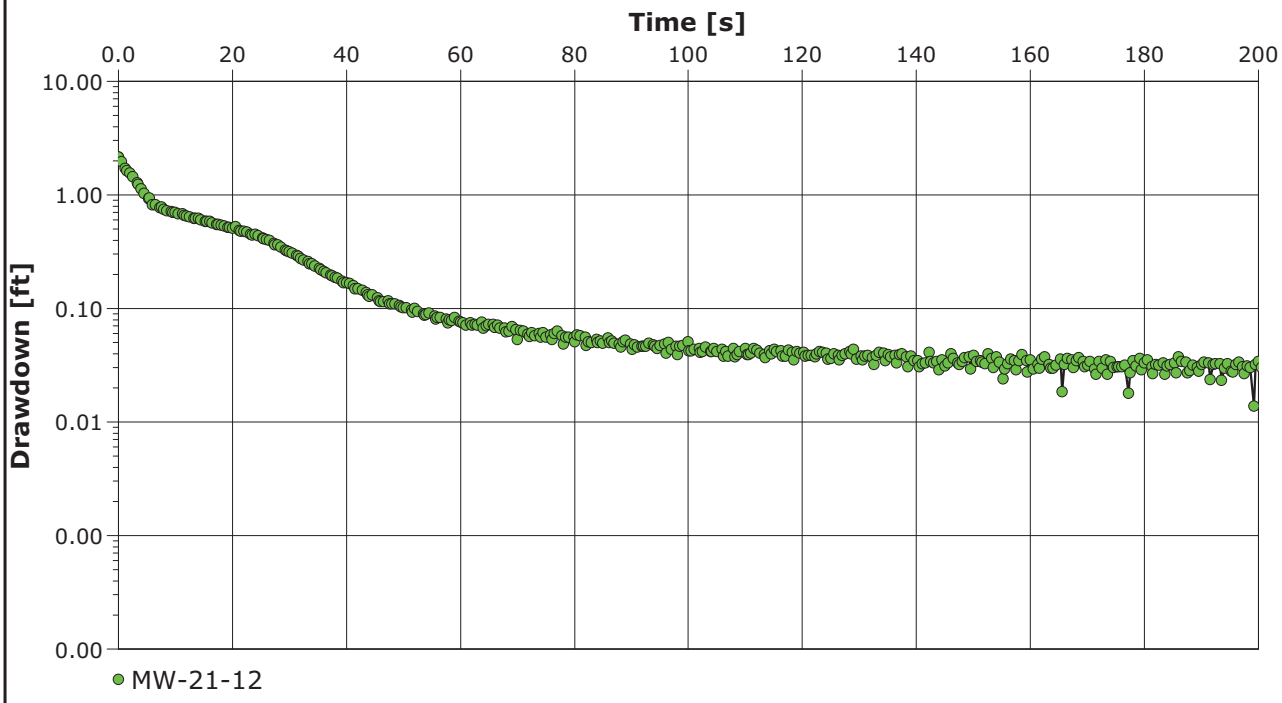
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-21-12 Test 4	Test Well: MW-21-12
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 11.55 ft		



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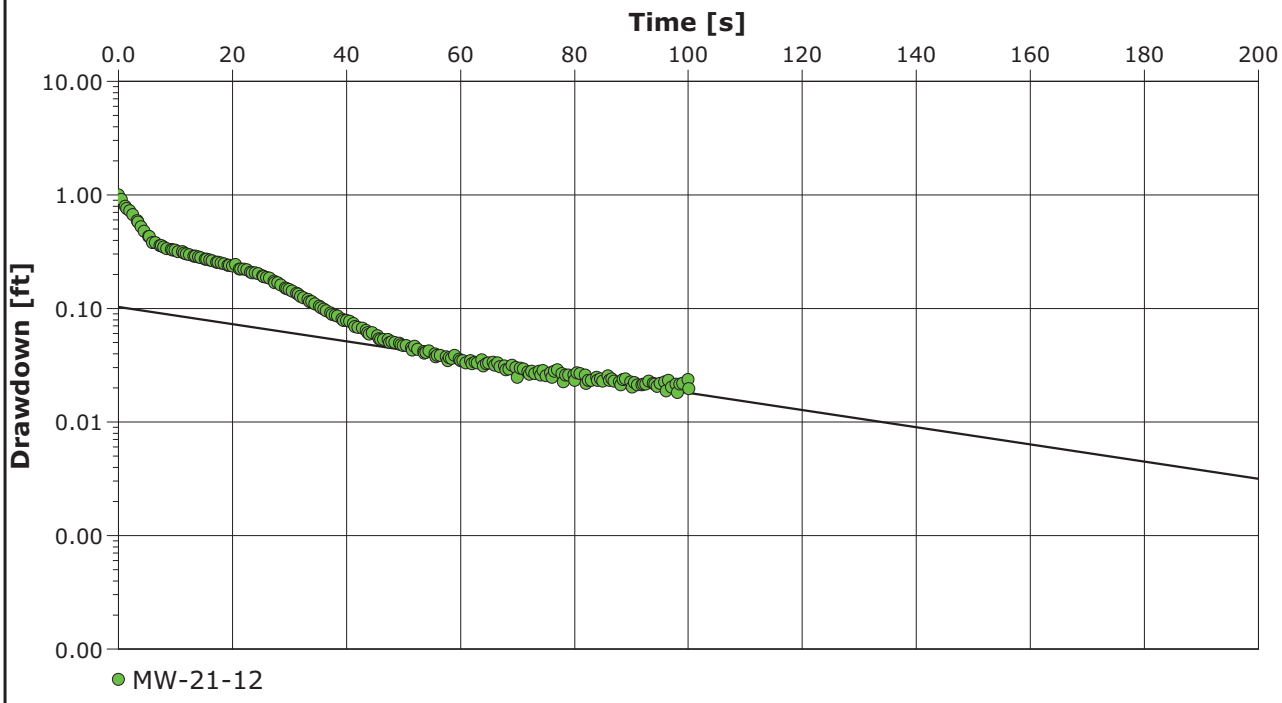
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-21-12 Test 4	Test Well: MW-21-12
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 11.55 ft		

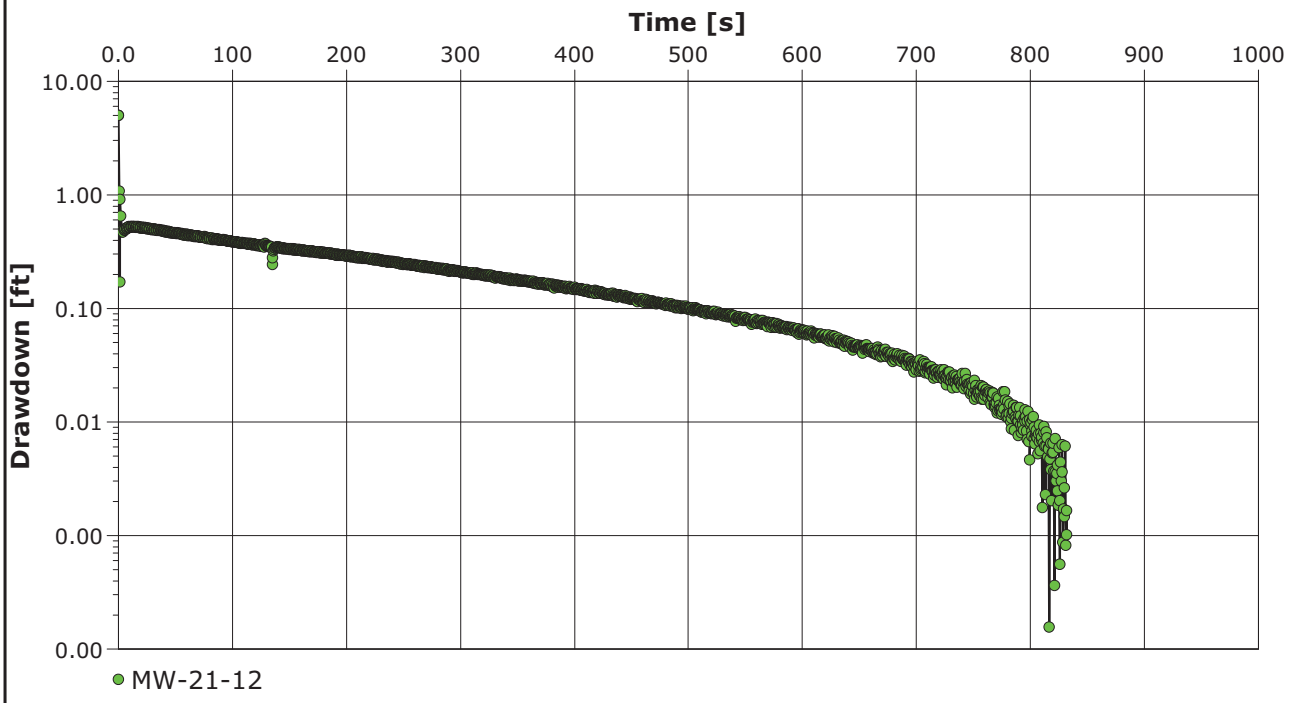


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-21-12	6.65×10^{-1}	

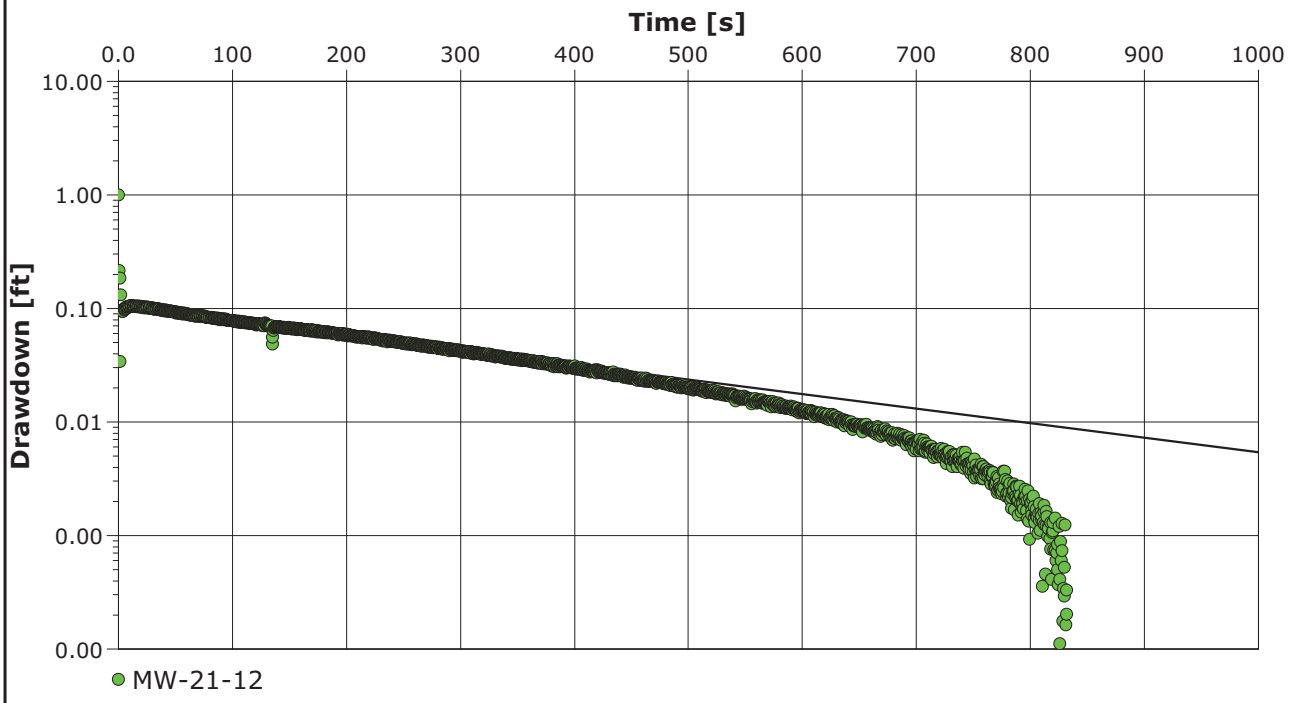
ANCHOR QEA **City, State/Province** **Address** **Contact Info** **Company Name** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report**	
	Project: Gasco Ground Water Source Control	
	Number: 000029-02.28 task 3A	
	Client: NW Natural	

Location: Portland, Oregon	Slug Test: MW-23-27 Test 1	Test Well: MW-21-12
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 5.59 ft		



ANCHOR QEA **City, State/Province** **Address** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 **Contact Info** Phone 503.670.1108 Fax 503.670.1128 **Company Name**	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-23-27 Test 1	Test Well: MW-21-12
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 5.59 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-21-12	1.10×10^{-1}	

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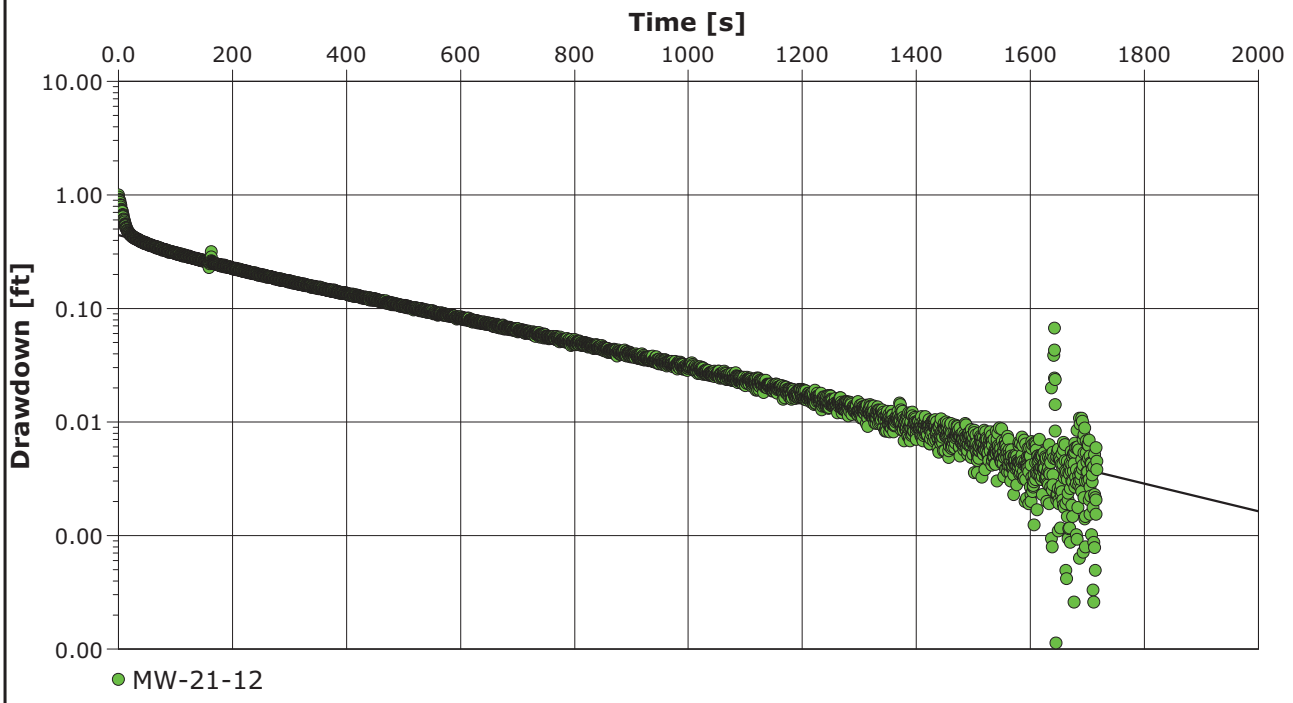
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-23-27 Test 2	Test Well: MW-21-12
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 5.59 ft		



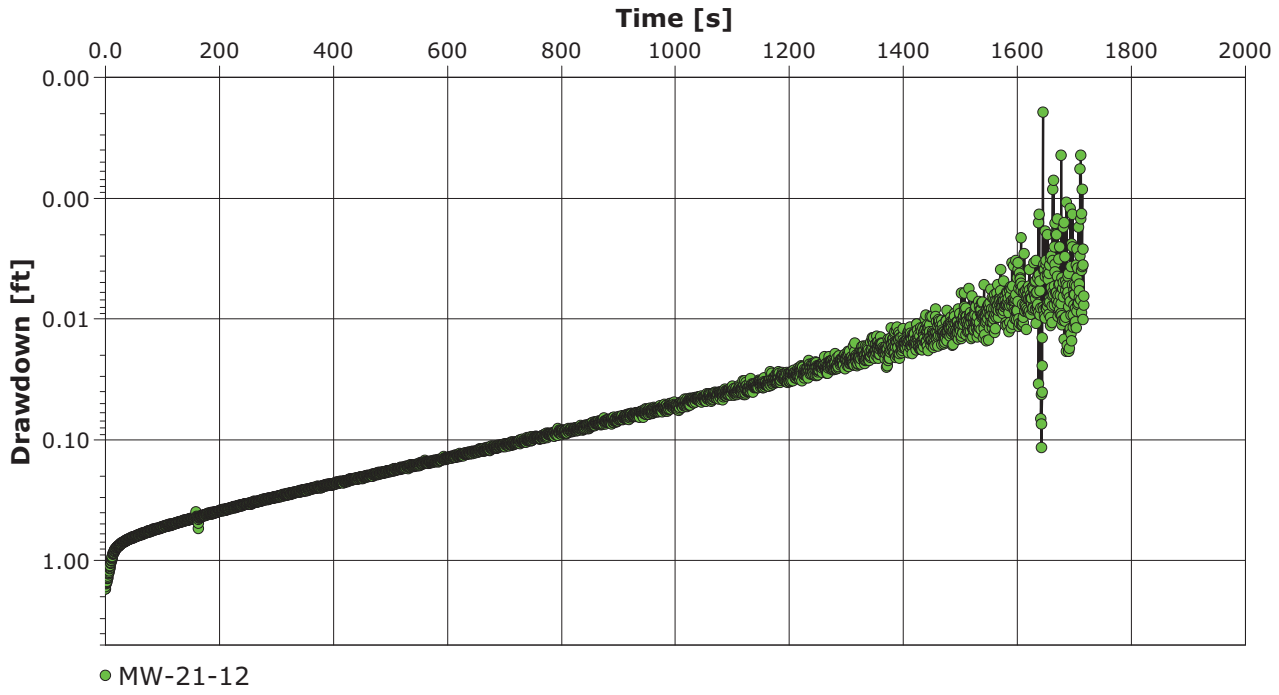
Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-21-12	1.05×10^{-1}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

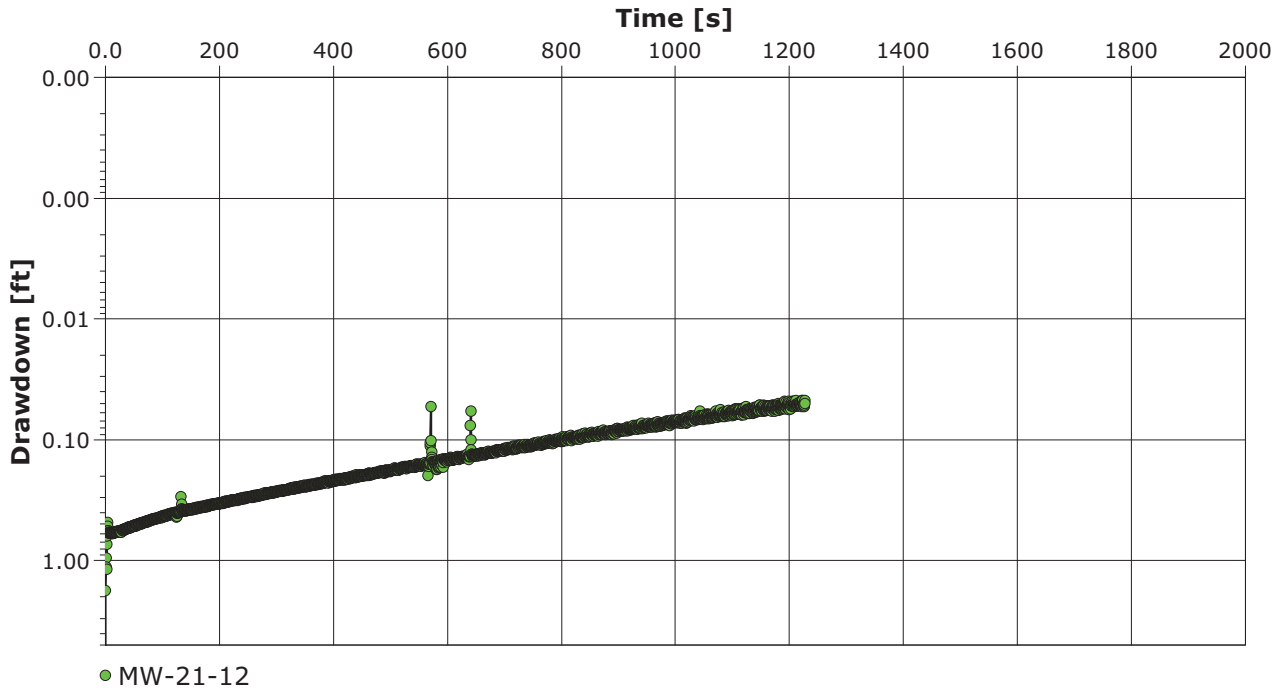
Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: MW-23-27 Test 2	Test Well: MW-21-12
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 5.59 ft		



City, State/Province **Address** **Contact Info** **Company Name** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-23-27 Test 3	Test Well: MW-21-12
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 5.59 ft		



ANCHOR QEA
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Contact Info Phone 503.670.1108
Fax 503.670.1128
Company Name

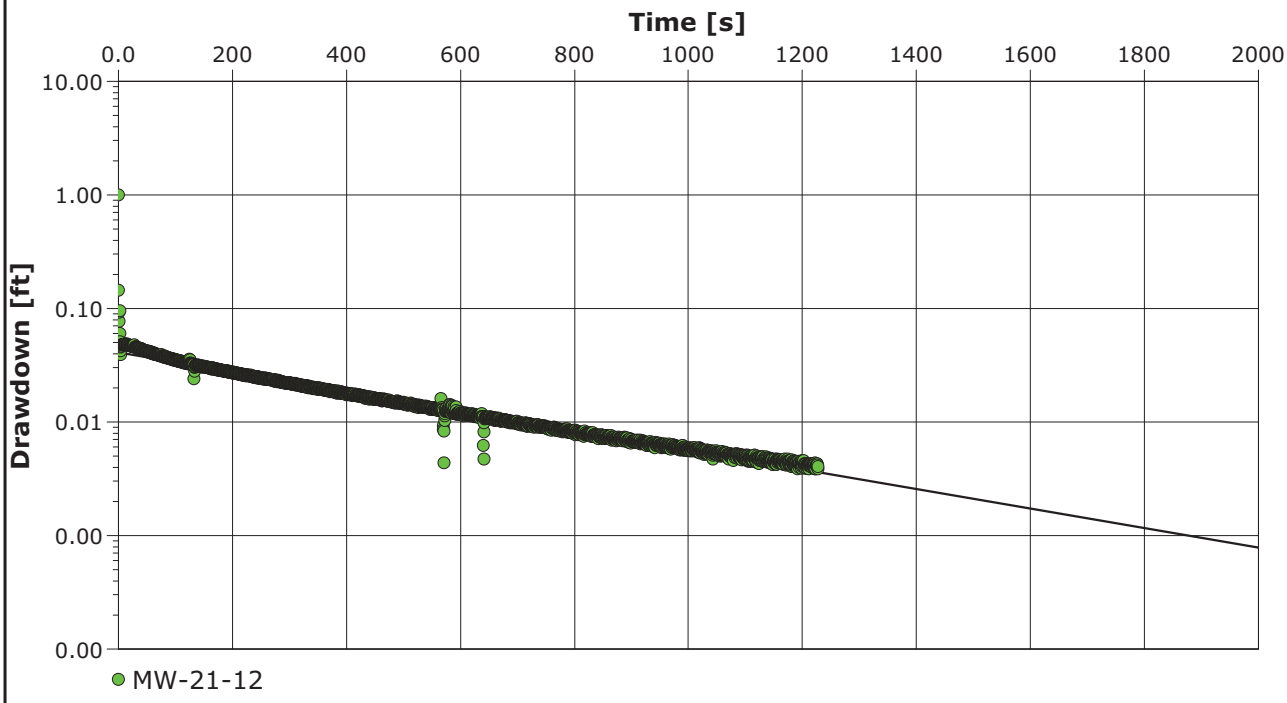
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-23-27 Test 3	Test Well: MW-21-12
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 5.59 ft		



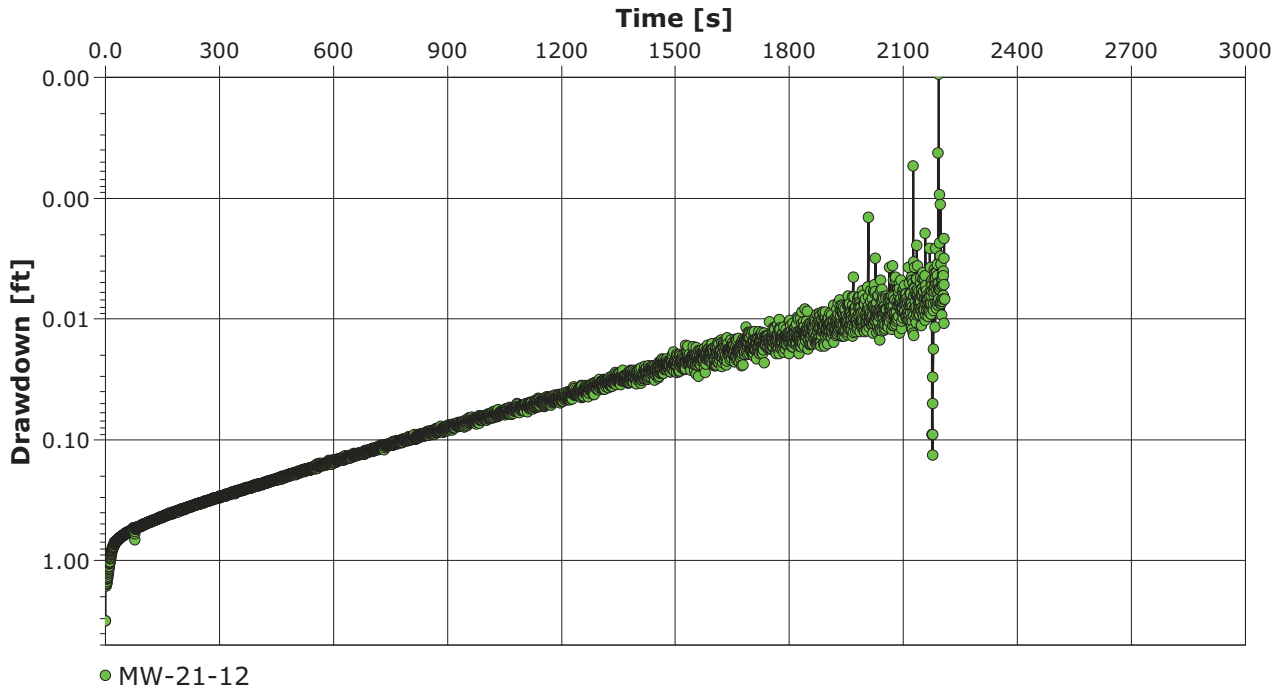
Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-21-12	7.40×10^{-2}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

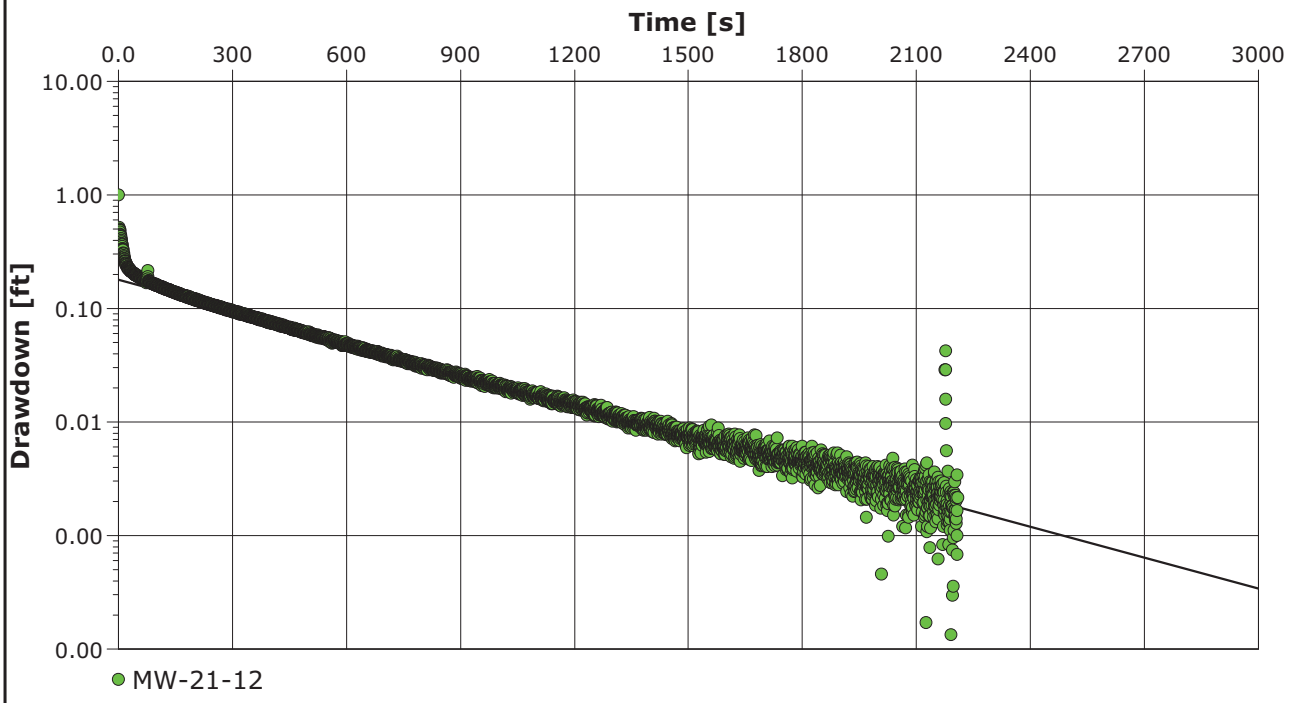
Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: MW-21-12 Test 4	Test Well: MW-21-12
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 11.55 ft		



ANCHOR QEA **City, State/Province** **Address** **Contact Info** **Company Name** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-21-12 Test 4	Test Well: MW-21-12
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 11.55 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-21-12	7.95×10^{-2}	

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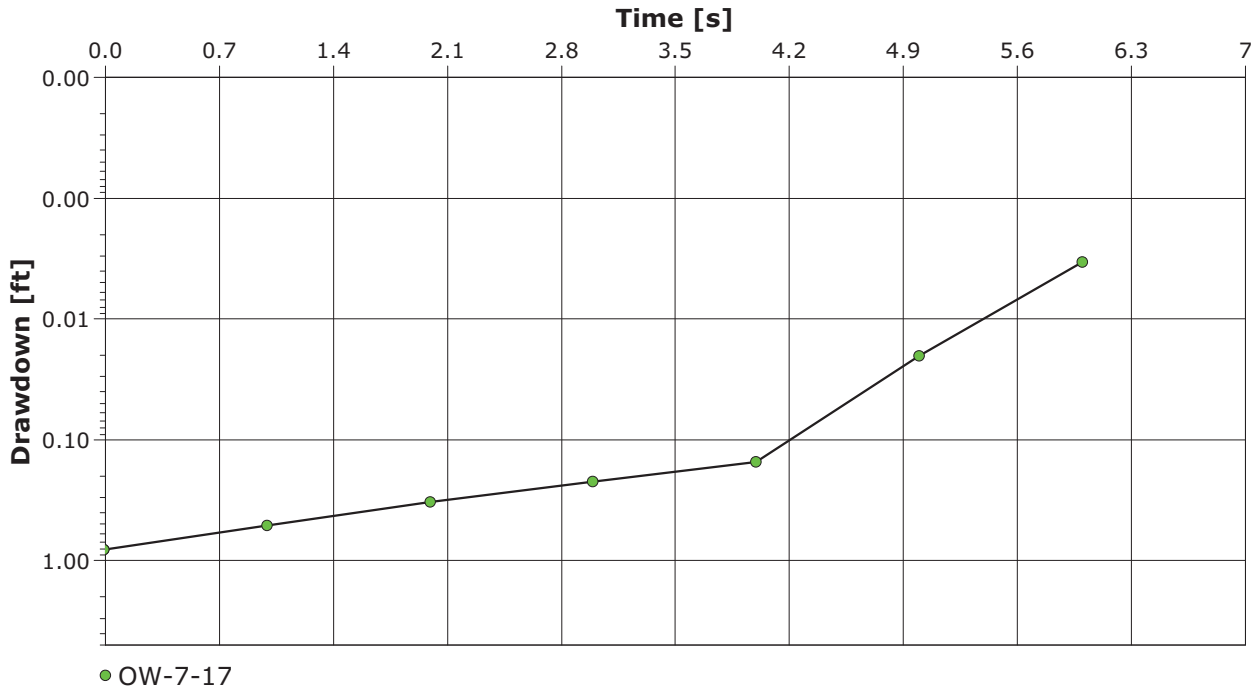
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-7-17 Test 1	Test Well: OW-7-17
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 5.75 ft		



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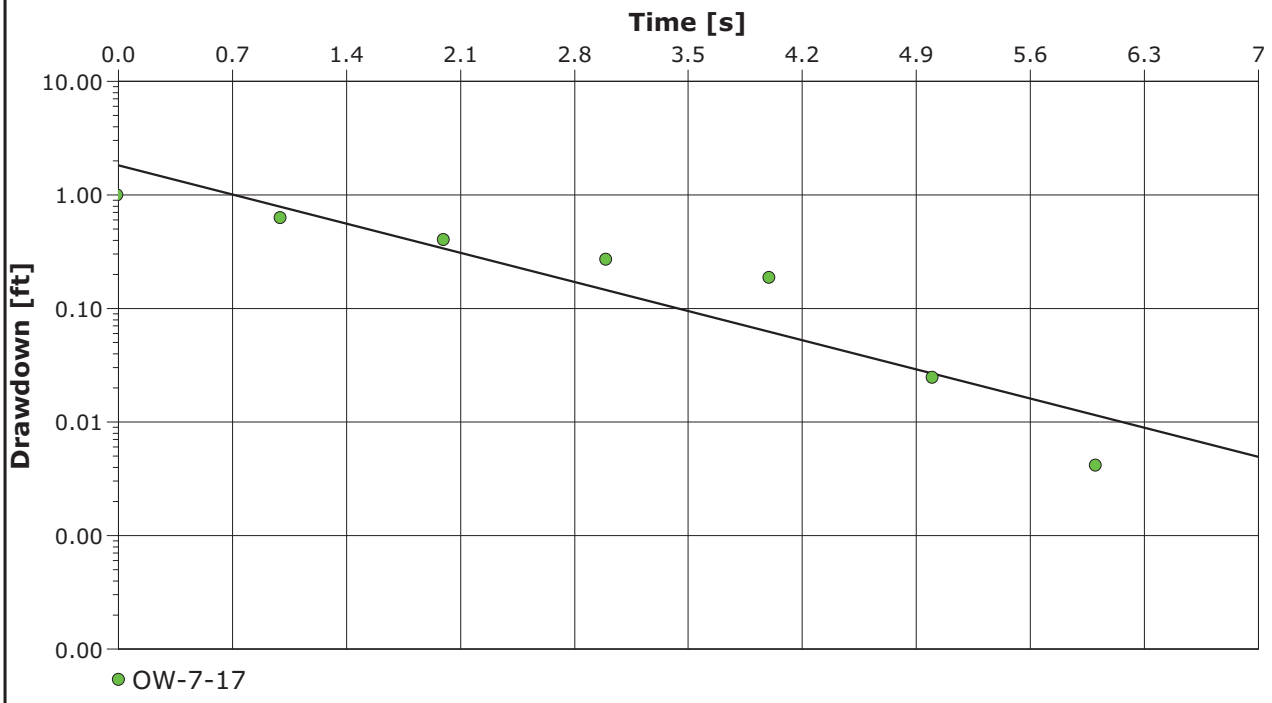
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-7-17 Test 1	Test Well: OW-7-17
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 5.75 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
OW-7-17	5.38×10^{1}	

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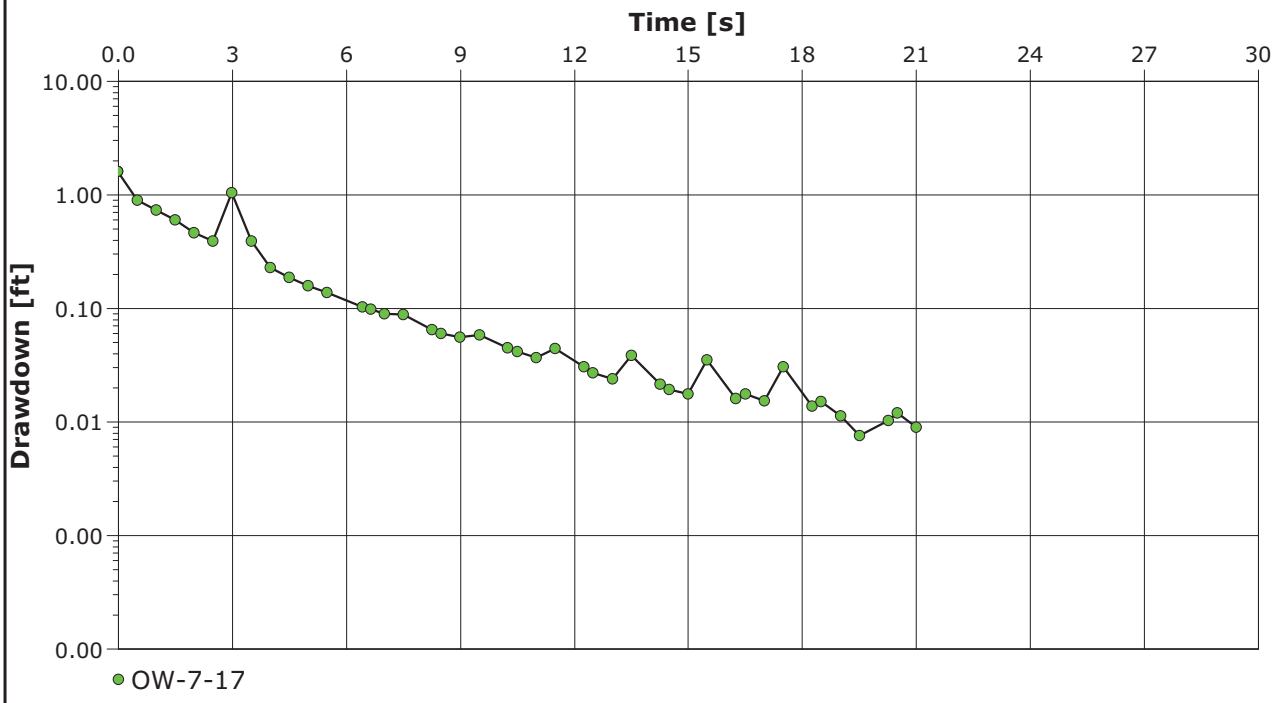
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-7-17 Test 2	Test Well: OW-7-17
Test conducted by: MWilson/DLaffoon		Test date: 1/14/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 5.75 ft		



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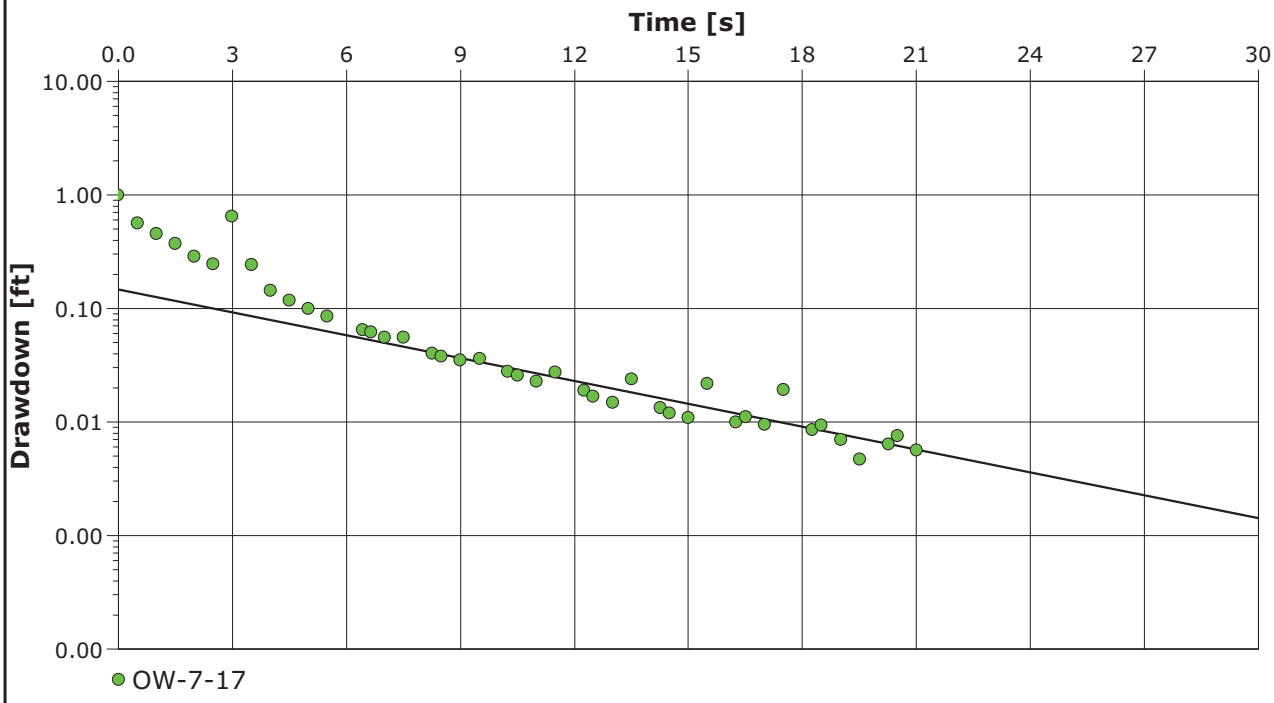
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-7-17 Test 2	Test Well: OW-7-17
Test conducted by: MWilson/DLaffoon		Test date: 1/14/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 5.75 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
OW-7-17	9.83×10^{0}	

ANCHOR QEA
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Portland, Oregon 97224
Phone 503.670.1108
Fax 503.670.1128

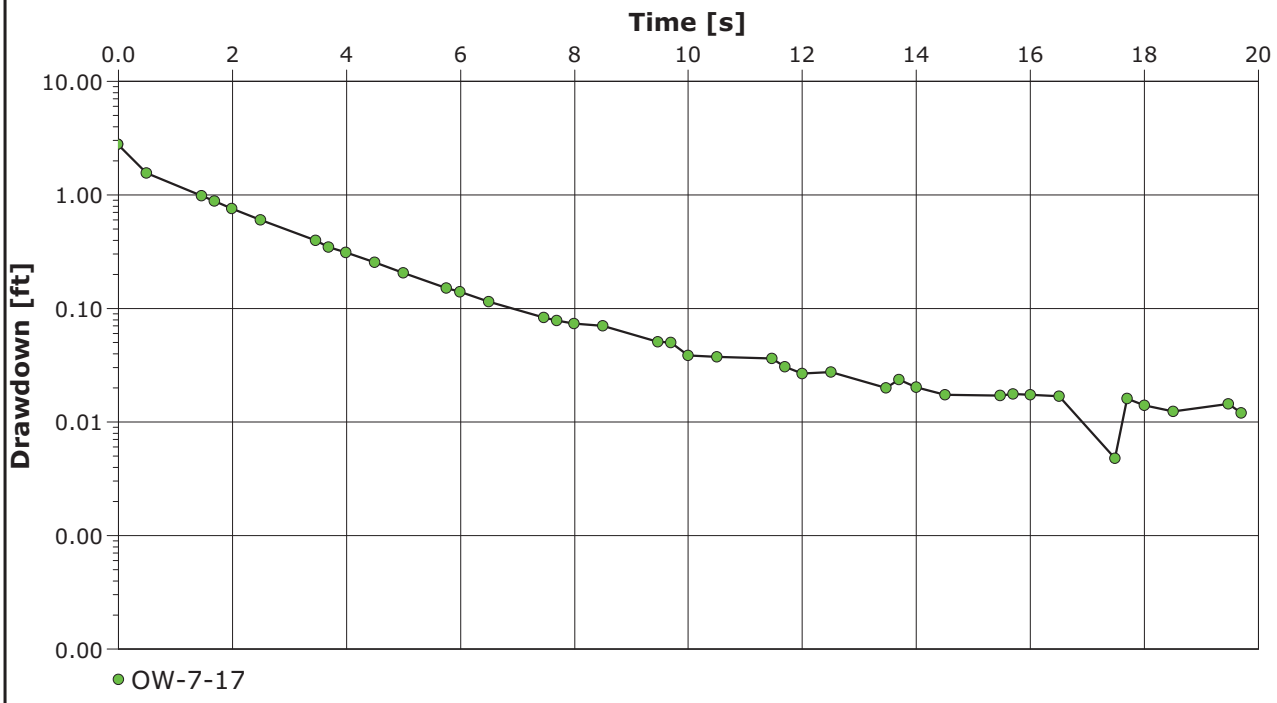
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-7-17 Test 3	Test Well: OW-7-17
Test conducted by: MWilson/DLaffoon		Test date: 1/14/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 5.75 ft		



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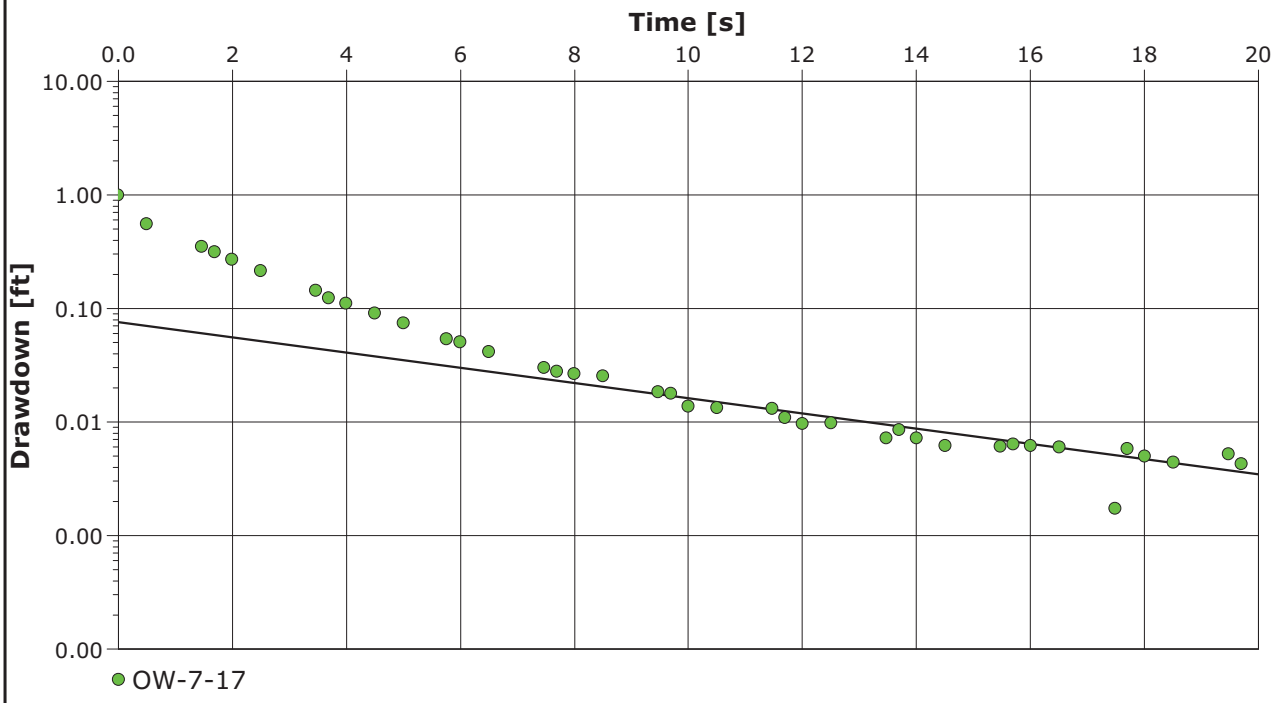
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-7-17 Test 3	Test Well: OW-7-17
Test conducted by: MWilson/DLaffoon		Test date: 1/14/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 5.75 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
OW-7-17	9.83×10^{0}	

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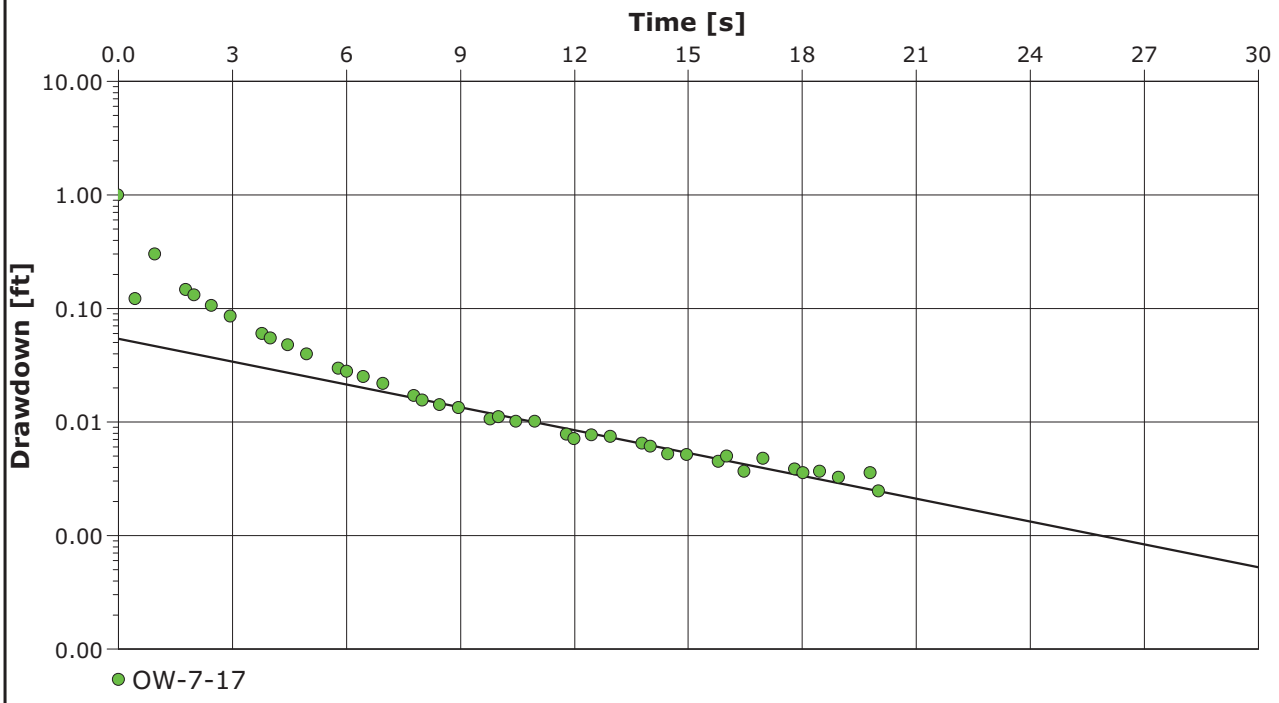
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-7-17 Test 4	Test Well: OW-7-17
Test conducted by: MWilson/DLaffoon		Test date: 1/14/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 5.75 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
OW-7-17	9.83×10^{0}	

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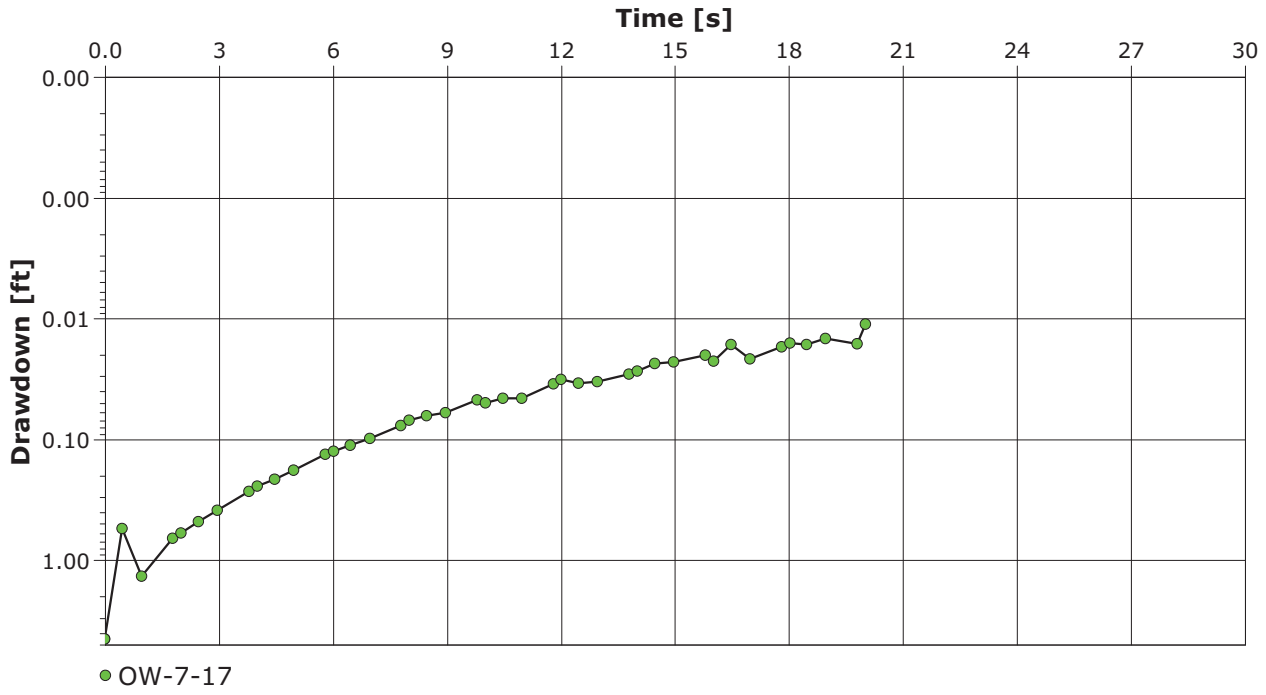
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-7-17 Test 4	Test Well: OW-7-17
Test conducted by: MWilson/DLaffoon		Test date: 1/14/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 5.75 ft		



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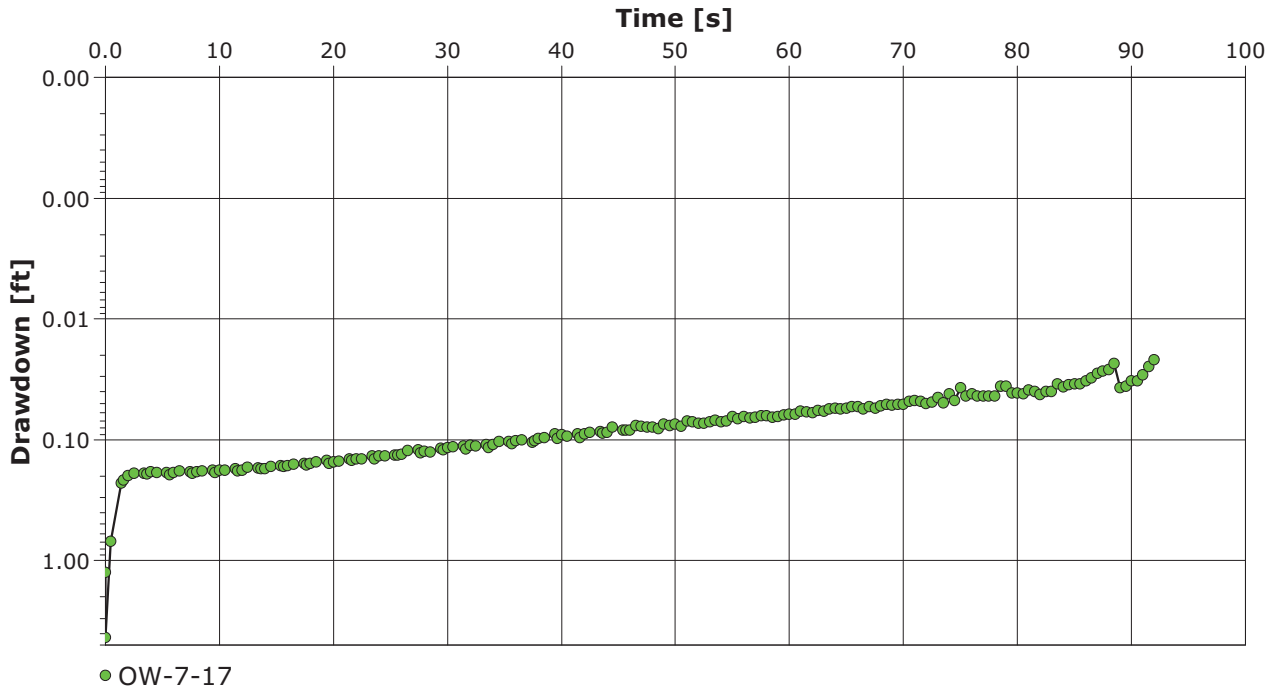
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-7-17 Test 5	Test Well: OW-7-17
Test conducted by: MWilson/DLaffoon		Test date: 1/14/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 5.75 ft		



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Fax 503.670.1128

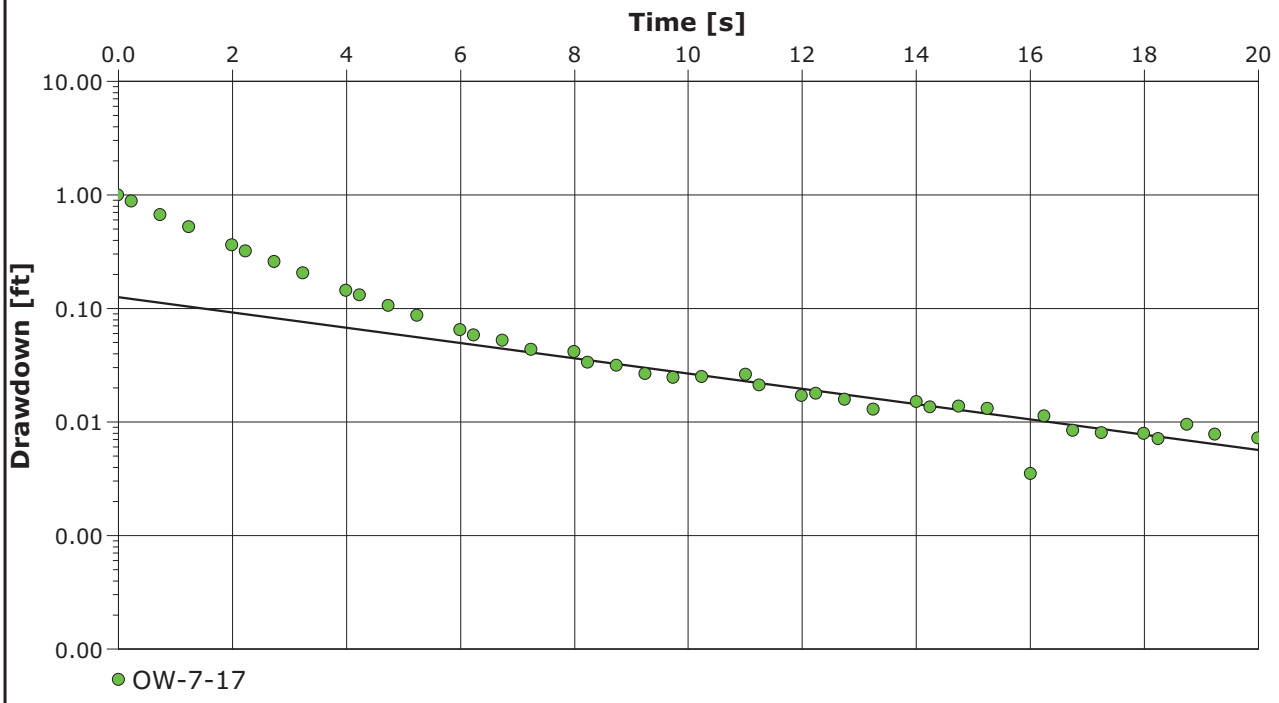
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-7-17 Test 5	Test Well: OW-7-17
Test conducted by: MWilson/DLaffoon		Test date: 1/14/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 5.75 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
OW-7-17	9.83×10^{0}	

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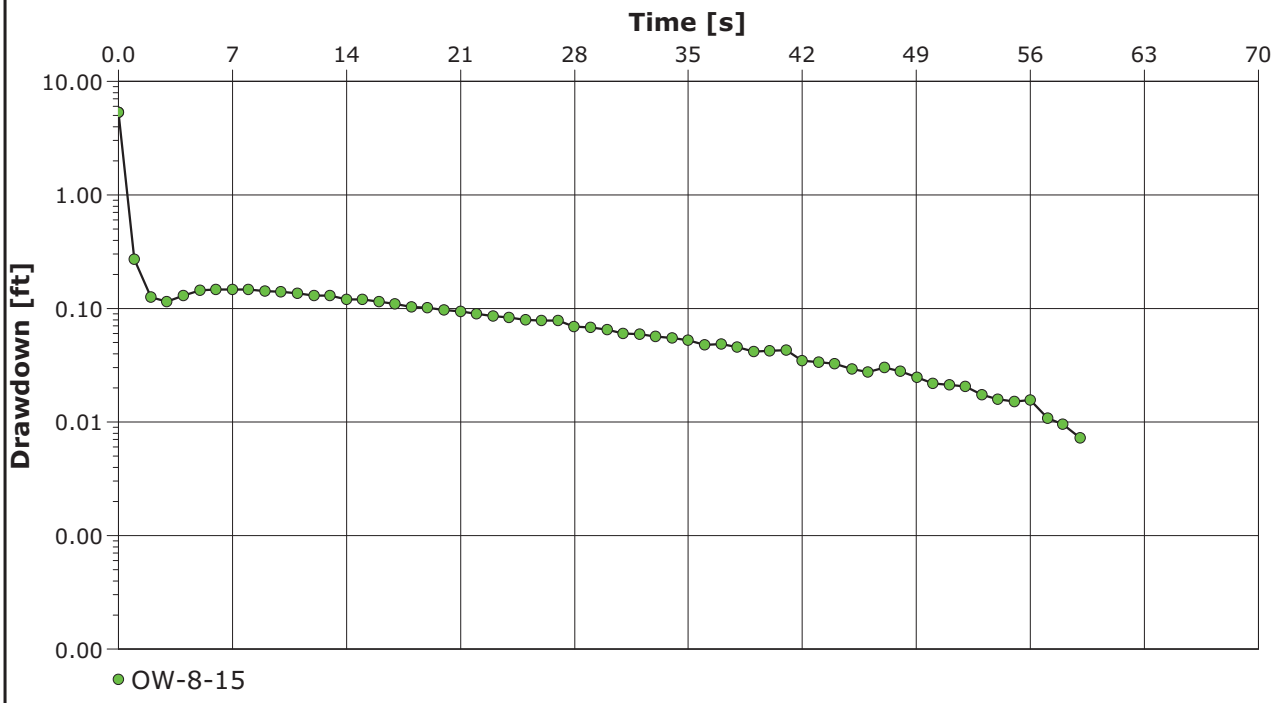
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-8-15 Test 1	Test Well: OW-8-15
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 4.69 ft		



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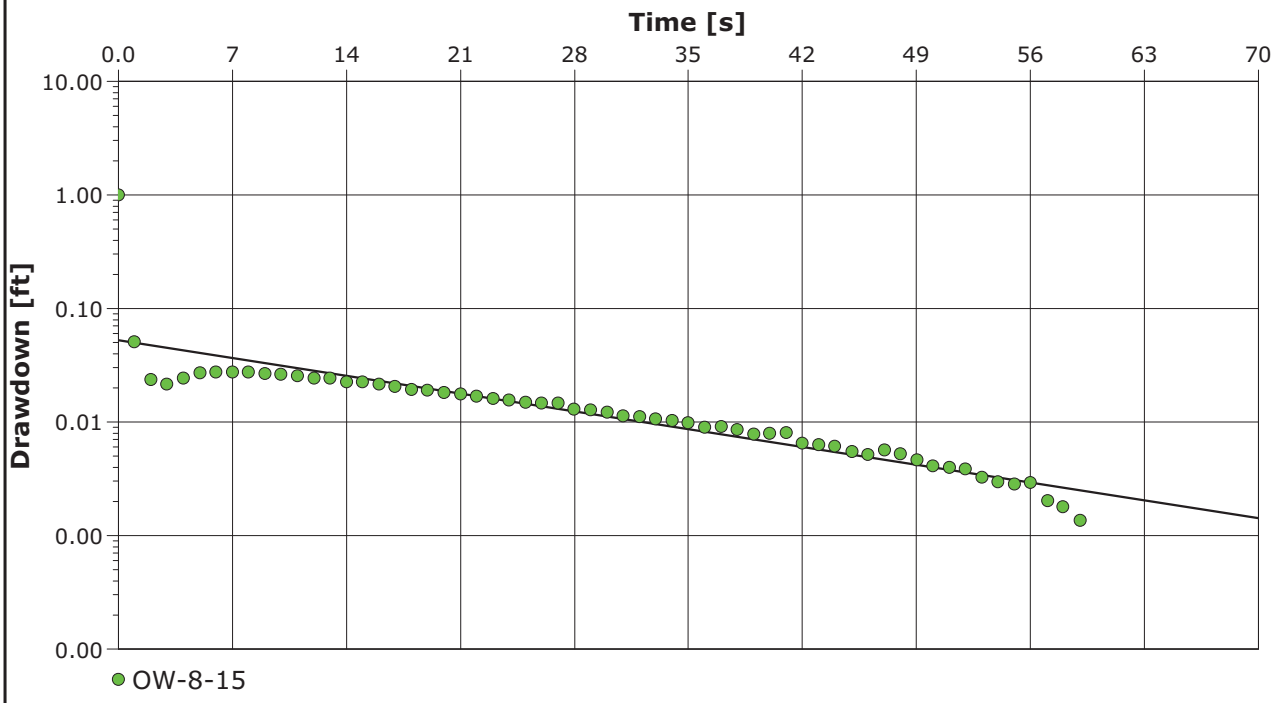
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-8-15 Test 1	Test Well: OW-8-15
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 4.69 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
OW-8-15	2.25×10^{0}	

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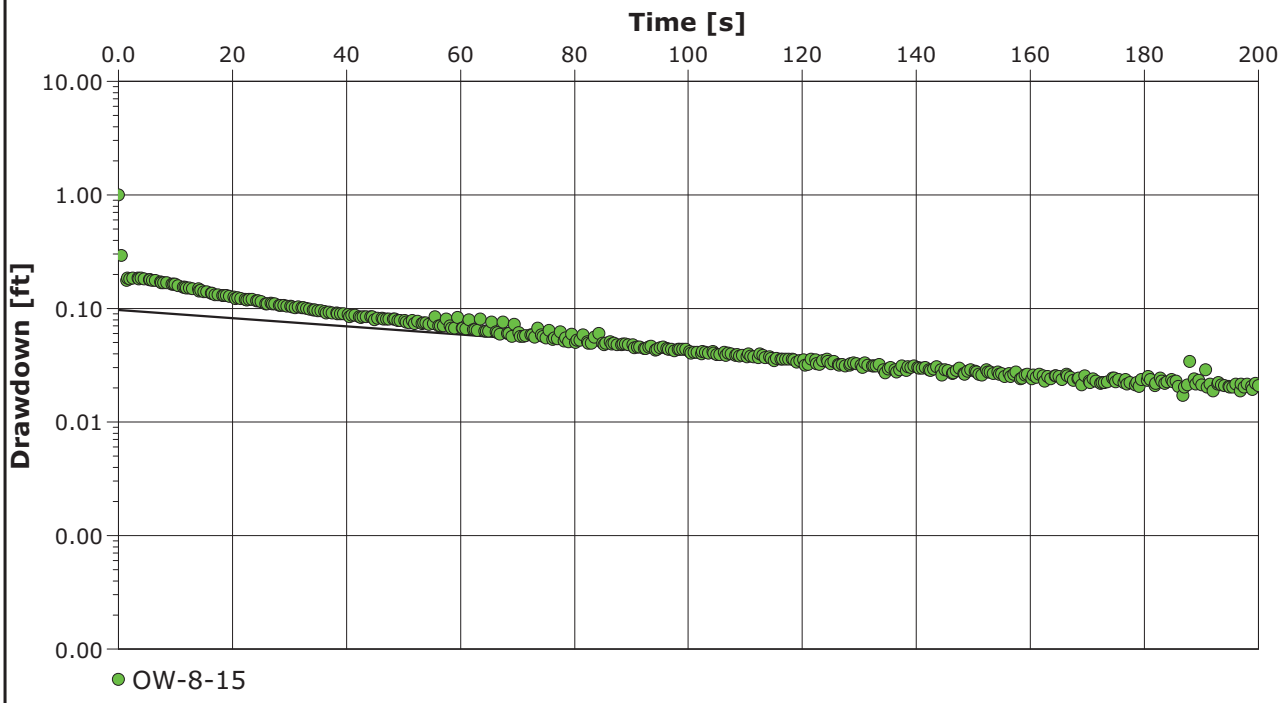
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-8-15 Test 2	Test Well: OW-8-15
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 4.69 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
OW-8-15	3.65×10^{-1}	

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Slug Test Analysis Report

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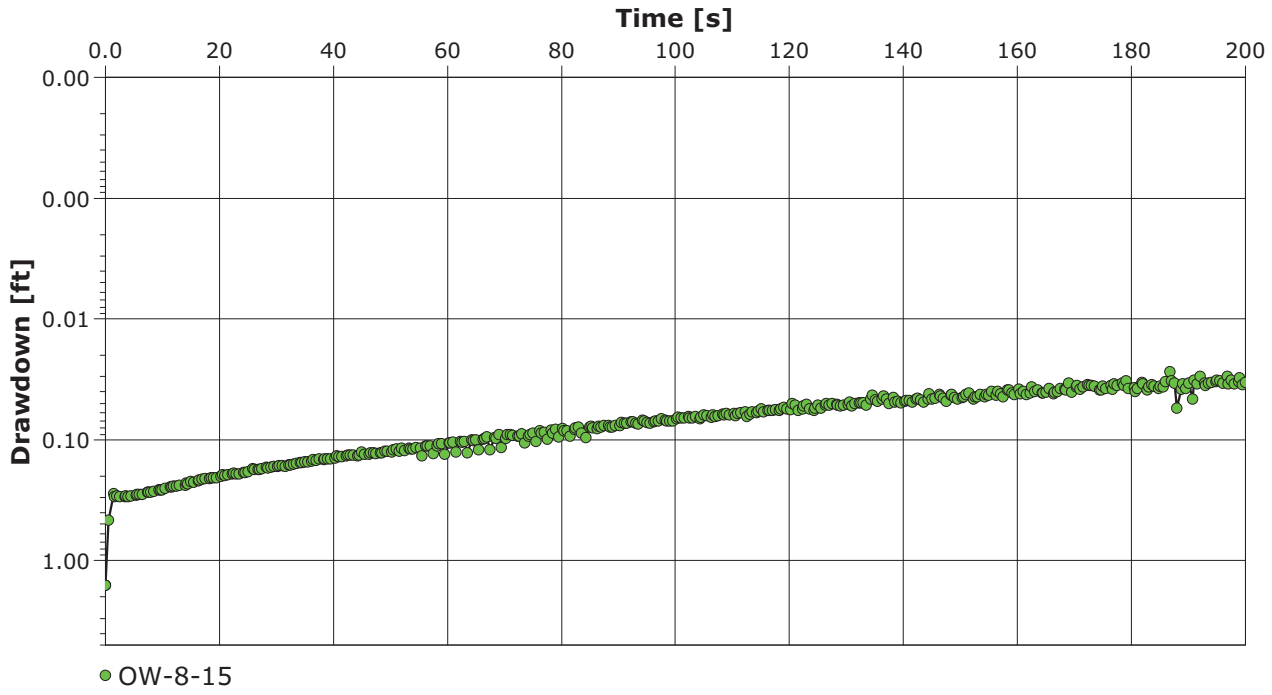
Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-8-15 Test 2	Test Well: OW-8-15
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 4.69 ft		



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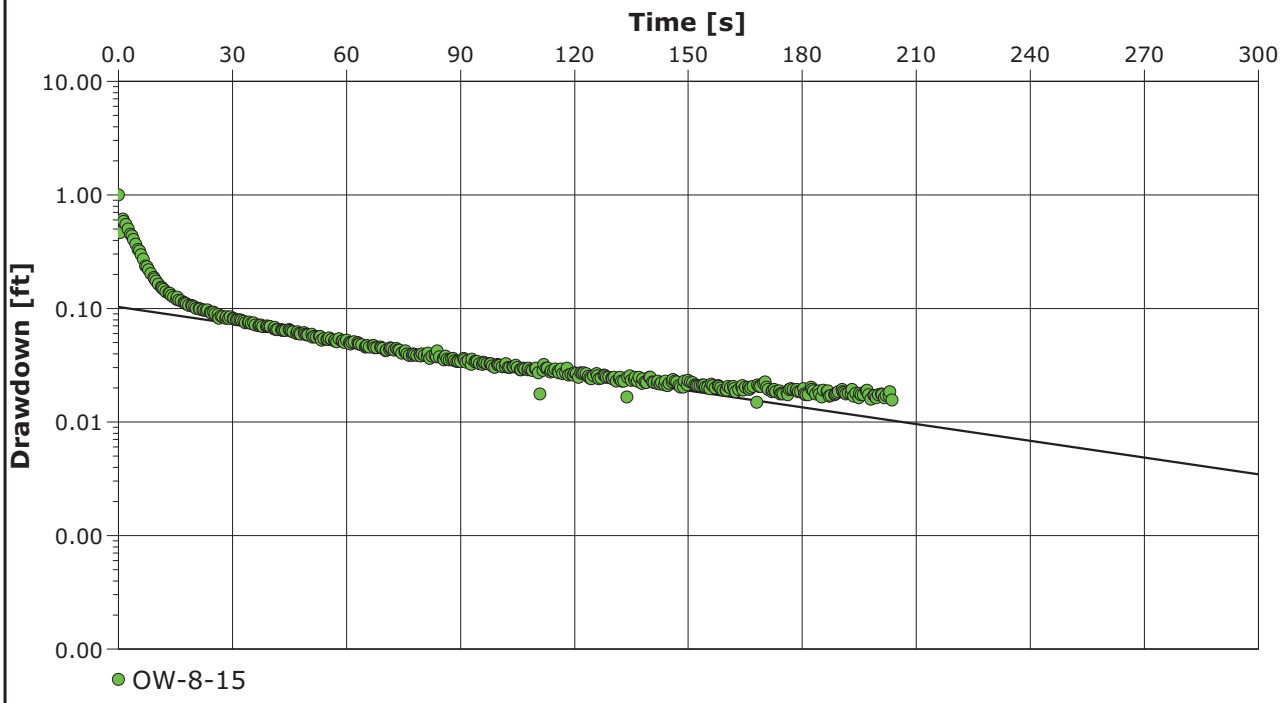
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-8-15 Test 3	Test Well: OW-8-15
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 4.69 ft		

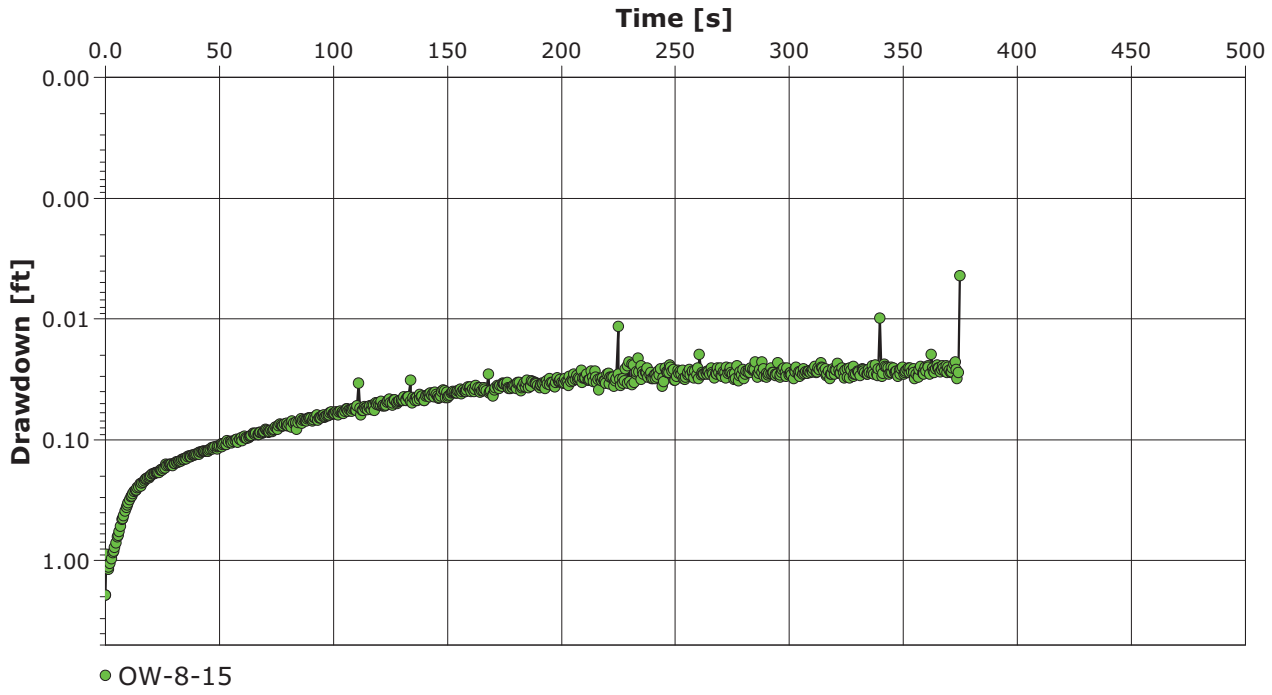


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
OW-8-15	4.93×10^{-1}	

ANCHOR QEA City, State/Province Address Contact Info Company Name 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-8-15 Test 3	Test Well: OW-8-15
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 4.69 ft		



ANCHOR QEA
City, State/Province
Address 6650 SW Redwood Lane, Suite 333
Portland, Oregon 97224
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Company Name

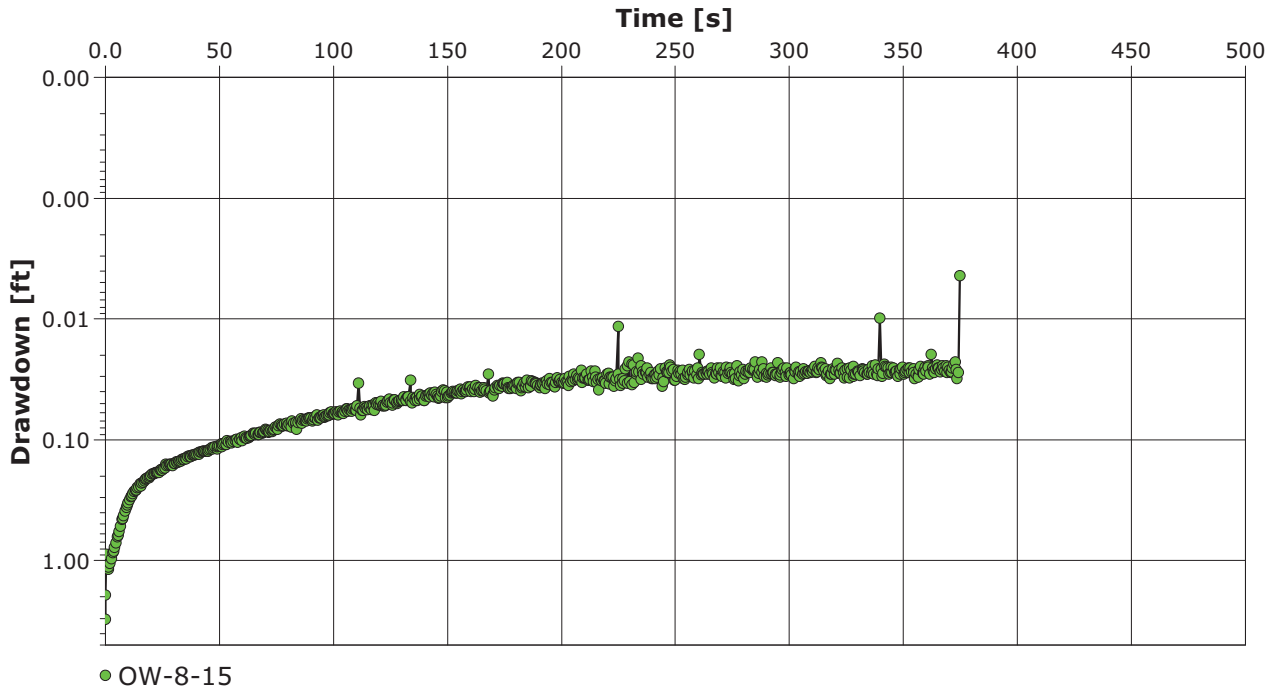
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-8-15 Test 4	Test Well: OW-8-15
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 4.69 ft		



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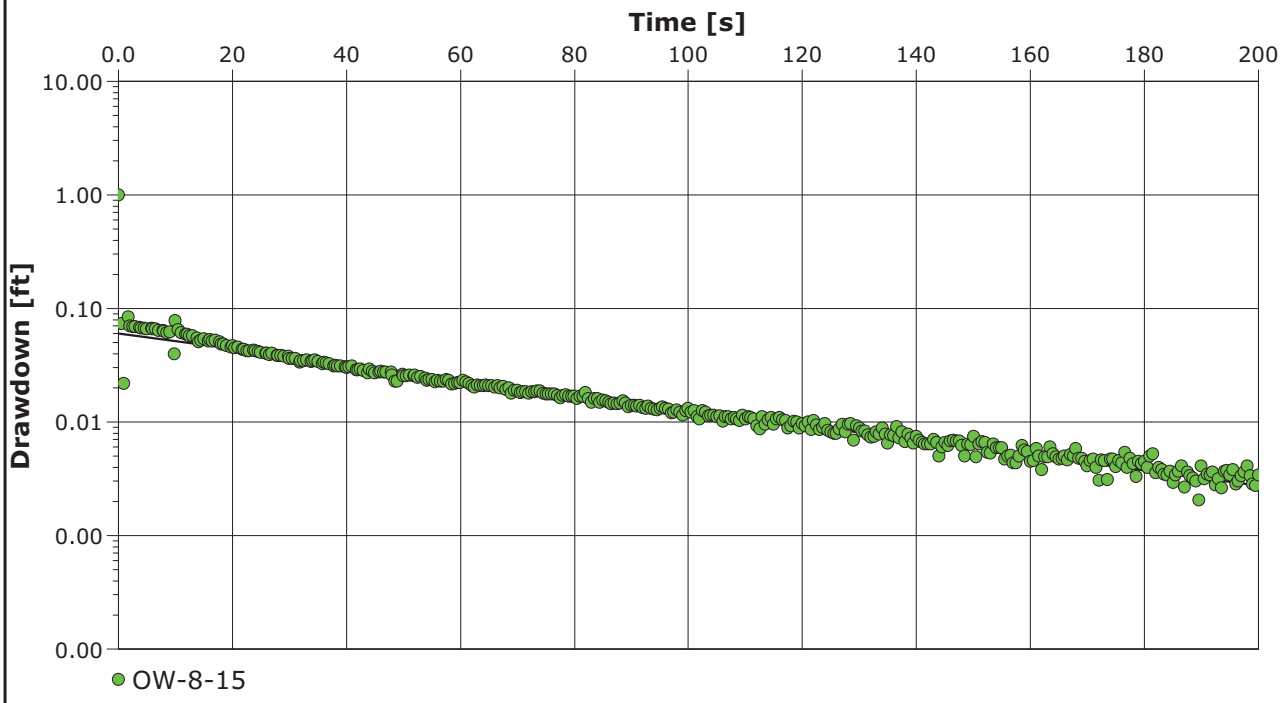
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-8-15 Test 4	Test Well: OW-8-15
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 4.69 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
OW-8-15	6.74×10^{-1}	

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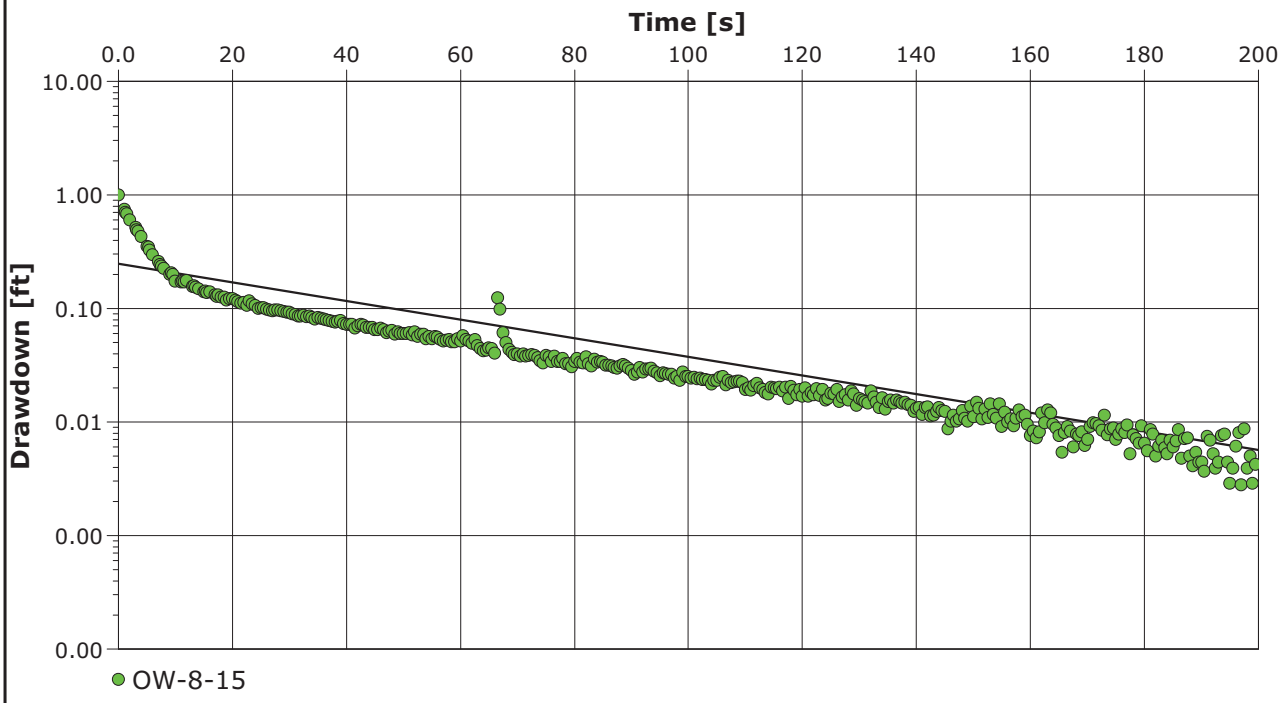
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-8-15 Test 5	Test Well: OW-8-15
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 4.69 ft		

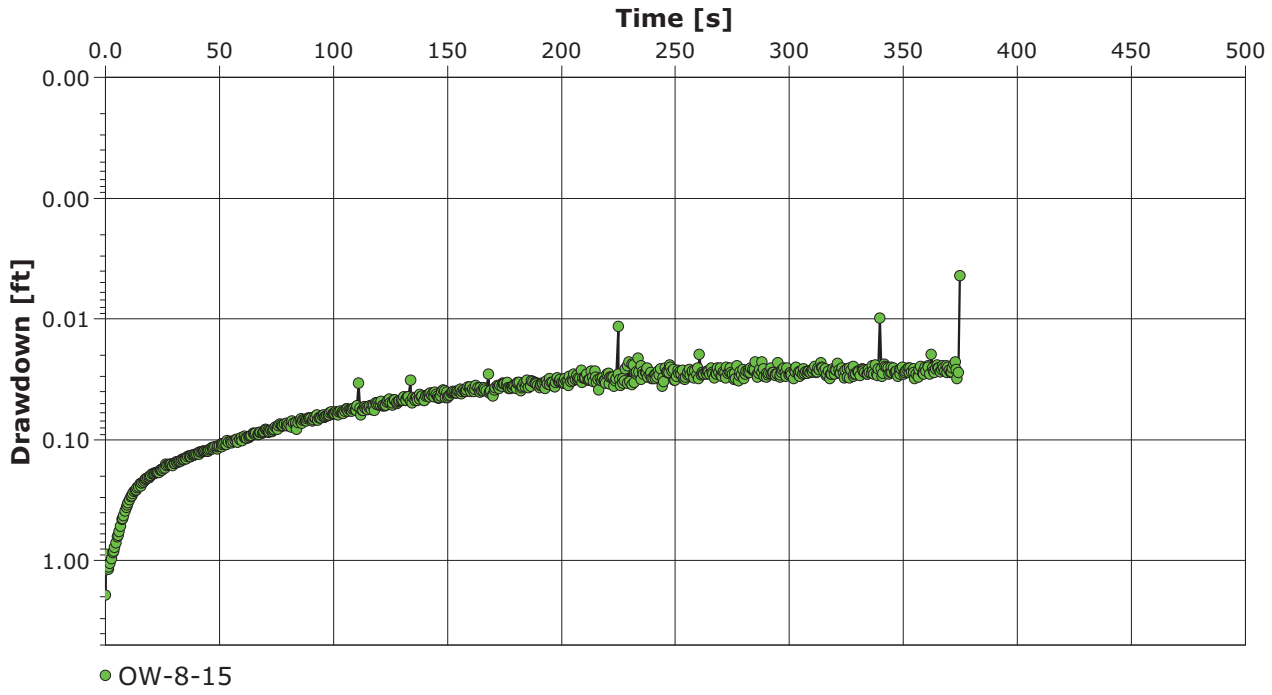


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
OW-8-15	8.29×10^{-1}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-8-15 Test 5	Test Well: OW-8-15
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 4.69 ft		



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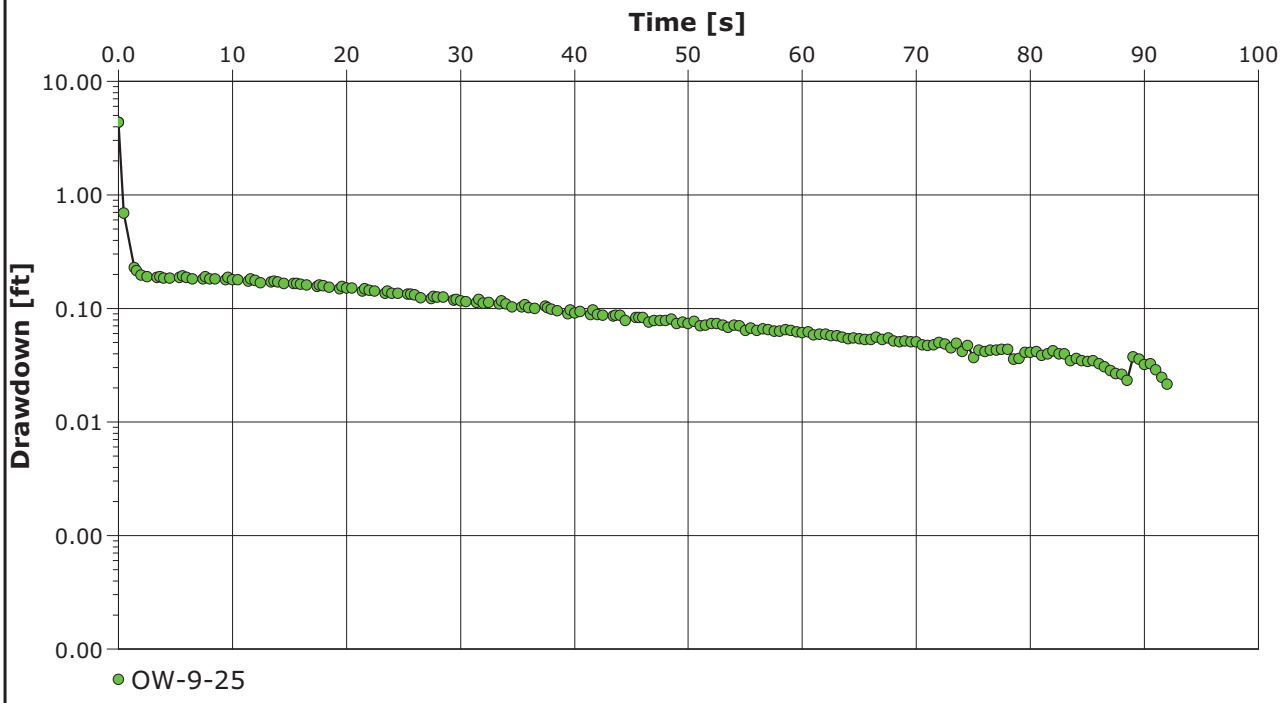
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-9-25 Test 1	Test Well: OW-9-25
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 3.46 ft		



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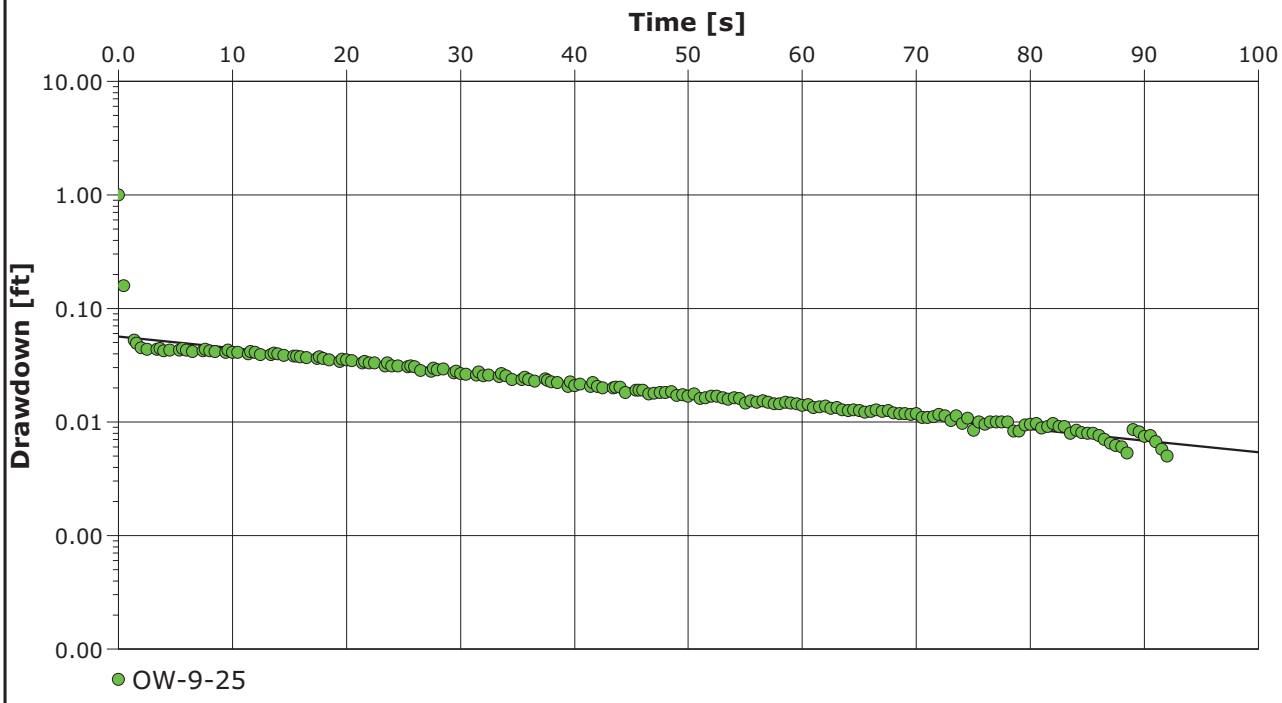
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-9-25 Test 1	Test Well: OW-9-25
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 3.46 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
OW-9-25	8.14×10^{-1}	

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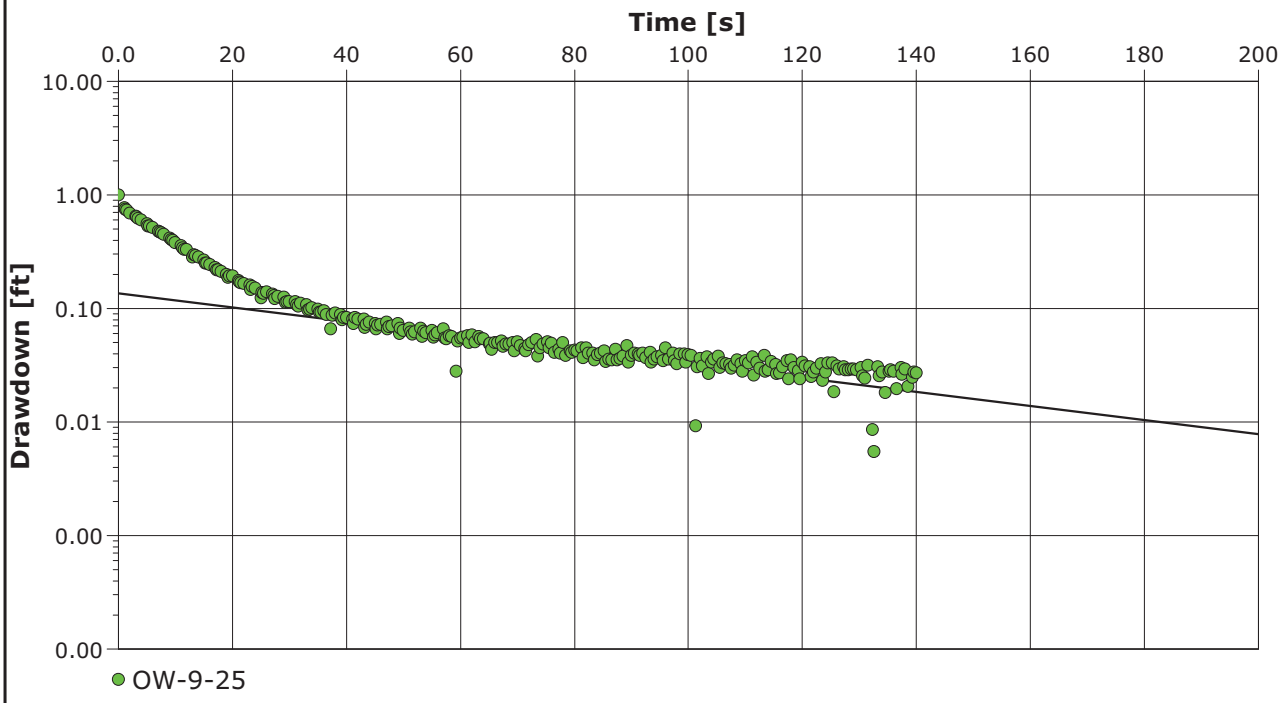
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-9-25 Test 2	Test Well: OW-9-25
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 3.46 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
OW-9-25	4.93×10^{-1}	

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Slug Test Analysis Report

Project: Gasco Ground Water Source Control

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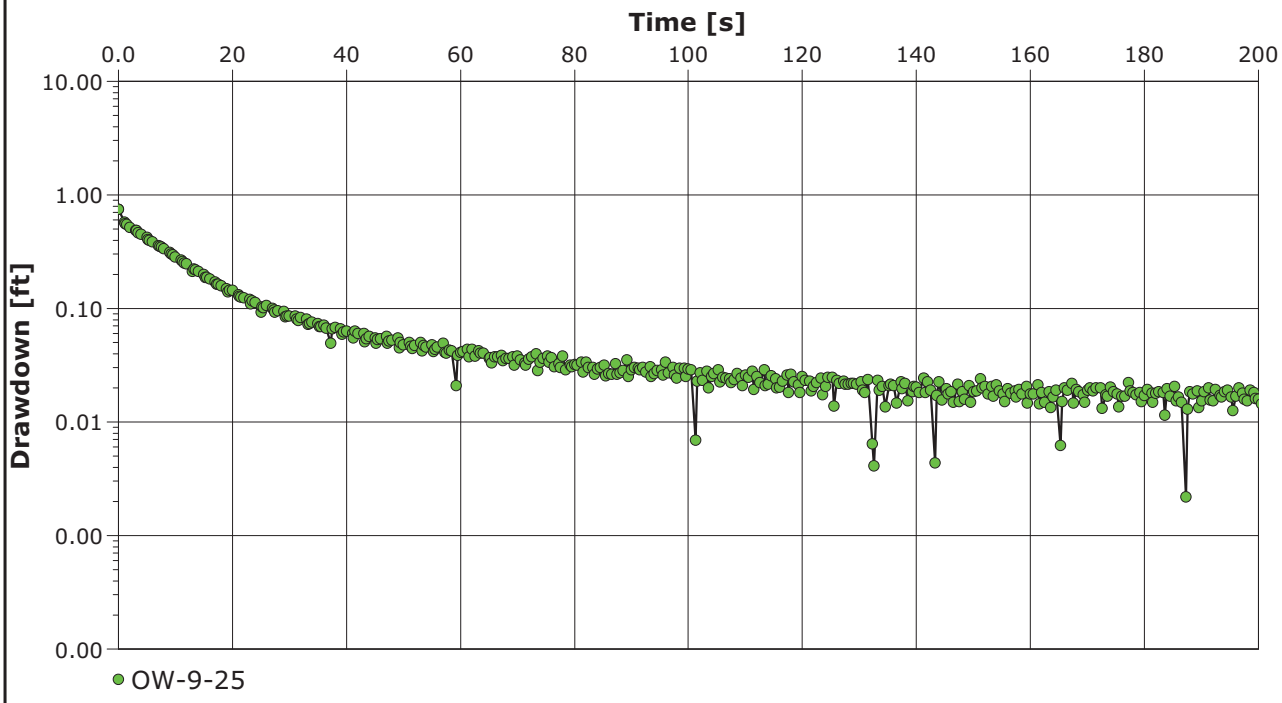
Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-9-25 Test 2	Test Well: OW-9-25
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 3.46 ft		



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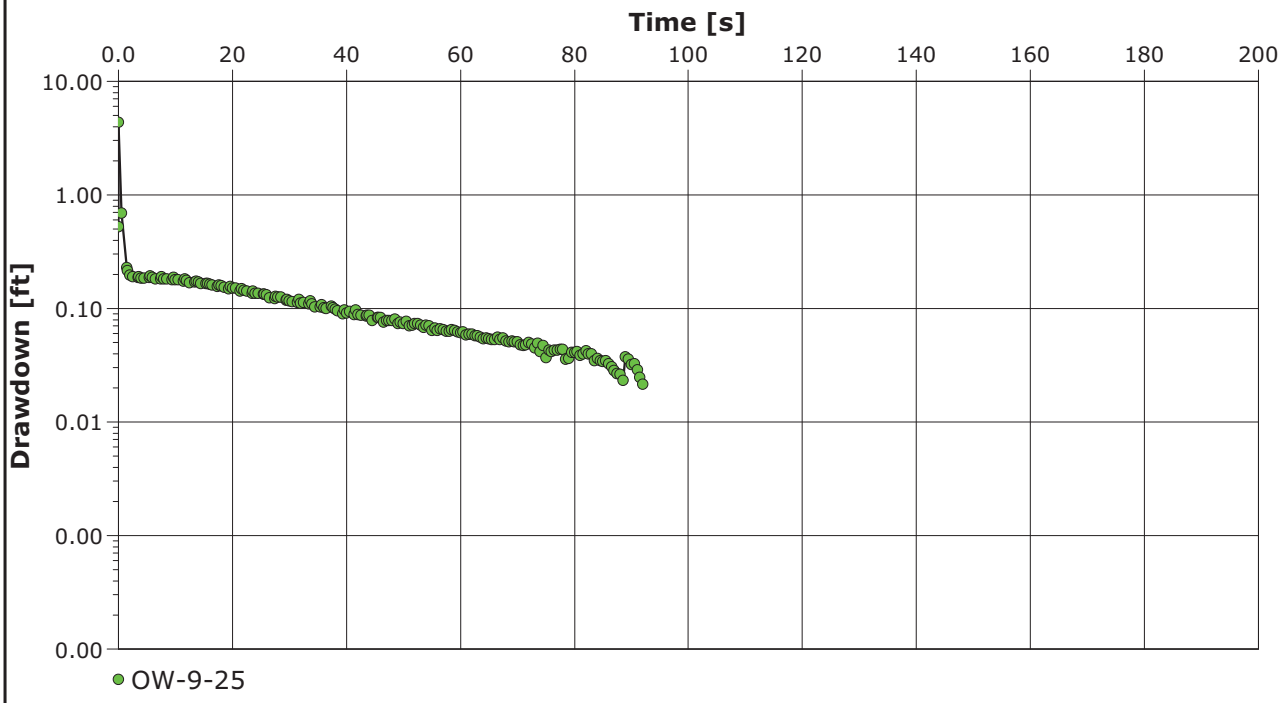
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-9-25 Test 3	Test Well: OW-9-25
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 3.46 ft		



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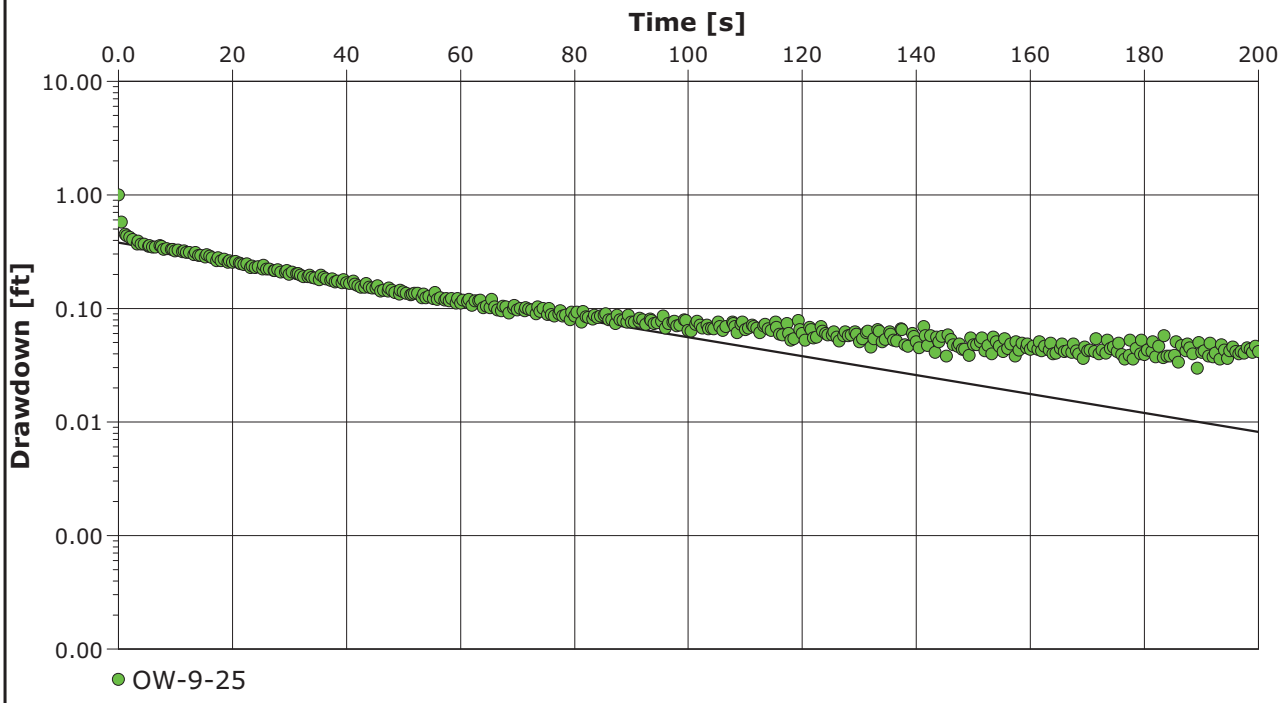
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-9-25 Test 3	Test Well: OW-9-25
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 3.46 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
OW-9-25	6.65×10^{-1}	

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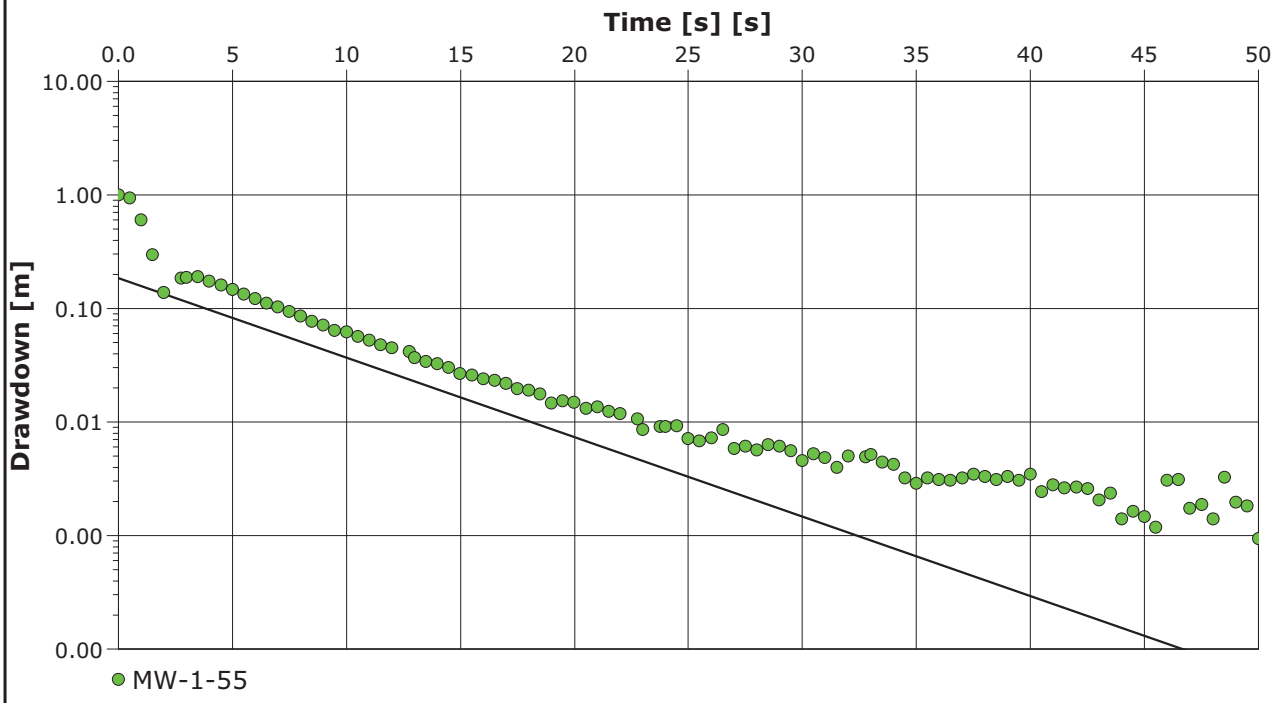
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-1-55 Test 1	Test Well: MW-1-55
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 32.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-1-55	1.79×10^{1}	

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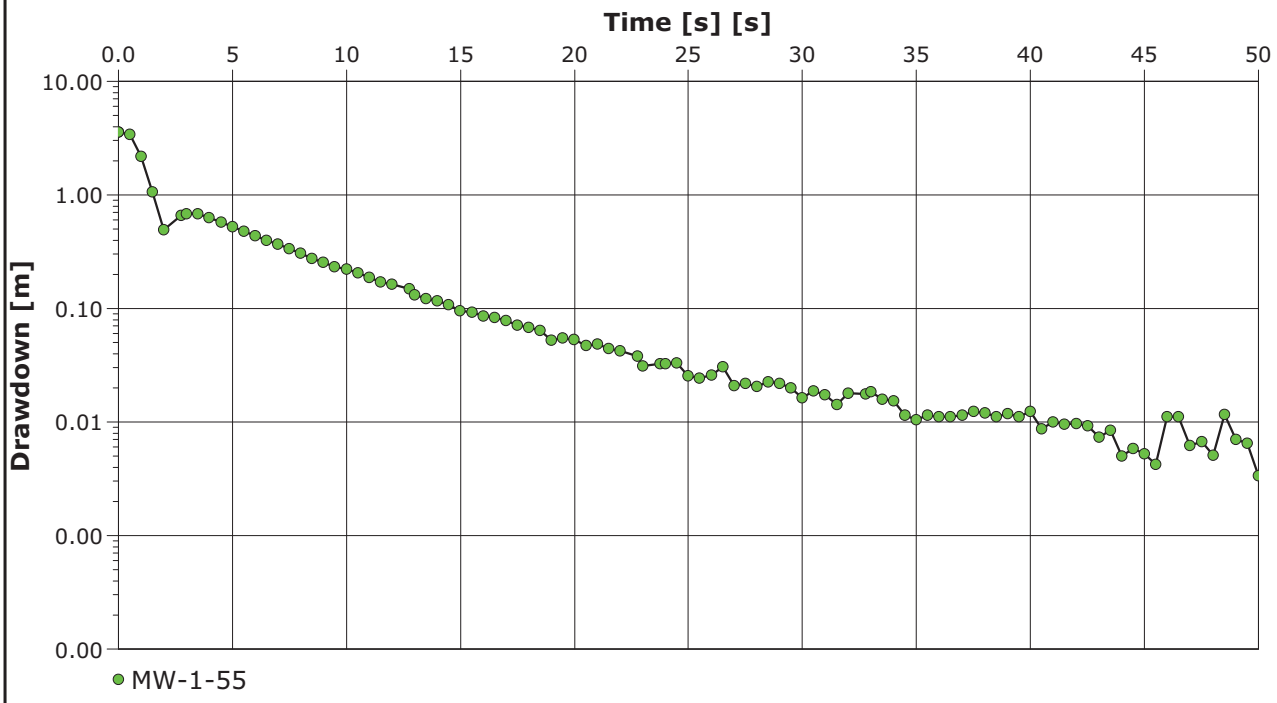
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-1-55 Test 1	Test Well: MW-1-55
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/17/2011
Aquifer Thickness: 32.00 ft		



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Slug Test Analysis Report

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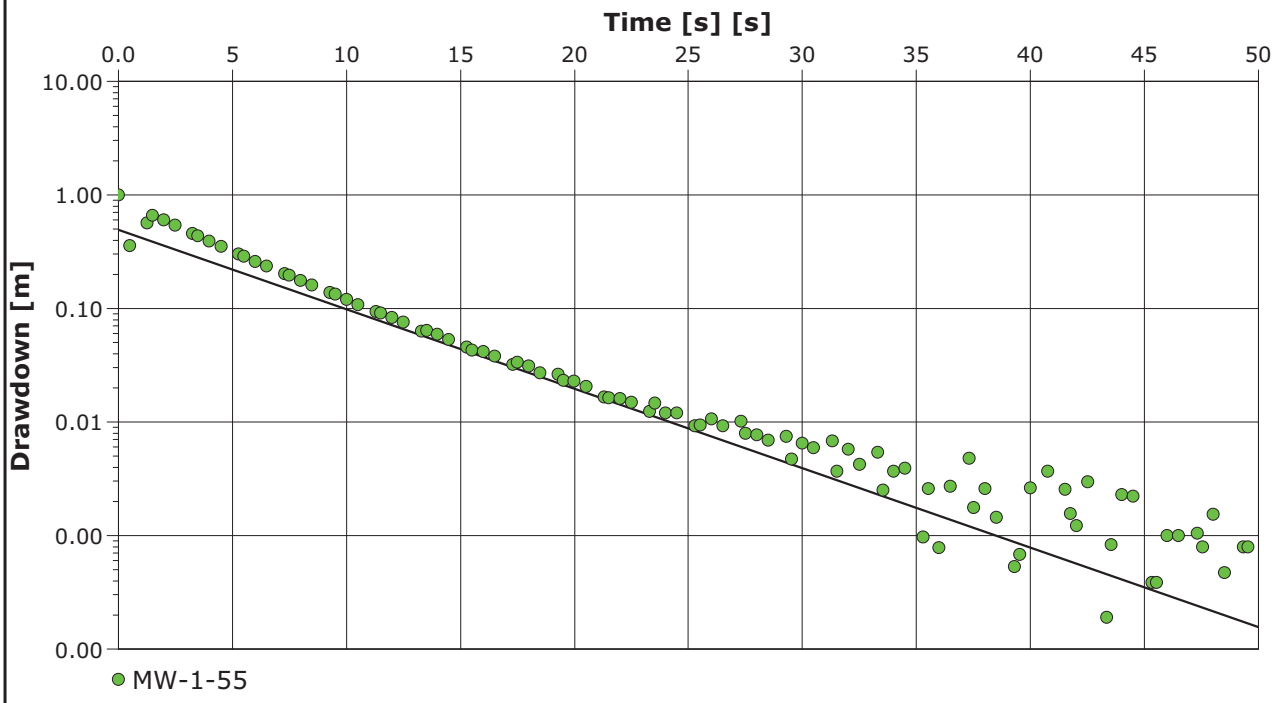
Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-1-55 Test 1	Test Well: MW-1-55
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 32.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-1-55	1.79×10^{1}	

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Slug Test Analysis Report

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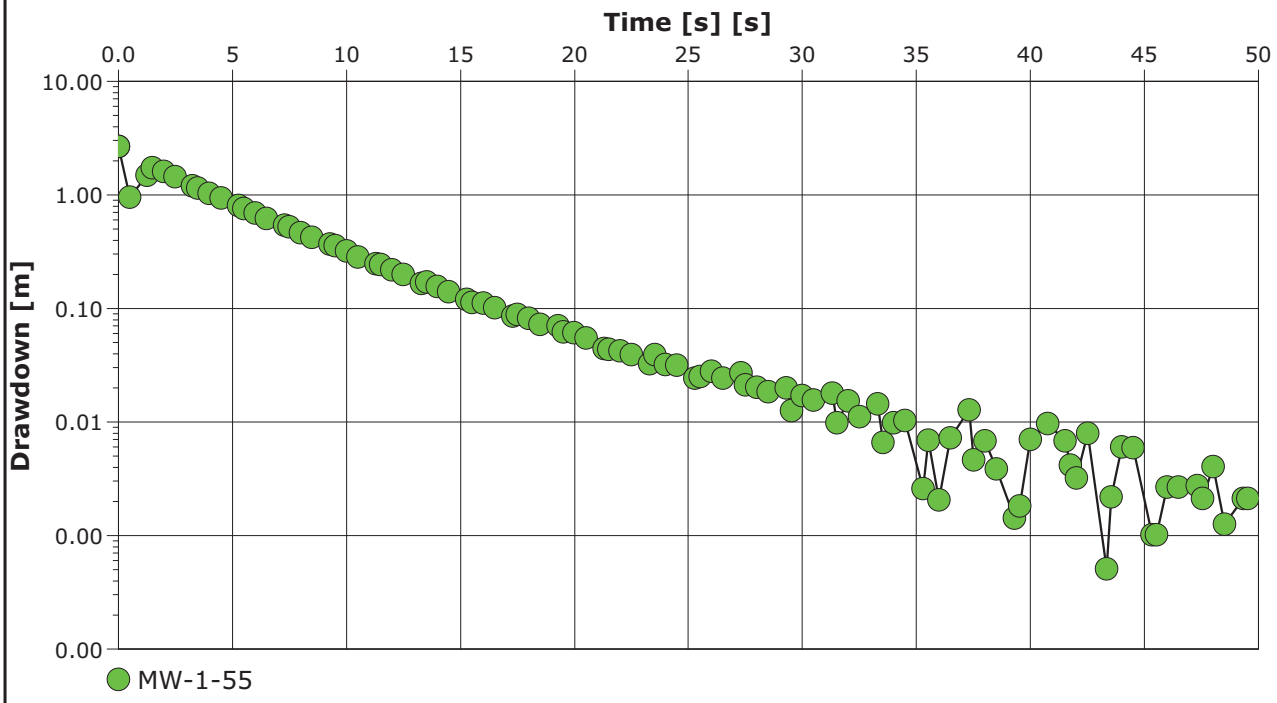
Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-1-55 Test 1	Test Well: MW-1-55
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/17/2011
Aquifer Thickness: 32.00 ft		



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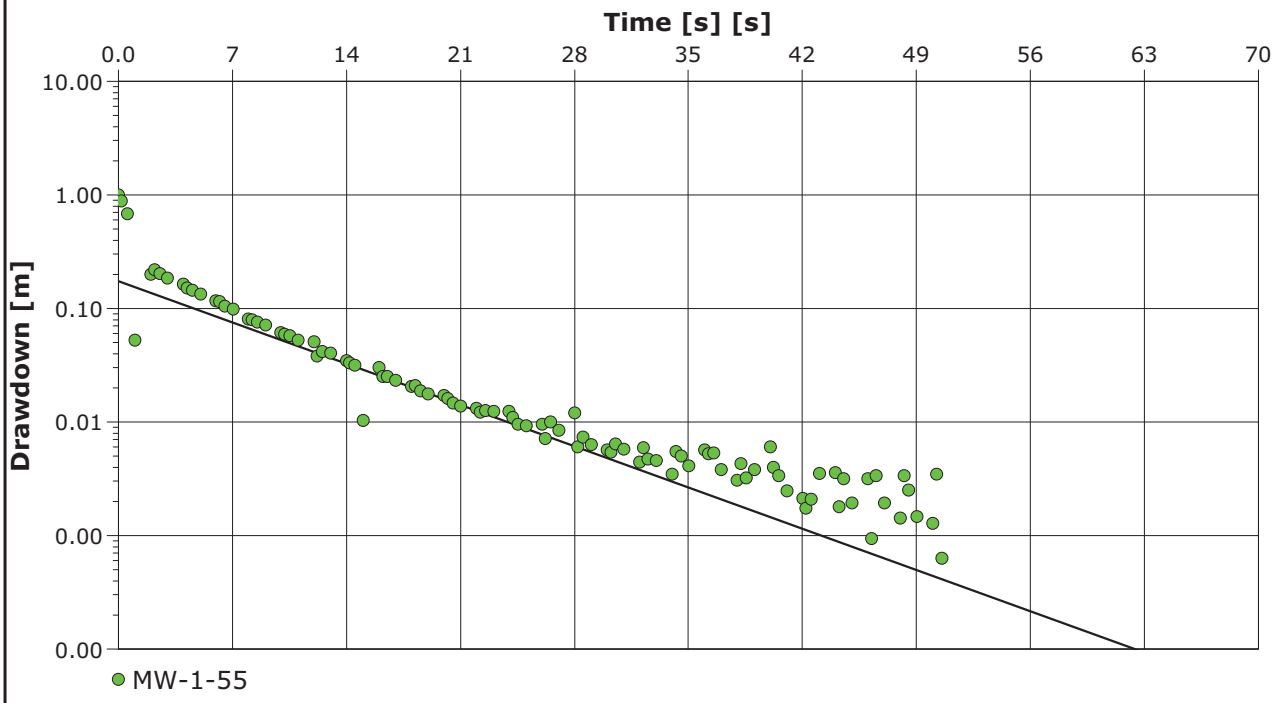
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-1-55 Test 1	Test Well: MW-1-55
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 32.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-1-55	1.33×10^{1}	

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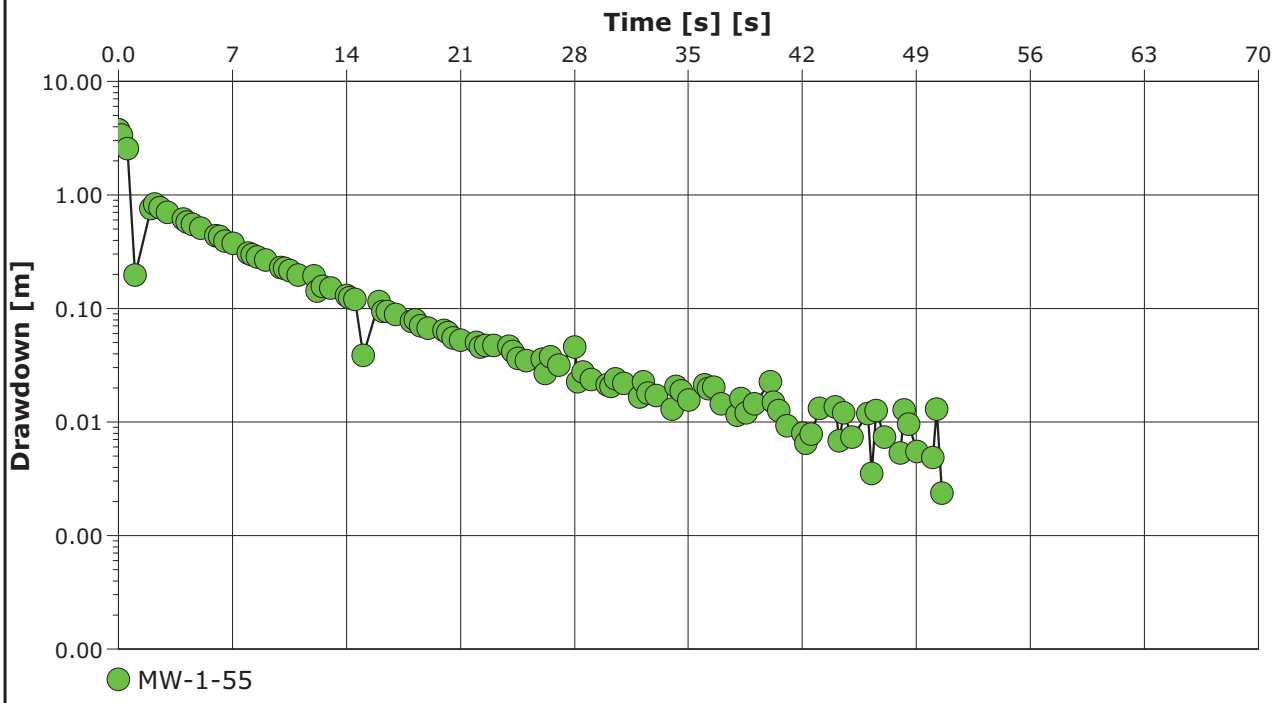
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-1-55 Test 1	Test Well: MW-1-55
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/17/2011
Aquifer Thickness: 32.00 ft		



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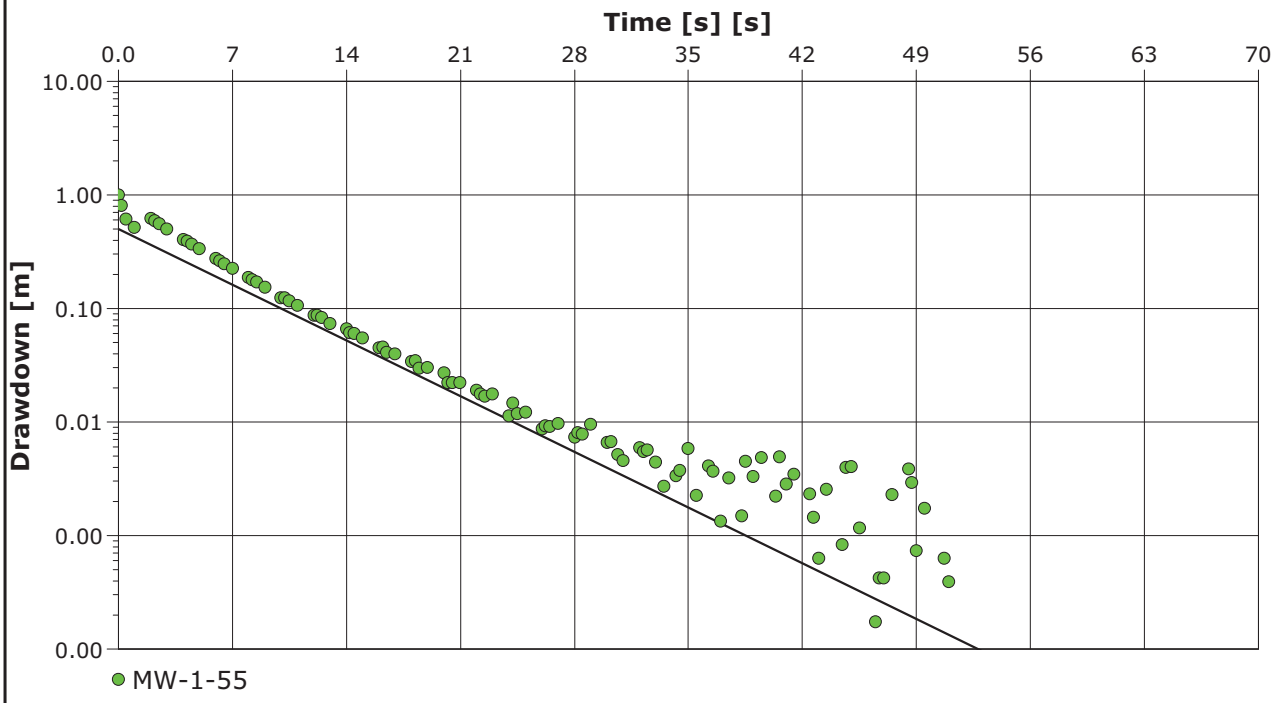
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-1-55 Test 1	Test Well: MW-1-55
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 32.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-1-55	1.79×10^{1}	

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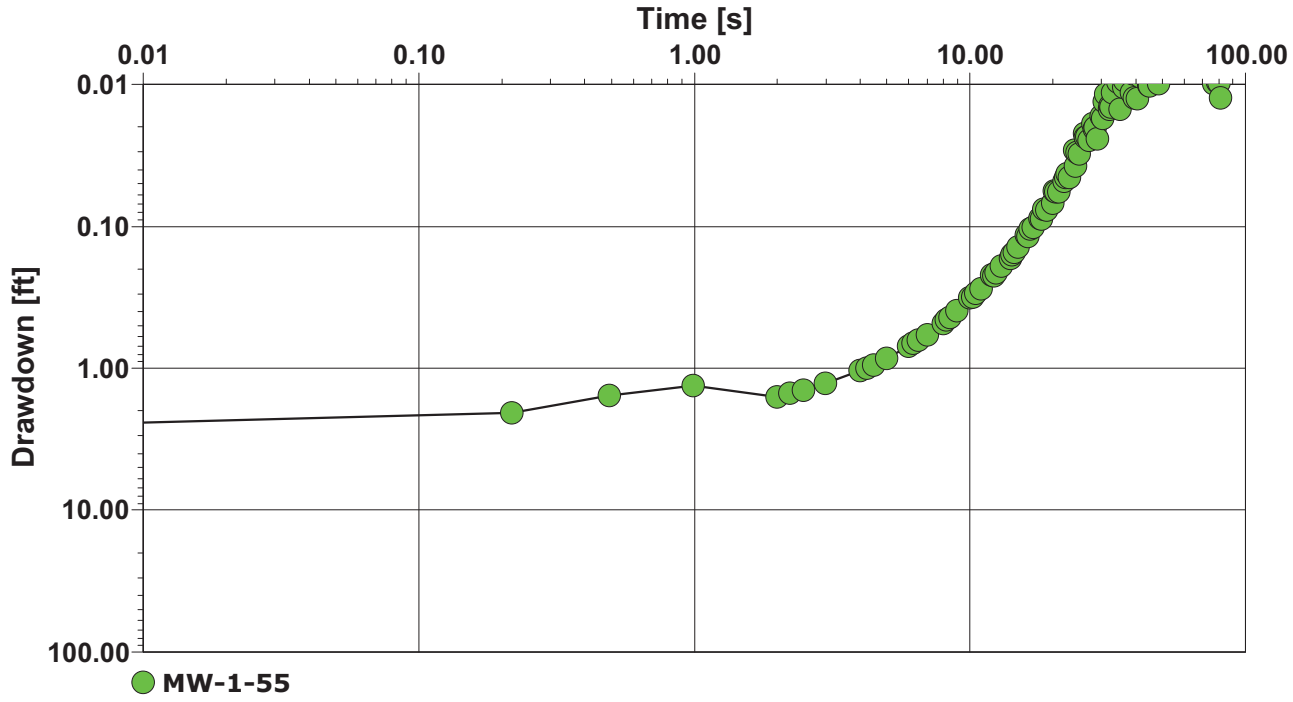
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-1-55 Test 1	Test Well: MW-1-55
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/17/2011
Aquifer Thickness: 32.00 ft		



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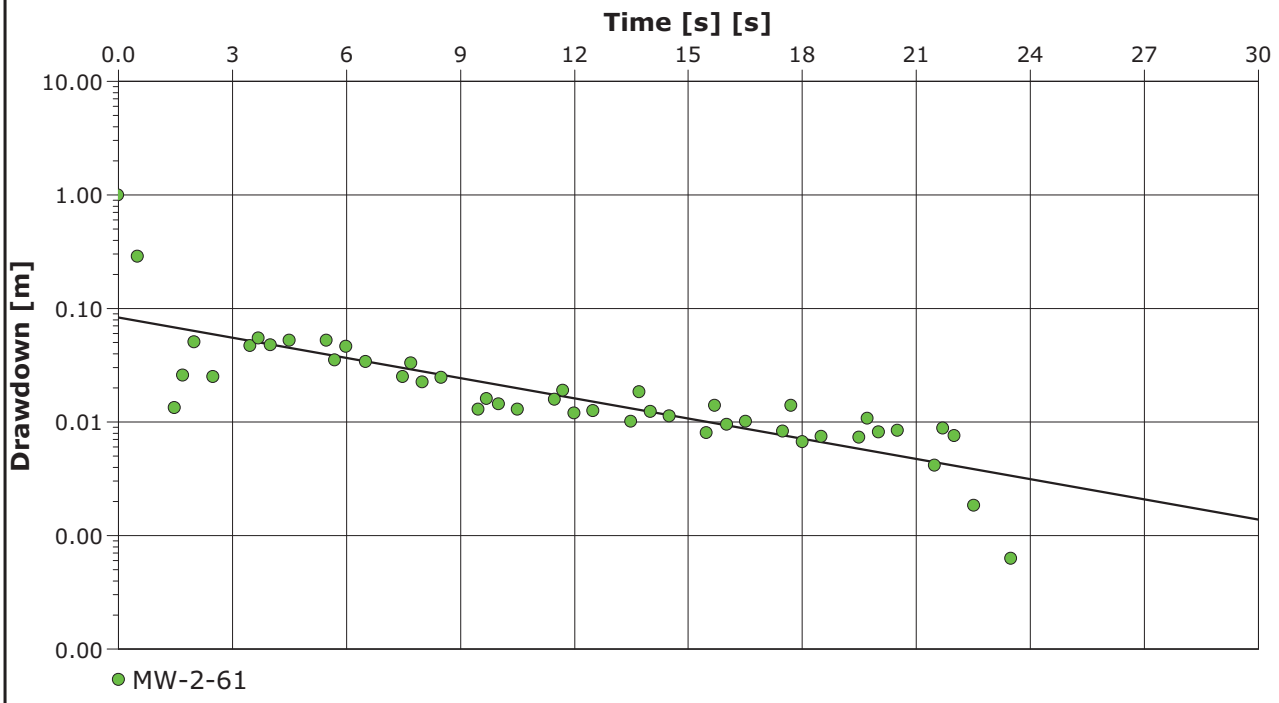
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-2-61 Test 1	Test Well: MW-2-61
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 33.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-2-61	4.98×10^{0}	

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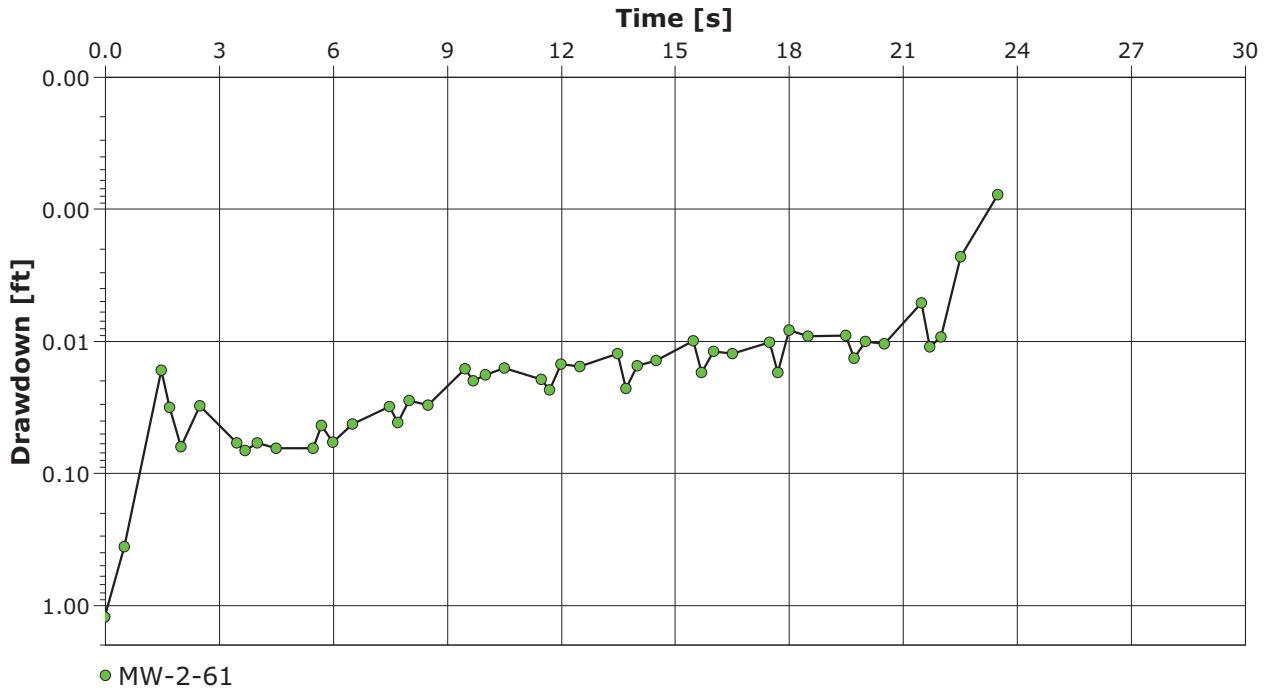
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-2-61 Test 1	Test Well: MW-2-61
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/17/2011
Aquifer Thickness: 33.00 ft		



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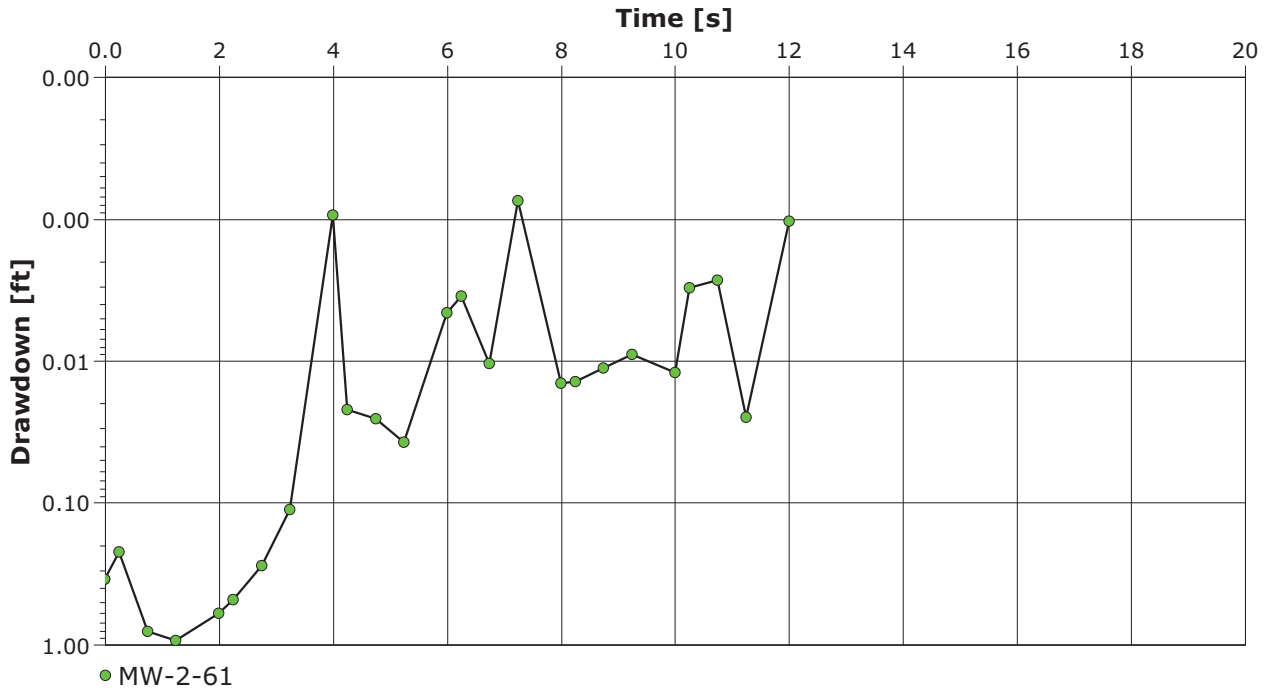
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-2-61 Test 2	Test Well: MW-2-61
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/17/2011
Aquifer Thickness: 33.00 ft		



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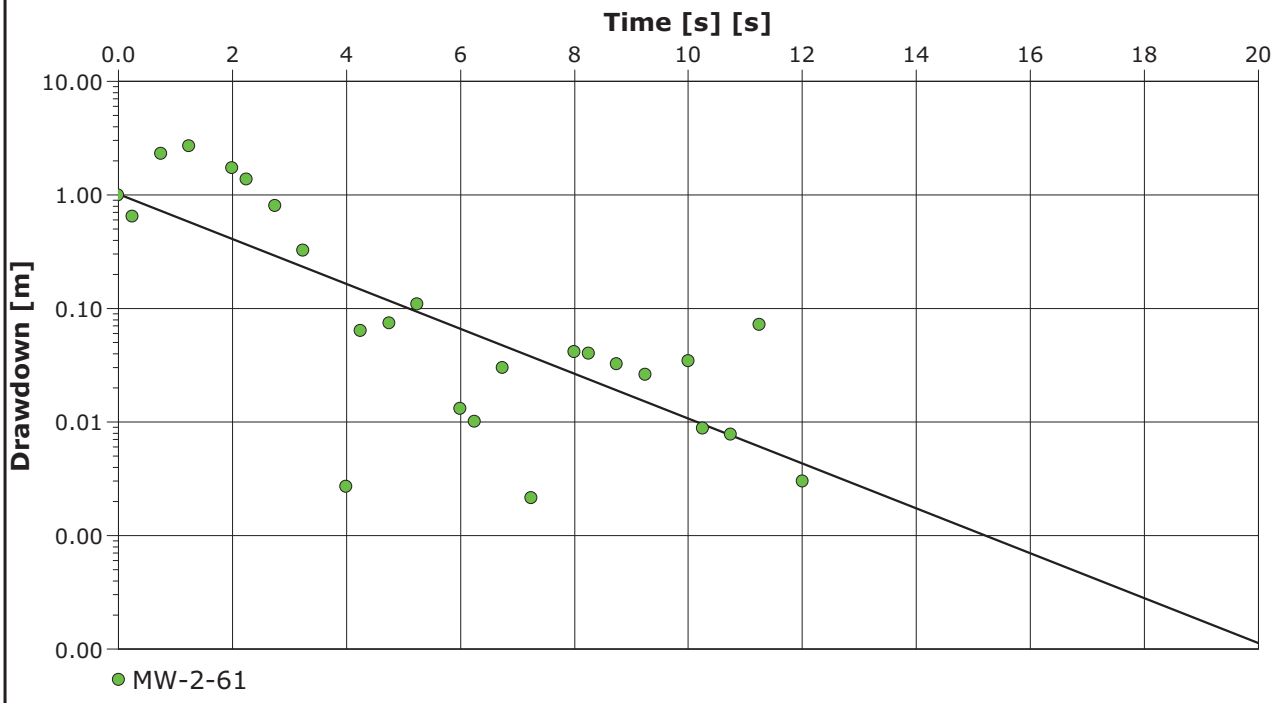
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-2-61 Test 2	Test Well: MW-2-61
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 33.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-2-61	1.65×10^{1}	

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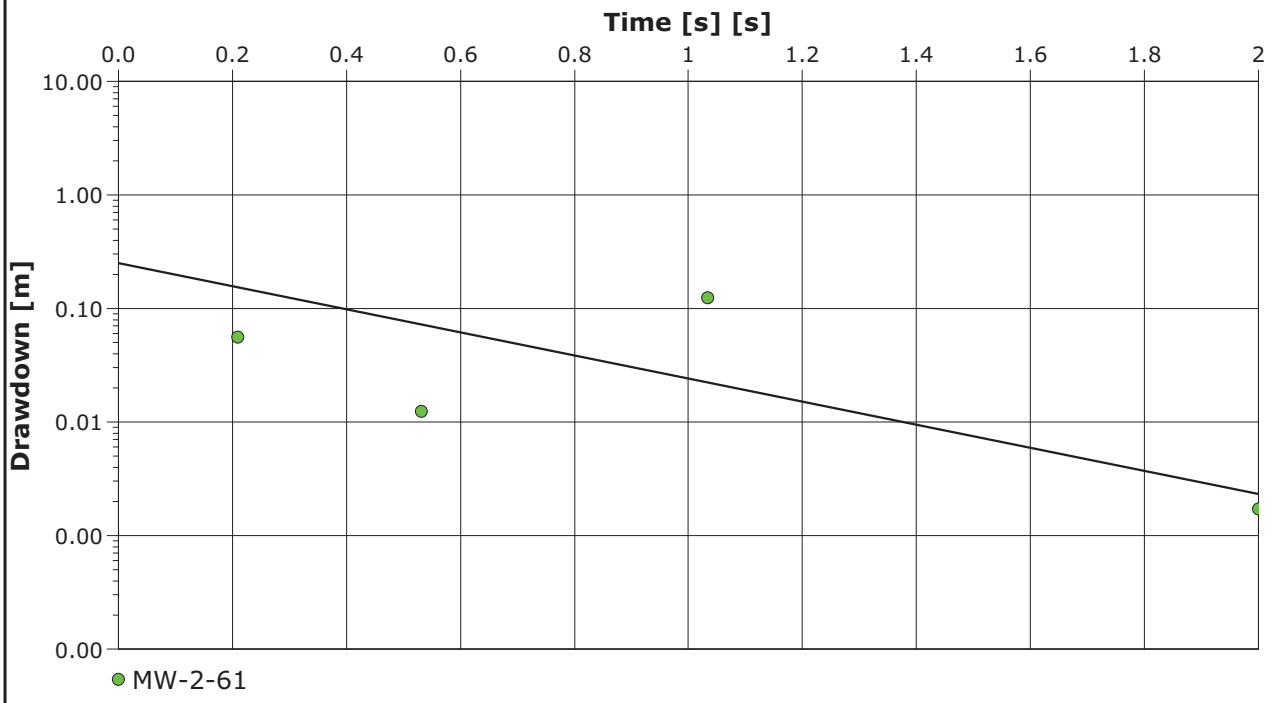
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-2-61 Test 3	Test Well: MW-2-61
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 33.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-2-61	8.53×10^{1}	

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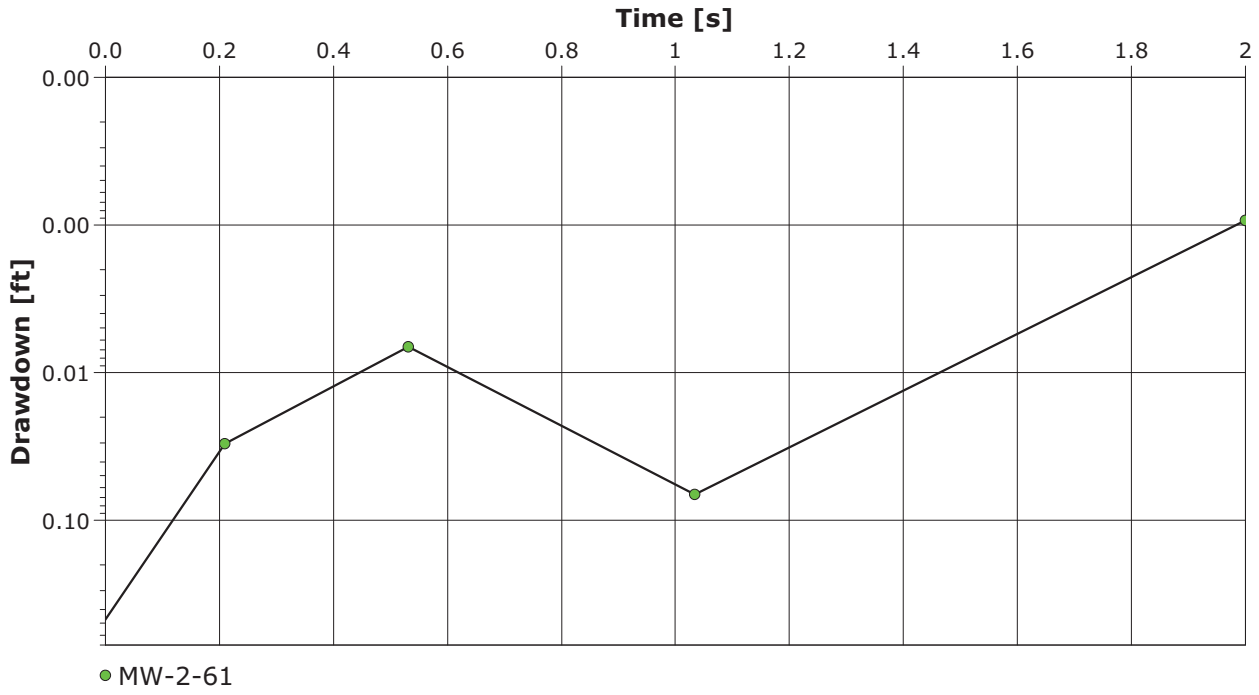
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-2-61 Test 3	Test Well: MW-2-61
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/17/2011
Aquifer Thickness: 33.00 ft		



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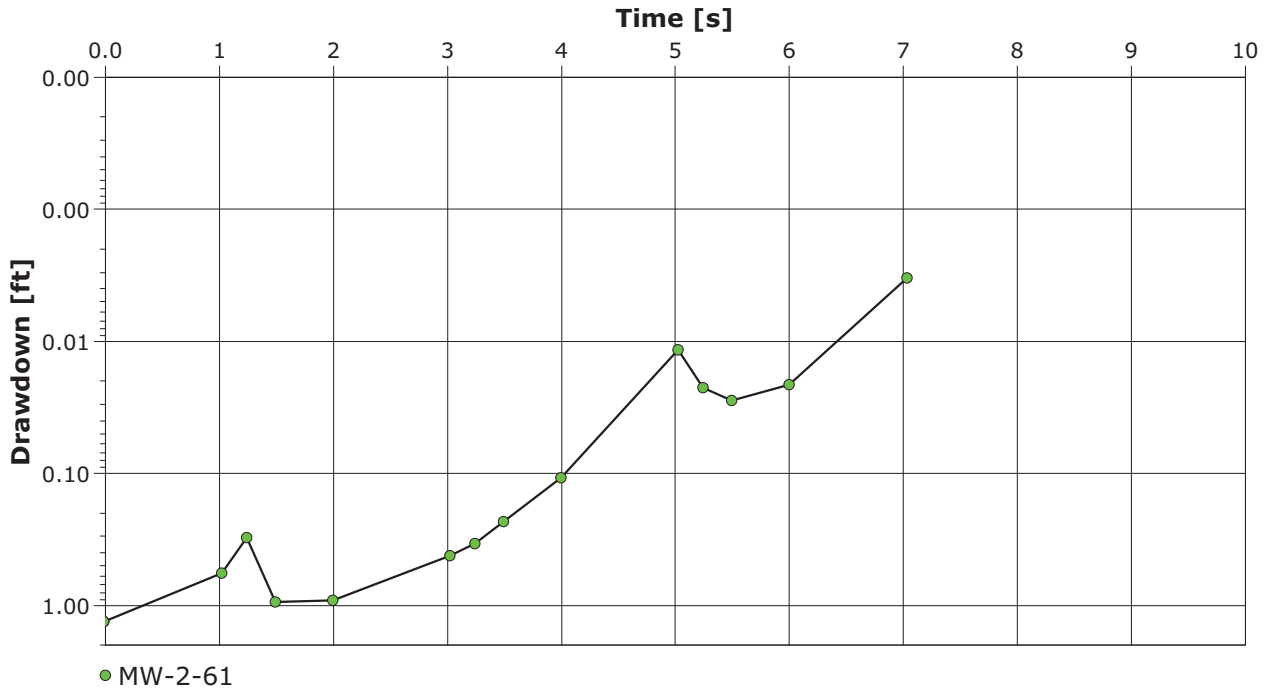
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-2-61 Test 4	Test Well: MW-2-61
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/17/2011
Aquifer Thickness: 33.00 ft		



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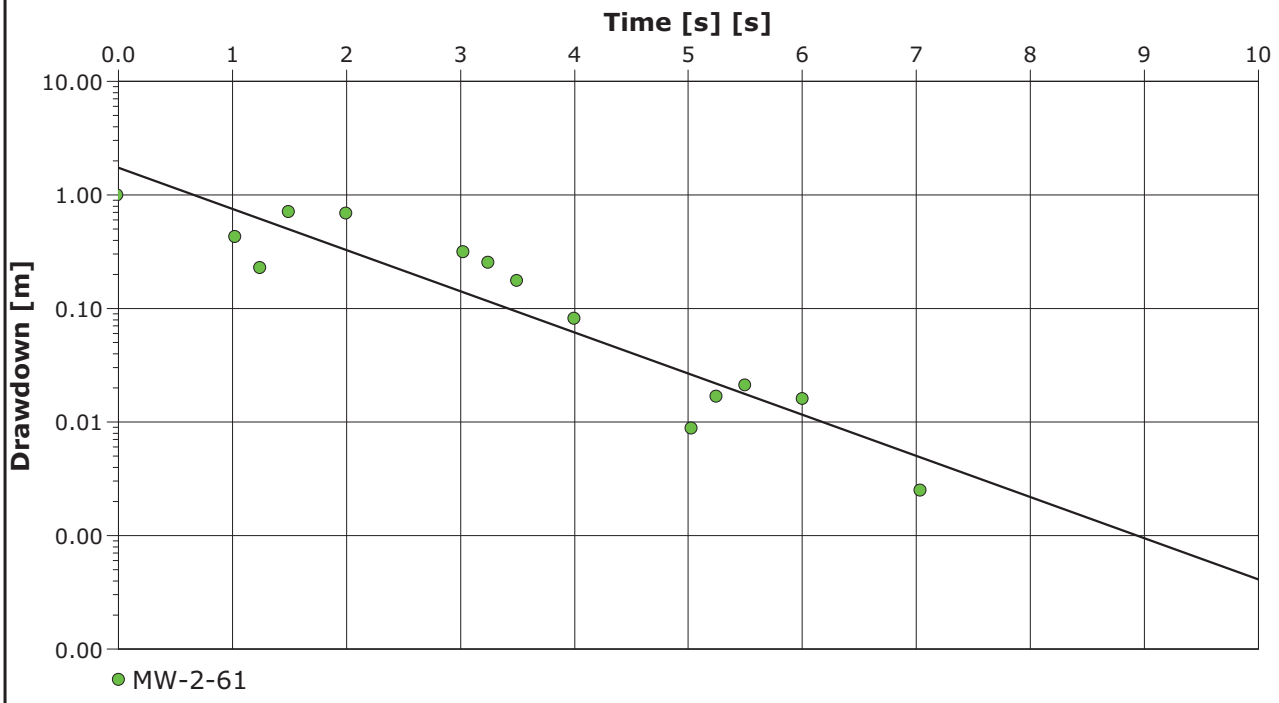
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-2-61 Test 4	Test Well: MW-2-61
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 33.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-2-61	3.04×10^{1}	

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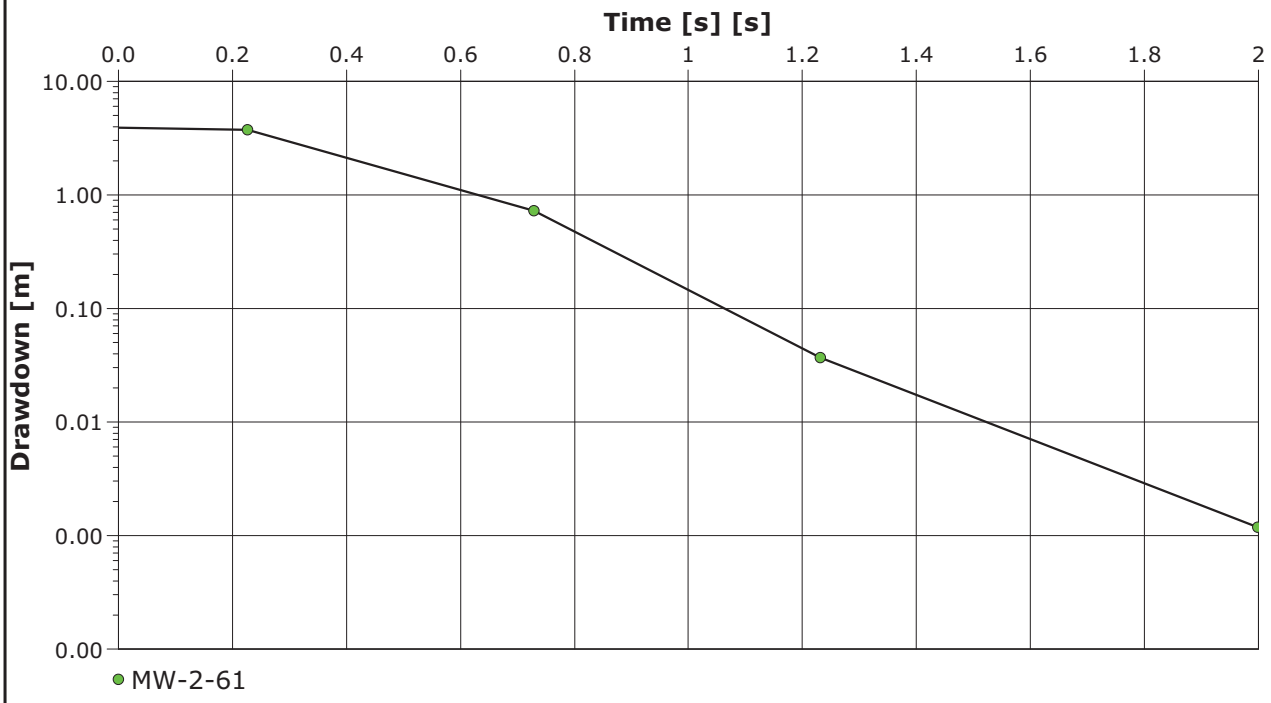
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-2-61 Test 5	Test Well: MW-2-61
Test conducted by: MWilson/DLaffoon		Test date: 1/14/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/17/2011
Aquifer Thickness: 33.00 ft		



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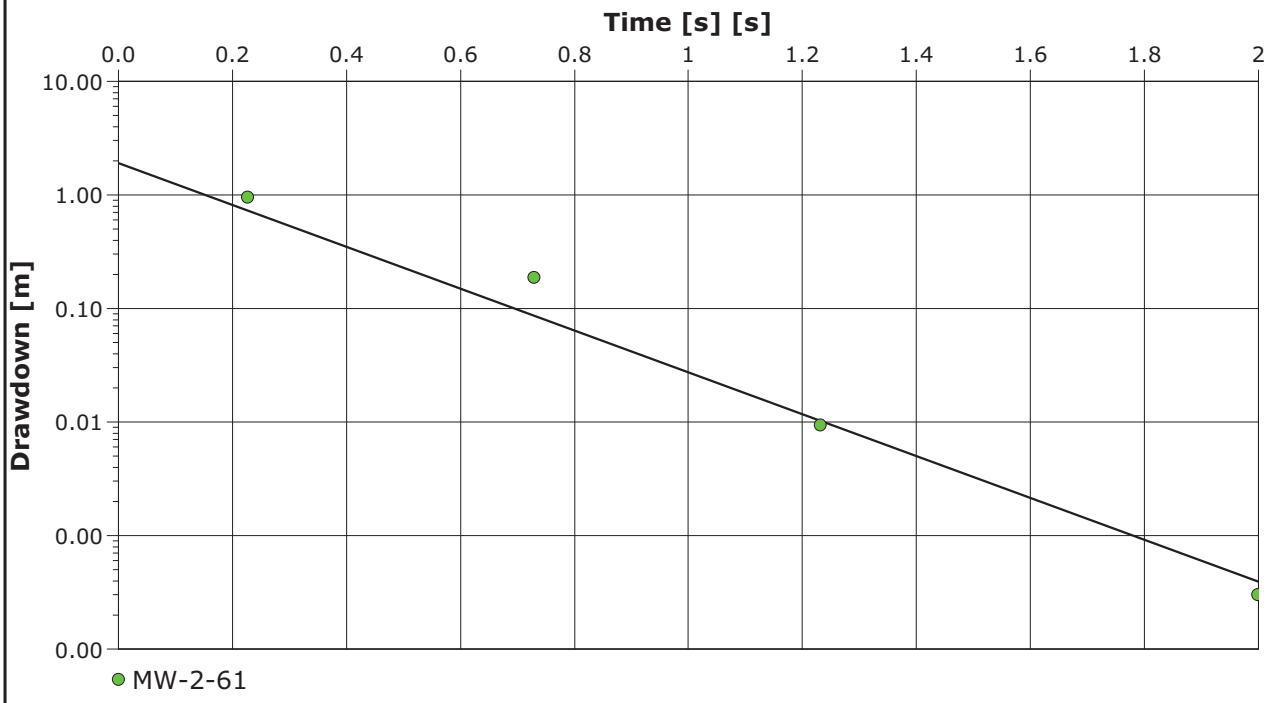
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-2-61 Test 5	Test Well: MW-2-61
Test conducted by: MWilson/DLaffoon		Test date: 1/14/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 33.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-2-61	1.55×10^2	

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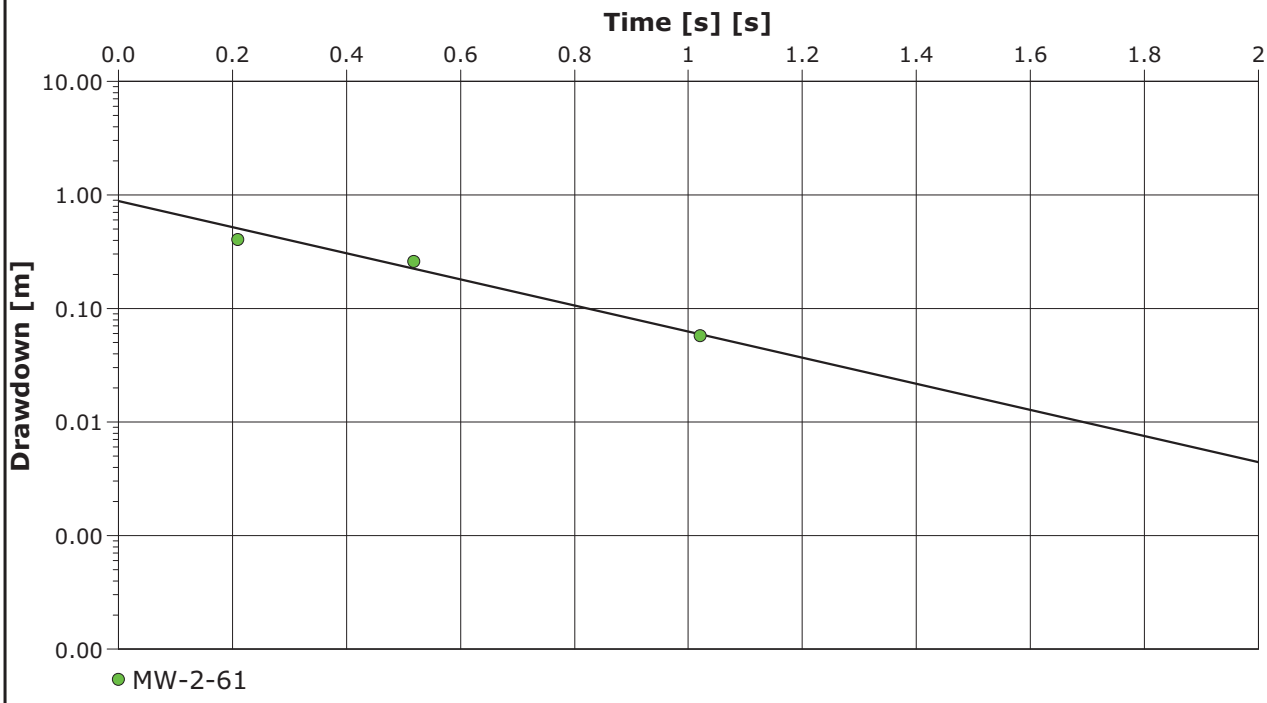
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-2-61 Test 6	Test Well: MW-2-61
Test conducted by: MWilson/DLaffoon		Test date: 1/14/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 33.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-2-61	9.66×10^{1}	

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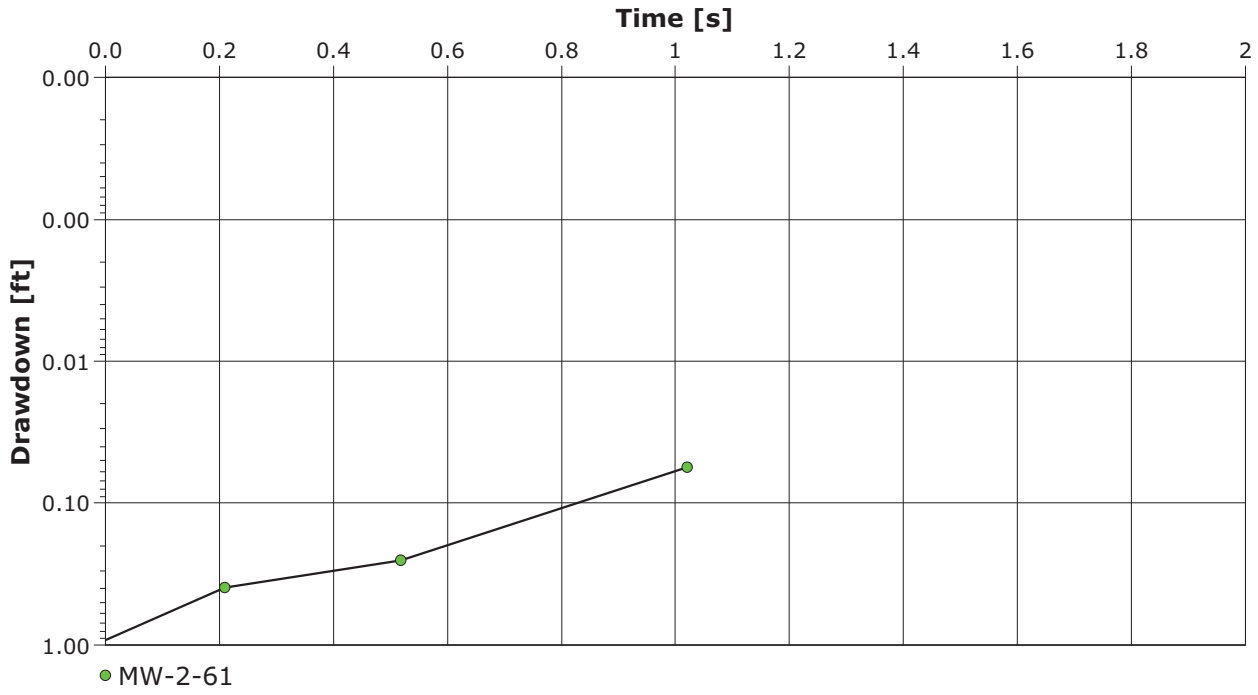
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-2-61 Test 6	Test Well: MW-2-61
Test conducted by: MWilson/DLaffoon		Test date: 1/14/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/17/2011
Aquifer Thickness: 33.00 ft		



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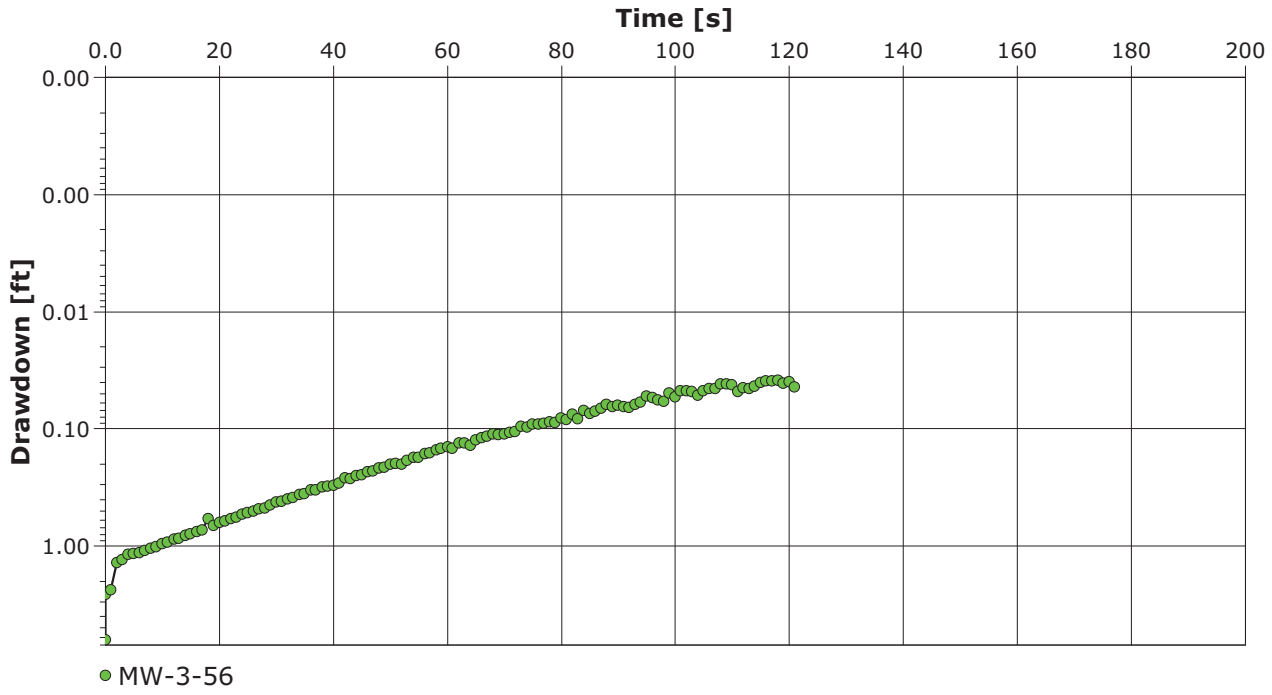
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-3-56 Test 1	Test Well: MW-3-56
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 43.00 ft		



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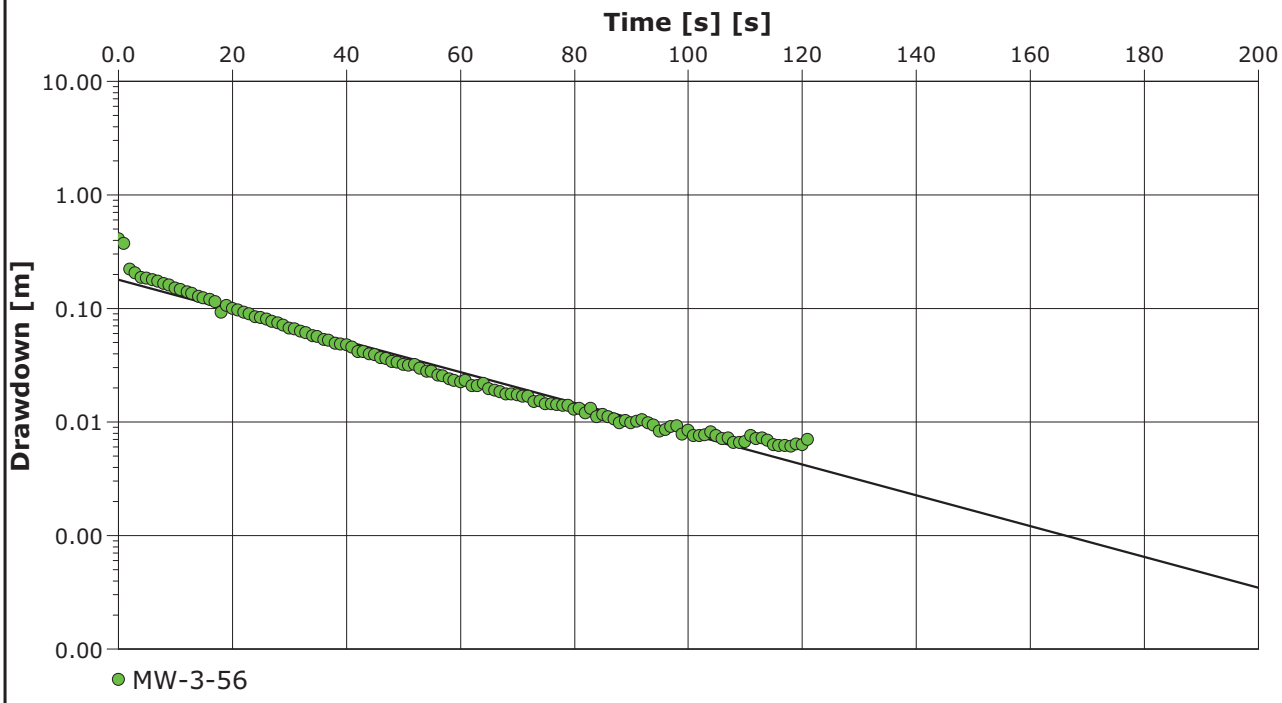
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-3-56 Test 1	Test Well: MW-3-56
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 43.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-3-56	3.46×10^{0}	

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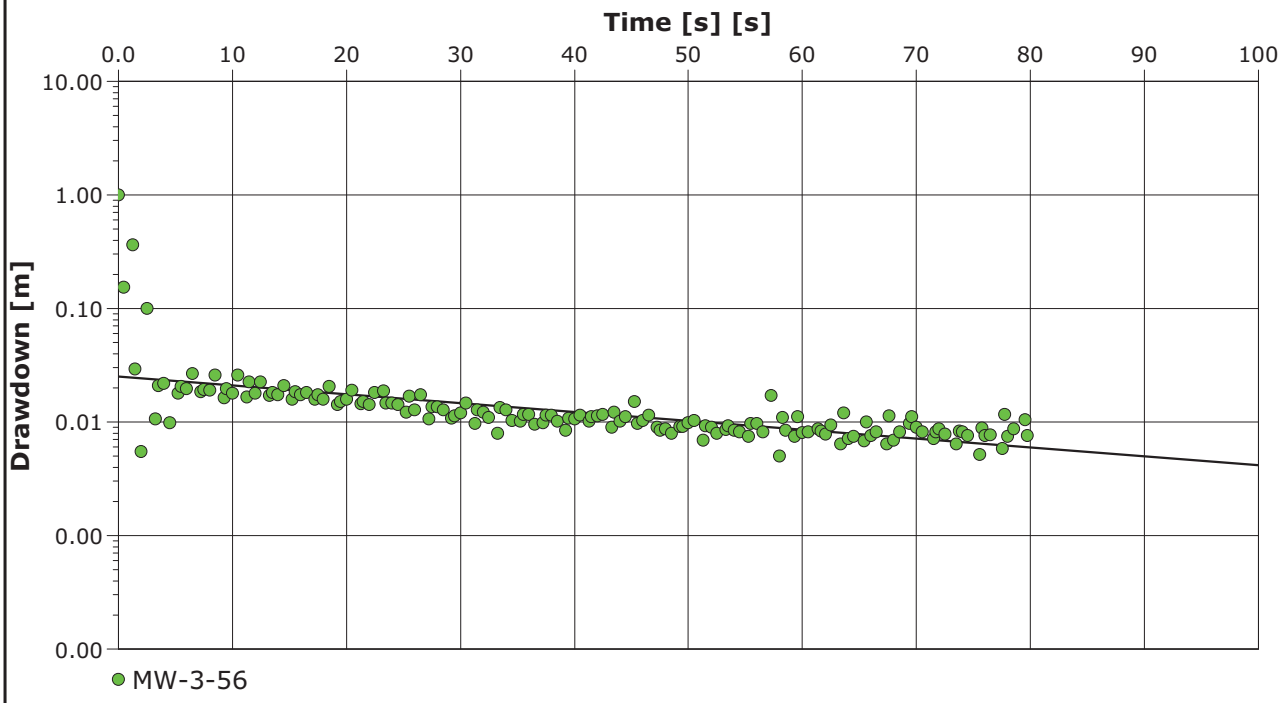
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-3-56 Test 2	Test Well: MW-3-56
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 43.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-3-56	1.99×10^{0}	

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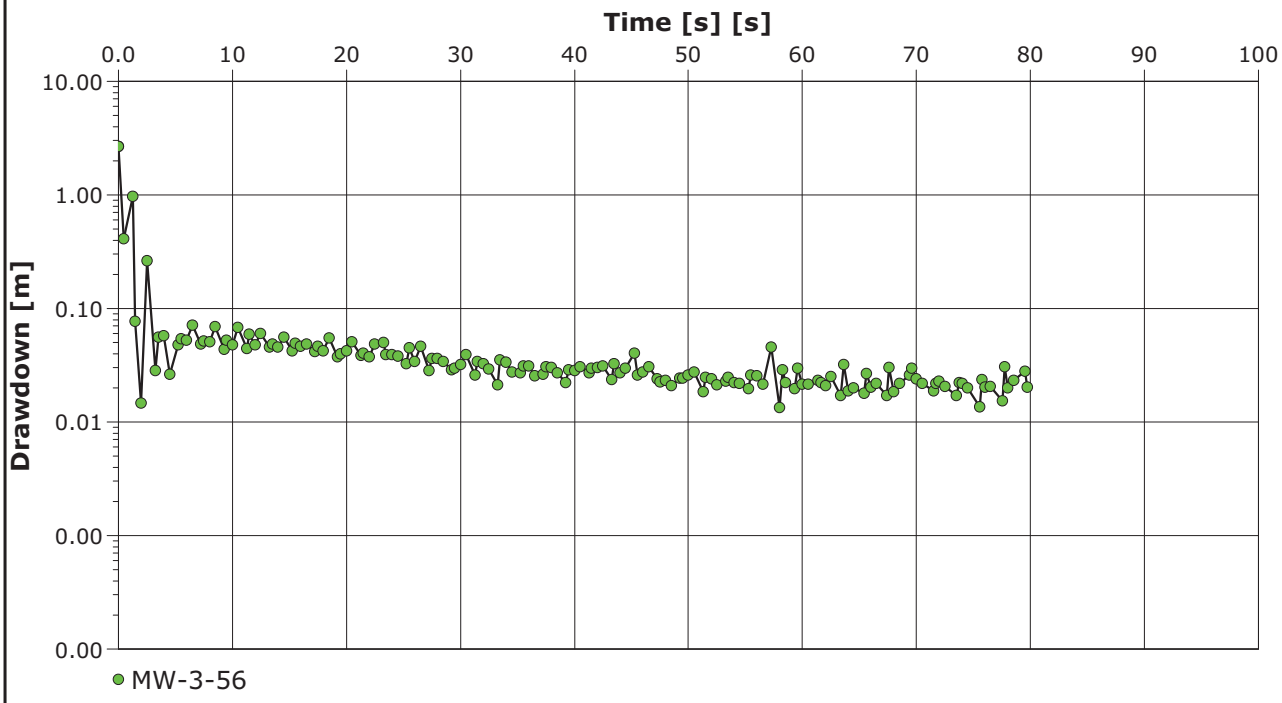
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-3-56 Test 2	Test Well: MW-3-56
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 43.00 ft		



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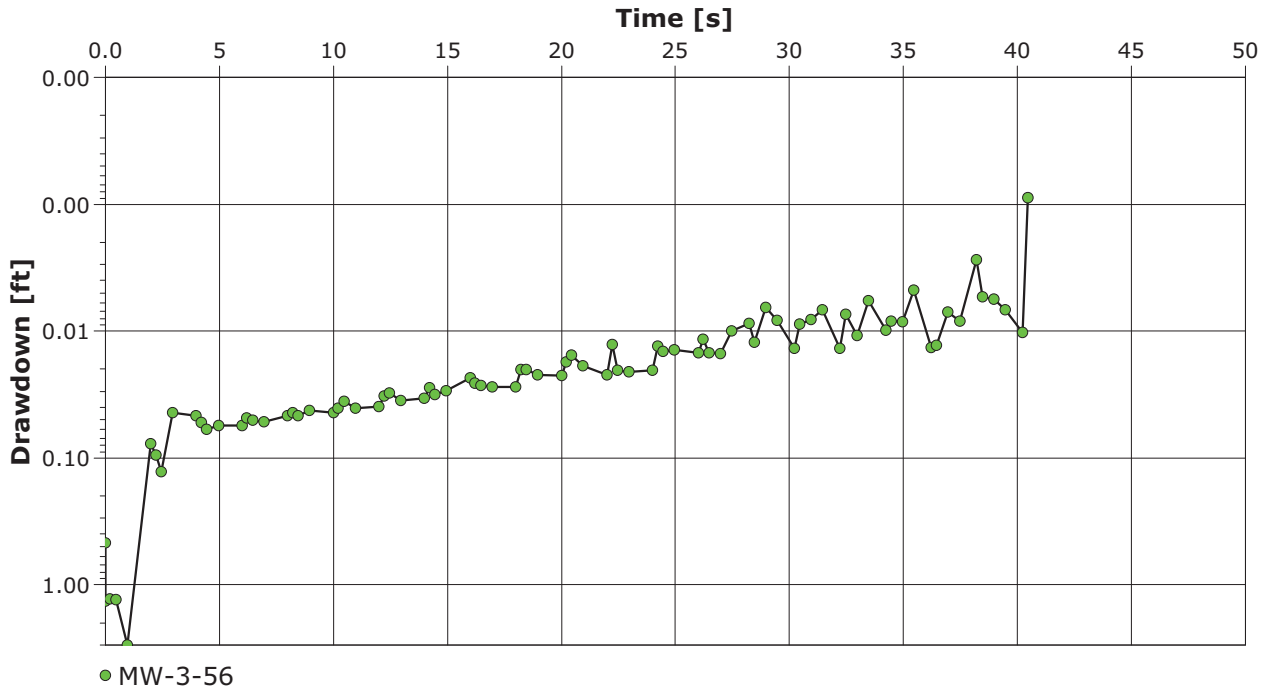
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-3-56 Test 3	Test Well: MW-3-56
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 43.00 ft		



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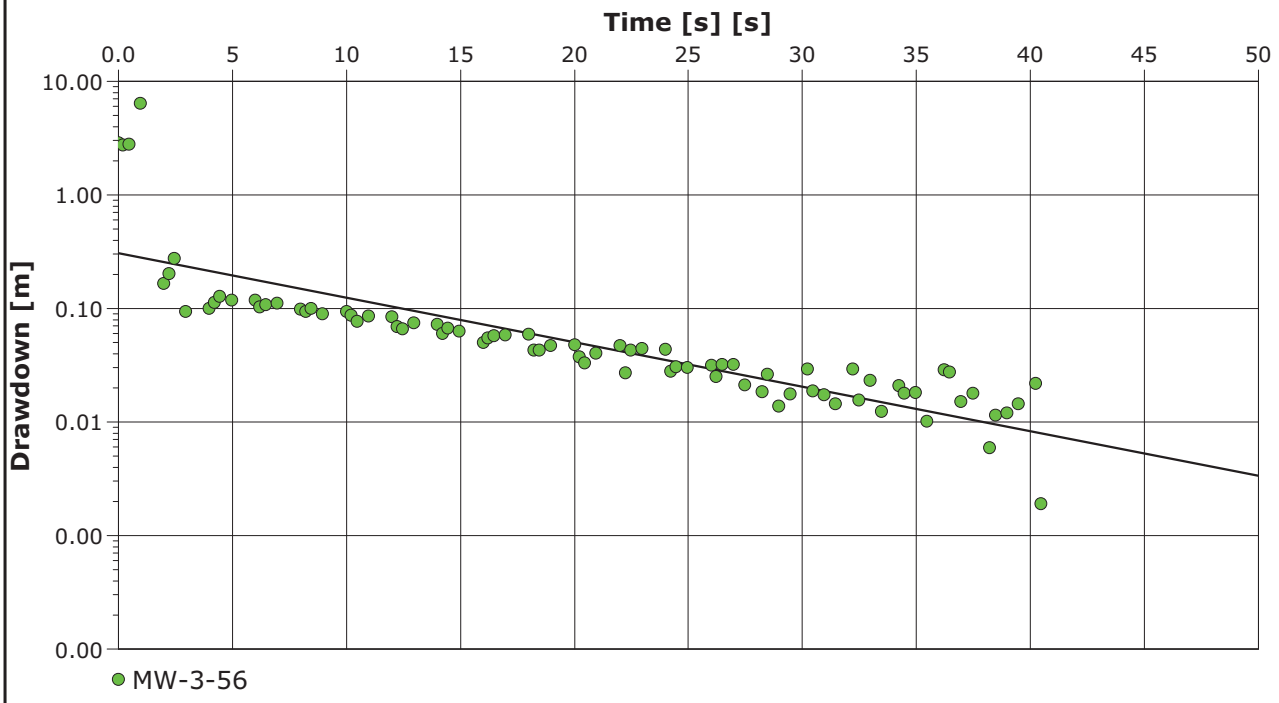
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-3-56 Test 3	Test Well: MW-3-56
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 43.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-3-56	9.99×10^{0}	

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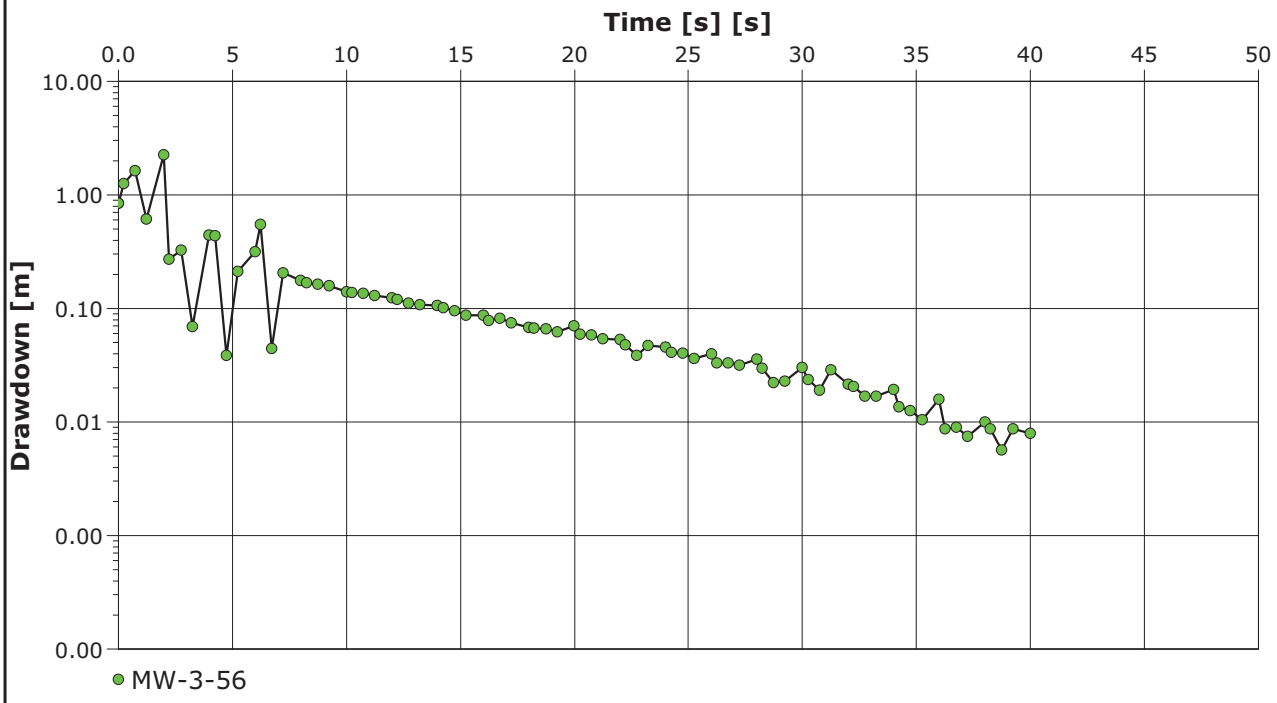
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-3-56 Test 4	Test Well: MW-3-56
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 43.00 ft		



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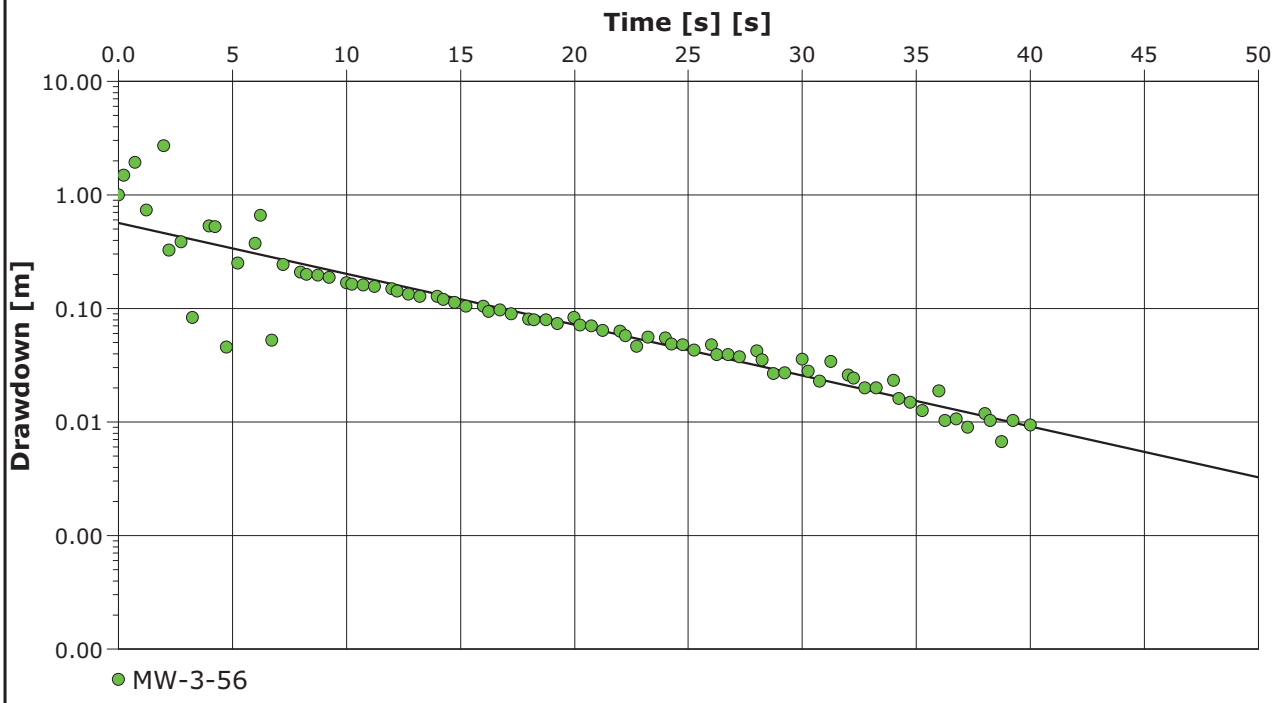
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-3-56 Test 4	Test Well: MW-3-56
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 43.00 ft		



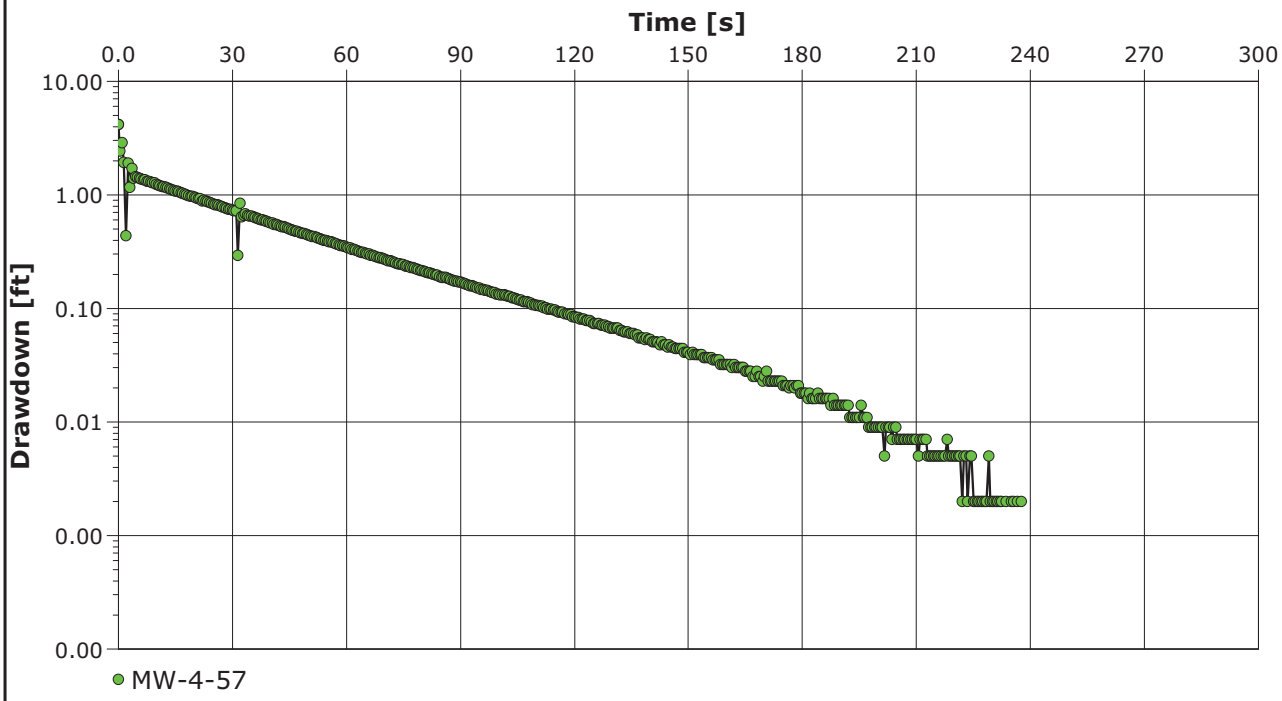
Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-3-56	1.14×10^{1}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

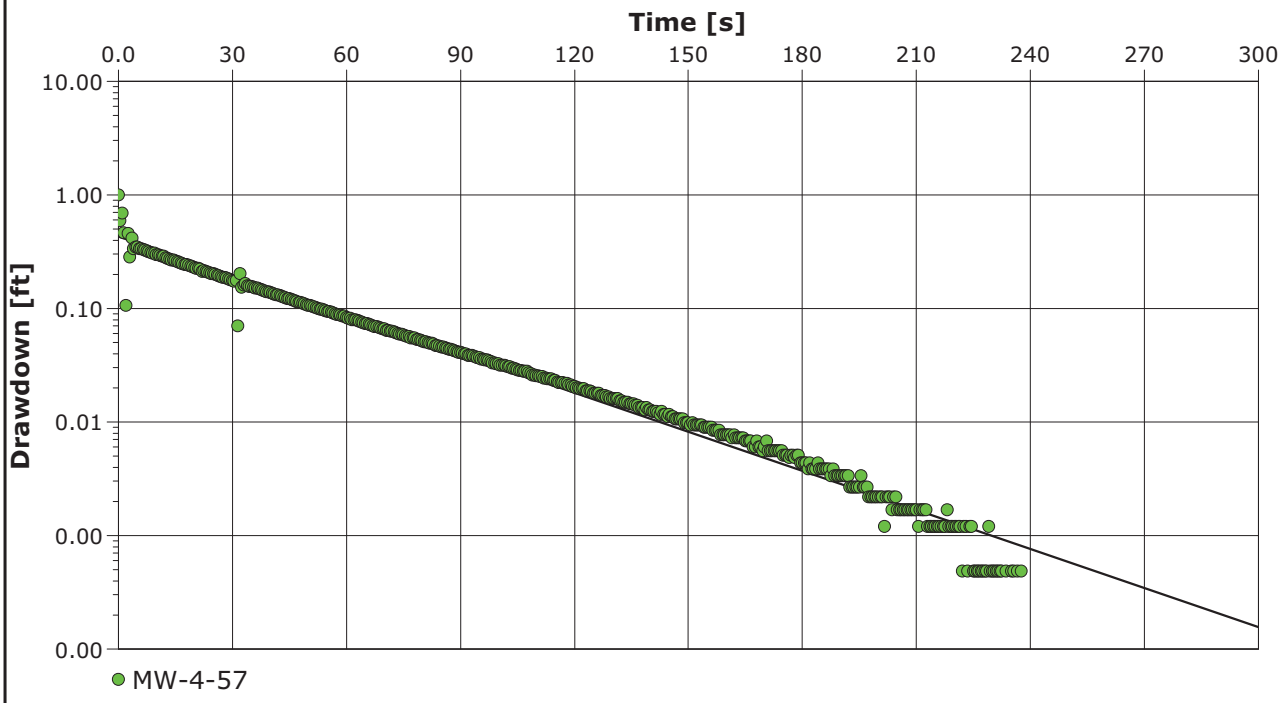
Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: MW-4-57 Test 1	Test Well: MW-4-57
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 61.00 ft		



City, State/Province **Address** **Contact Info** **Company Name** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-4-57 Test 1	Test Well: MW-4-57
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 61.00 ft		

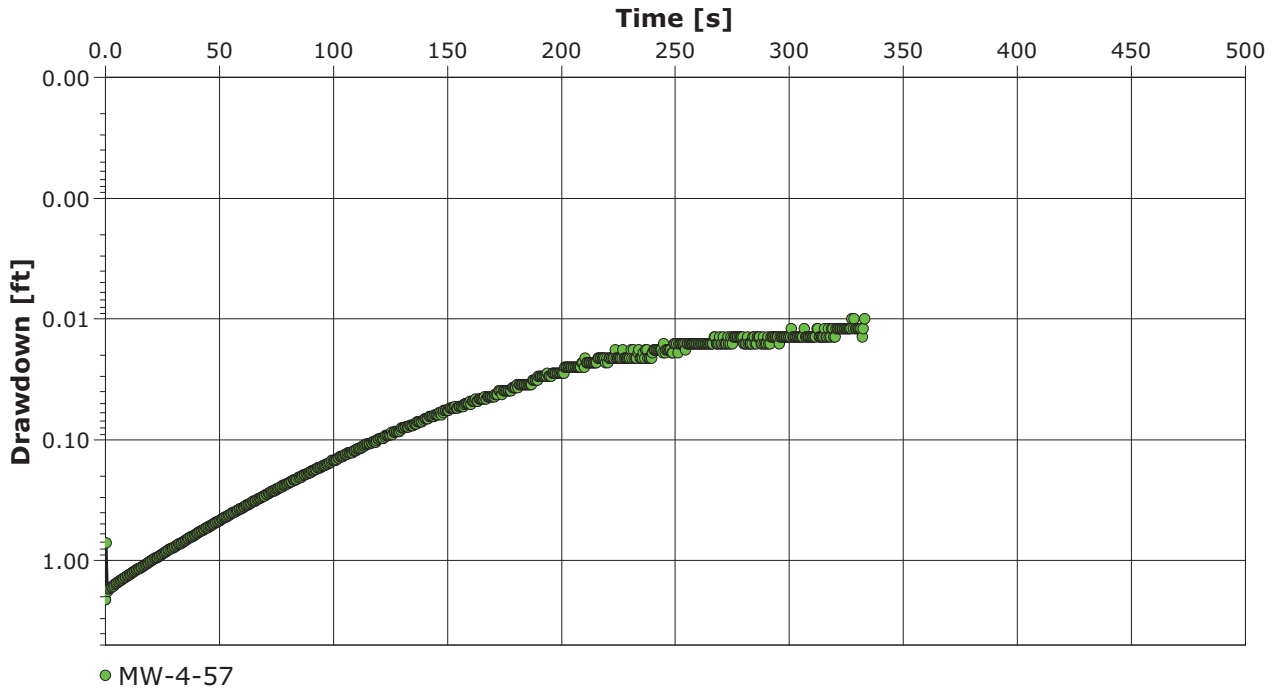


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-4-57	2.93×10^{0}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-4-57 Test 2	Test Well: MW-4-57
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 61.00 ft		



ANCHOR QEA
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Fax 503.670.1128

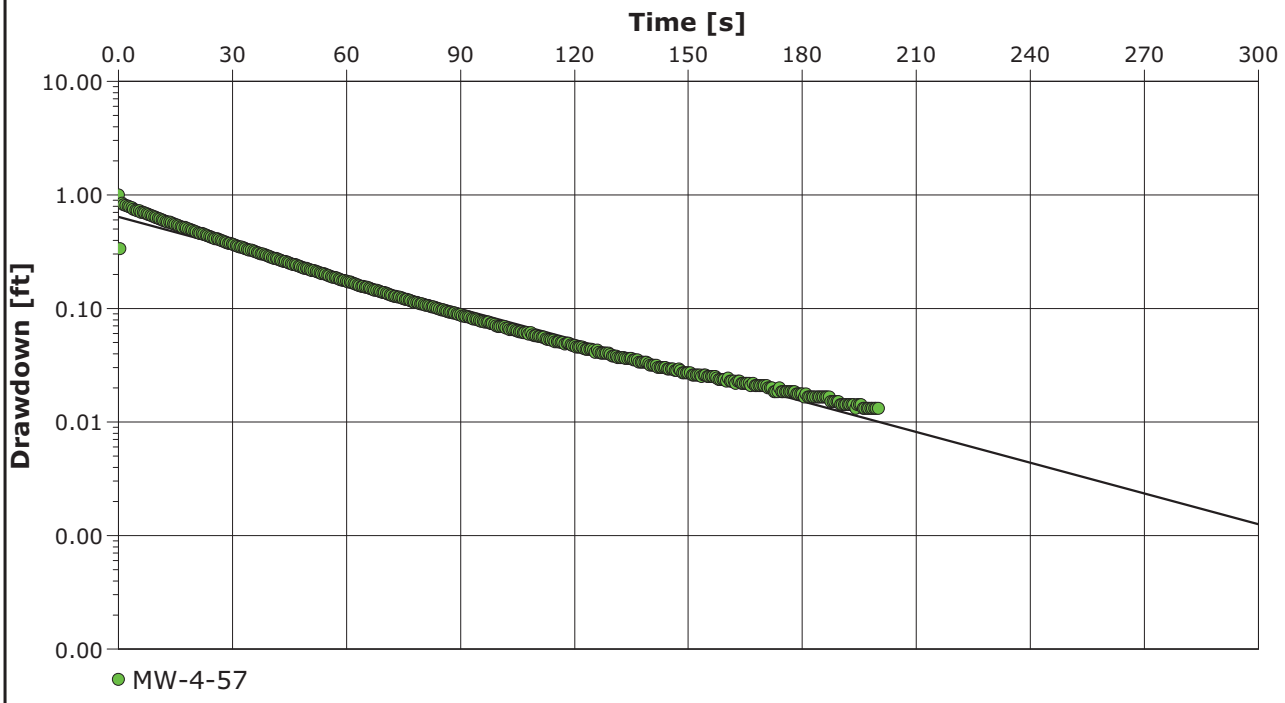
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-4-57 Test 2	Test Well: MW-4-57
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 61.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-4-57	2.30×10^{0}	

ANCHOR QEA
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Company Name

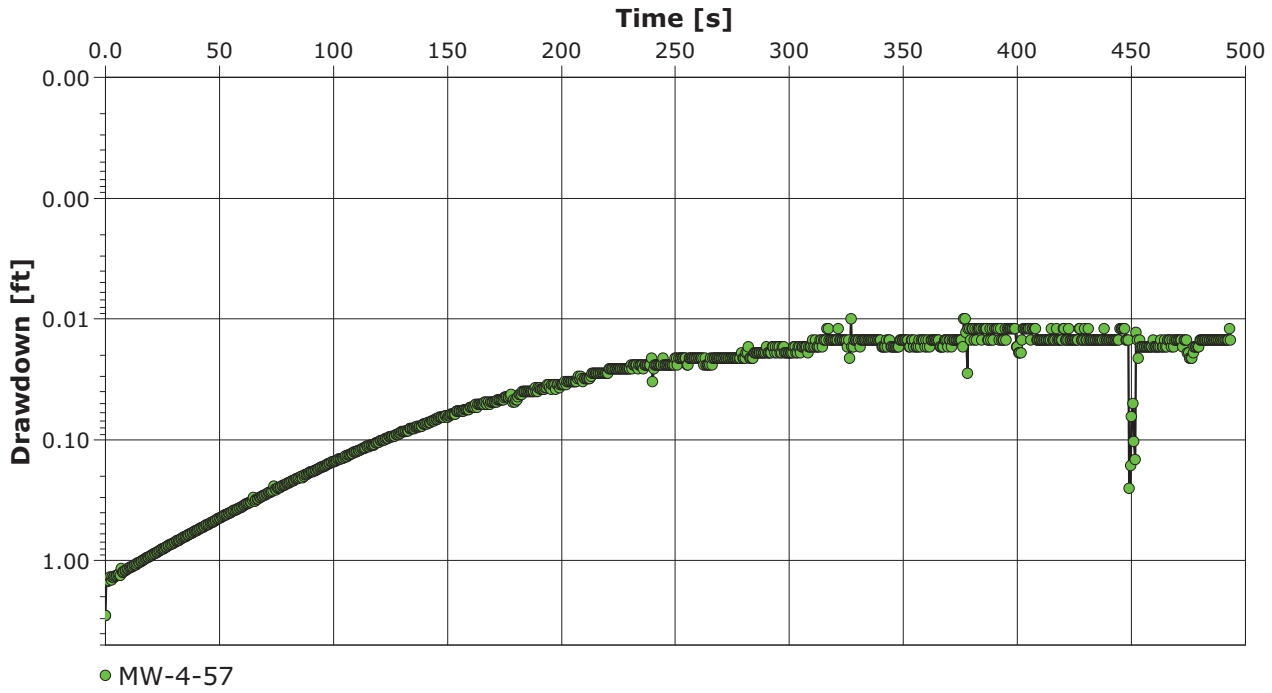
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-4-57 Test 3	Test Well: MW-4-57
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 61.00 ft		



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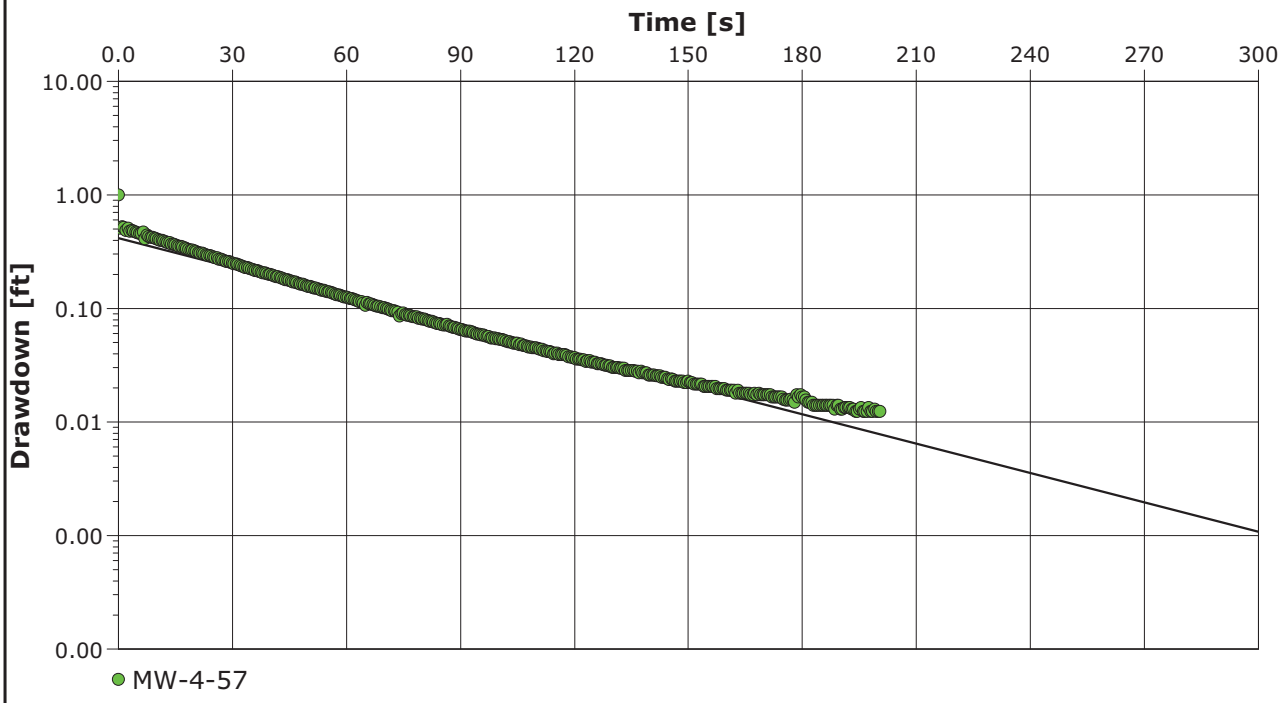
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-4-57 Test 3	Test Well: MW-4-57
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 61.00 ft		

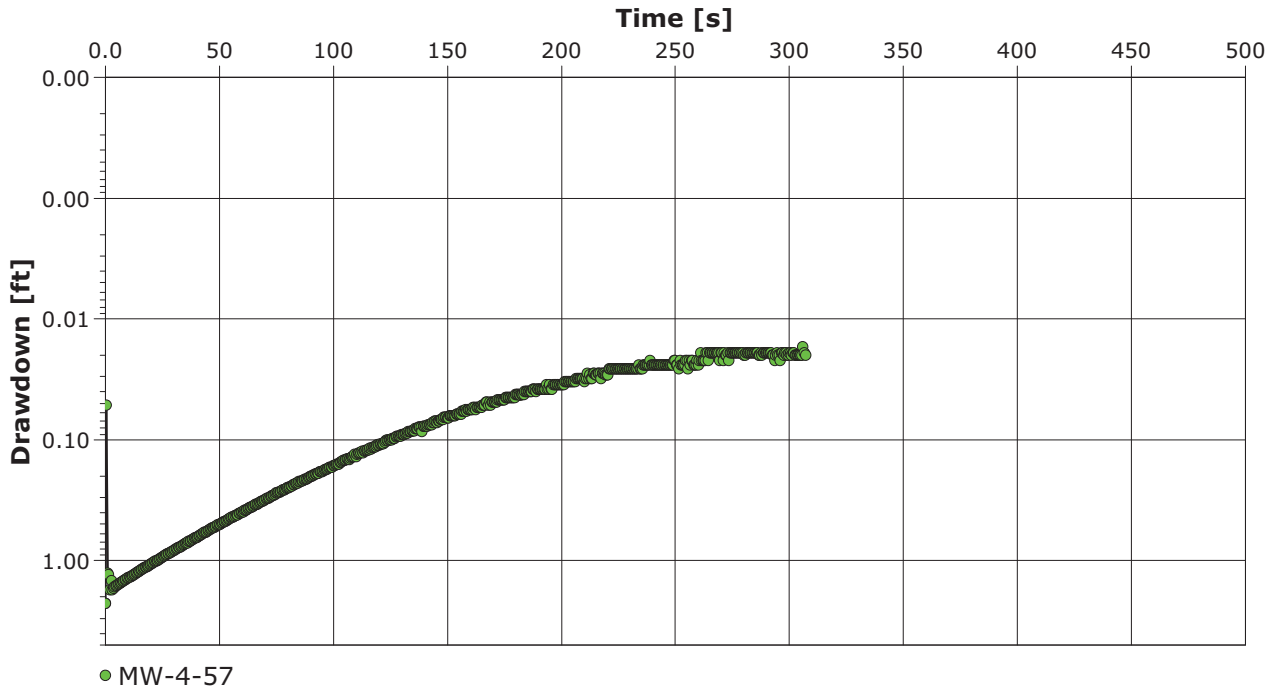


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-4-57	2.20×10^{0}	

City, State/Province **Address** **Contact Info** **Company Name** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-4-57 Test 4	Test Well: MW-4-57
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 61.00 ft		



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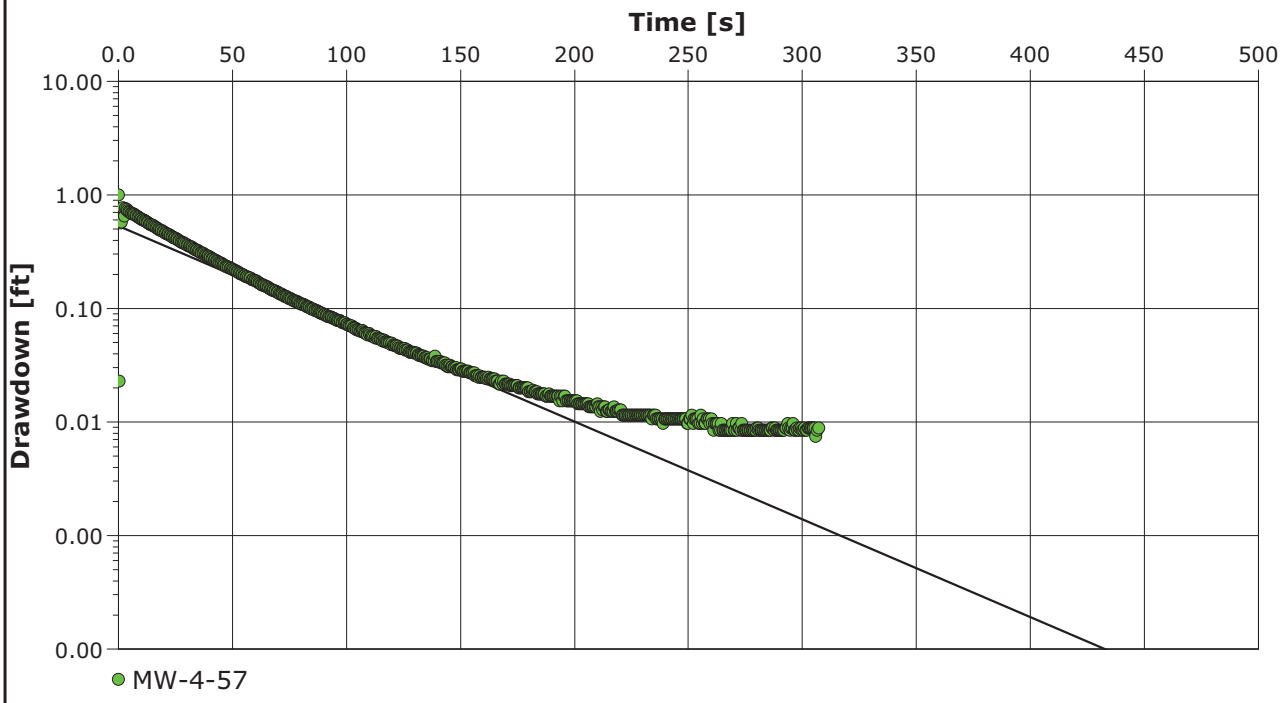
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-4-57 Test 4	Test Well: MW-4-57
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 61.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-4-57	2.20×10^{0}	

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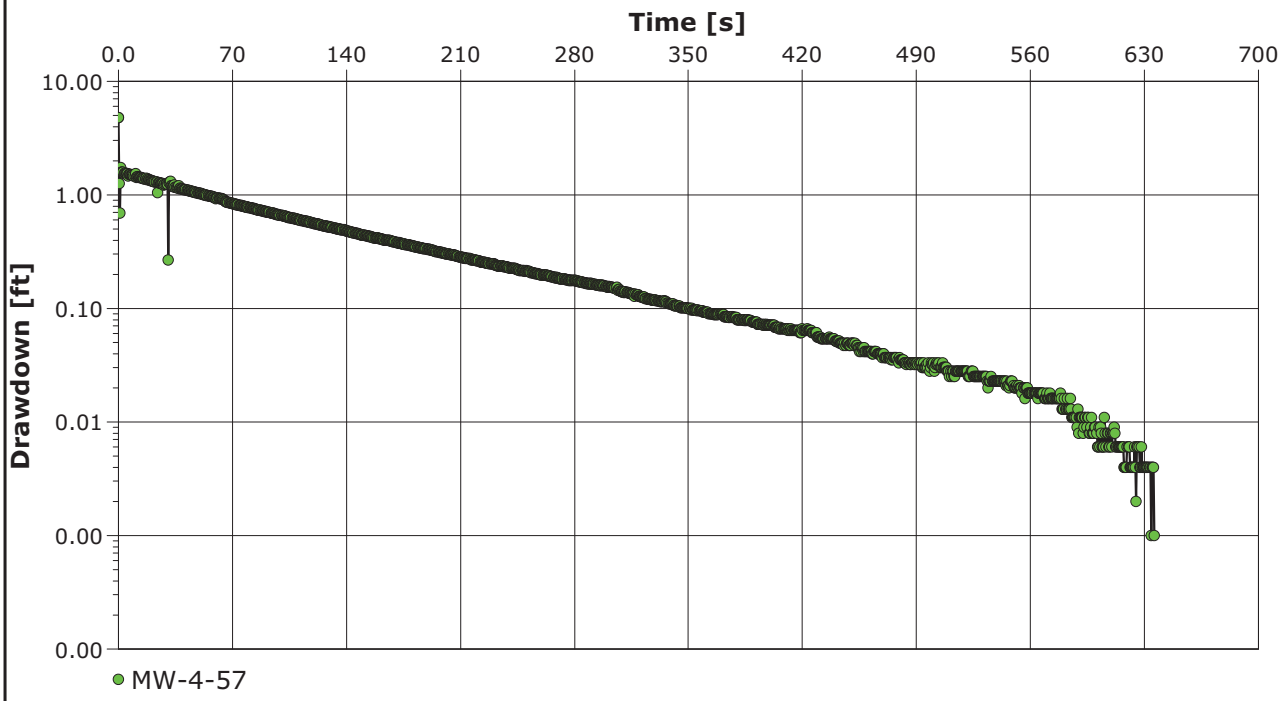
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

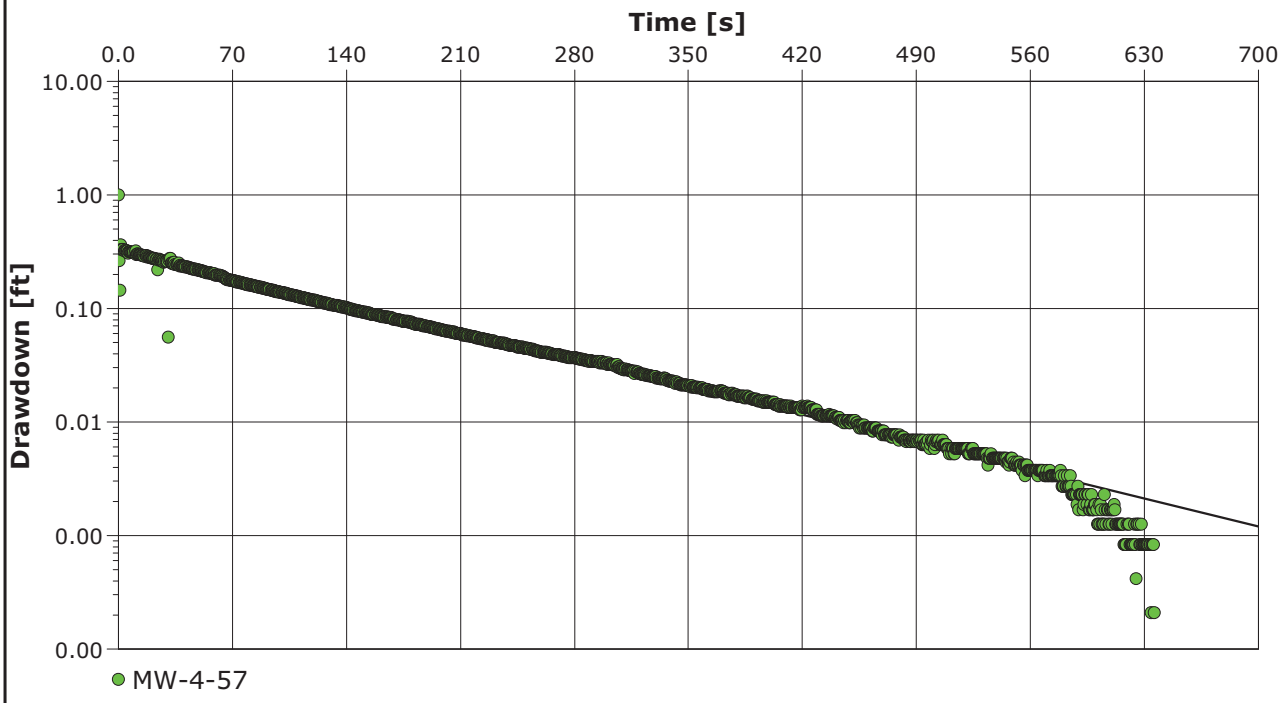
Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-5-32 Test 1	Test Well: MW-4-57
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 65.00 ft		



ANCHOR QEA City, State/Province Address Contact Info Company Name 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report**	
	Project: Gasco Ground Water Source Control	
	Number: 000029-02.28 task 3A	
	Client: NW Natural	

Location: Portland, Oregon	Slug Test: MW-5-32 Test 1	Test Well: MW-4-57
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 65.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-4-57	8.96×10^{-1}	

ANCHOR QEA
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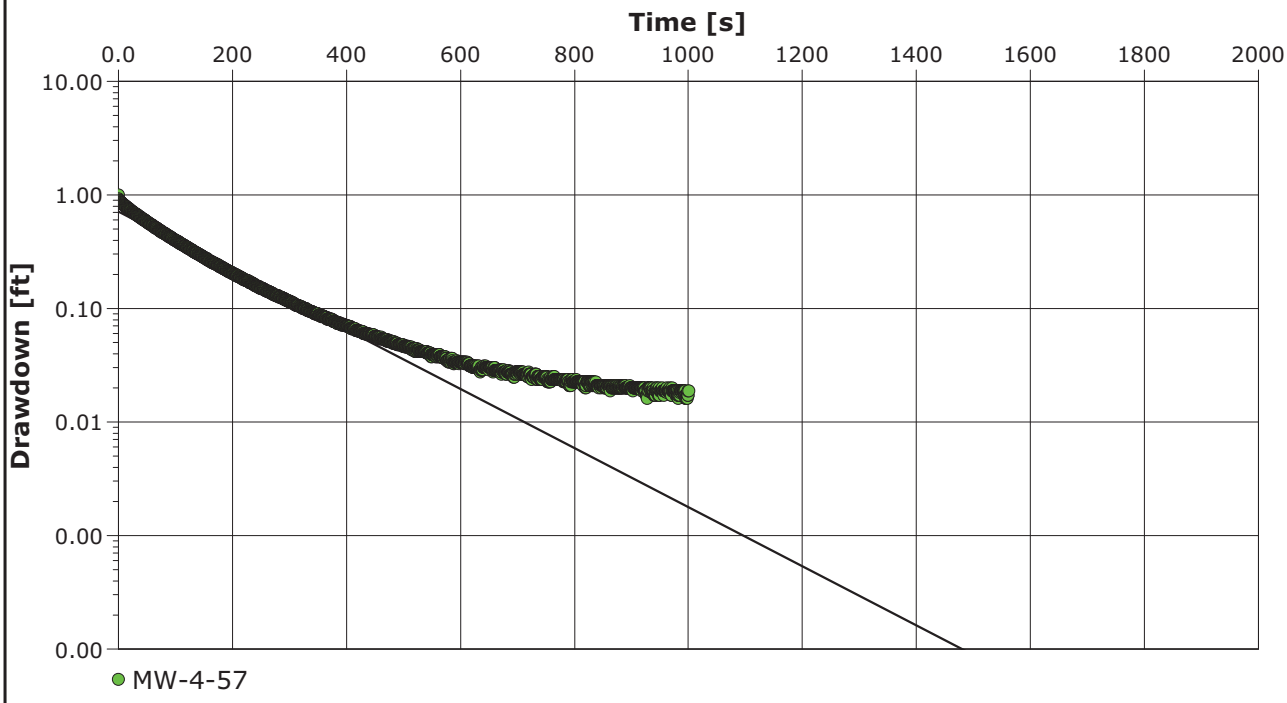
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-5-32 Test 2	Test Well: MW-4-57
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 65.00 ft		



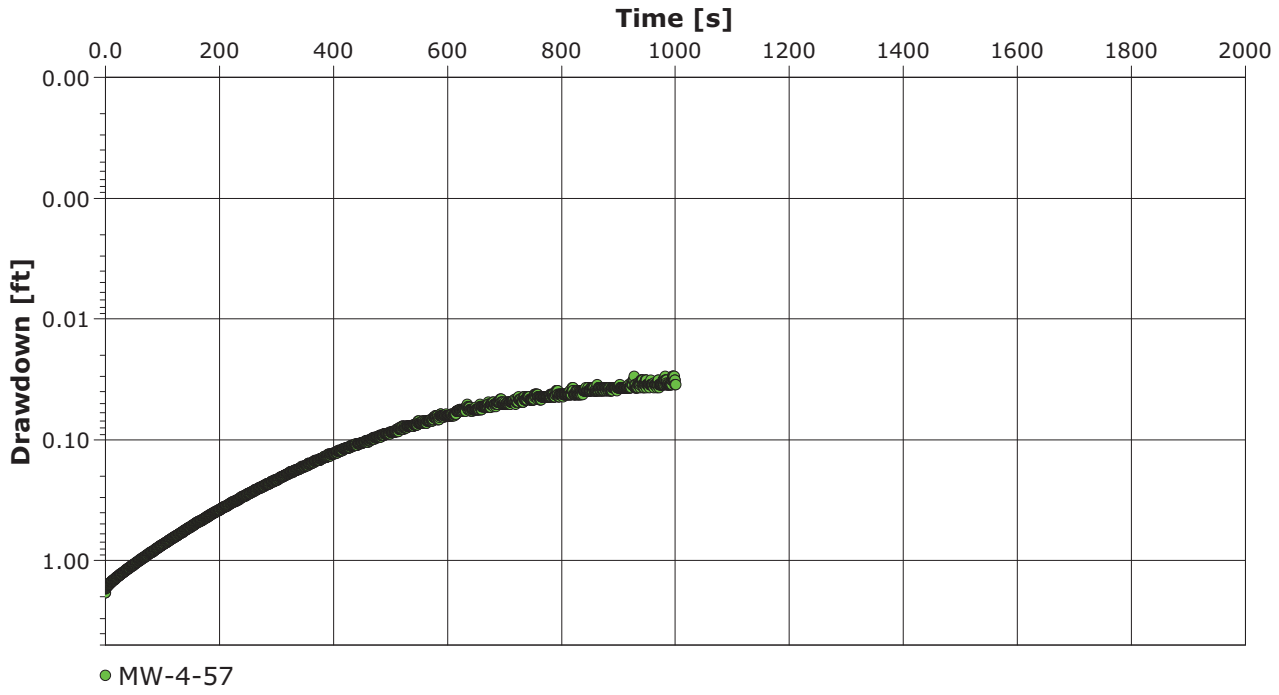
Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-4-57	6.65×10^{-1}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: MW-5-32 Test 2	Test Well: MW-4-57
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 65.00 ft		



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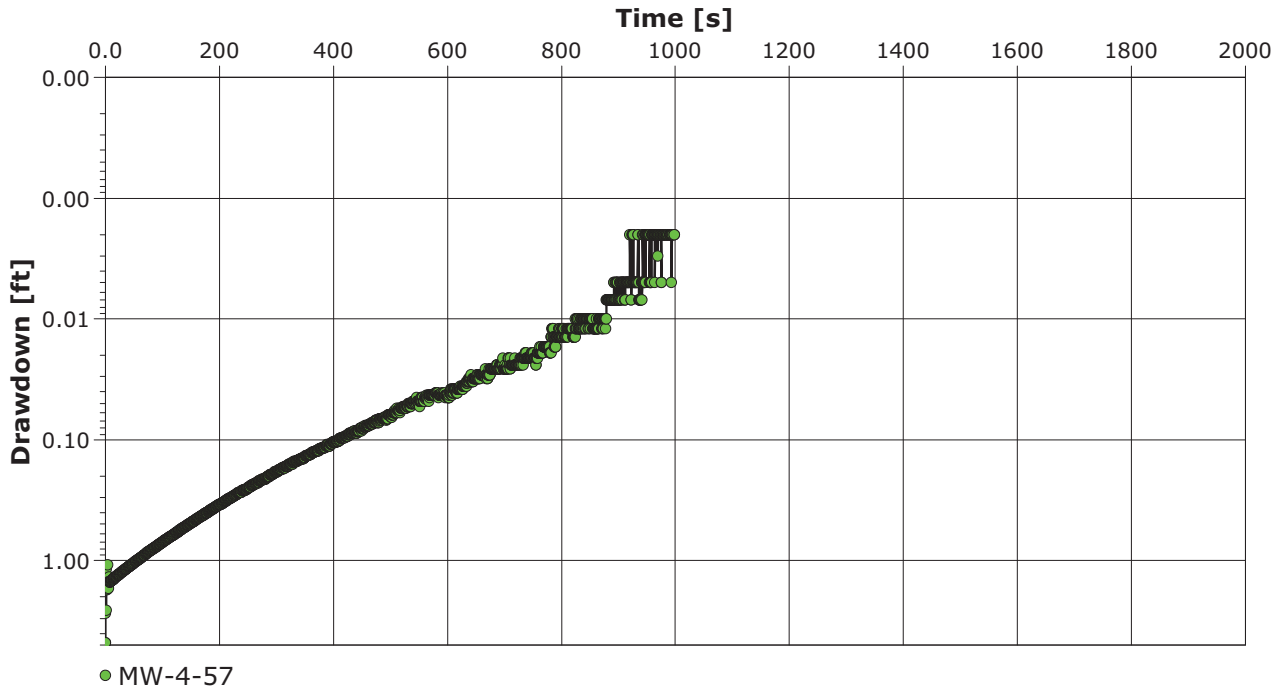
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

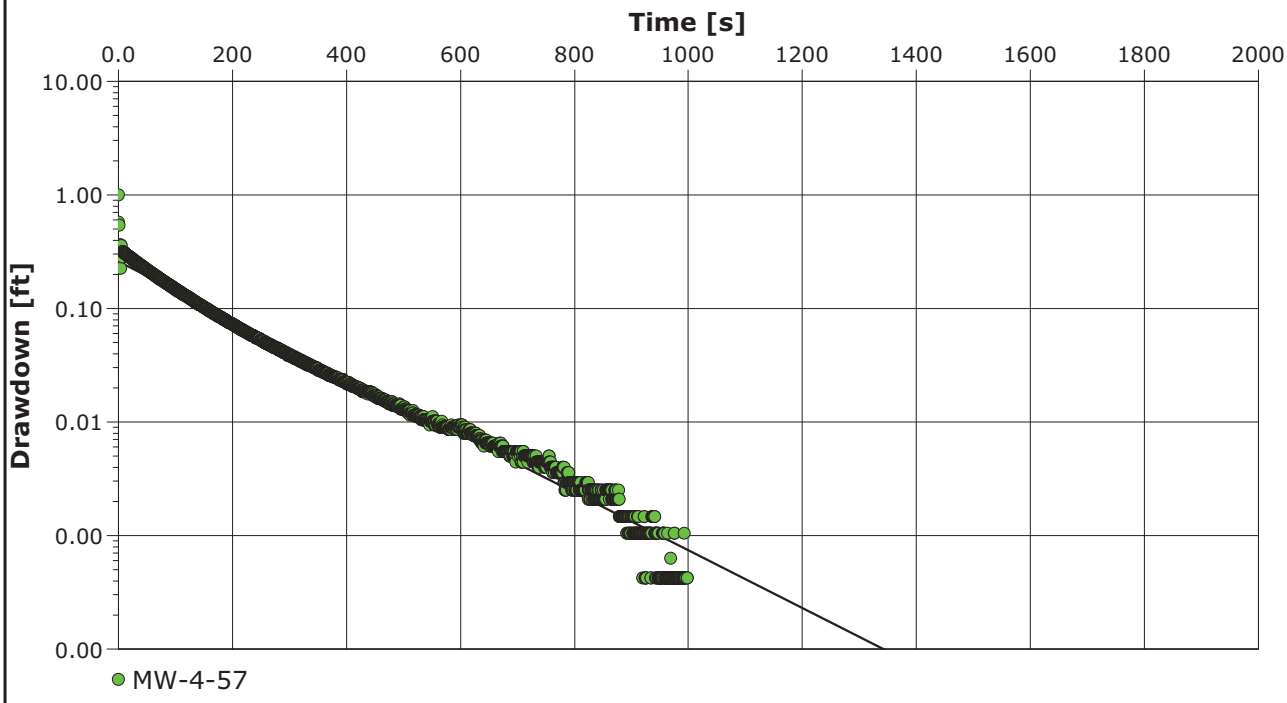
Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-5-32 Test 3	Test Well: MW-4-57
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 65.00 ft		



City, State/Province **Address** **Contact Info** **Company Name** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-5-32 Test 3	Test Well: MW-4-57
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 65.00 ft		



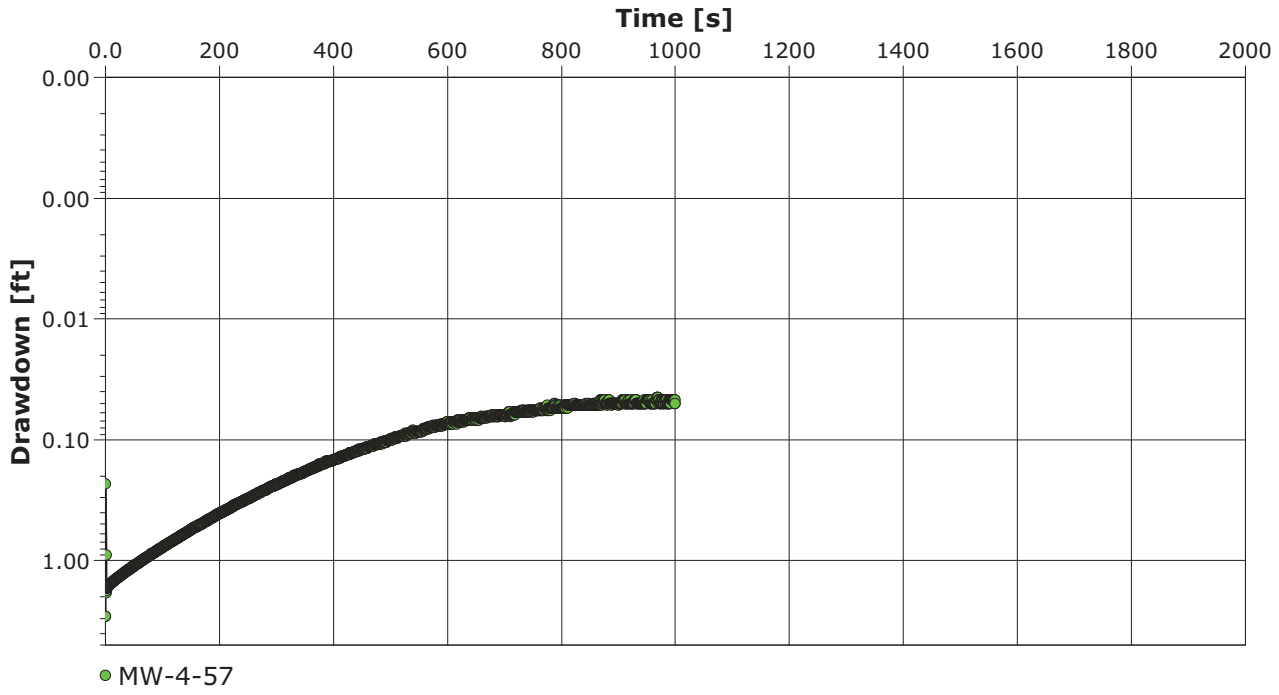
Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-4-57	6.50×10^{-1}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: MW-5-32 Test 4	Test Well: MW-4-57
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 65.00 ft		



ANCHOR QEA
City, State/Province
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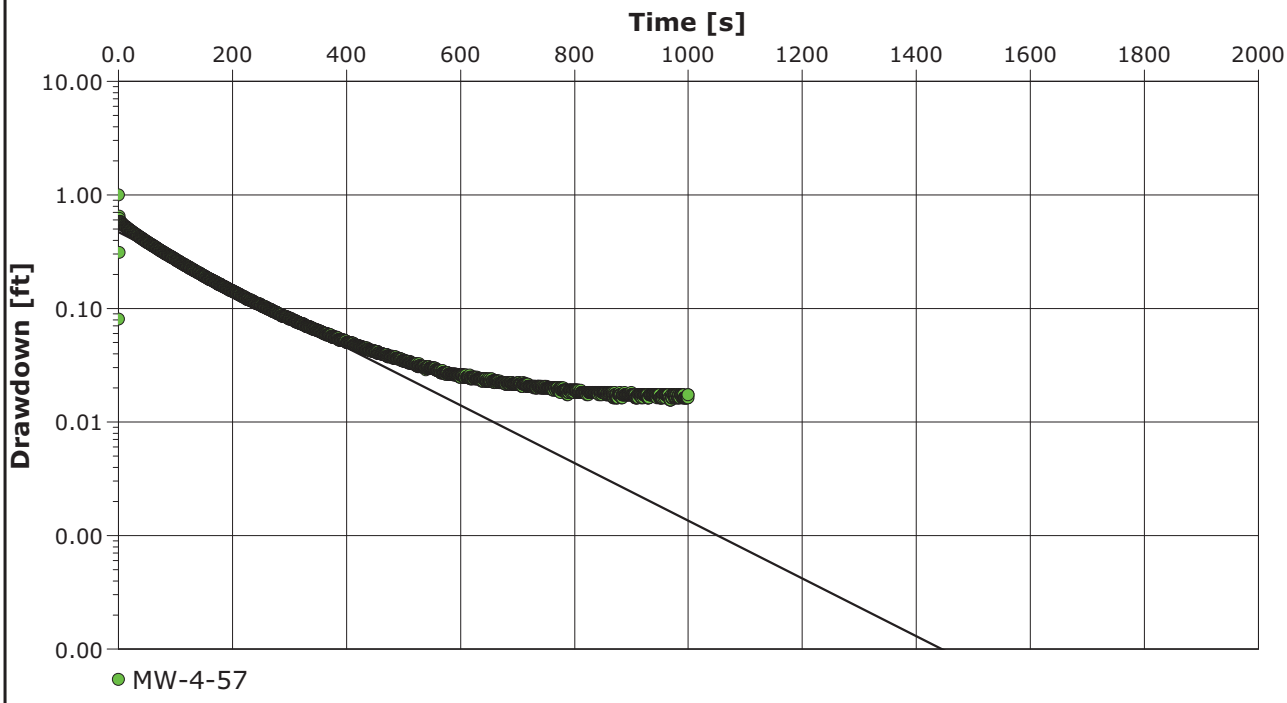
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-5-32 Test 4	Test Well: MW-4-57
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 65.00 ft		

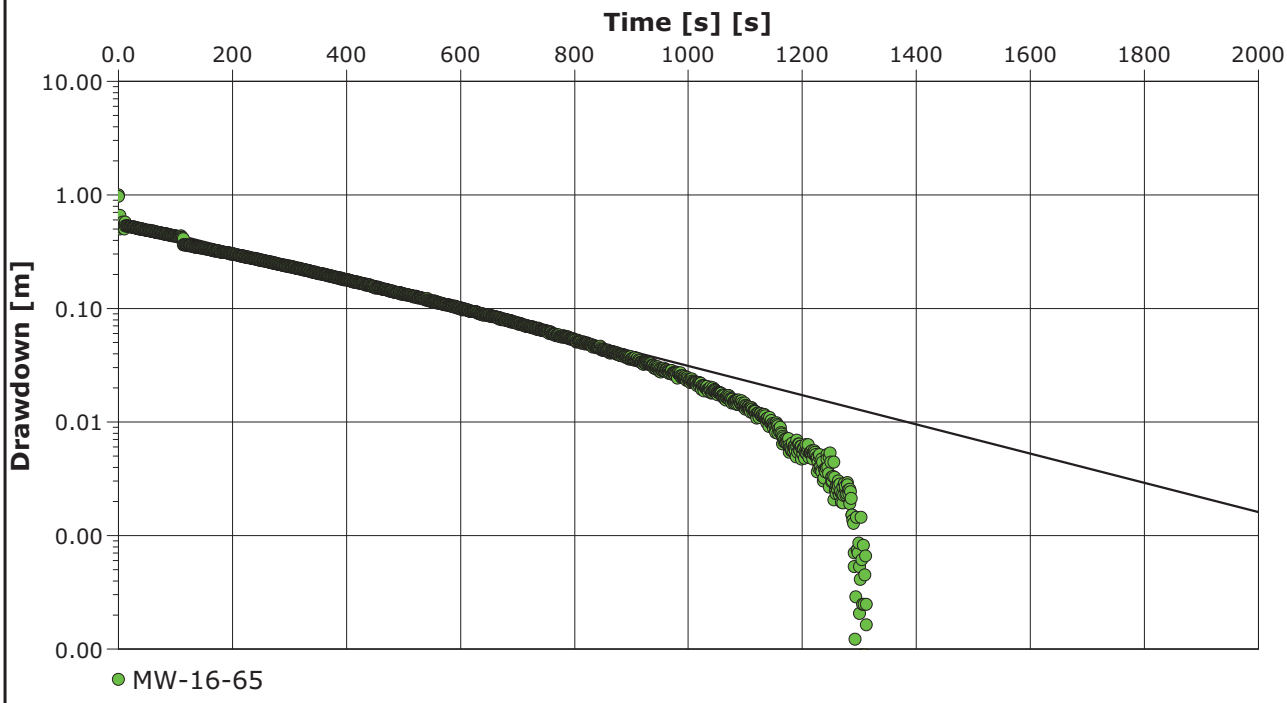


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-4-57	6.50×10^{-1}	

ANCHOR QEA City, State/Province Address Contact Info Company Name 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-16-65 Test 1	Test Well: MW-16-65
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 64.00 ft		



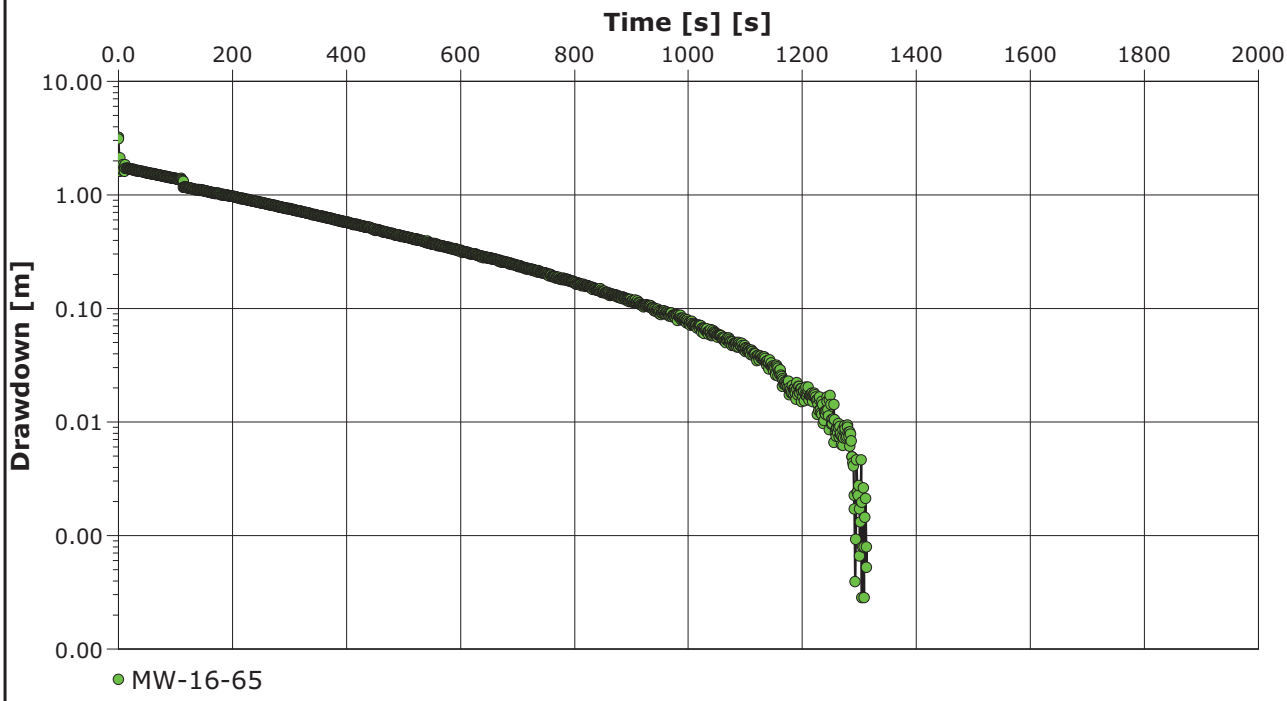
Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-16-65	3.28×10^{-1}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

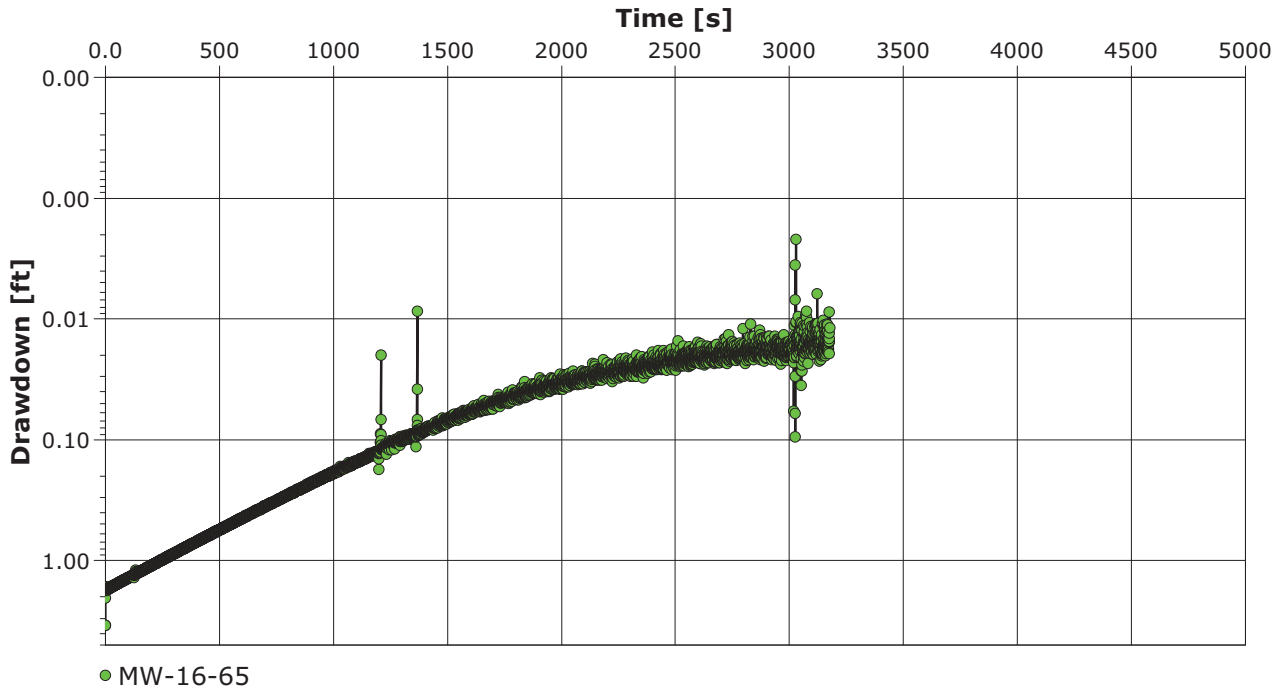
Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: MW-16-65 Test 1	Test Well: MW-16-65
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 64.00 ft		



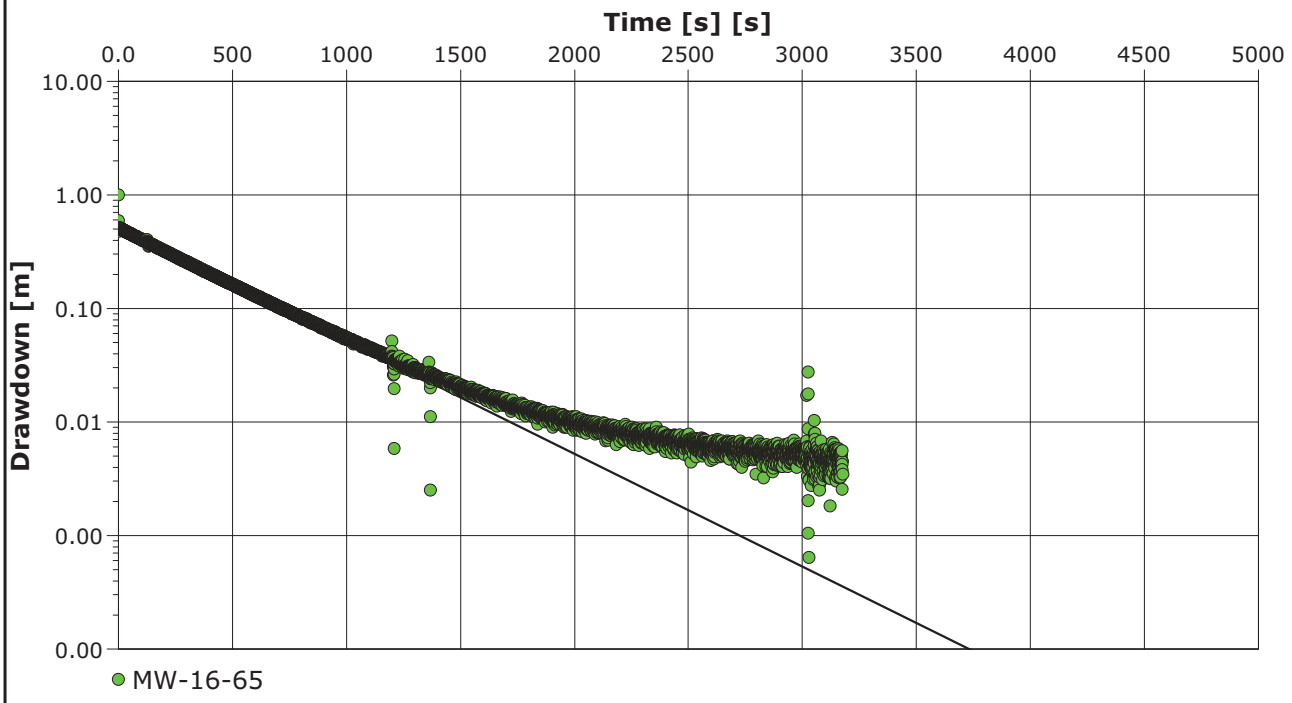
City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-16-65 Test 2	Test Well: MW-16-65
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 64.00 ft		



City, State/Province **Address** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 **Contact Info** Phone 503.670.1108 Fax 503.670.1128 **Company Name**	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-16-65 Test 2	Test Well: MW-16-65
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 64.00 ft		

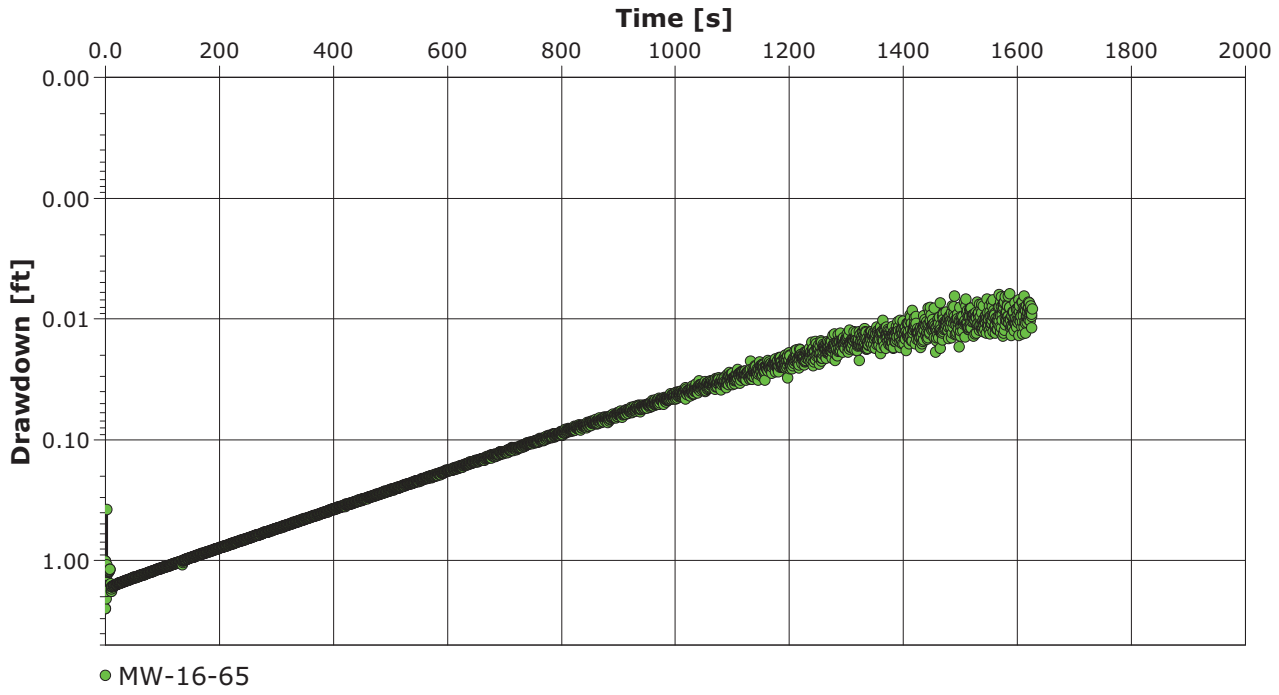


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-16-65	2.54×10^{-1}	

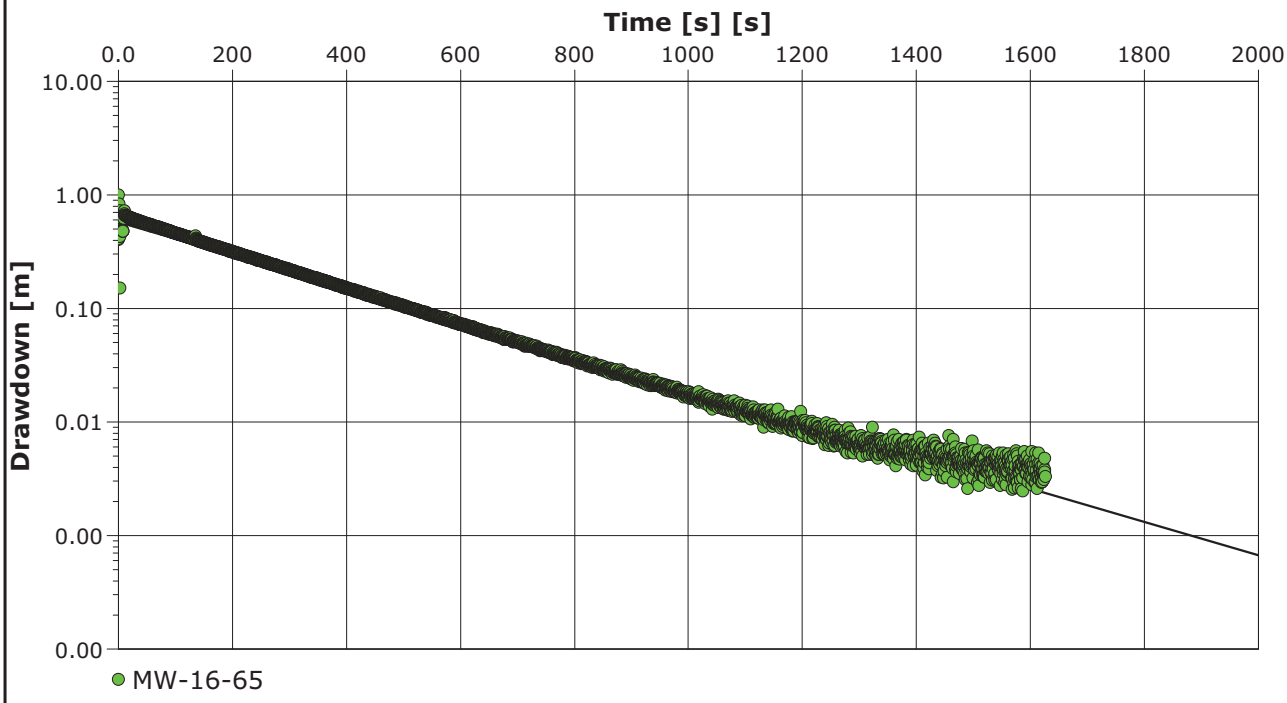
ANCHOR QEA **City, State/Province** **Address** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 **Contact Info** Phone 503.670.1108 Fax 503.670.1128 **Company Name**	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-16-65 Test 3	Test Well: MW-16-65
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 64.00 ft		



ANCHOR QEA **City, State/Province** **Address** **Contact Info** **Company Name** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-16-65 Test 3	Test Well: MW-16-65
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 64.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-16-65	3.74×10^{-1}	

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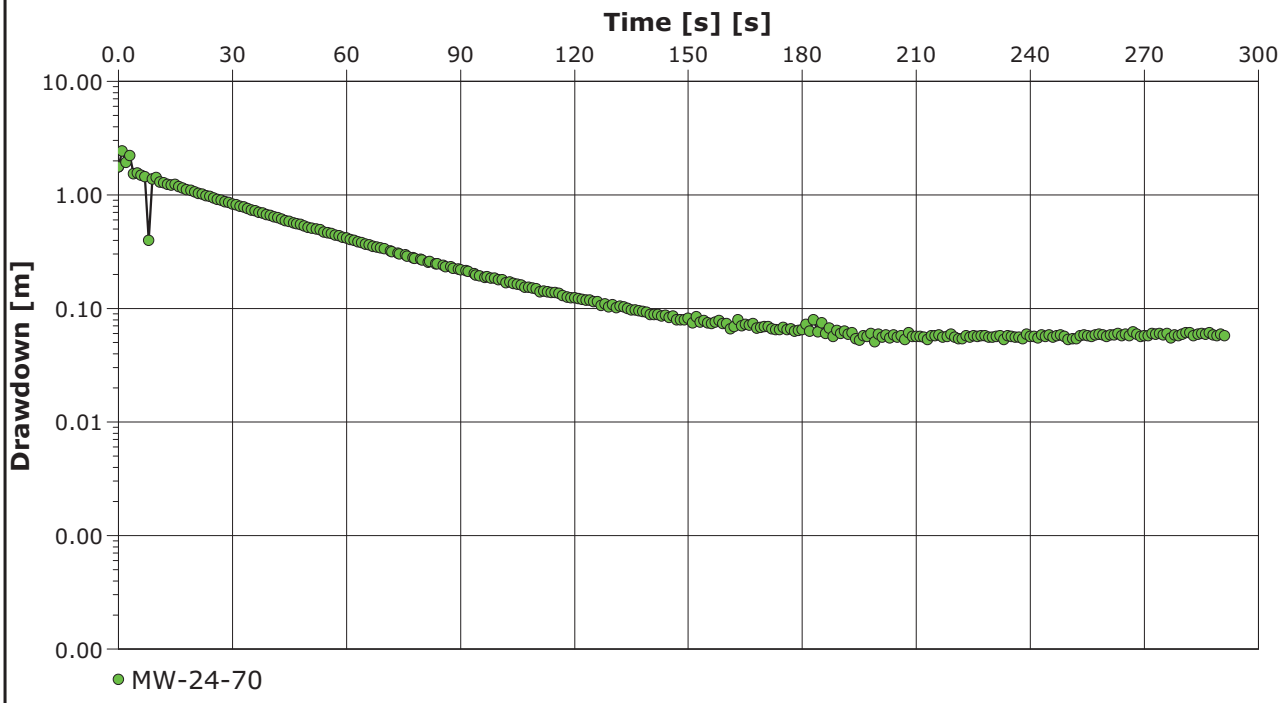
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-24-70 Test 1	Test Well: MW-24-70
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 43.00 ft		



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Fax 503.670.1128

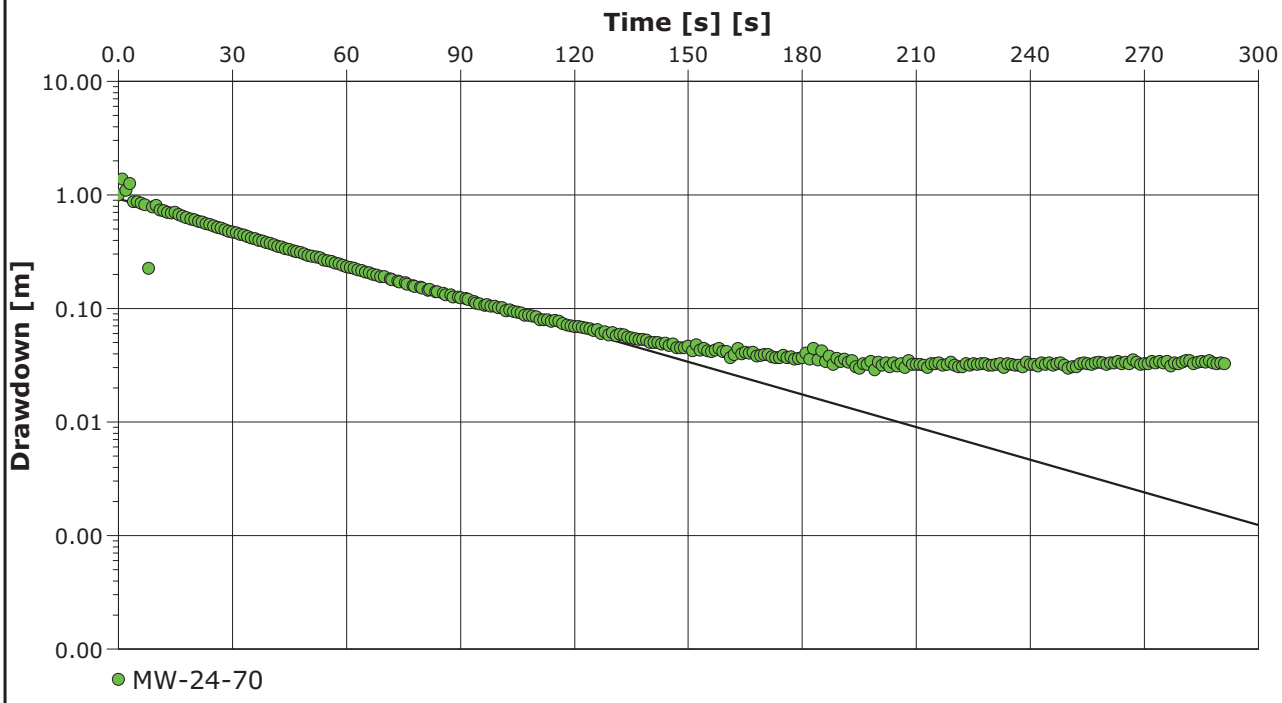
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-24-70 Test 1	Test Well: MW-24-70
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 43.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-24-70	2.45×10^{0}	

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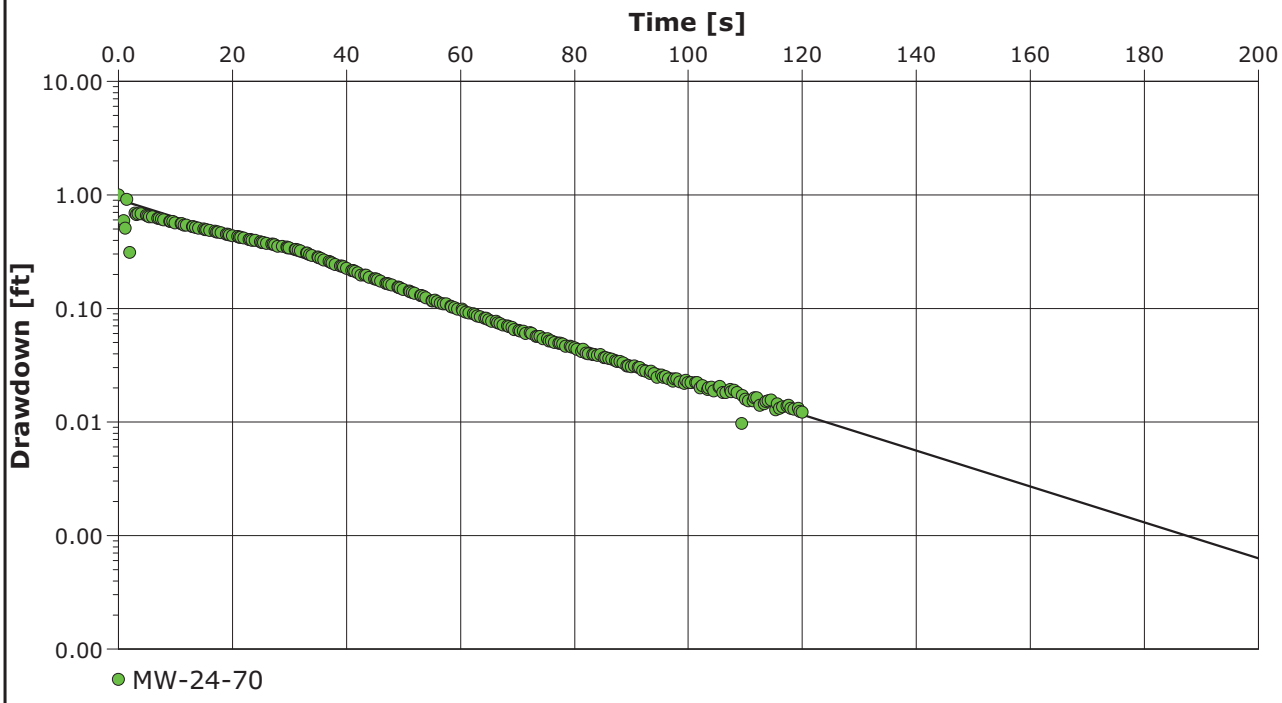
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-24-70 Test 2	Test Well: MW-24-70
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 43.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-24-70	4.03×10^{0}	

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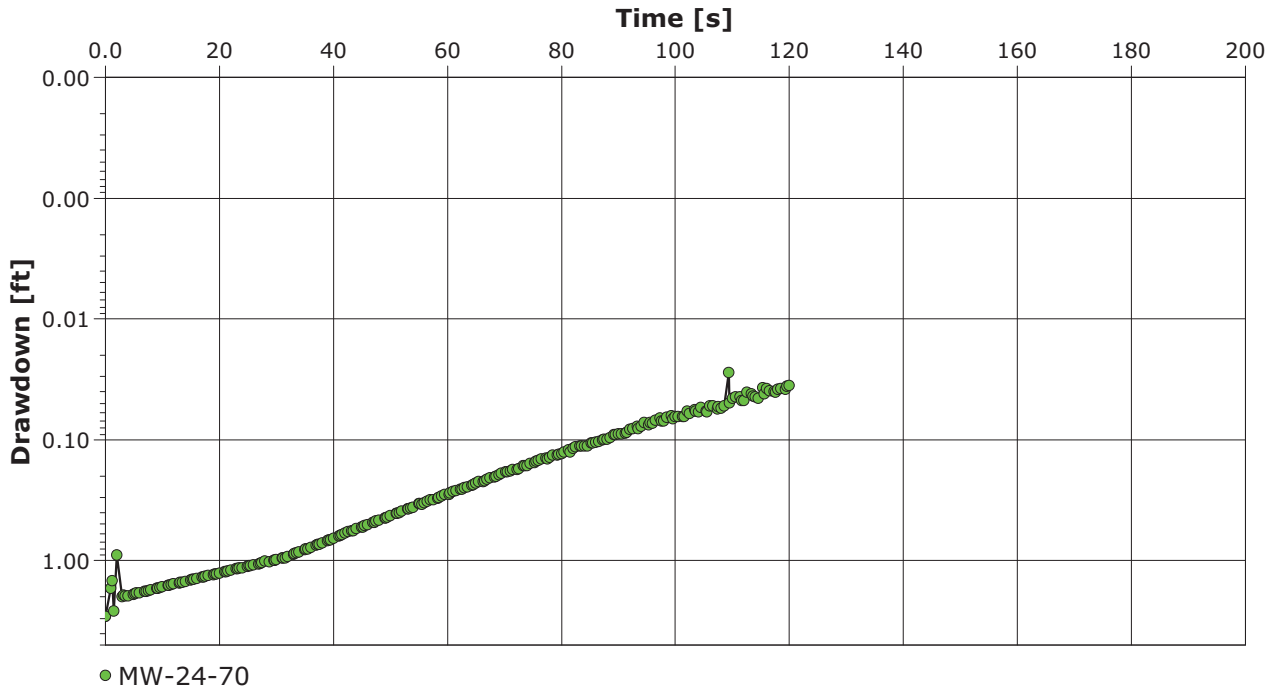
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-24-70 Test 2	Test Well: MW-24-70
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 43.00 ft		



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Slug Test Analysis Report

Project: Gasco Ground Water Source Control

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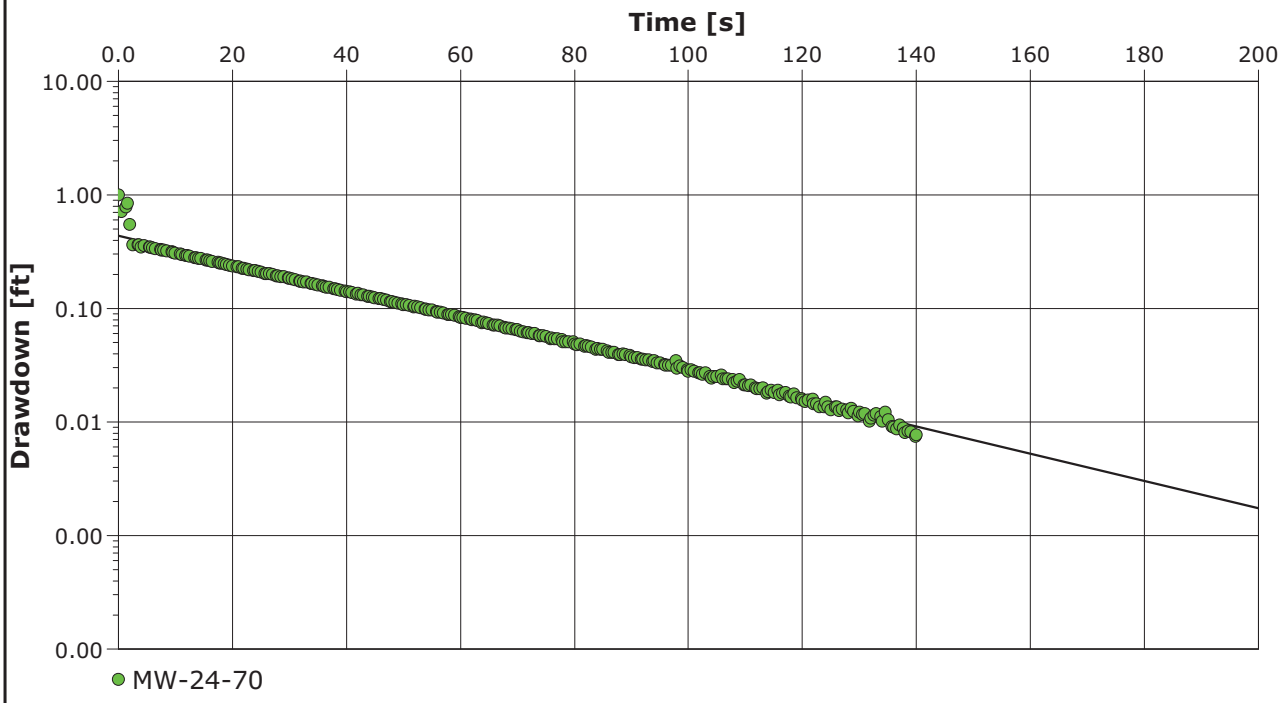
Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-24-70 Test 3	Test Well: MW-24-70
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 43.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-24-70	3.07×10^{0}	

ANCHOR QEA
6650 SW Redwood Lane, Suite 333
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Phone 503.670.1108
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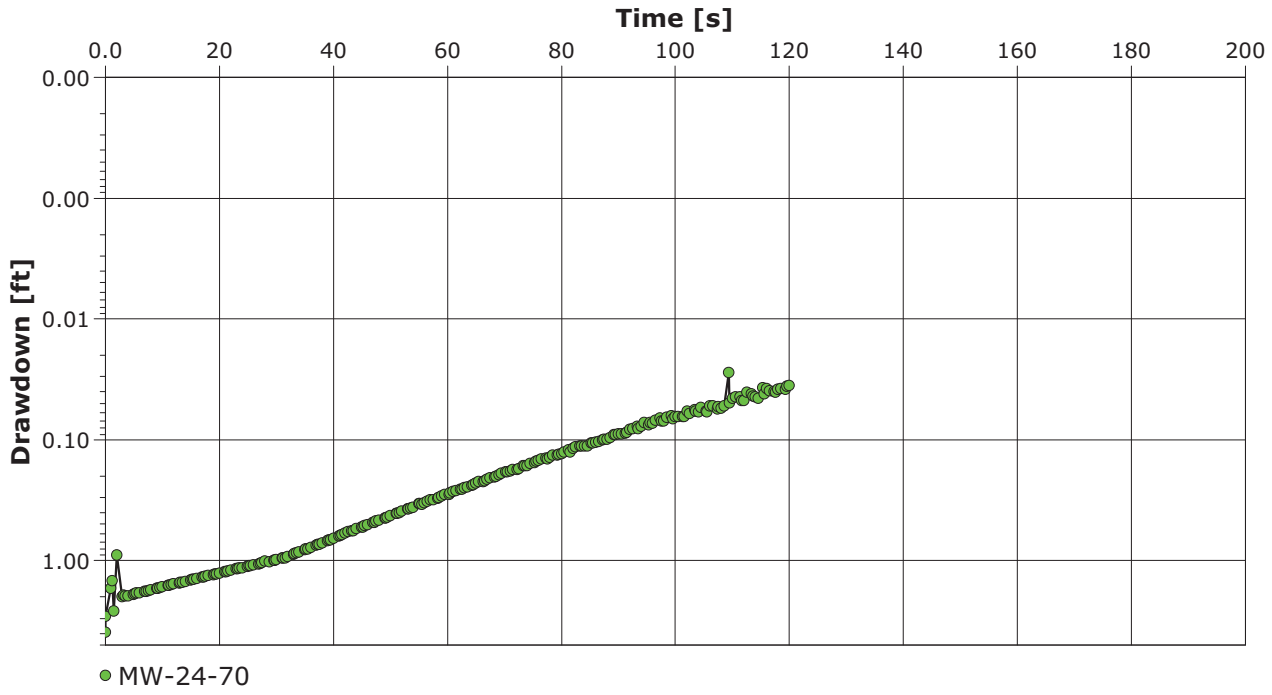
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-24-70 Test 3	Test Well: MW-24-70
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 43.00 ft		



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Portland, Oregon 97224
Phone 503.670.1108
Fax 503.670.1128

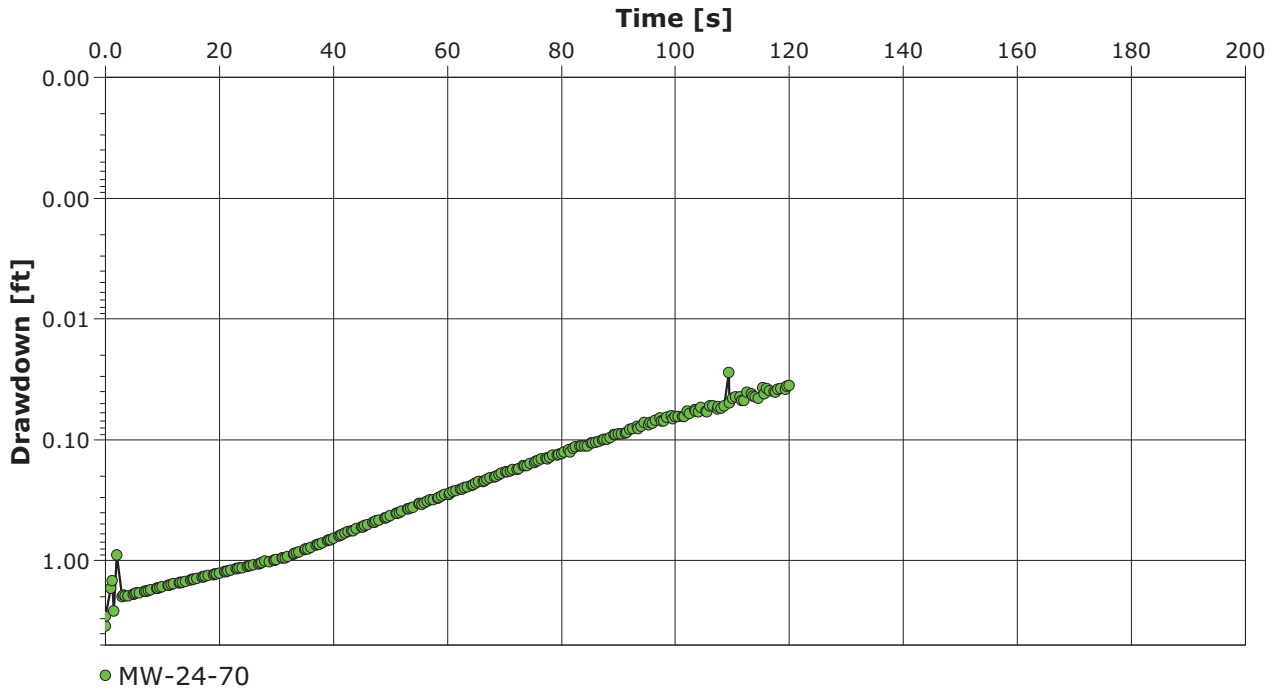
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-24-70 Test 4	Test Well: MW-24-70
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 43.00 ft		



ANCHOR QEA
6650 SW Redwood Lane, Suite 333
Portland, Oregon 97224
Phone 503.670.1108
Fax 503.670.1128

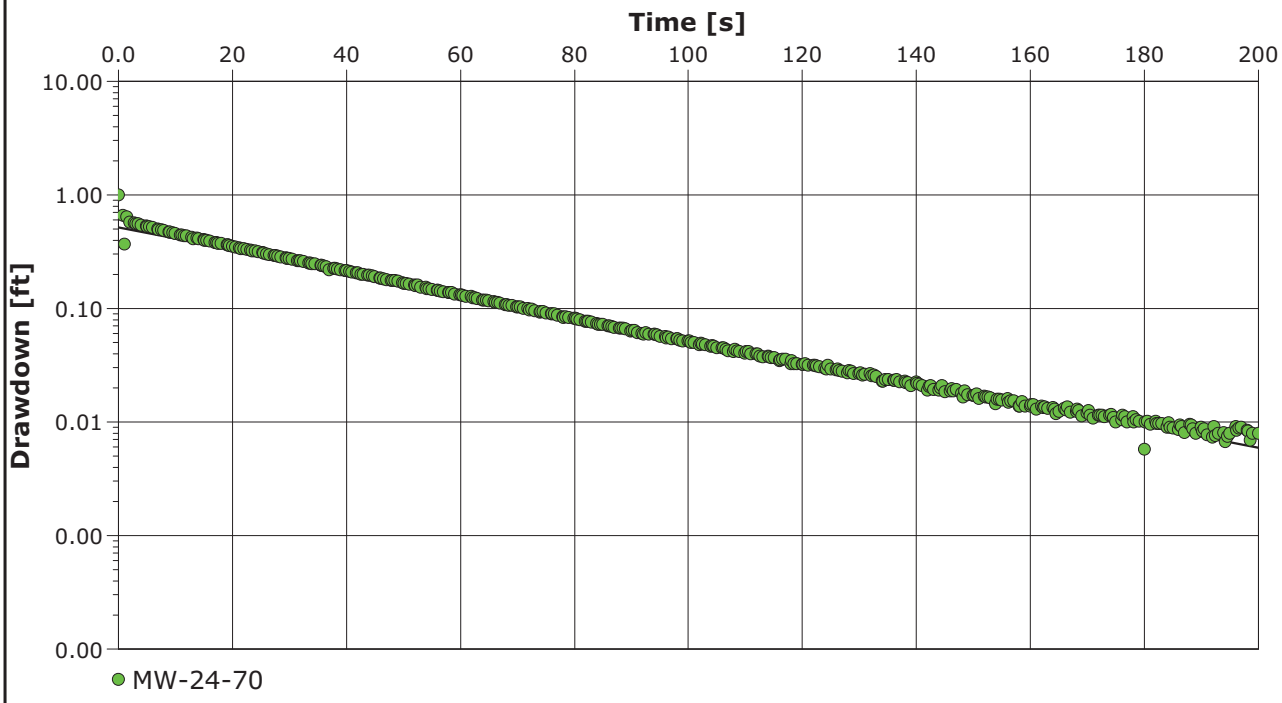
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: MW-24-70 Test 4	Test Well: MW-24-70
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 43.00 ft		

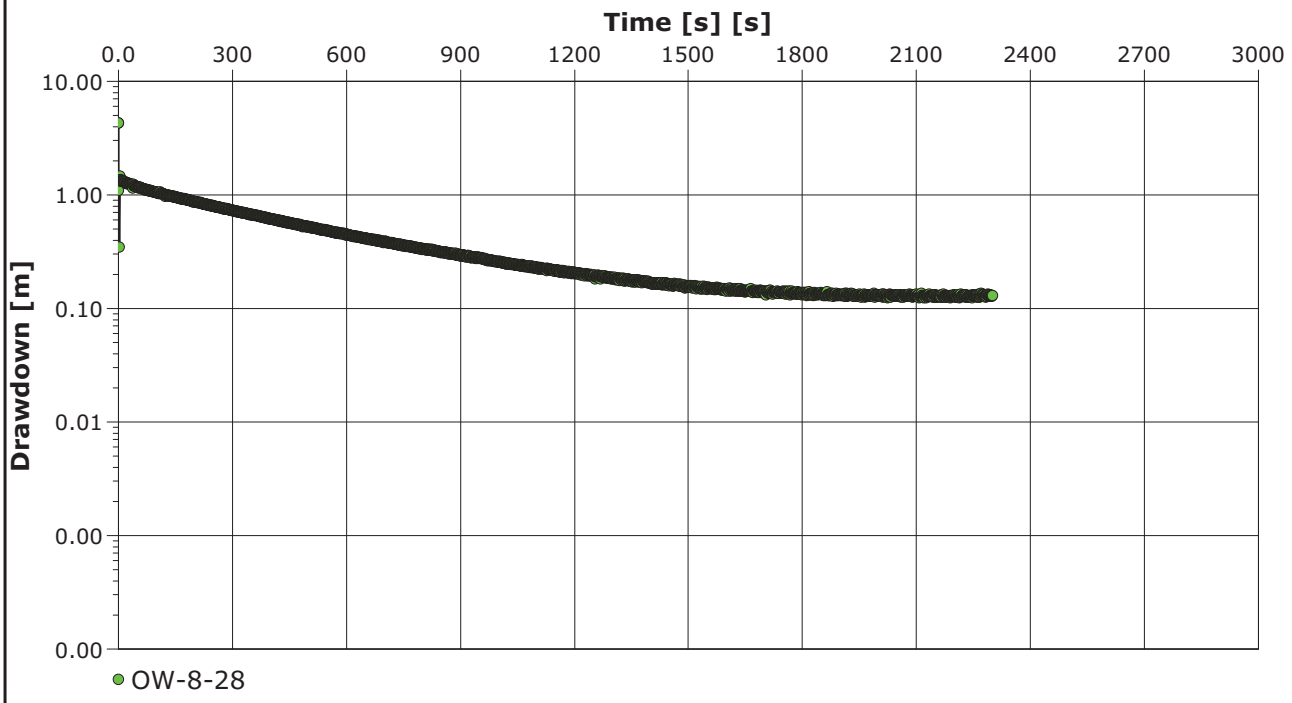


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
MW-24-70	2.48×10^{0}	

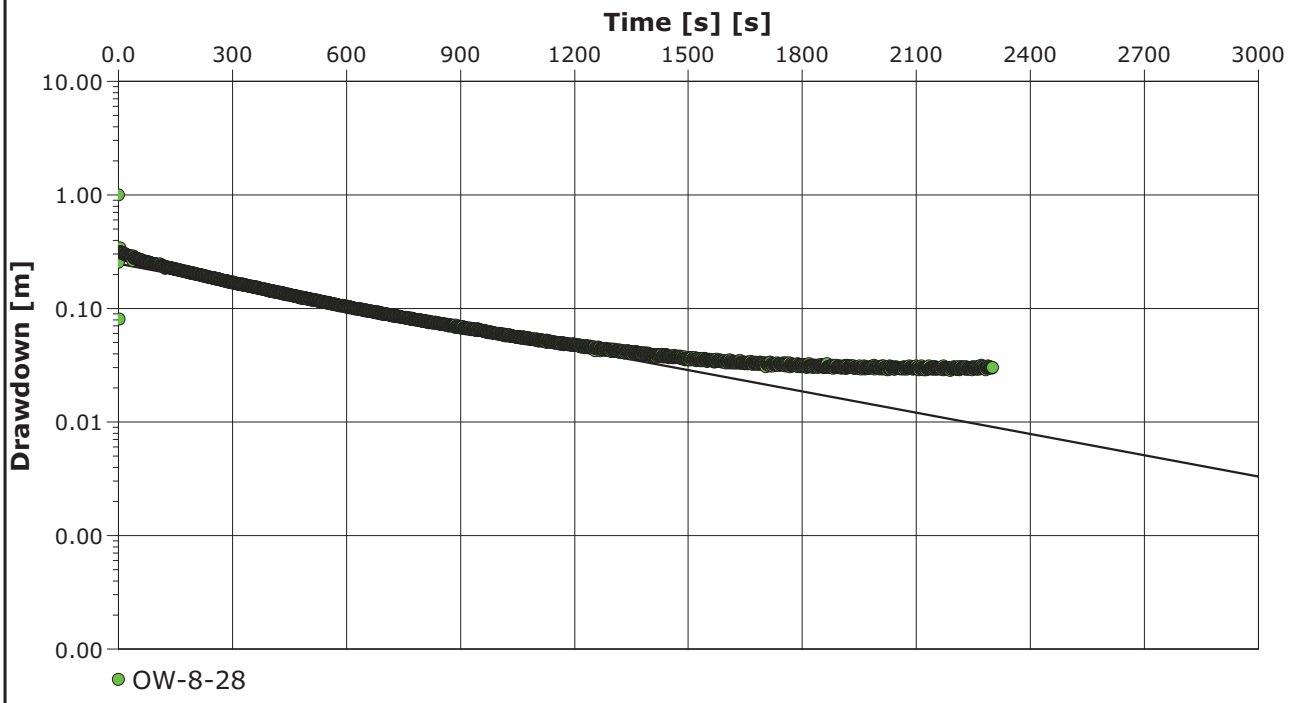
City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-8-28 Test 1	Test Well: OW-8-28
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 24.00 ft		



City, State/Province **Address** **Contact Info** **Company Name** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-8-28 Test 1	Test Well: OW-8-28
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 24.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
OW-8-28	2.71×10^{-1}	

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City, State/Province
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Contact Info Phone 503.670.1108
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Company Name

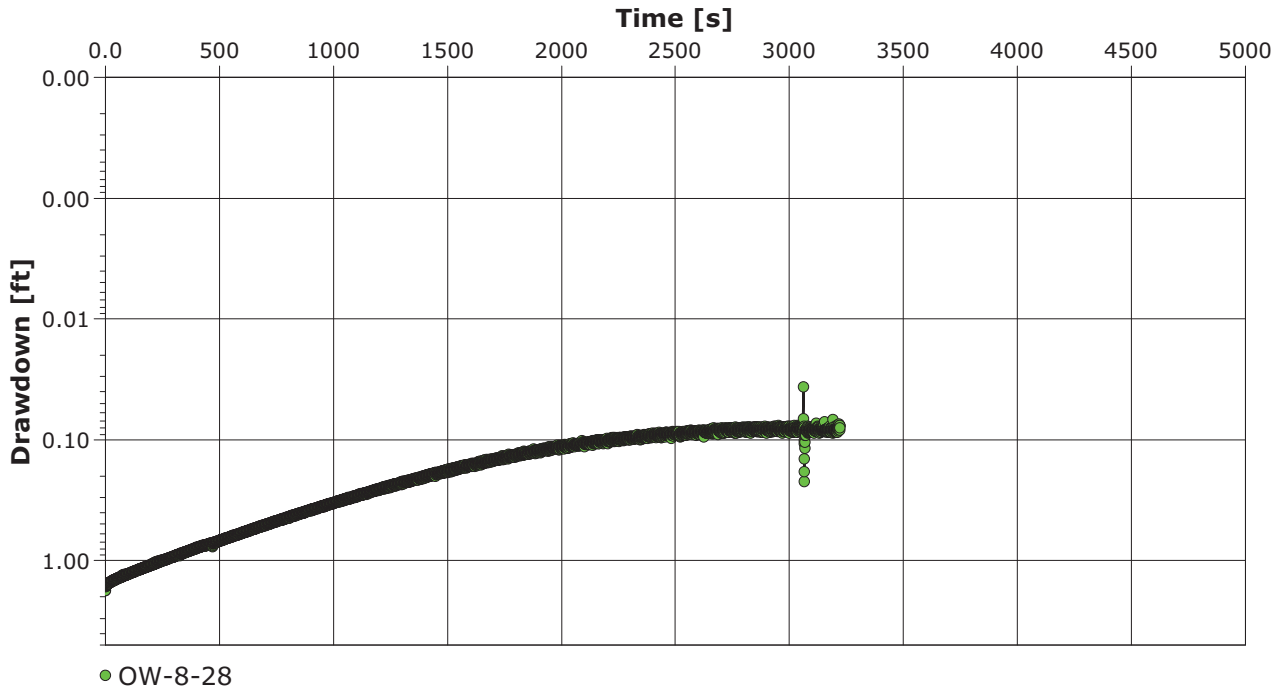
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-8-28 Test 2	Test Well: OW-8-28
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 24.00 ft		



ANCHOR QEA
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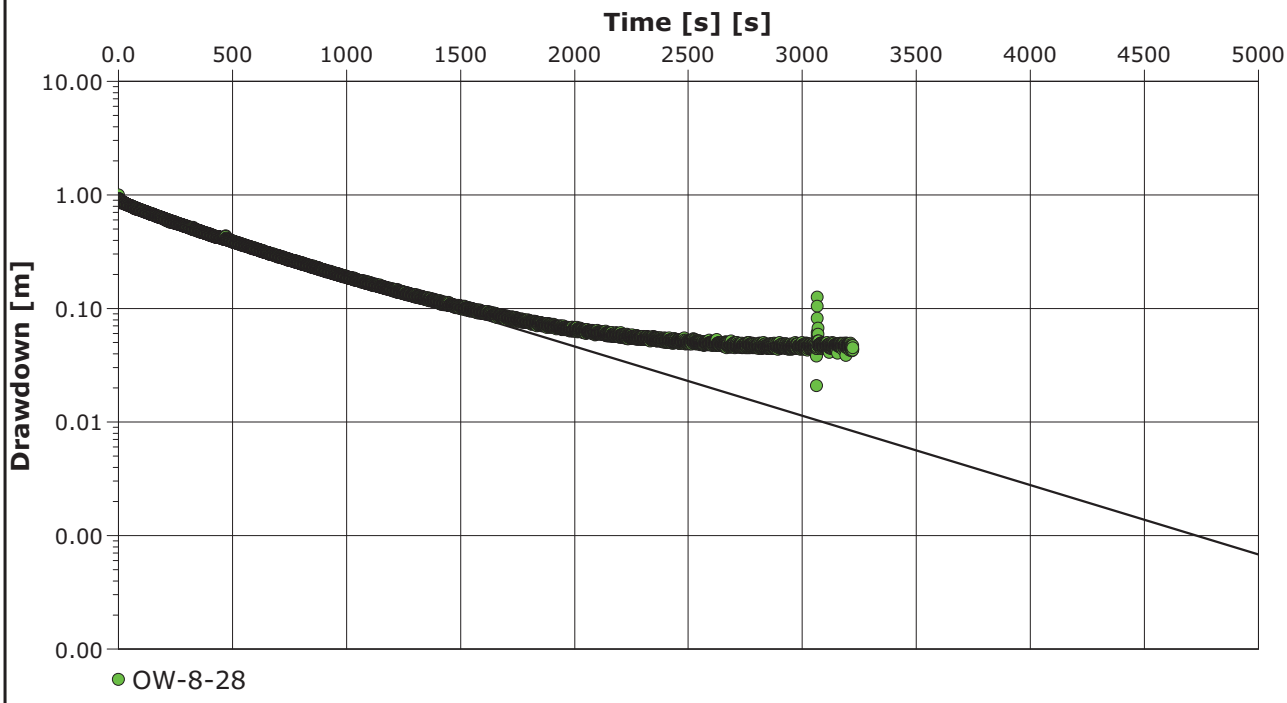
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-8-28 Test 2	Test Well: OW-8-28
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 24.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
OW-8-28	2.64×10^{-1}	

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Company Name

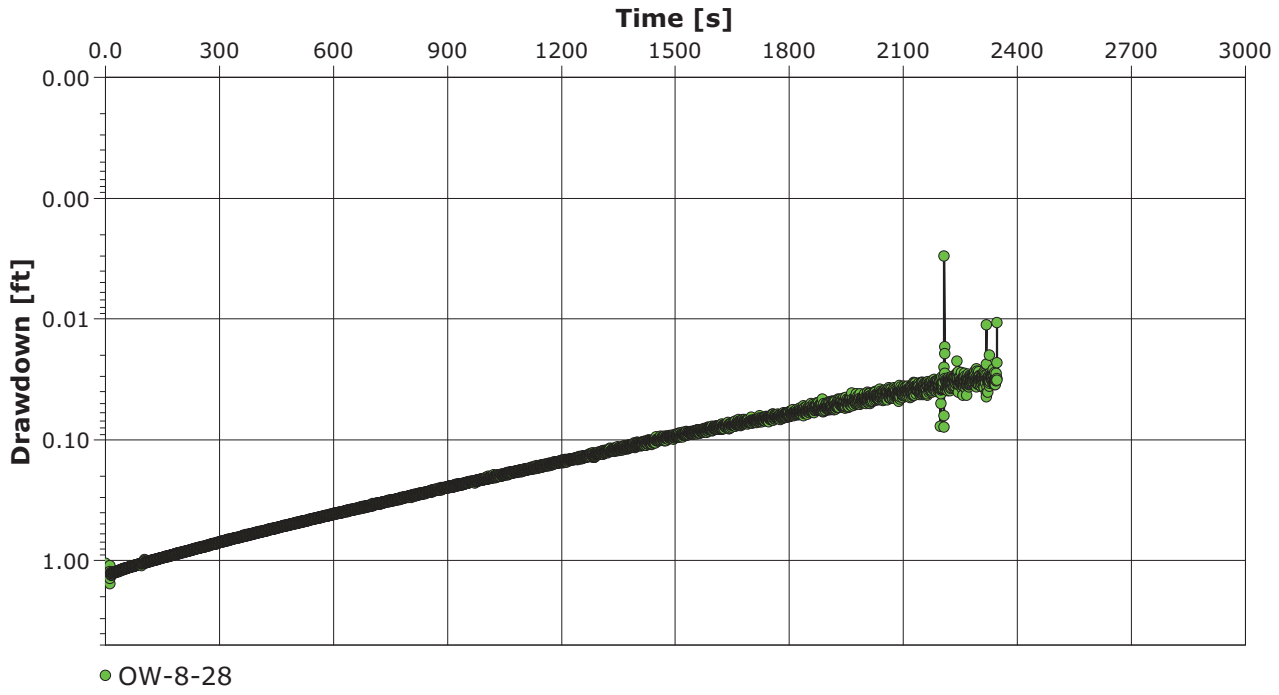
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

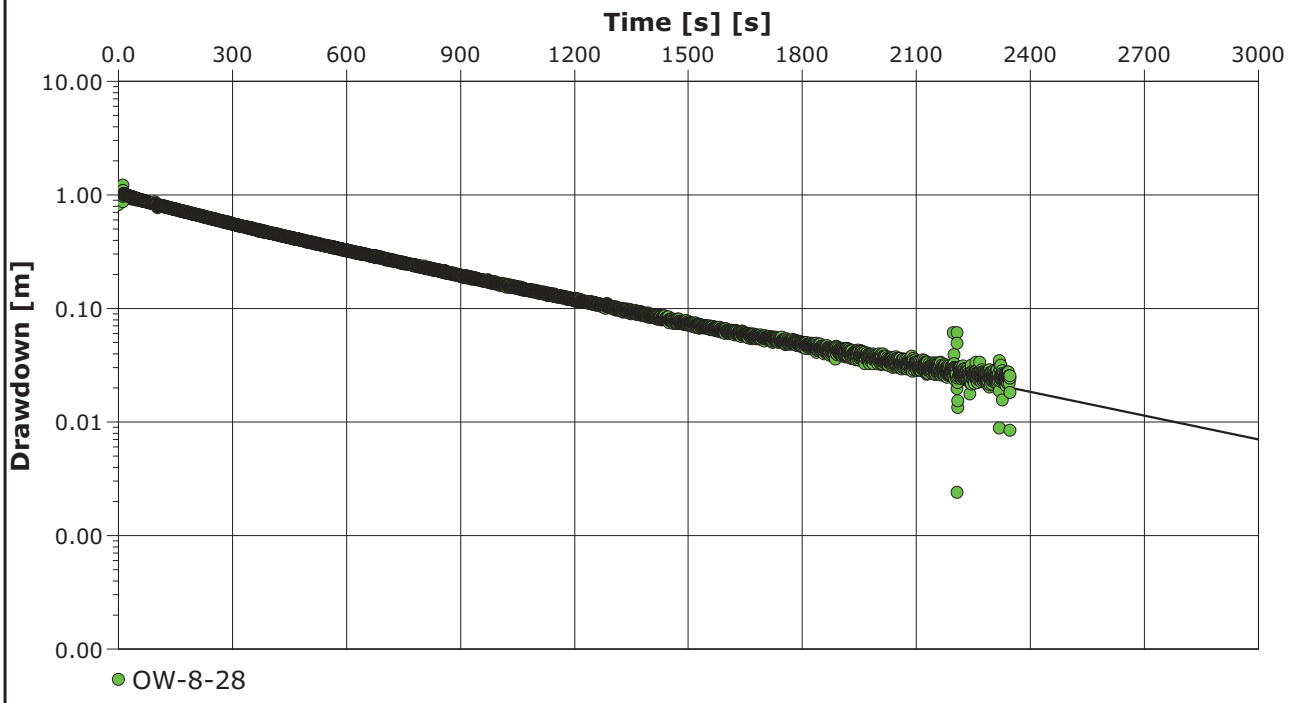
Location: Portland, Oregon	Slug Test: OW-8-28 Test 3	Test Well: OW-8-28
Test conducted by: MWilson/DLaffoon		Test date: 1/14/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 24.00 ft		



City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: OW-8-28 Test 3	Test Well: OW-8-28
Test conducted by: MWilson/DLaffoon		Test date: 1/14/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 24.00 ft		



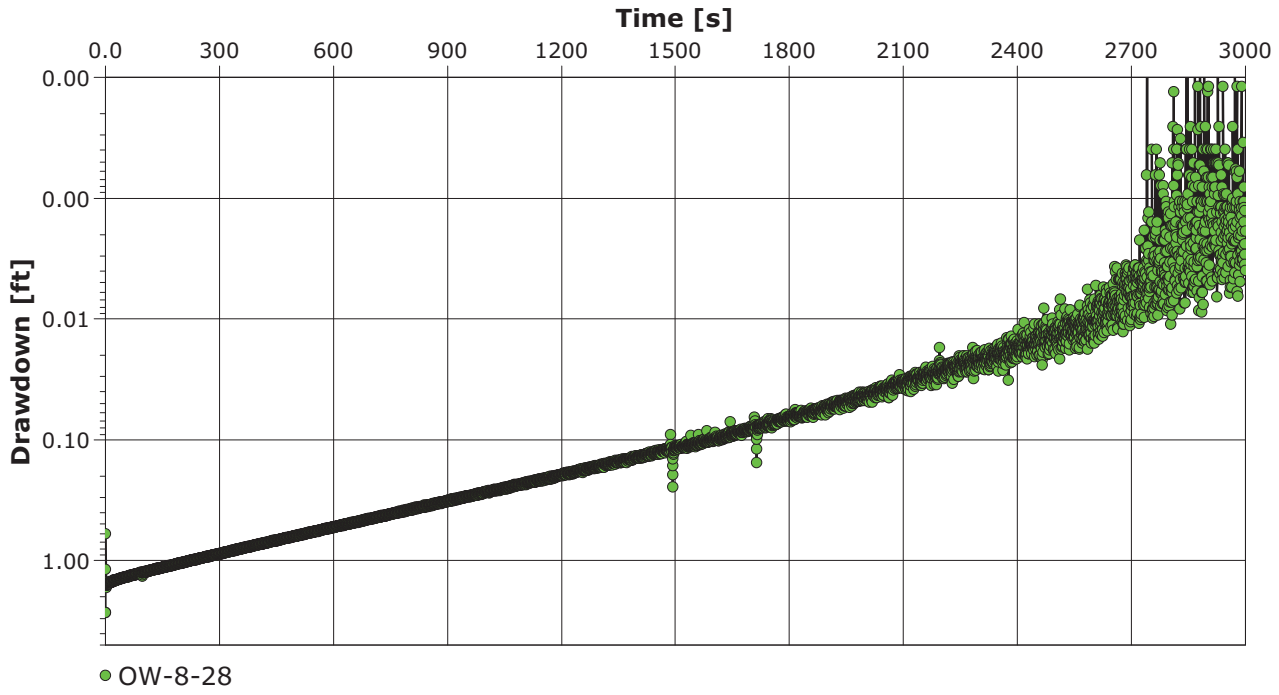
Calculation after Bouwer && Rice

Observation well	K [ft/d]	
OW-8-28	3.03×10^{-1}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

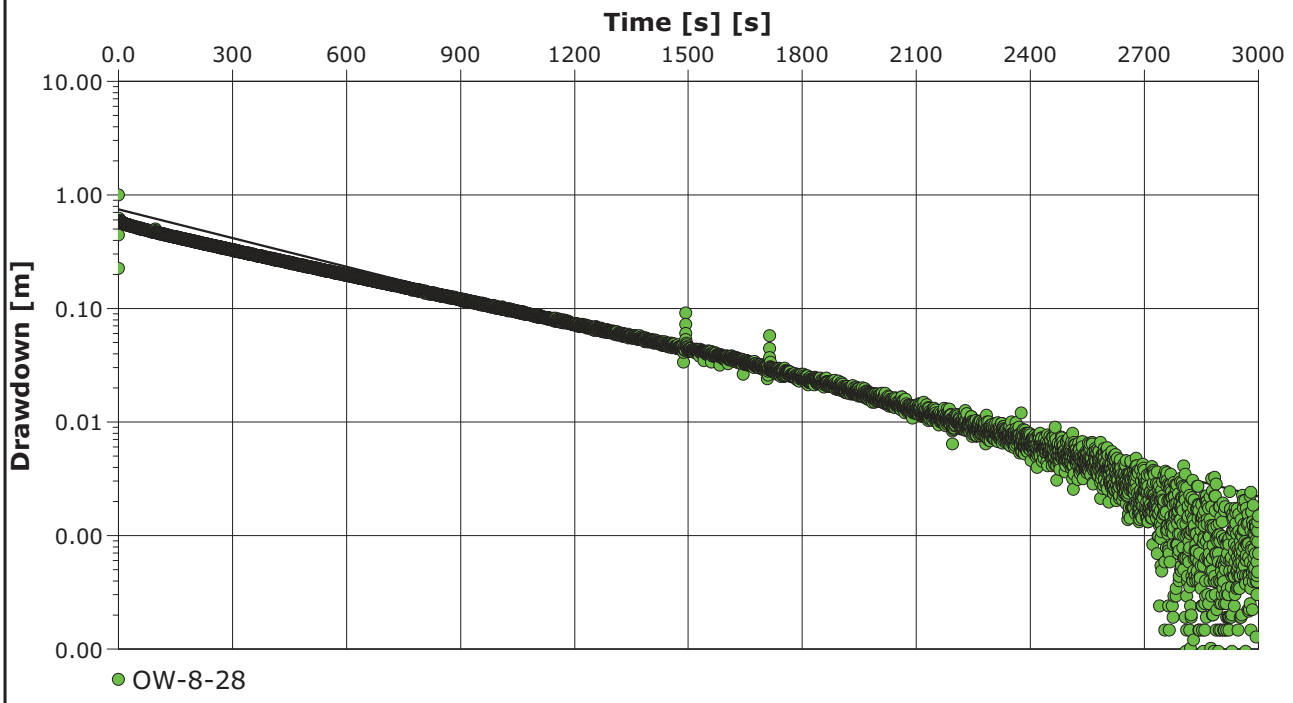
Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: OW-8-28 Test 4	Test Well: OW-8-28
Test conducted by: MWilson/DLaffoon		Test date: 1/14/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 24.00 ft		



ANCHOR QEA City, State/Province Address Contact Info Company Name 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-8-28 Test 4	Test Well: OW-8-28
Test conducted by: MWilson/DLaffoon		Test date: 1/14/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 24.00 ft		

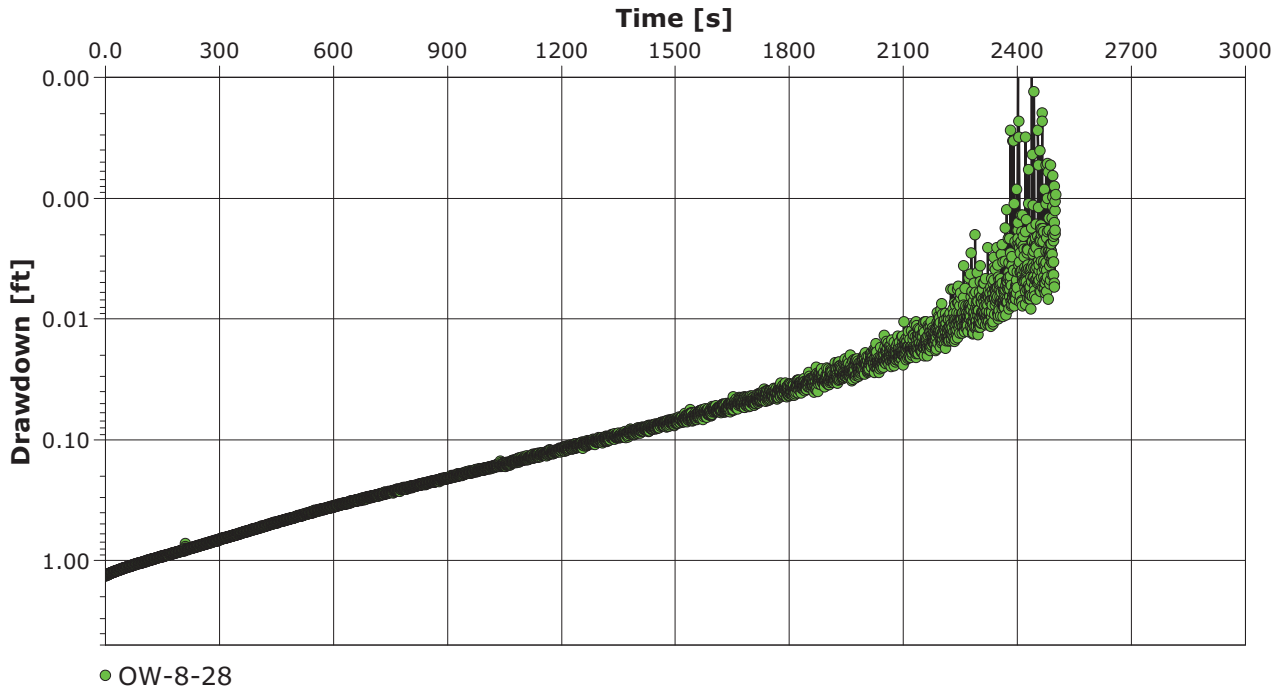


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
OW-8-28	3.65×10^{-1}	

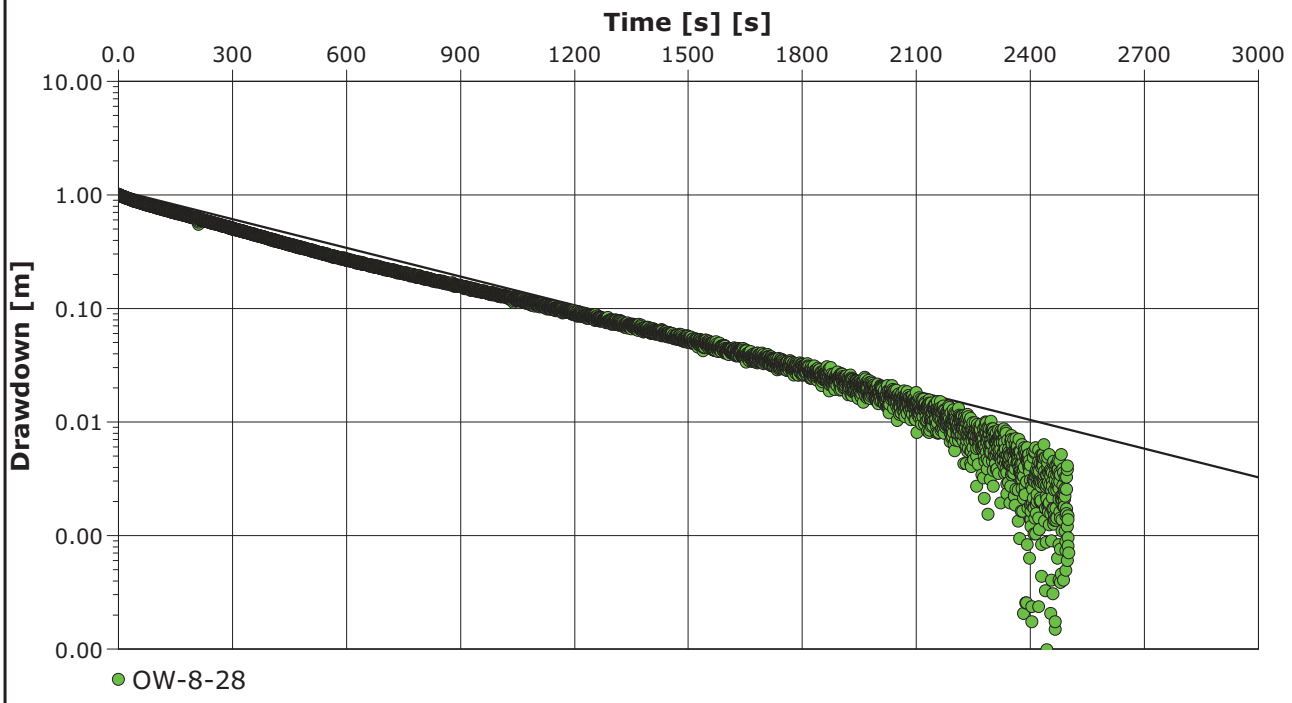
City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-8-28 Test 5	Test Well: OW-8-28
Test conducted by: MWilson/DLaffoon		Test date: 1/14/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 24.00 ft		



City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: OW-8-28 Test 5	Test Well: OW-8-28
Test conducted by: MWilson/DLaffoon		Test date: 1/14/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 24.00 ft		



Calculation after Bouwer && Rice		
Observation well	K [ft/d]	
OW-8-28	3.65×10^{-1}	

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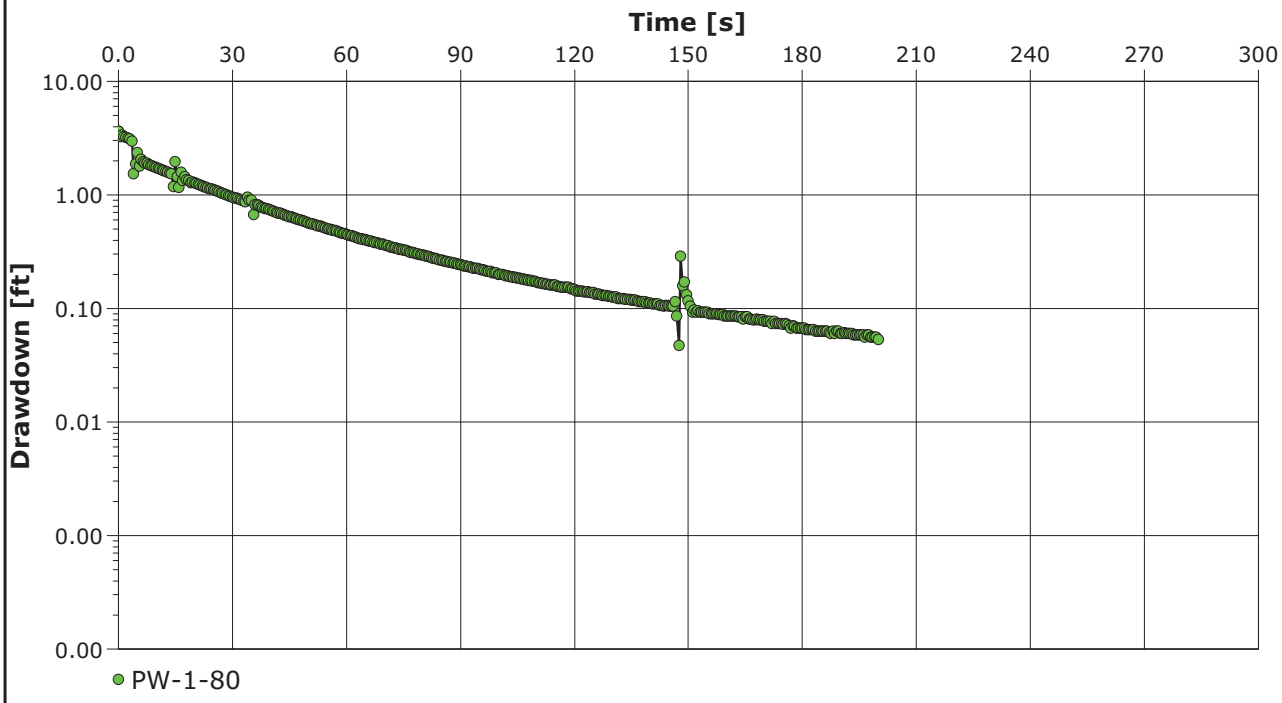
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: PW-1-80 Test 1	Test Well: PW-1-80
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 61.00 ft		



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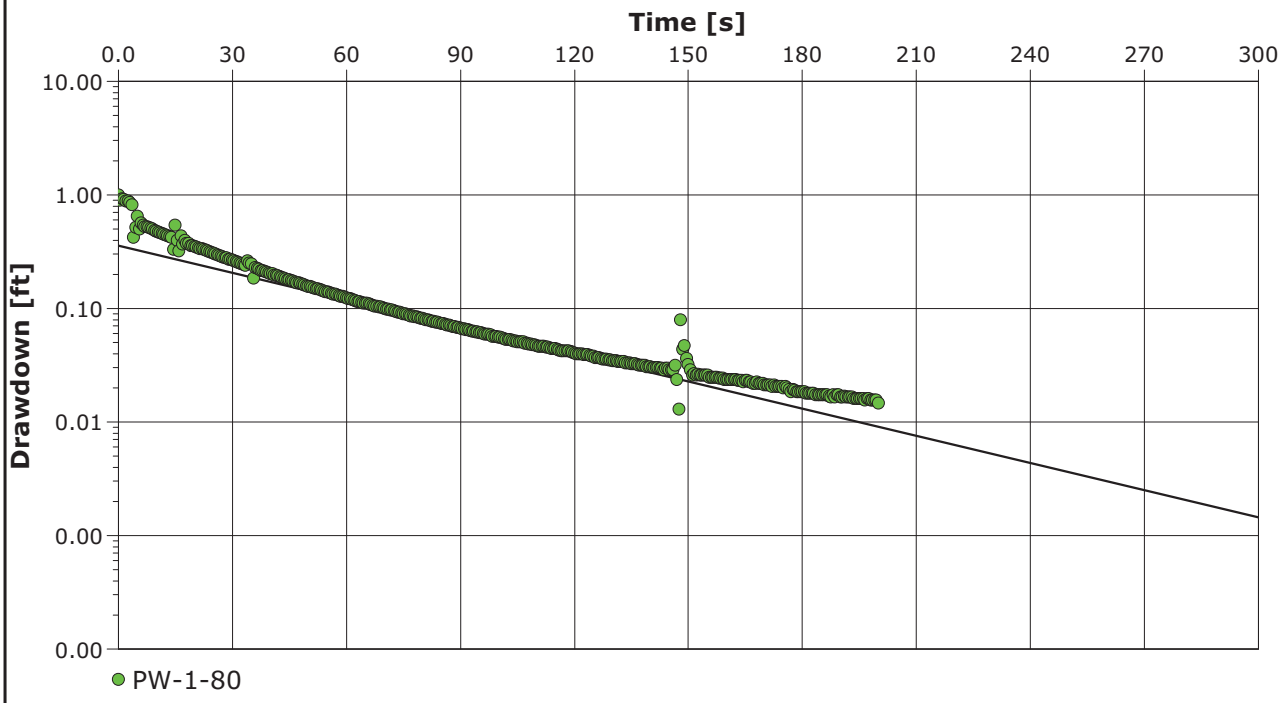
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: PW-1-80 Test 1	Test Well: PW-1-80
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 61.00 ft		

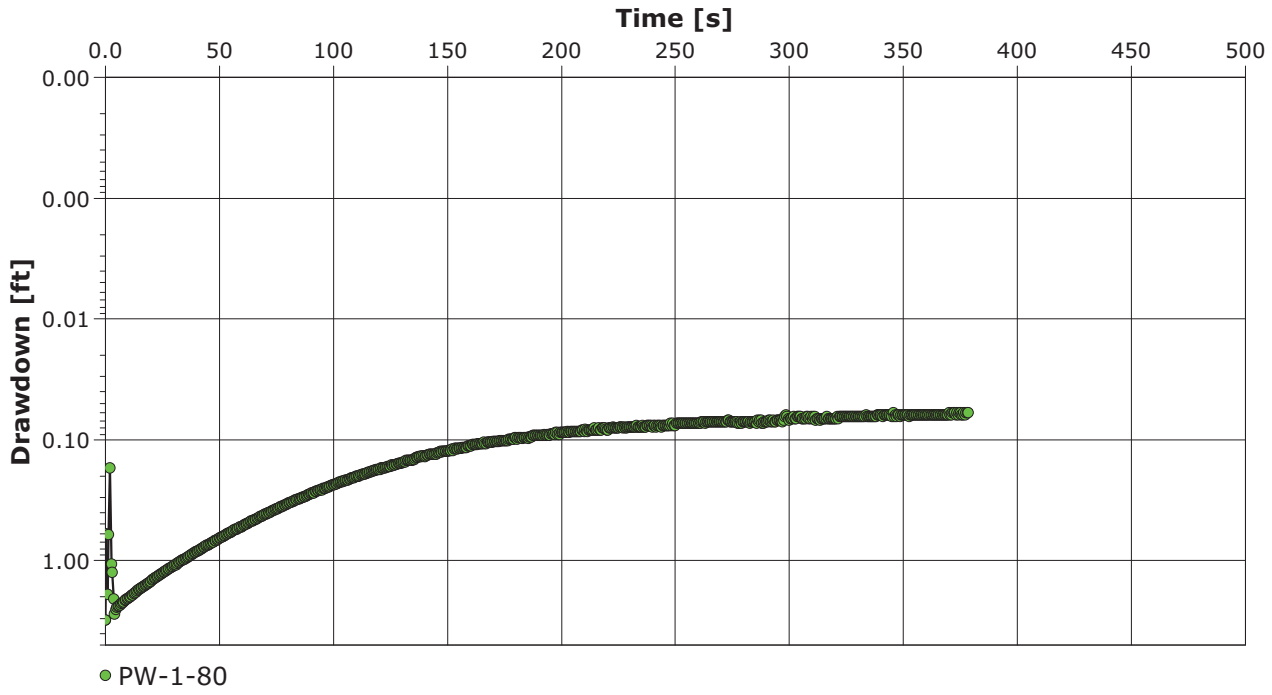


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PW-1-80	4.92×10^{0}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: PW-1-80 Test 2	Test Well: PW-1-80
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 61.00 ft		



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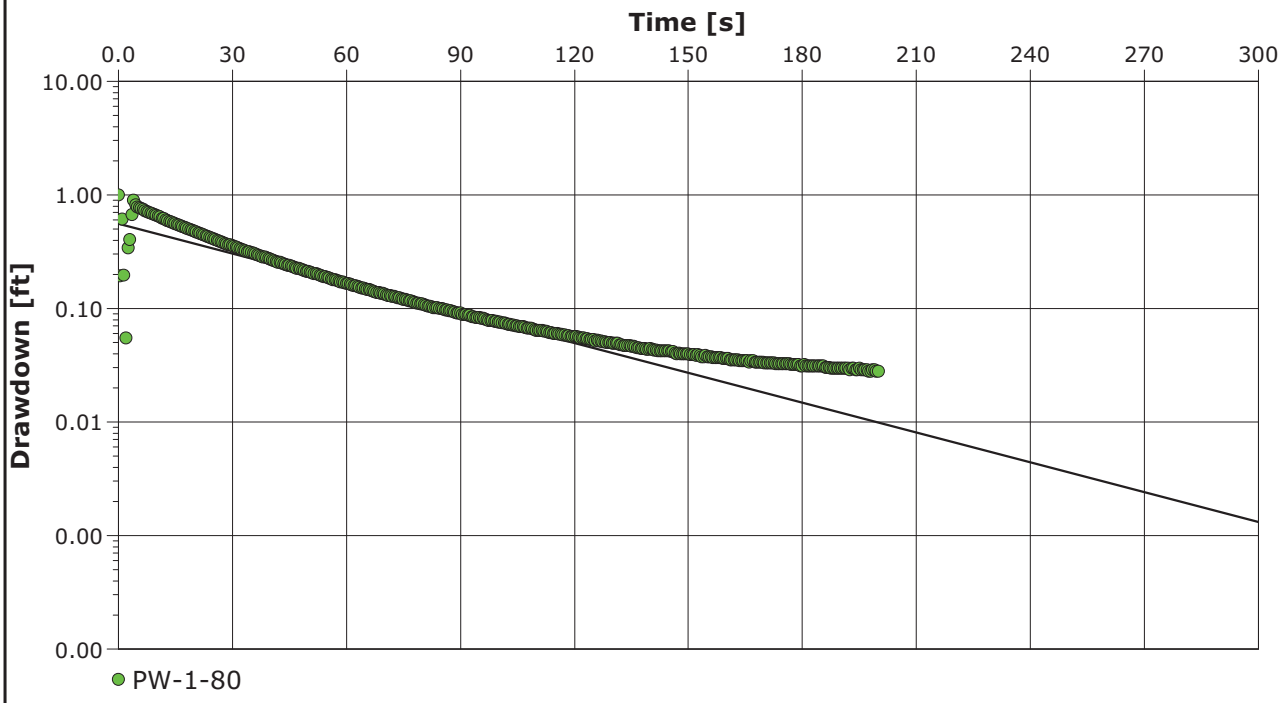
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: PW-1-80 Test 2	Test Well: PW-1-80
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 61.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PW-1-80	5.40×10^{0}	

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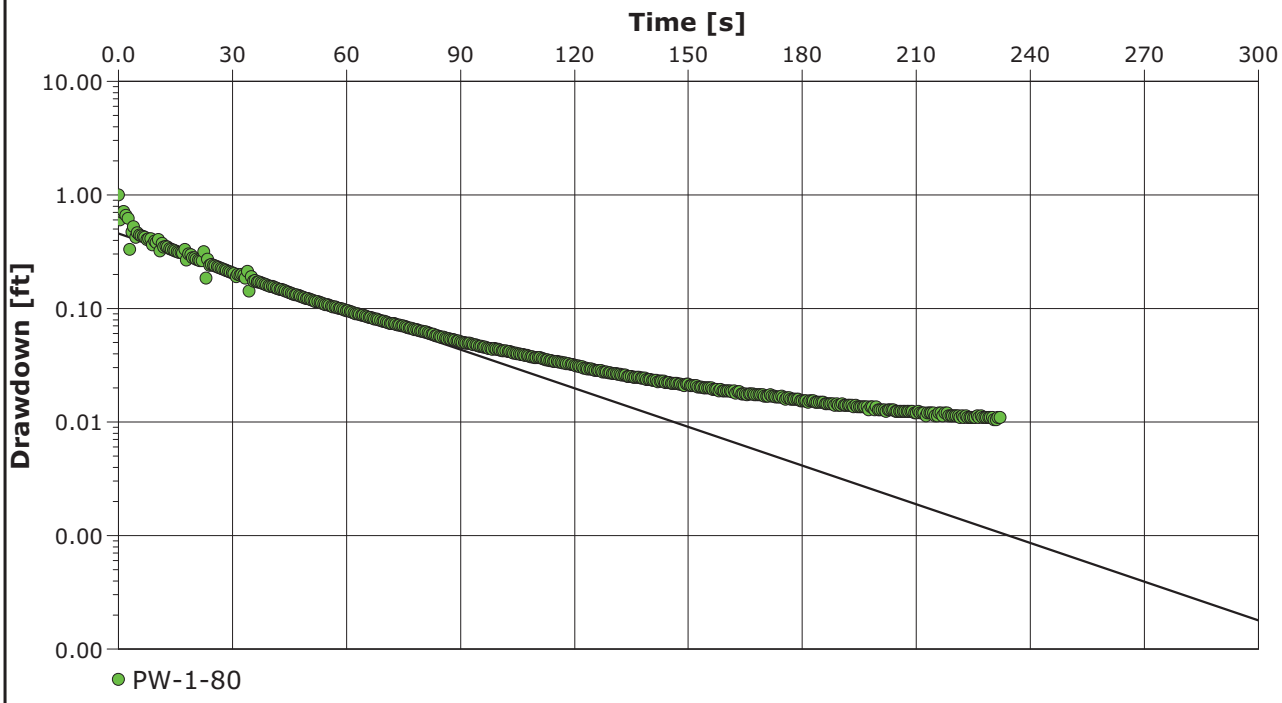
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: PW-1-80 Test 3	Test Well: PW-1-80
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 61.00 ft		



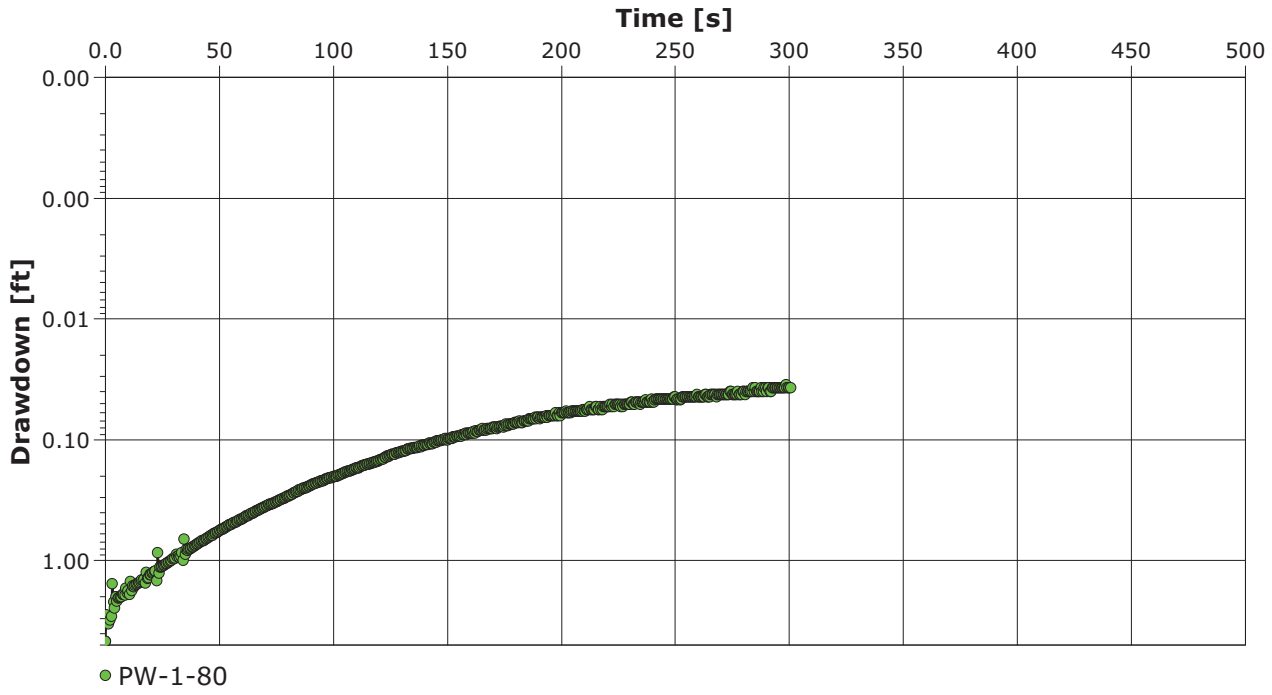
Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PW-1-80	7.00×10^{0}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

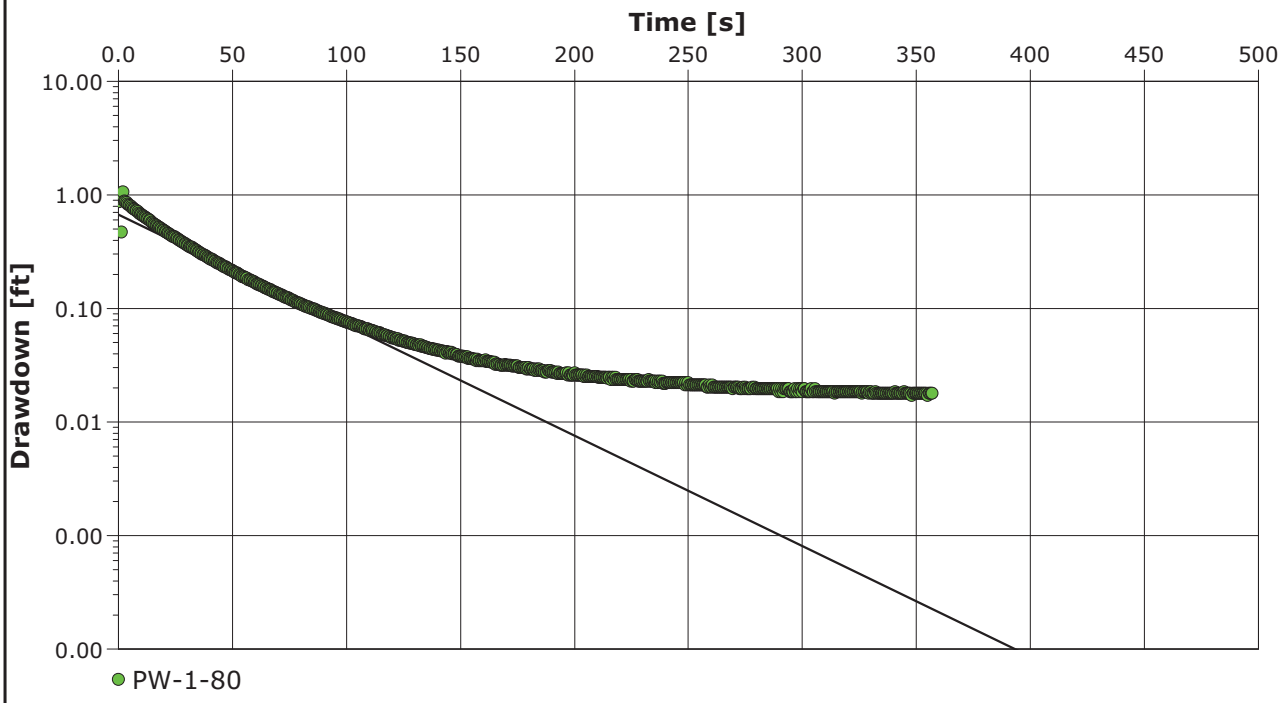
Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: PW-1-80 Test 3	Test Well: PW-1-80
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 61.00 ft		



ANCHOR QEA City, State/Province Address Contact Info Company Name 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: PW-1-80 Test 4	Test Well: PW-1-80
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 61.00 ft		

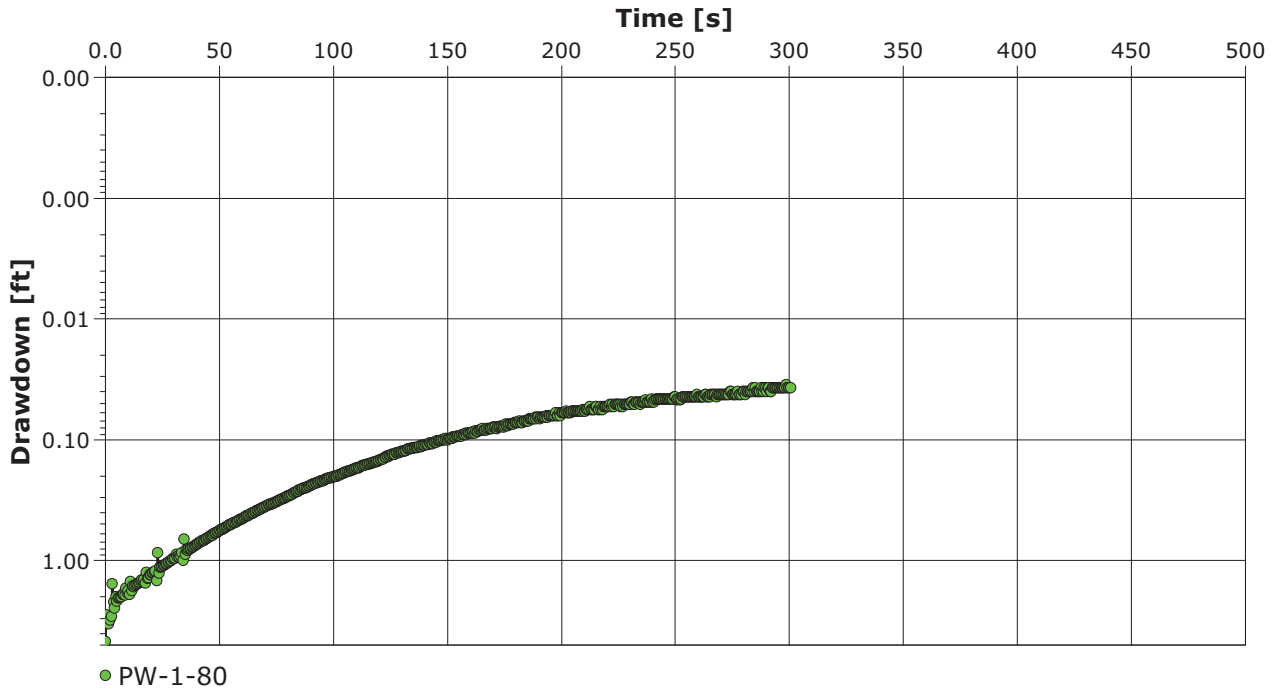


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PW-1-80	6.00×10^{0}	

ANCHOR QEA City, State/Province Address Contact Info Company Name	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

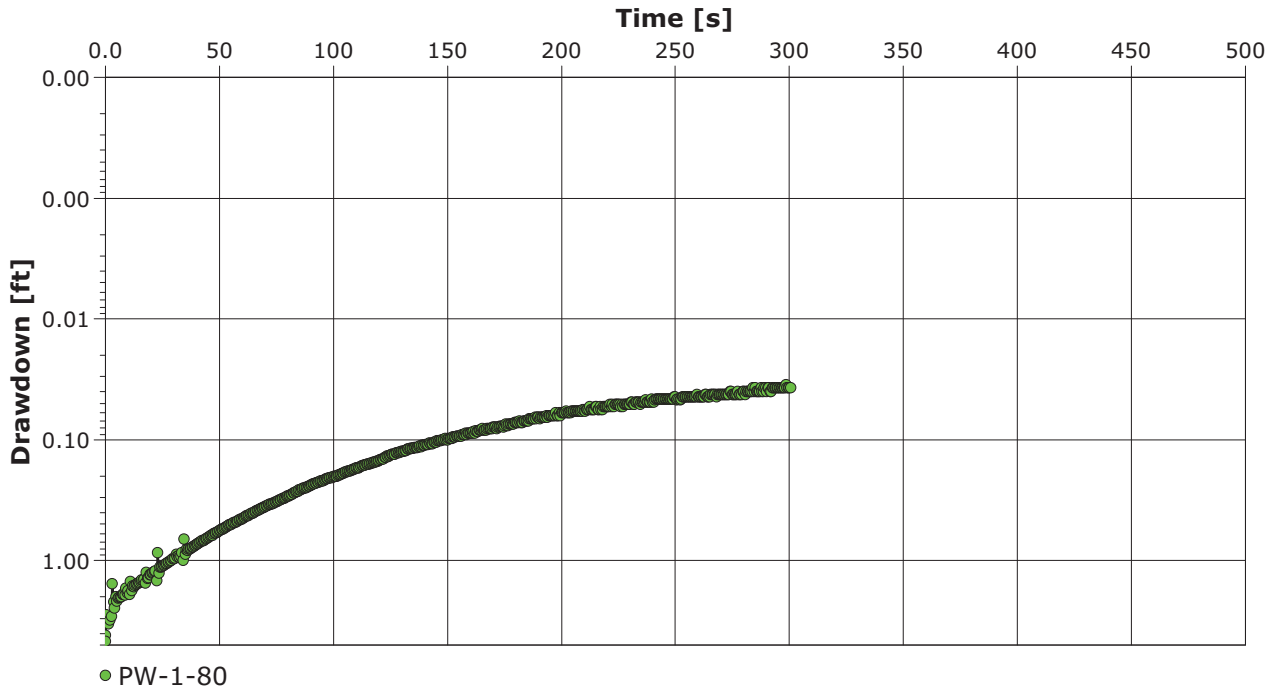
Location: Portland, Oregon	Slug Test: PW-1-80 Test 4	Test Well: PW-1-80
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 61.00 ft		



City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: PW-1-80 Test 5	Test Well: PW-1-80
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 61.00 ft		



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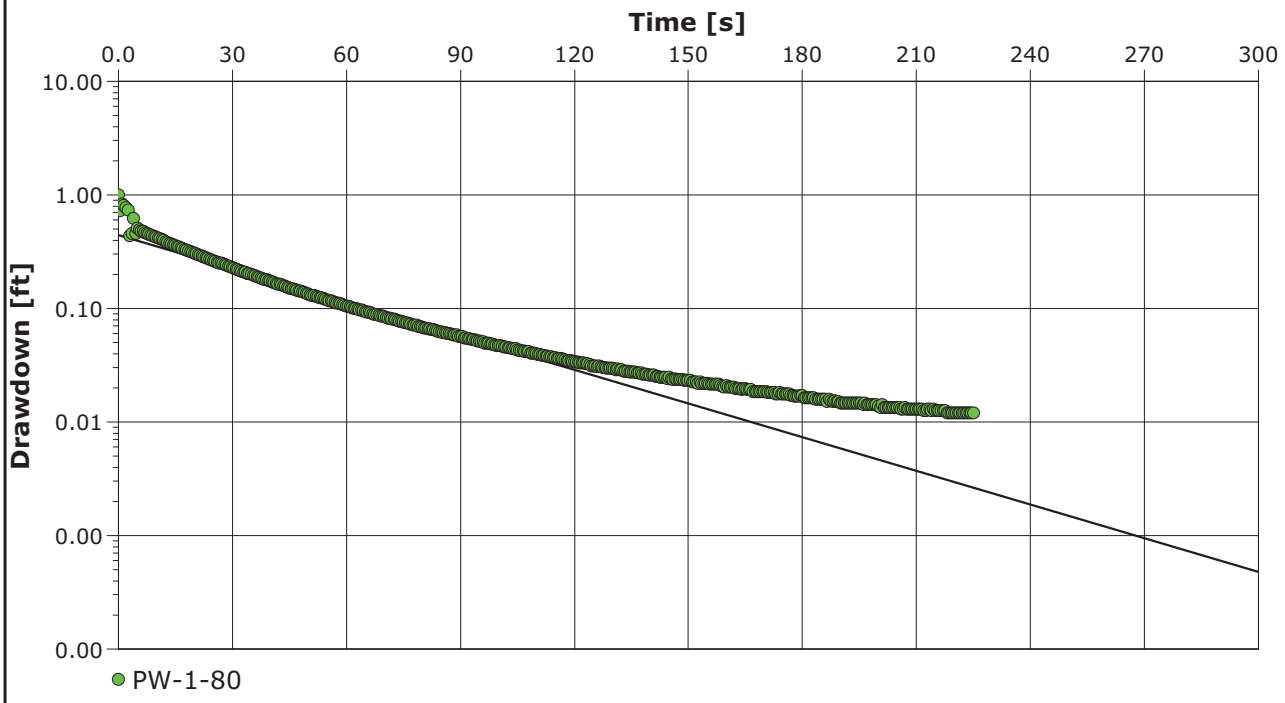
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: PW-1-80 Test 5	Test Well: PW-1-80
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 61.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PW-1-80	6.10×10^{0}	

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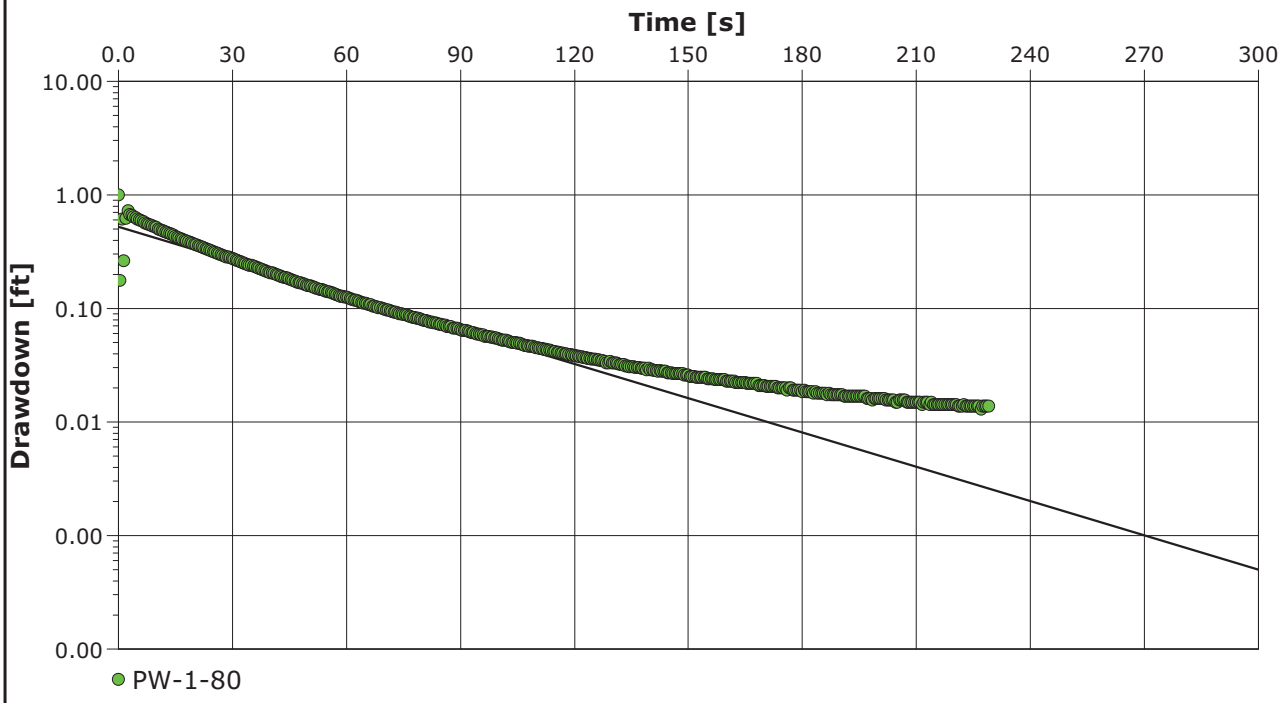
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: PW-1-80 Test 6	Test Well: PW-1-80
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 61.00 ft		

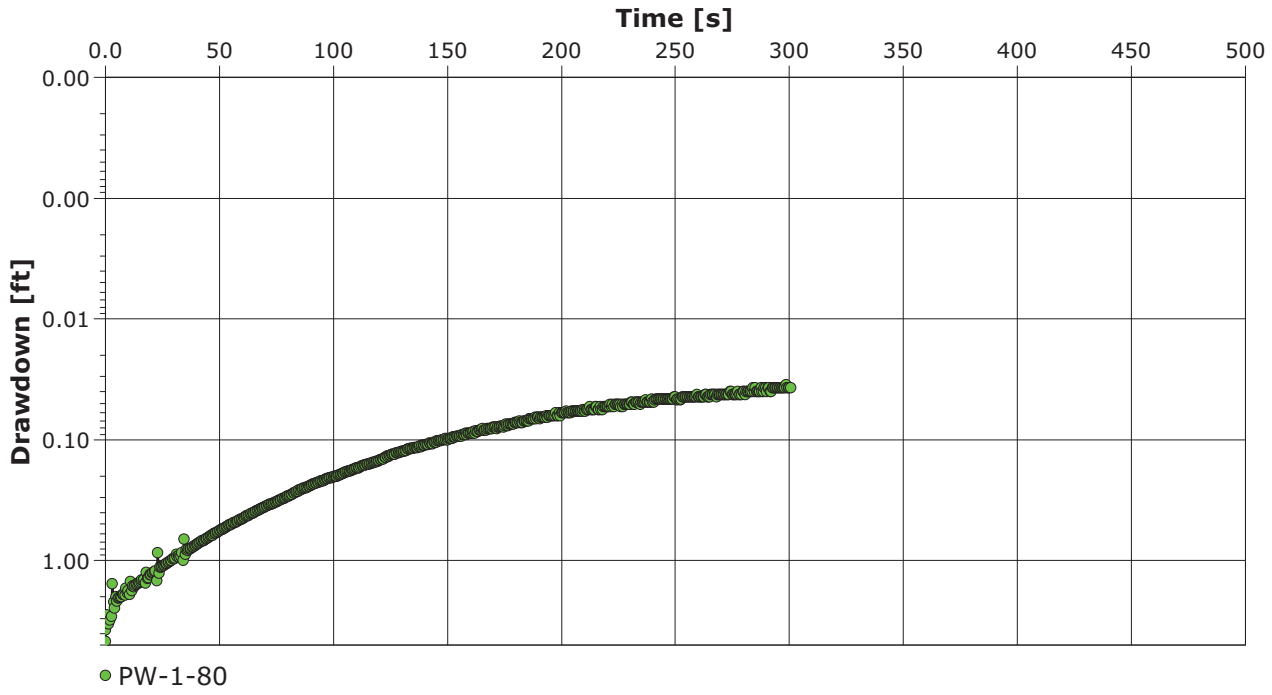


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PW-1-80	6.20×10^{0}	

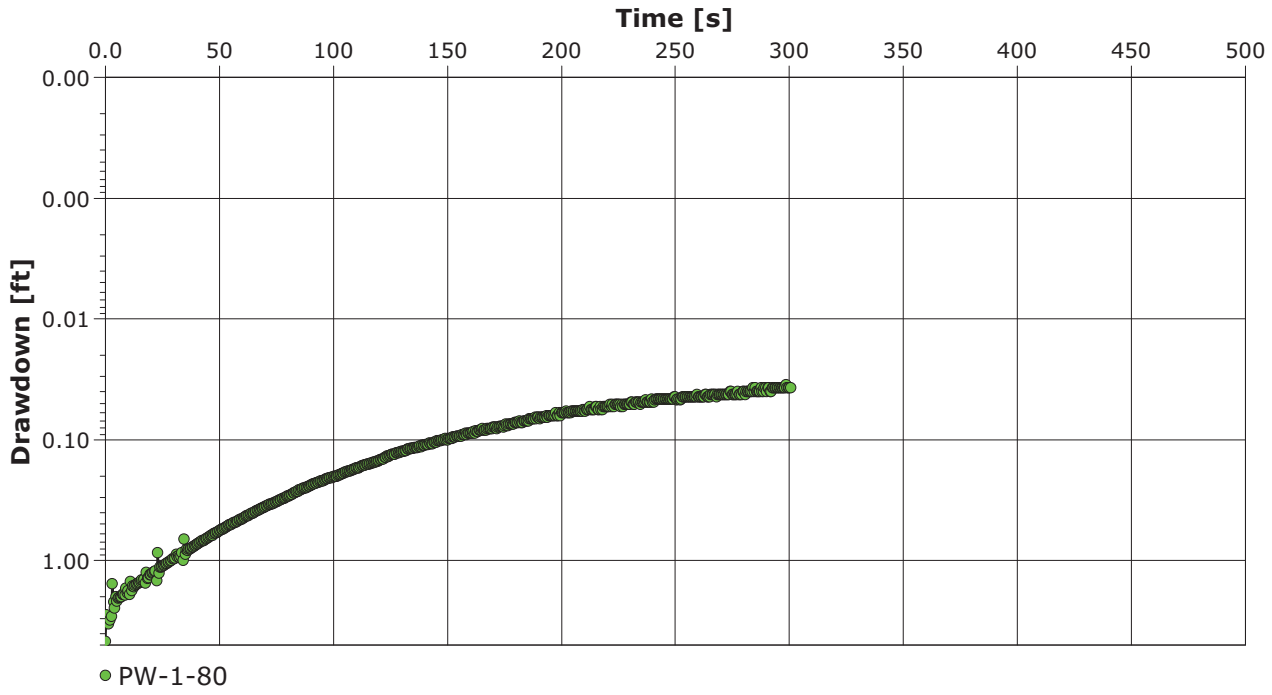
ANCHOR QEA **City, State/Province** **Address** **Contact Info** **Company Name** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report**	
	Project: Gasco Ground Water Source Control	
	Number: 000029-02.28 task 3A	
	Client: NW Natural	

Location: Portland, Oregon	Slug Test: PW-1-80 Test 6	Test Well: PW-1-80
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 61.00 ft		



ANCHOR QEA **City, State/Province** **Address** **Contact Info** **Company Name** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report**	
	Project: Gasco Ground Water Source Control	
	Number: 000029-02.28 task 3A	
	Client: NW Natural	

Location: Portland, Oregon	Slug Test: PW-1-80 Test 7	Test Well: PW-1-80
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 61.00 ft		



ANCHOR QEA
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Portland, Oregon 97224
Phone 503.670.1108
Fax 503.670.1128

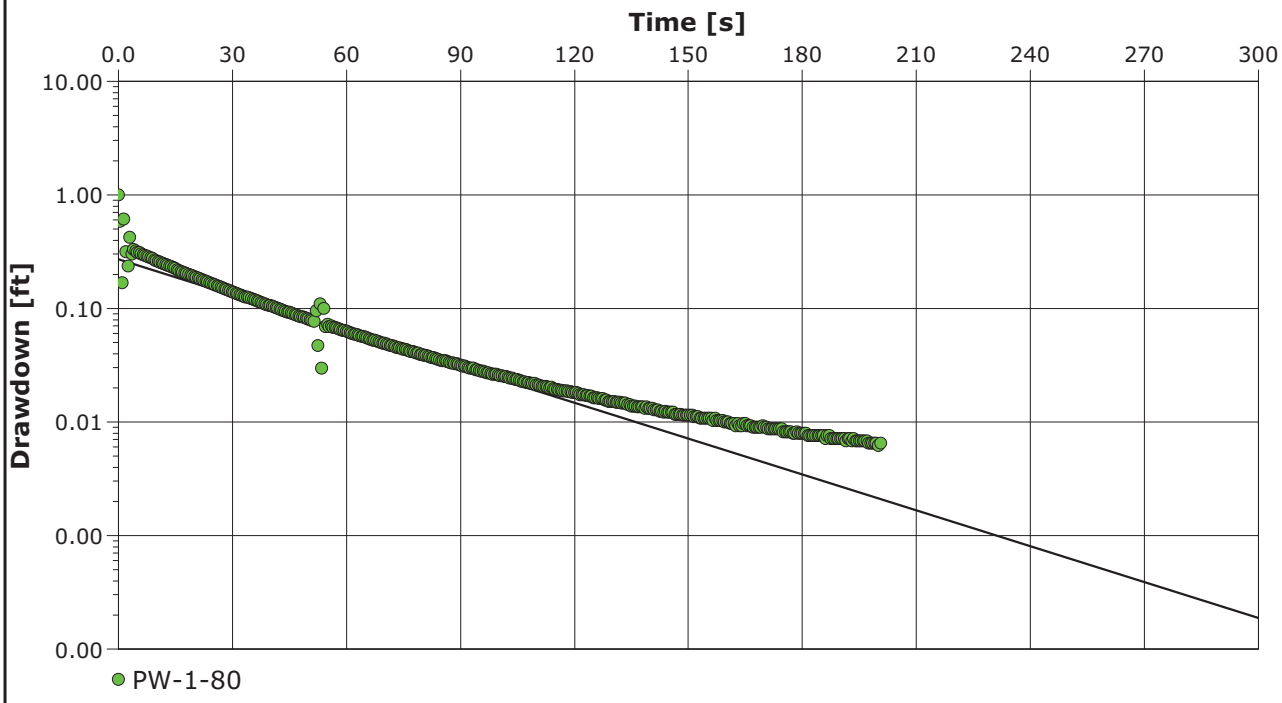
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: PW-1-80 Test 7	Test Well: PW-1-80
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 61.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PW-1-80	6.50×10^{0}	

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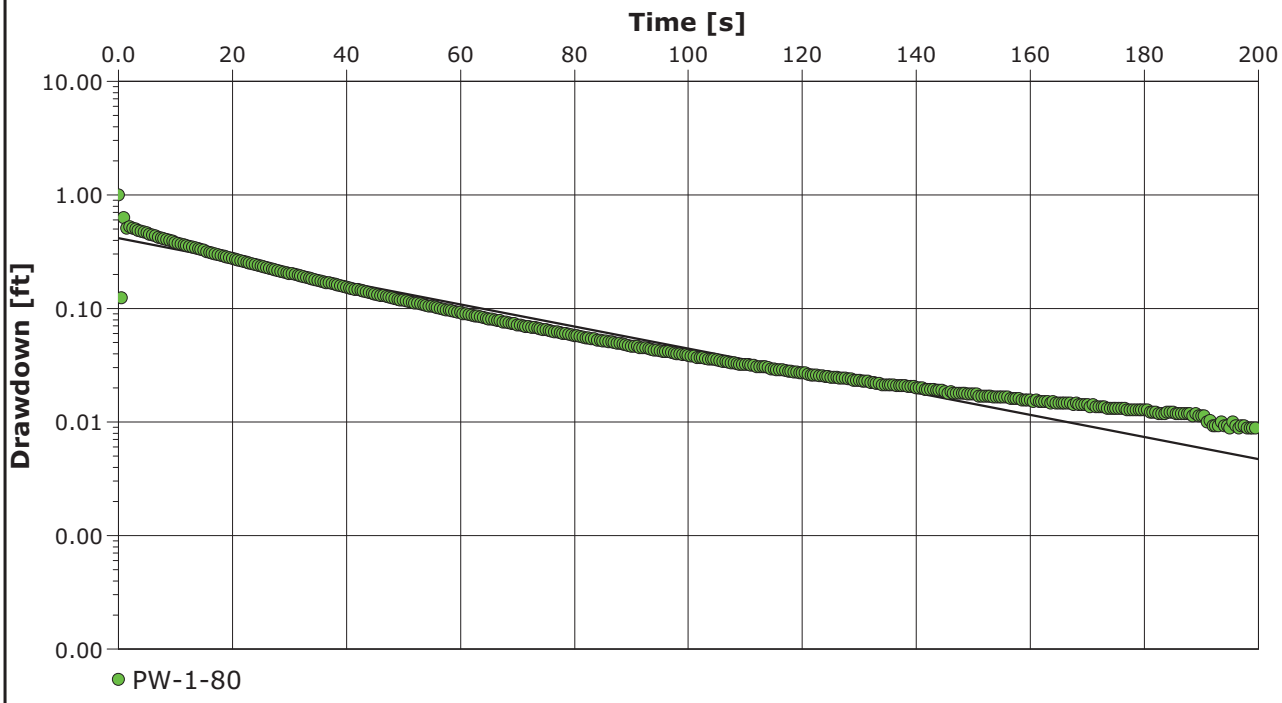
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: PW-1-80 Test 8	Test Well: PW-1-80
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 61.00 ft		



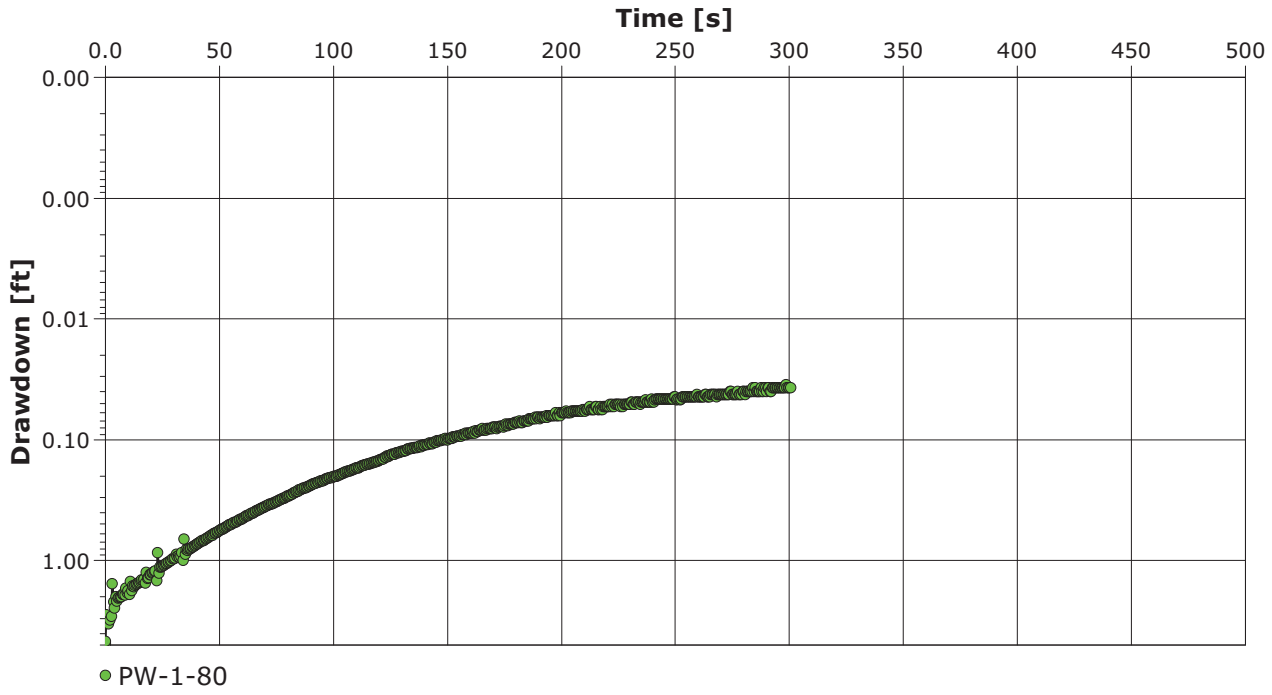
Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PW-1-80	6.00×10^{0}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

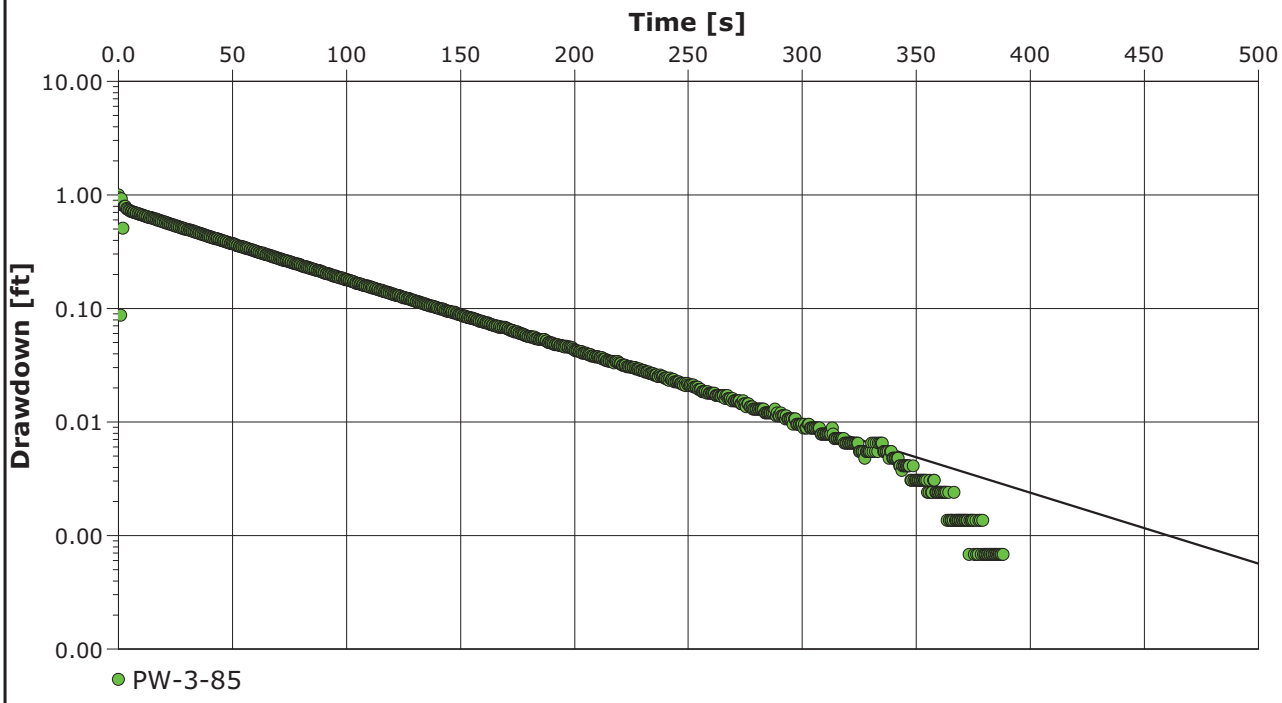
Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: PW-1-80 Test 8	Test Well: PW-1-80
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 61.00 ft		



City, State/Province **Address** **Contact Info** **Company Name** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: PW-3-85 Test 1	Test Well: PW-3-85
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 60.00 ft		

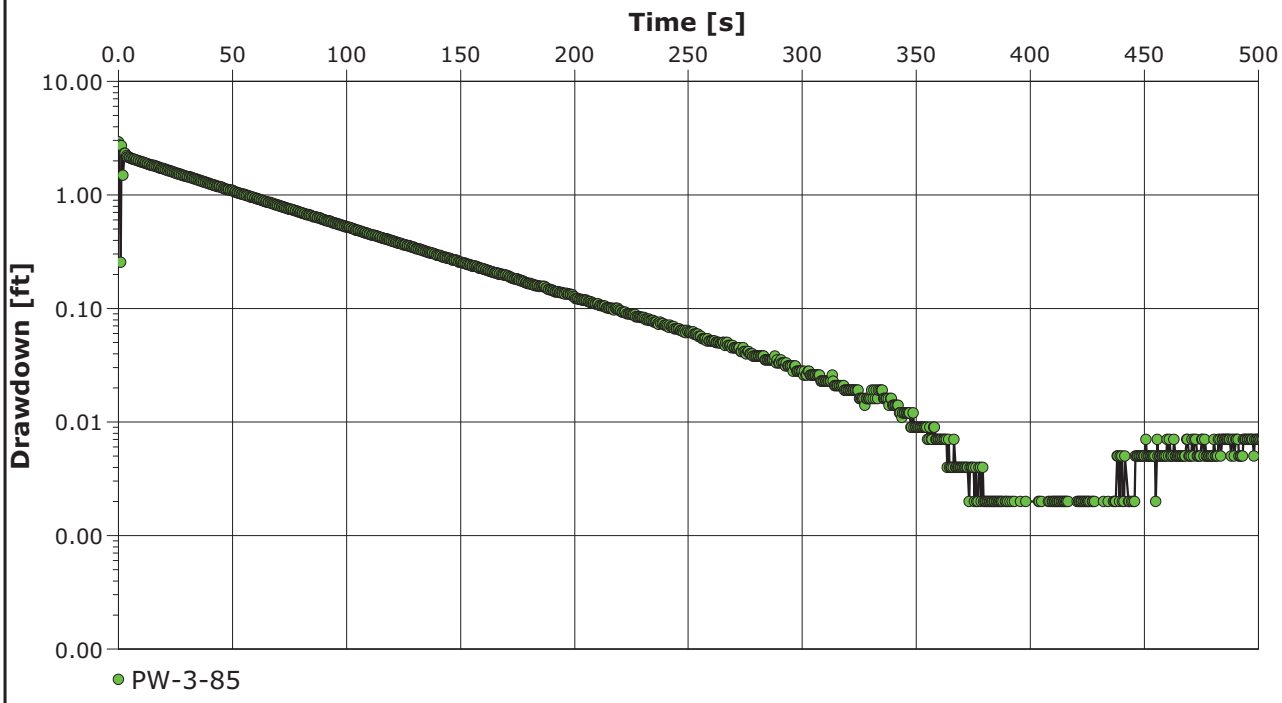


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PW-3-85	1.79×10^{1}	

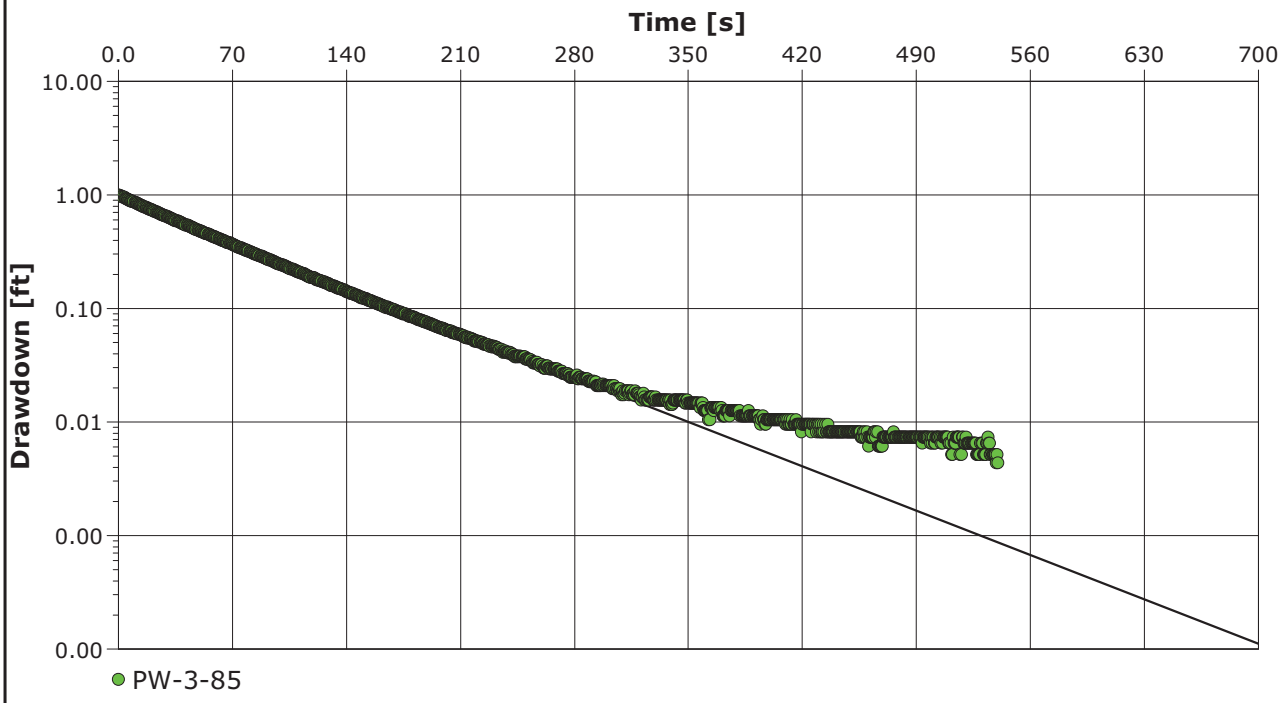
ANCHOR QEA **City, State/Province** **Address** **Contact Info** **Company Name** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: PW-3-85 Test 1	Test Well: PW-3-85
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 60.00 ft		



ANCHOR QEA **City, State/Province** **Address** **Contact Info** **Company Name** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: PW-3-85 Test 2	Test Well: PW-3-85
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 60.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PW-3-85	1.60×10^{1}	

ANCHOR QEA
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Company Name

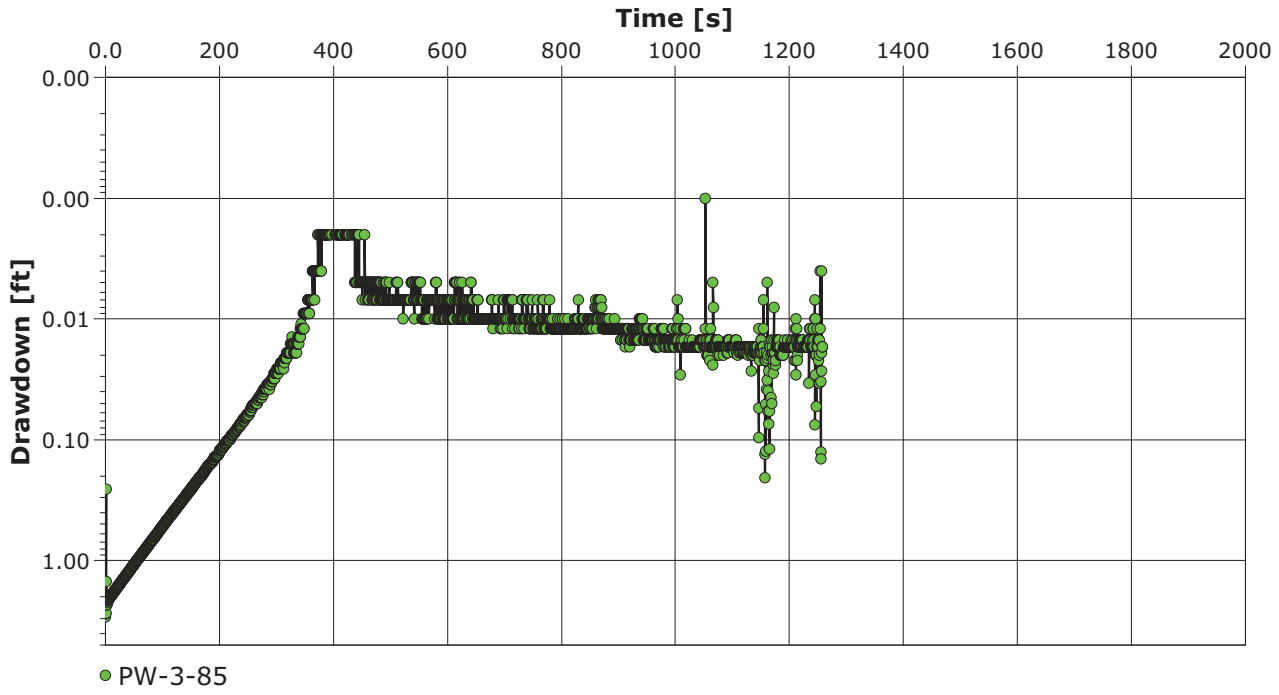
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

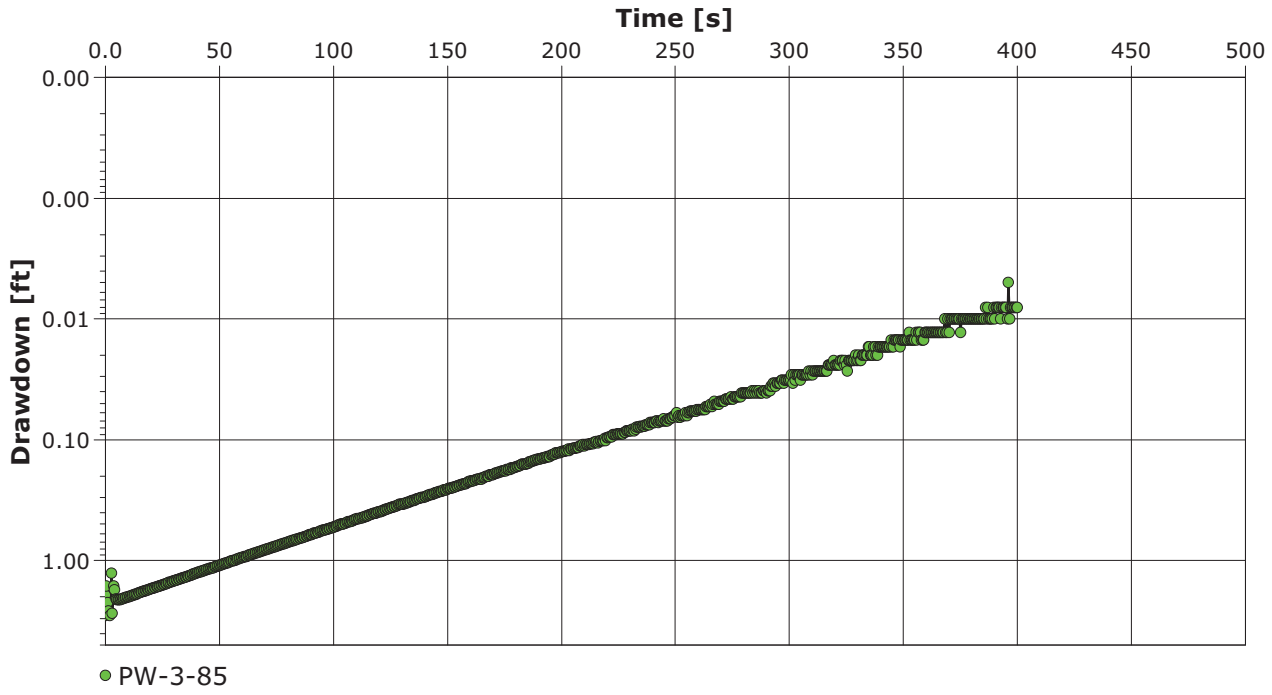
Client: NW Natural

Location: Portland, Oregon	Slug Test: PW-3-85 Test 2	Test Well: PW-3-85
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 60.00 ft		



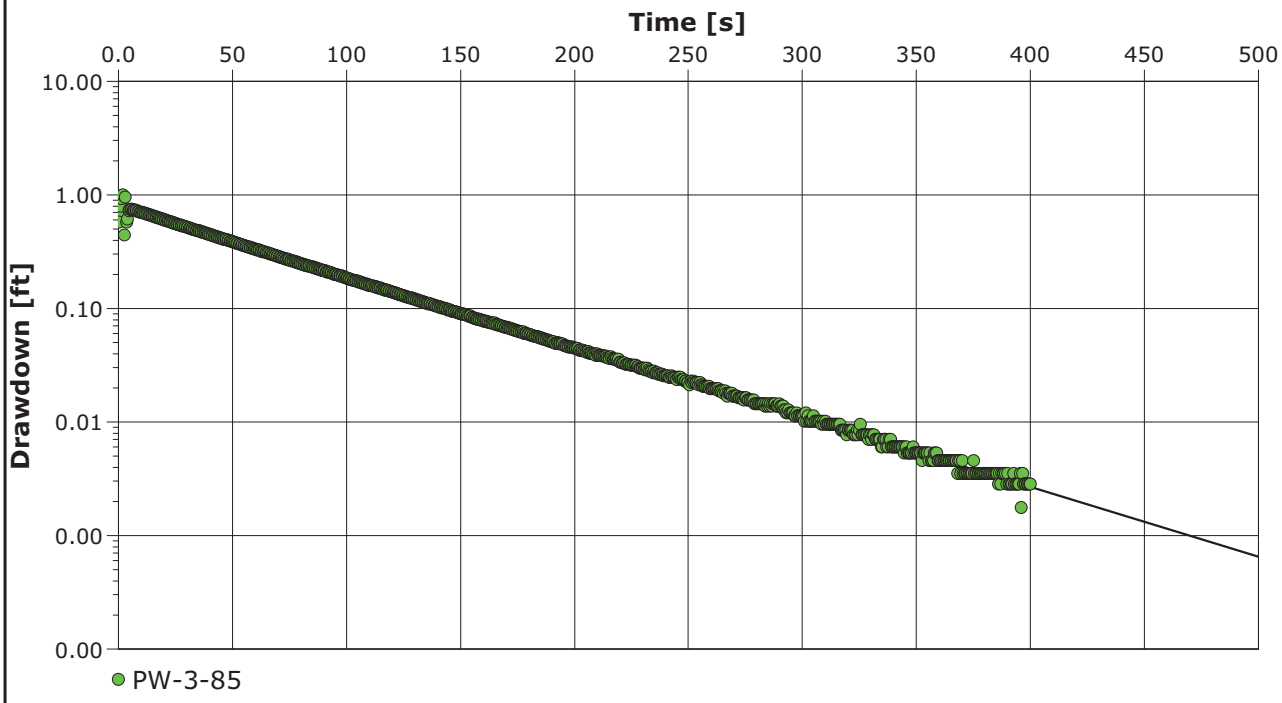
ANCHOR QEA City, State/Province Address Contact Info Company Name	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: PW-3-85 Test 3	Test Well: PW-3-85
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 60.00 ft		



City, State/Province **Address** **Contact Info** **Company Name** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: PW-3-85 Test 3	Test Well: PW-3-85
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 60.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PW-3-85	1.76×10^{1}	

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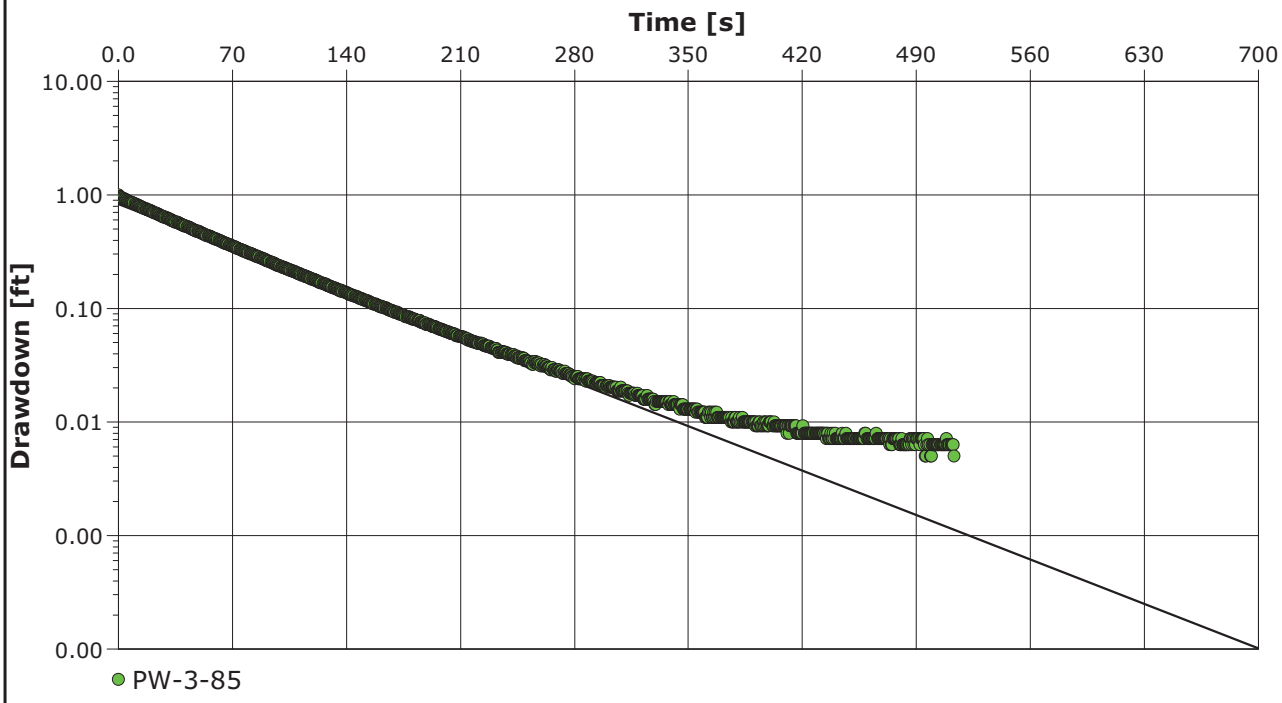
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: PW-3-85 Test 4	Test Well: PW-3-85
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 60.00 ft		



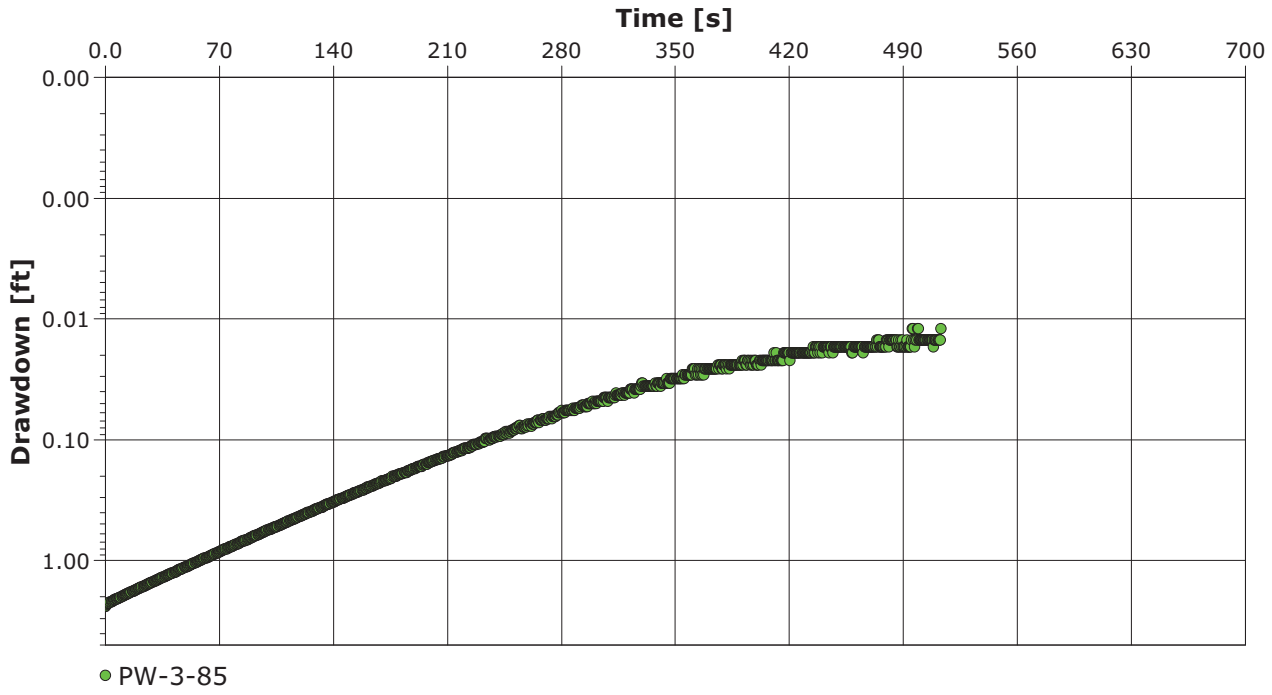
Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PW-3-85	1.60×10^{1}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

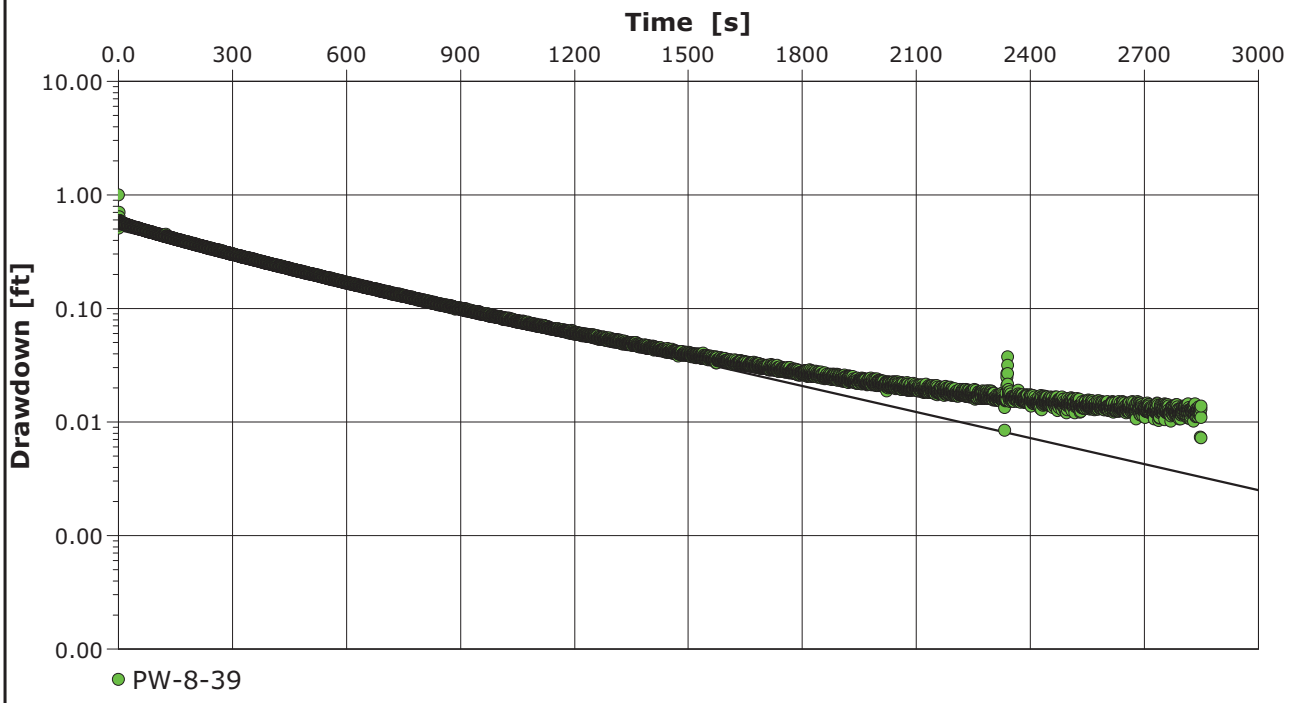
Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: PW-3-85 Test 4	Test Well: PW-3-85
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 60.00 ft		



ANCHOR QEA **City, State/Province** **Address** **Contact Info** **Company Name** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report**	
	Project: Gasco Ground Water Source Control	
	Number: 000029-02.28 task 3A	
	Client: NW Natural	

Location: Portland, Oregon	Slug Test: PW-8-39 Test 1	Test Well: PW-8-39
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 24.00 ft		

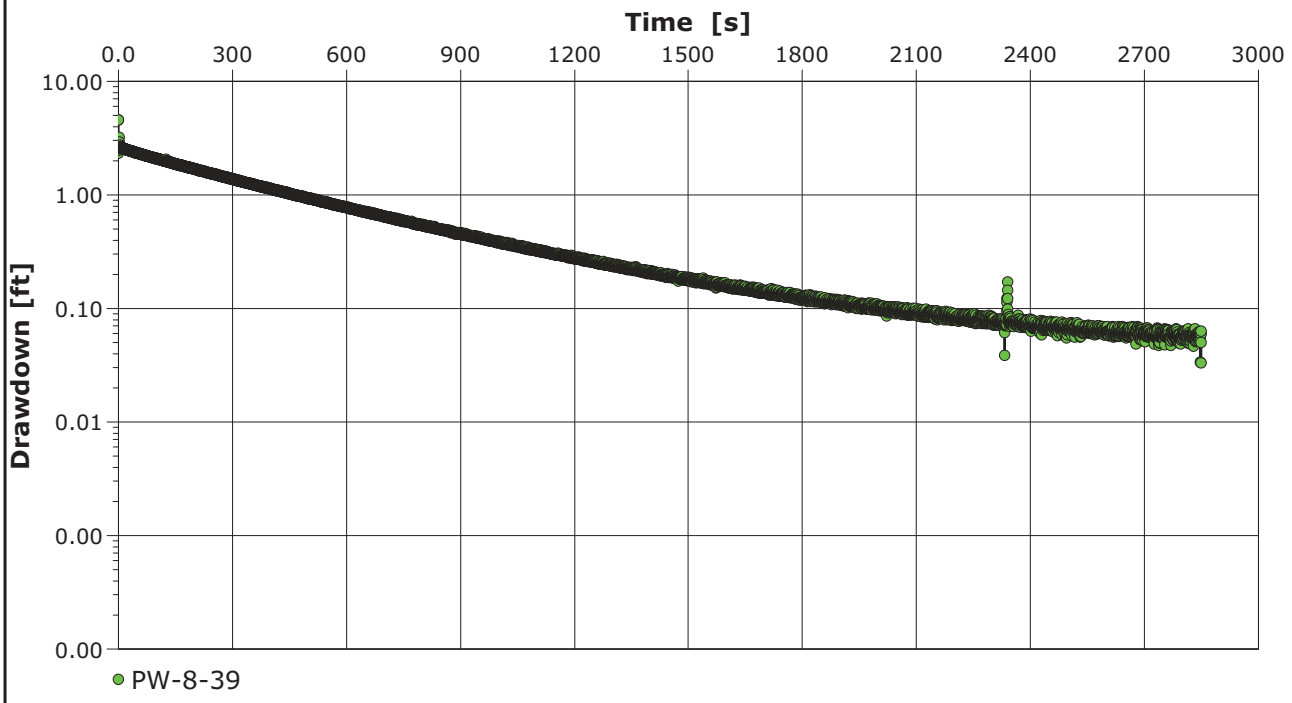


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PW-8-39	1.00×10^{0}	

ANCHOR QEA **City, State/Province** **Address** **Contact Info** **Company Name** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: PW-8-39 Test 1	Test Well: PW-8-39
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 24.00 ft		



ANCHOR QEA
City, State/Province
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Contact Info Phone 503.670.1108
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Company Name

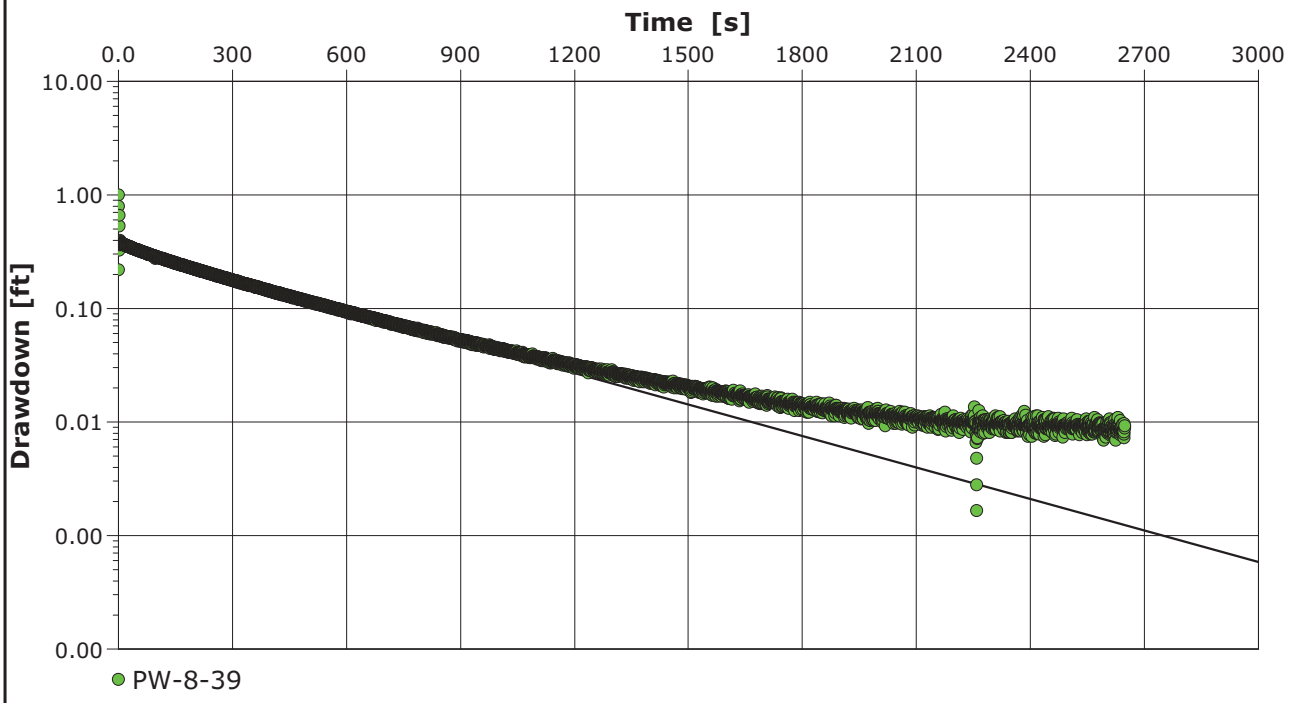
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: PW-8-39 Test 2	Test Well: PW-8-39
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 24.00 ft		

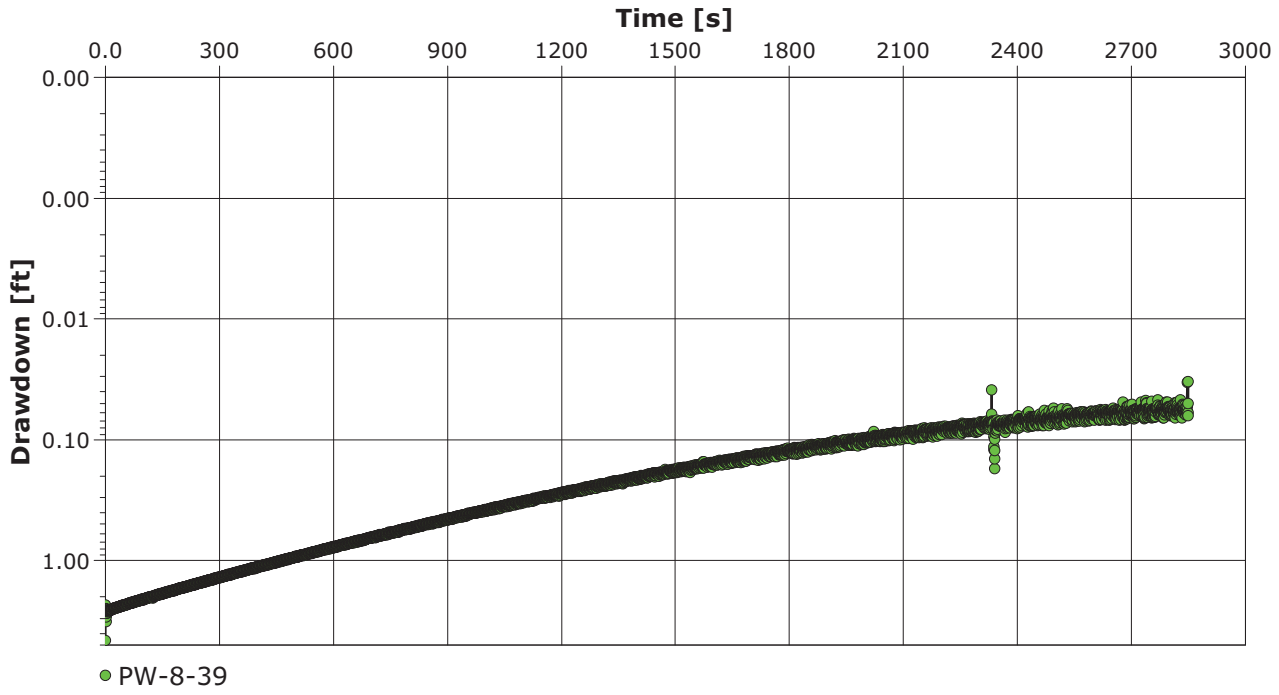


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PW-8-39	1.21×10^{0}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: PW-8-39 Test 2	Test Well: PW-8-39
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 24.00 ft		



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Contact Info Phone 503.670.1108
Fax 503.670.1128
Company Name

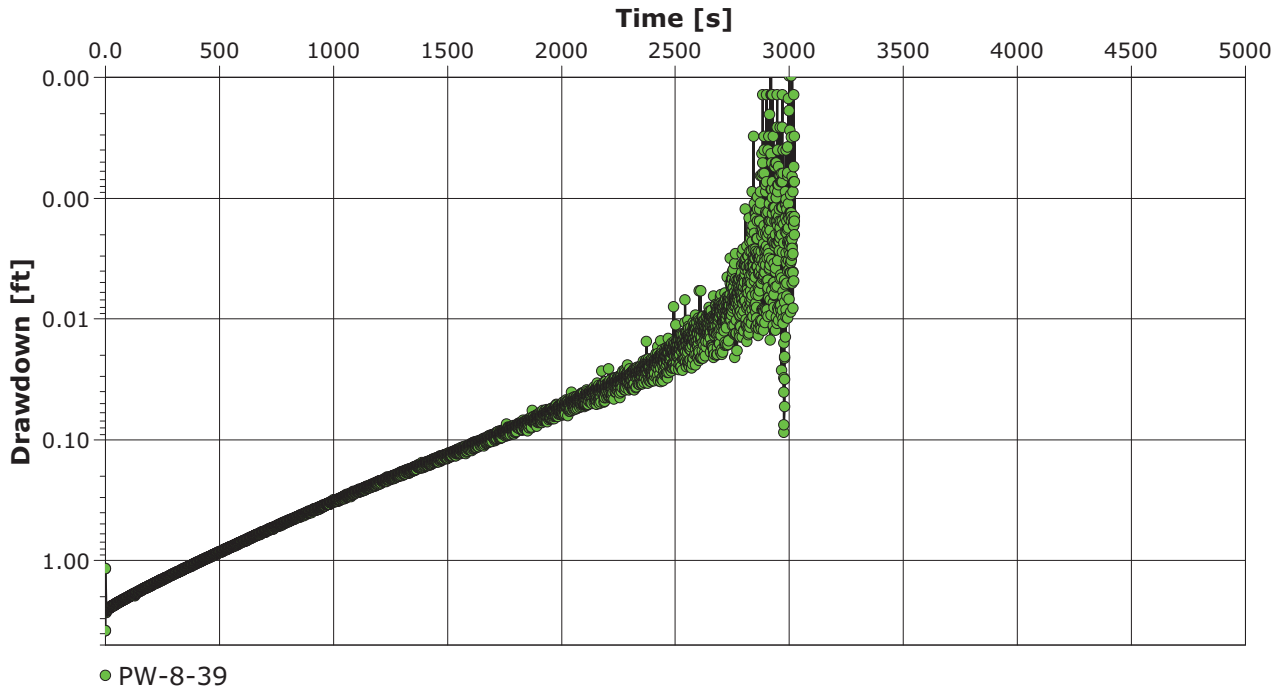
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

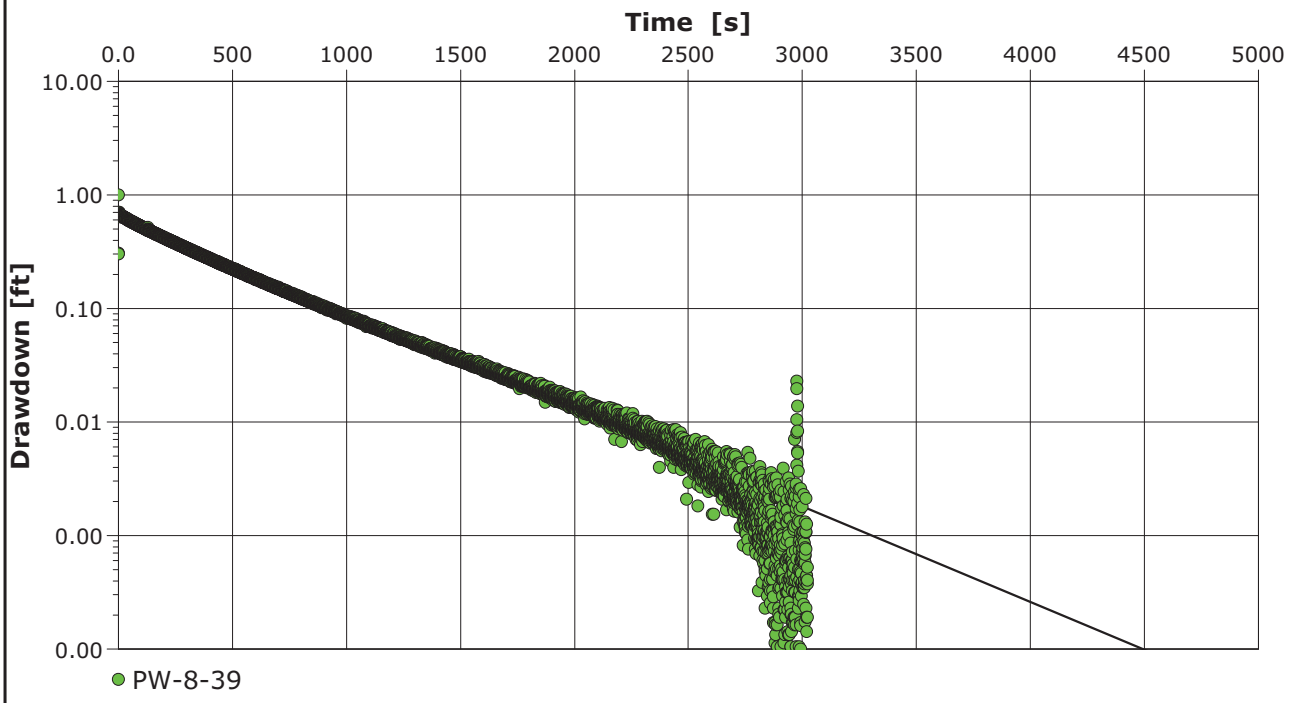
Location: Portland, Oregon	Slug Test: PW-8-39 Test 3	Test Well: PW-8-39
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 24.00 ft		



City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: PW-8-39 Test 3	Test Well: PW-8-39
Test conducted by: MWilson/DLaffoon		Test date: 1/20/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 24.00 ft		



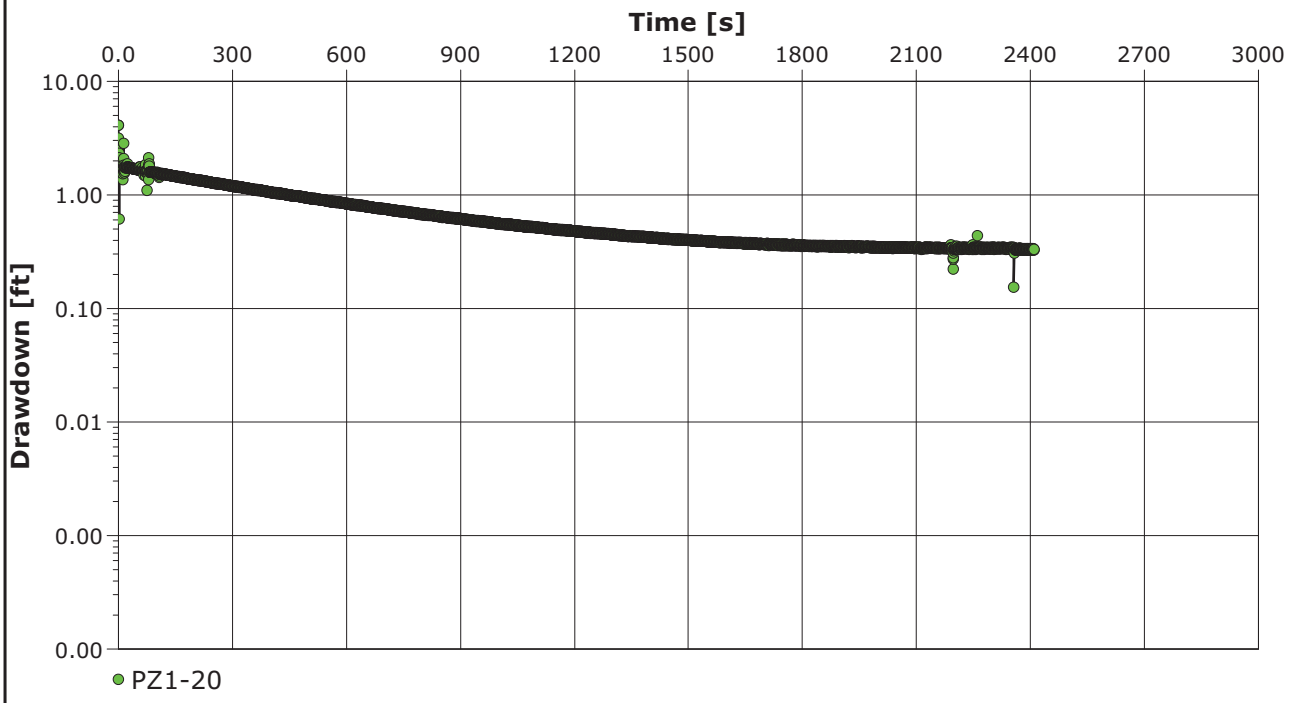
Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PW-8-39	1.10×10^{0}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

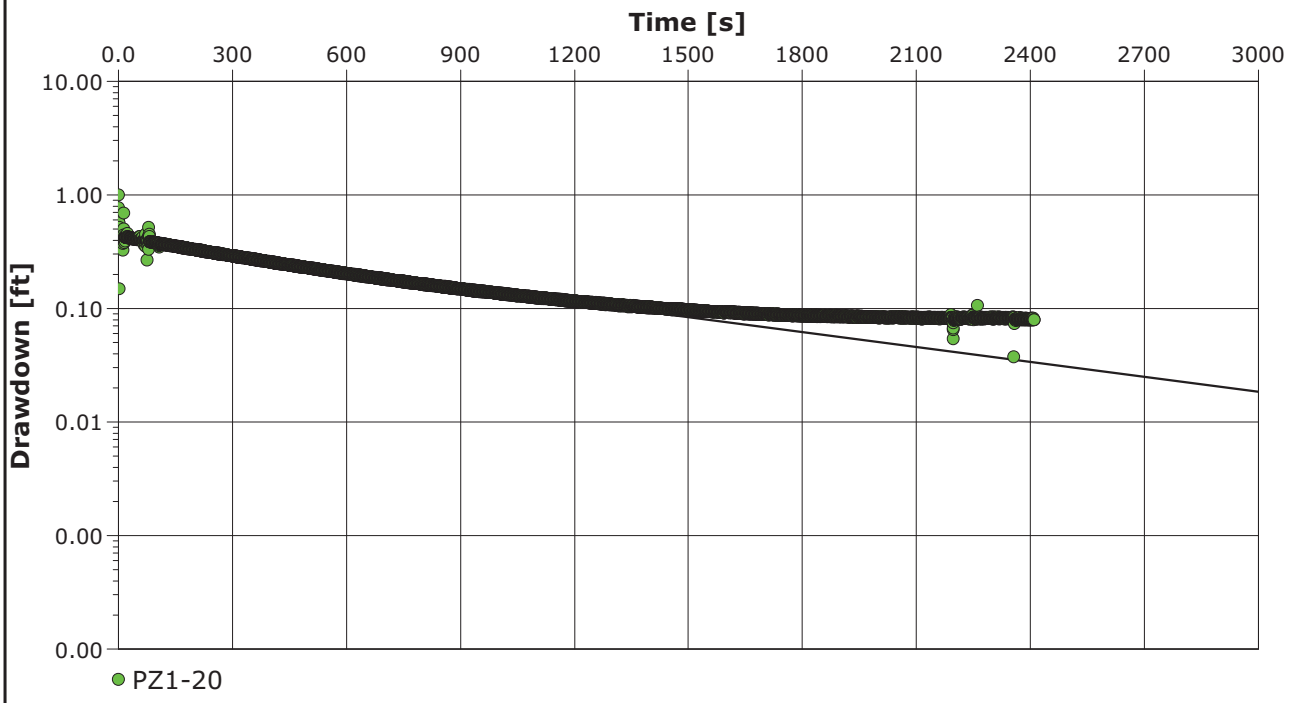
Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: PZ1-20 Test 1	Test Well: PZ1-20
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 30.00 ft		



City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: PZ1-20 Test 1	Test Well: PZ1-20
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 30.00 ft		

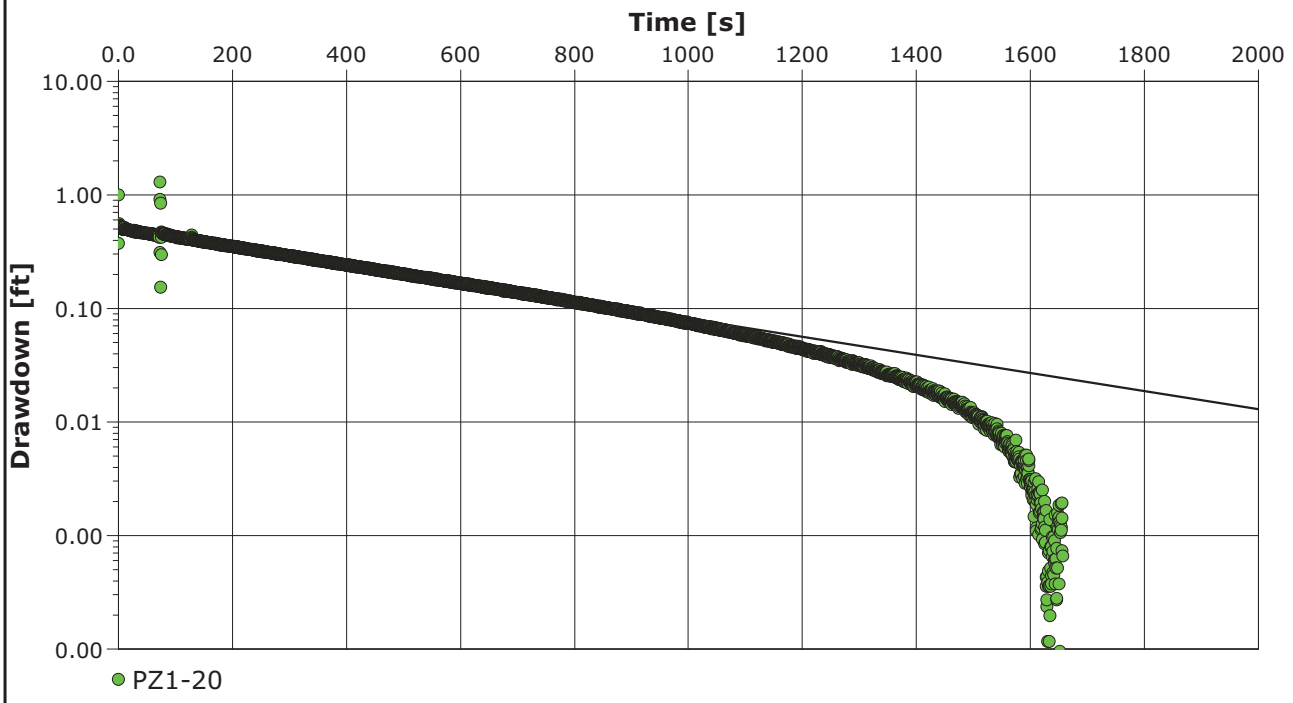


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PZ1-20	2.01×10^{-1}	

City, State/Province **Address** **Contact Info** **Company Name** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: PZ1-20 Test 2	Test Well: PZ1-20
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 30.00 ft		

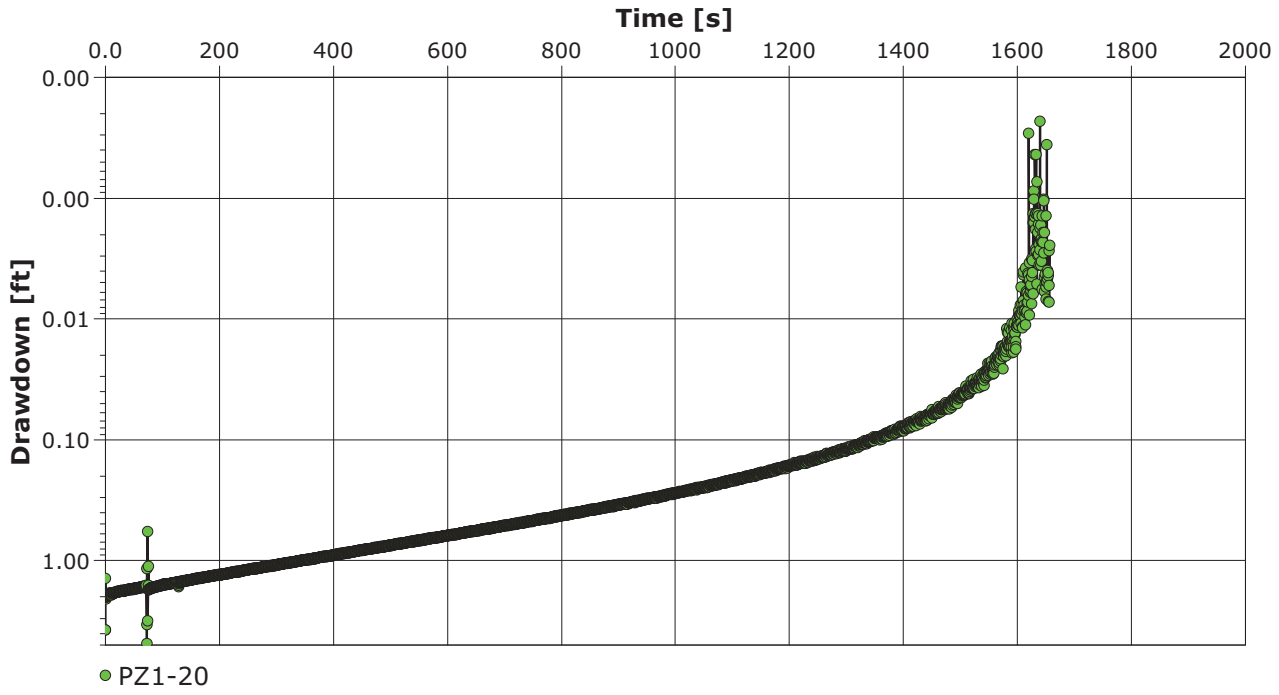


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PZ1-20	3.65×10^{-1}	

ANCHOR QEA **City, State/Province** **Address** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 **Contact Info** Phone 503.670.1108 Fax 503.670.1128 **Company Name**	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: PZ1-20 Test 2	Test Well: PZ1-20
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 30.00 ft		



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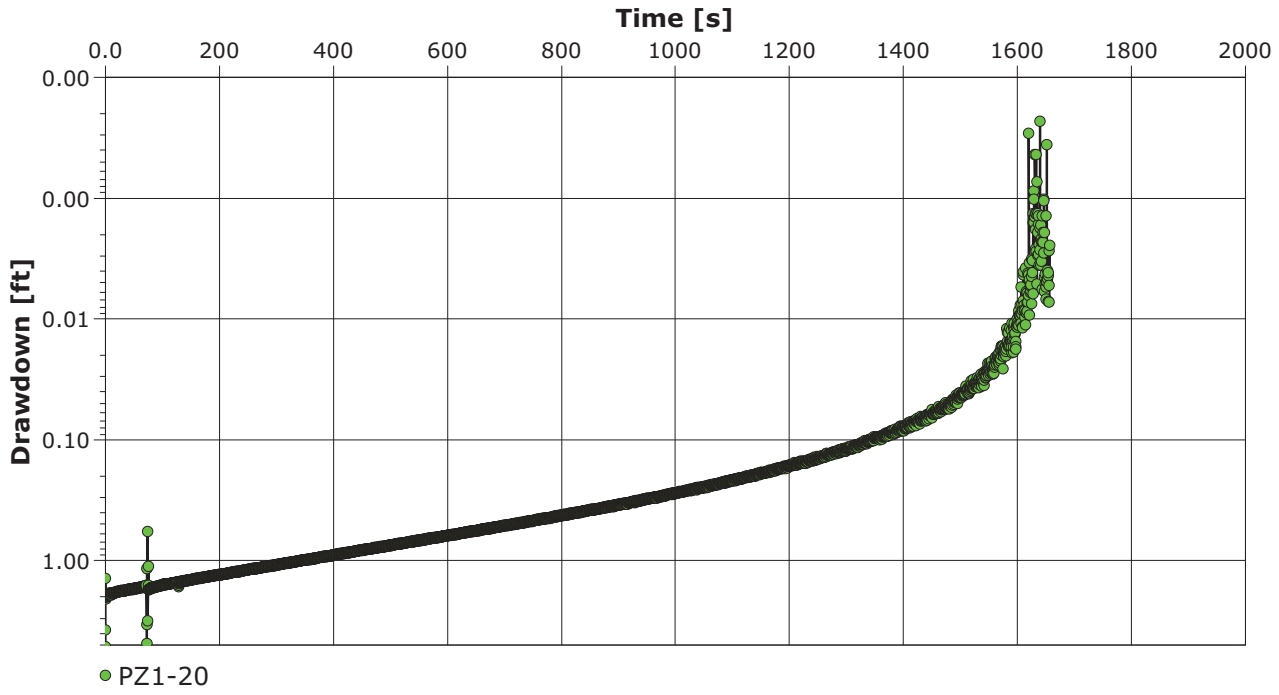
Location: Portland, Oregon	Slug Test: PZ1-20 Test 3	Test Well: PZ1-20
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 30.00 ft		



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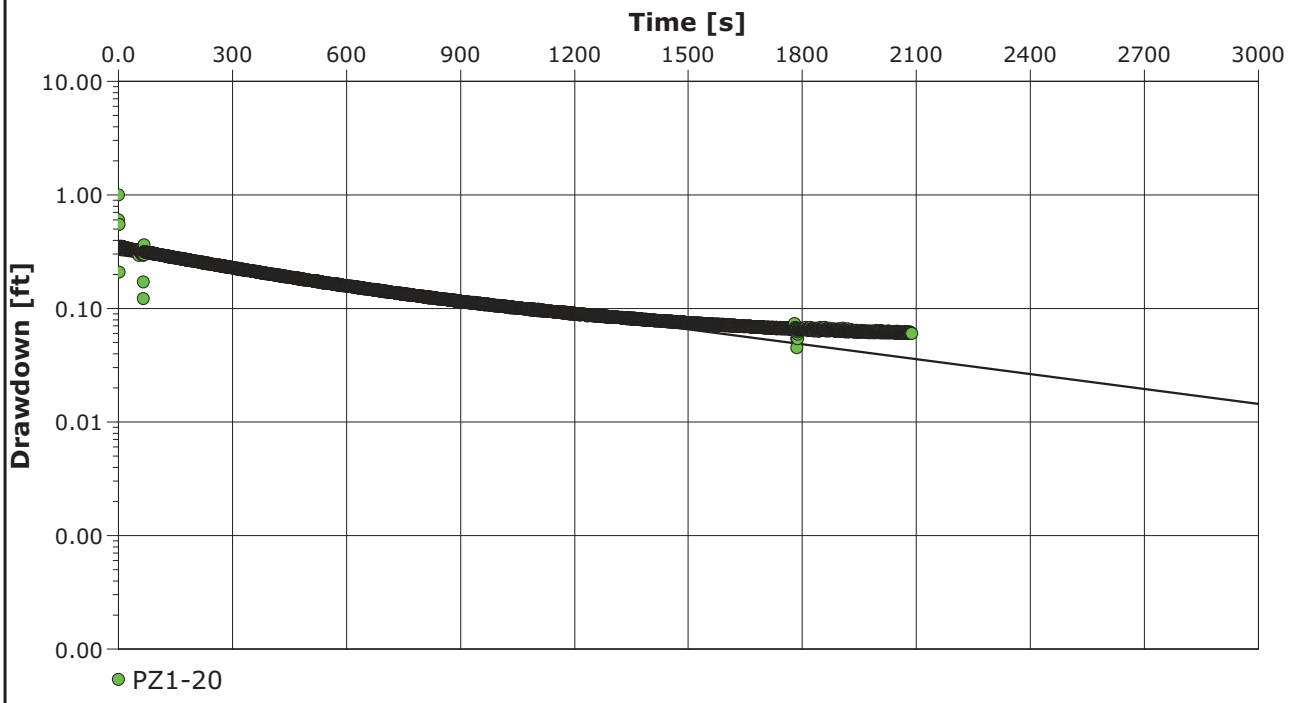
Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: PZ1-20 Test 3	Test Well: PZ1-20
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 30.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PZ1-20	2.01×10^{-1}	

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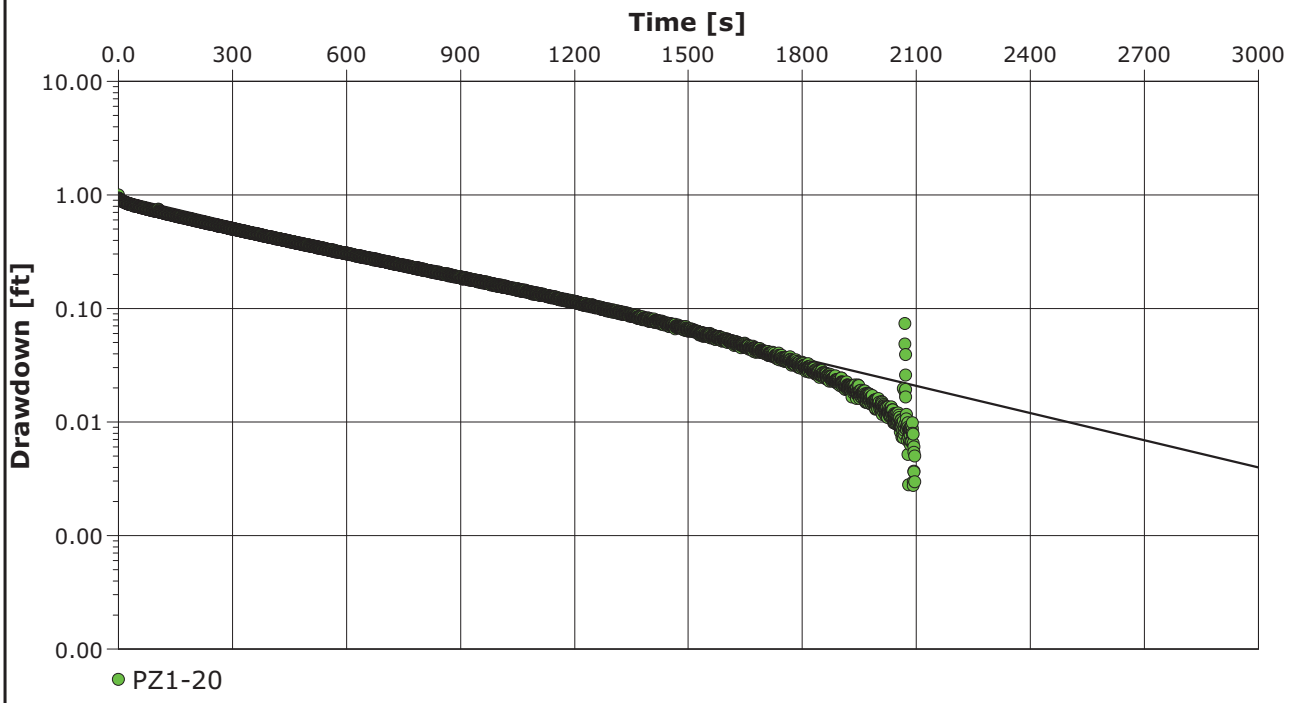
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: PZ1-20 Test 4	Test Well: PZ1-20
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 30.00 ft		

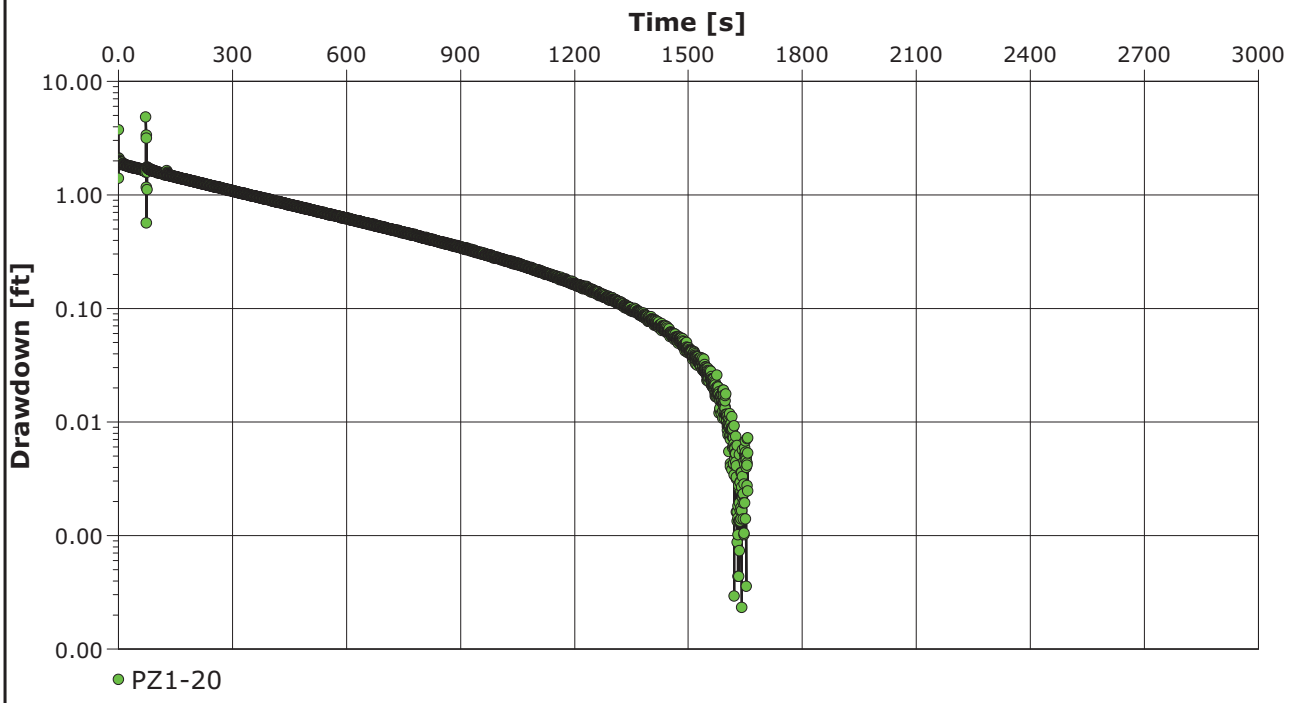


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PZ1-20	3.65×10^{-1}	

ANCHOR QEA **City, State/Province** **Address** **Contact Info** **Company Name** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

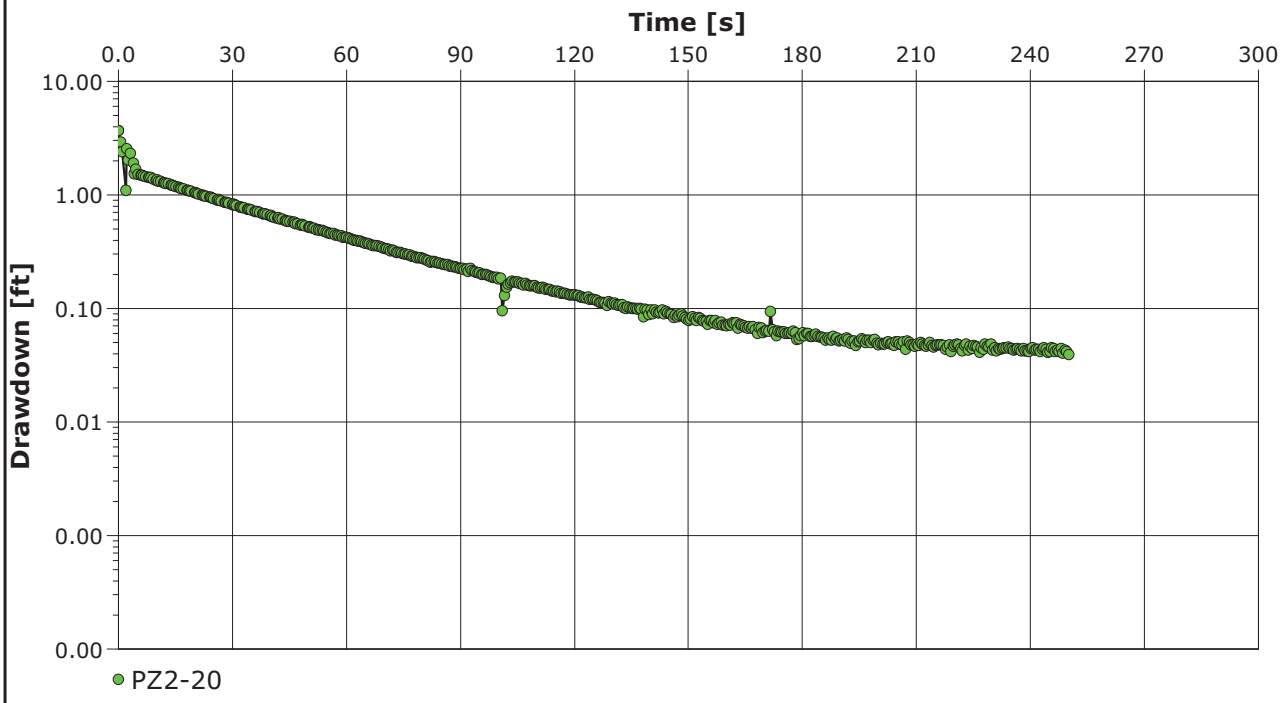
Location: Portland, Oregon	Slug Test: PZ1-20 Test 4	Test Well: PZ1-20
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 30.00 ft		



City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

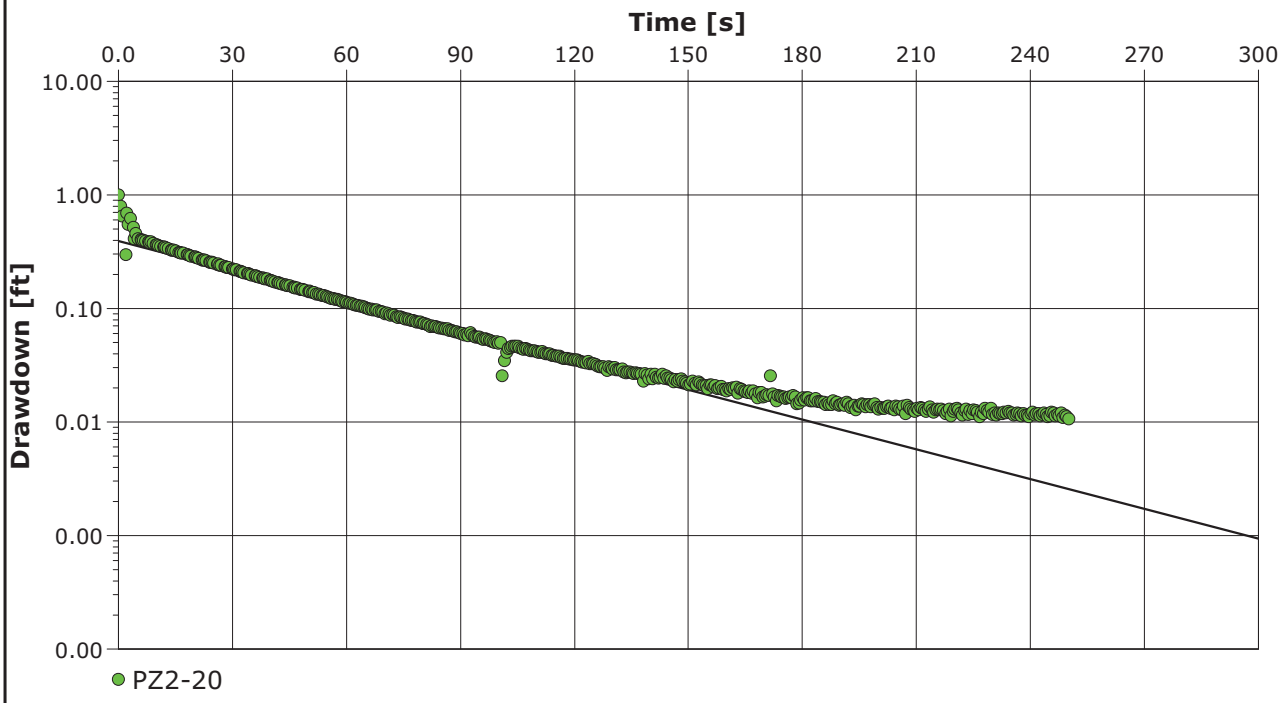
Location: Portland, Oregon	Slug Test: PZ2-20 Test 1	Test Well: PZ2-20
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 18.00 ft		



City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: PZ2-20 Test 1	Test Well: PZ2-20
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 18.00 ft		



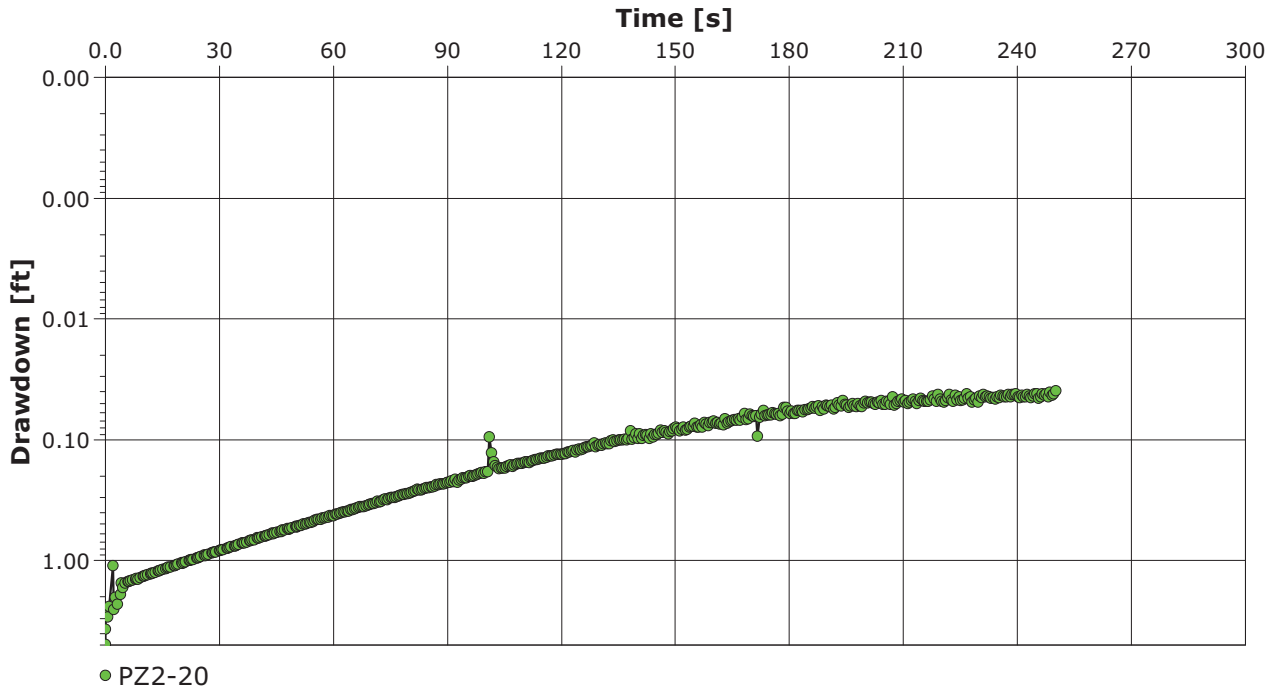
Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PZ2-20	4.00×10^{0}	

ANCHOR QEA	City, State/Province Address Contact Info Company Name	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: PZ2-20 Test 2	Test Well: PZ2-20
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 18.00 ft		



ANCHOR QEA
6650 SW Redwood Lane, Suite 333
Portland, Oregon 97224
Phone 503.670.1108
Fax 503.670.1128

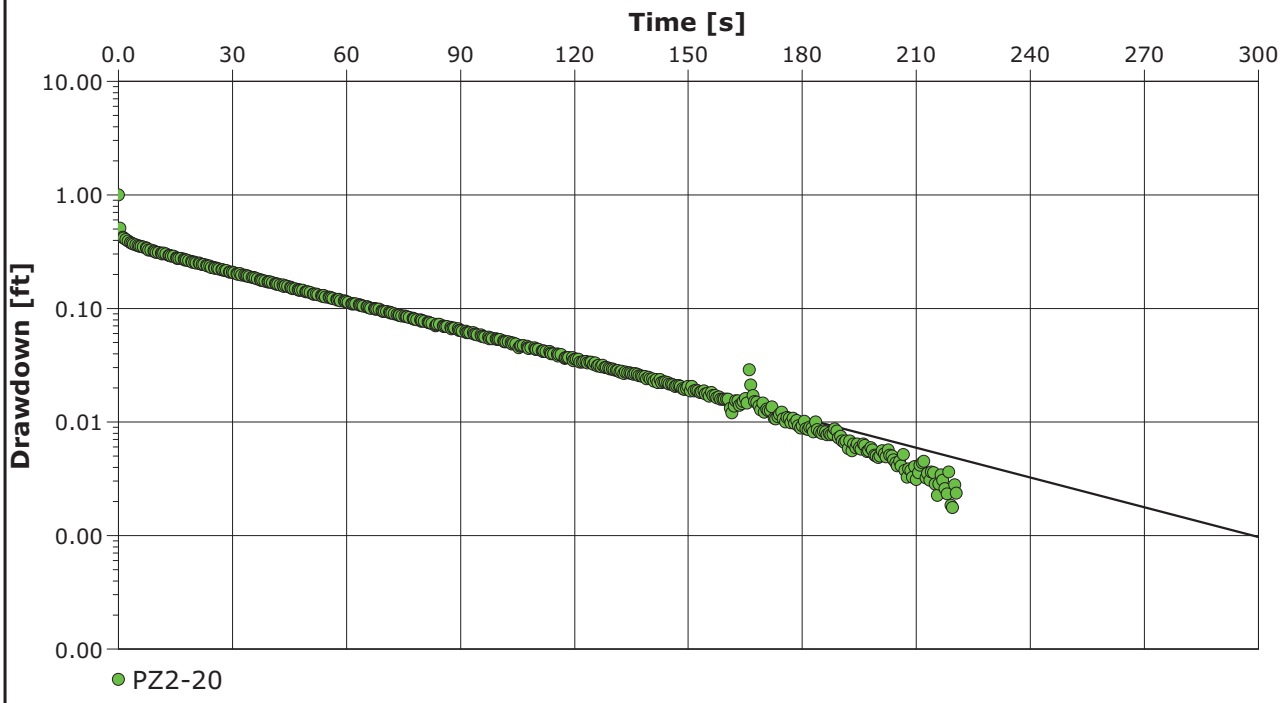
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: PZ2-20 Test 2	Test Well: PZ2-20
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 18.00 ft		



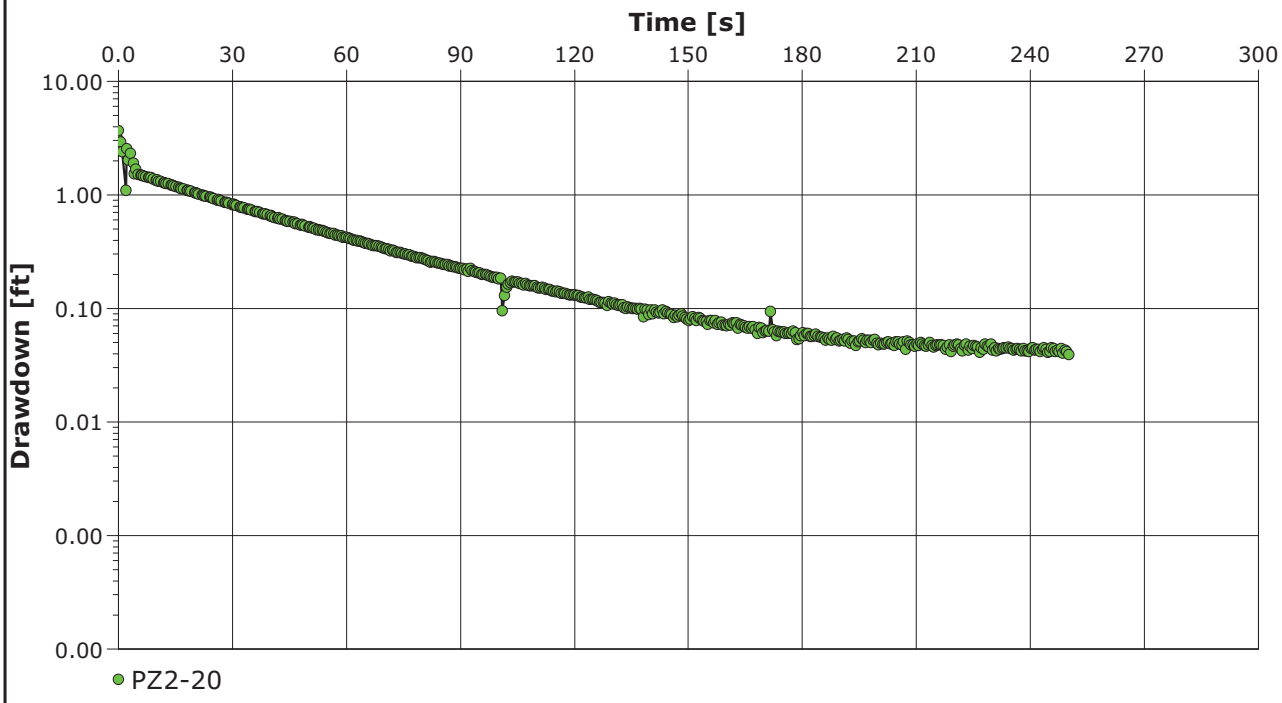
Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PZ2-20	4.00×10^{0}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: PZ2-20 Test 3	Test Well: PZ2-20
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 18.00 ft		



ANCHOR QEA
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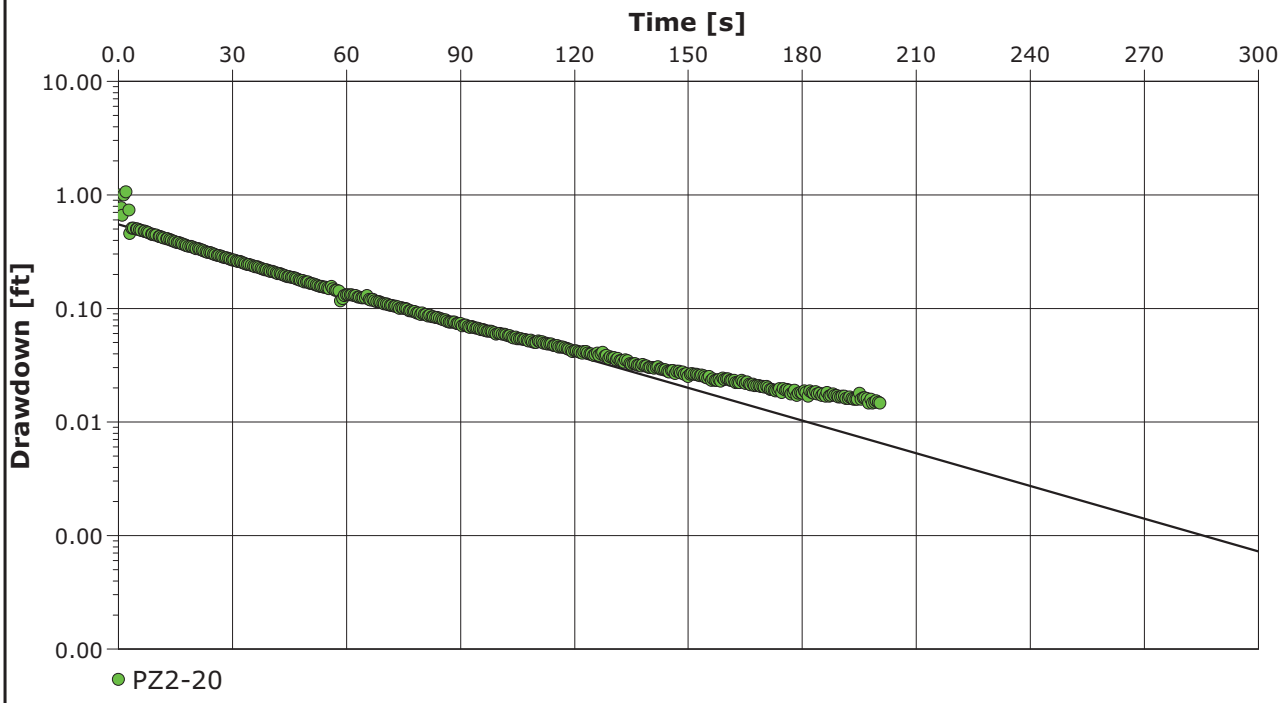
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: PZ2-20 Test 3	Test Well: PZ2-20
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 18.00 ft		



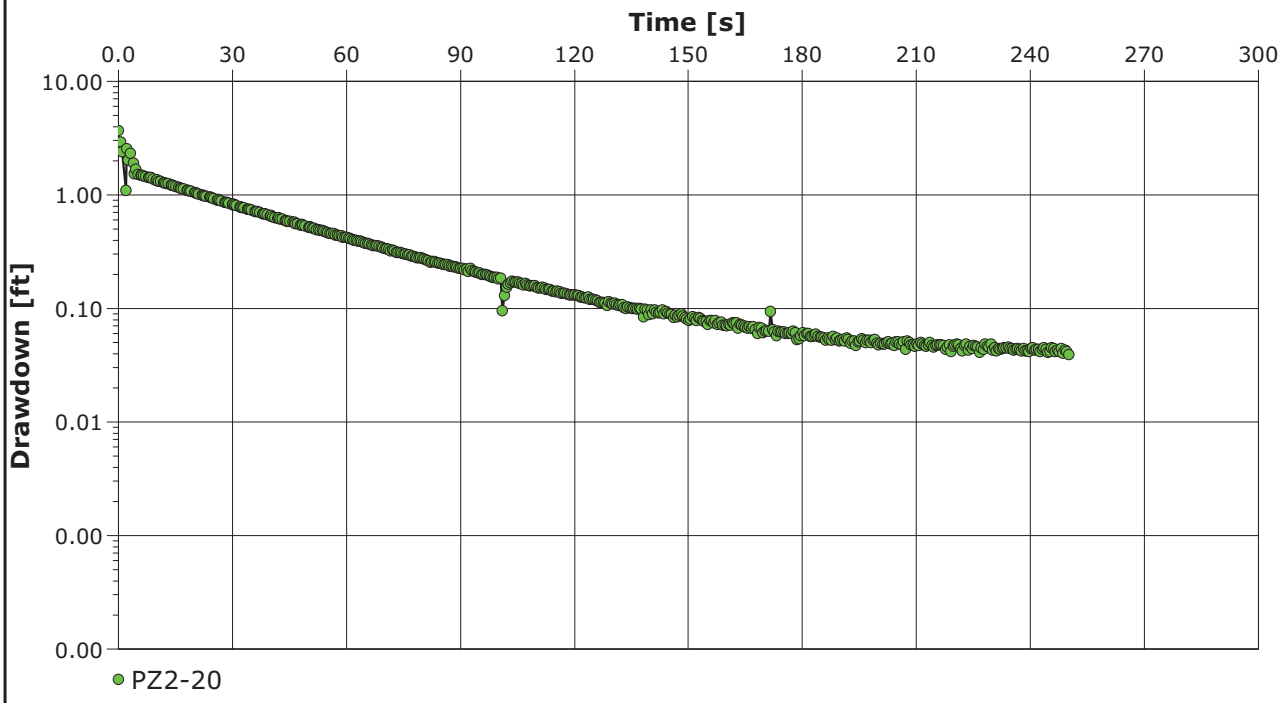
Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PZ2-20	4.40×10^{0}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: PZ2-20 Test 4	Test Well: PZ2-20
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 18.00 ft		



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Portland, Oregon 97224
Phone 503.670.1108
Fax 503.670.1128

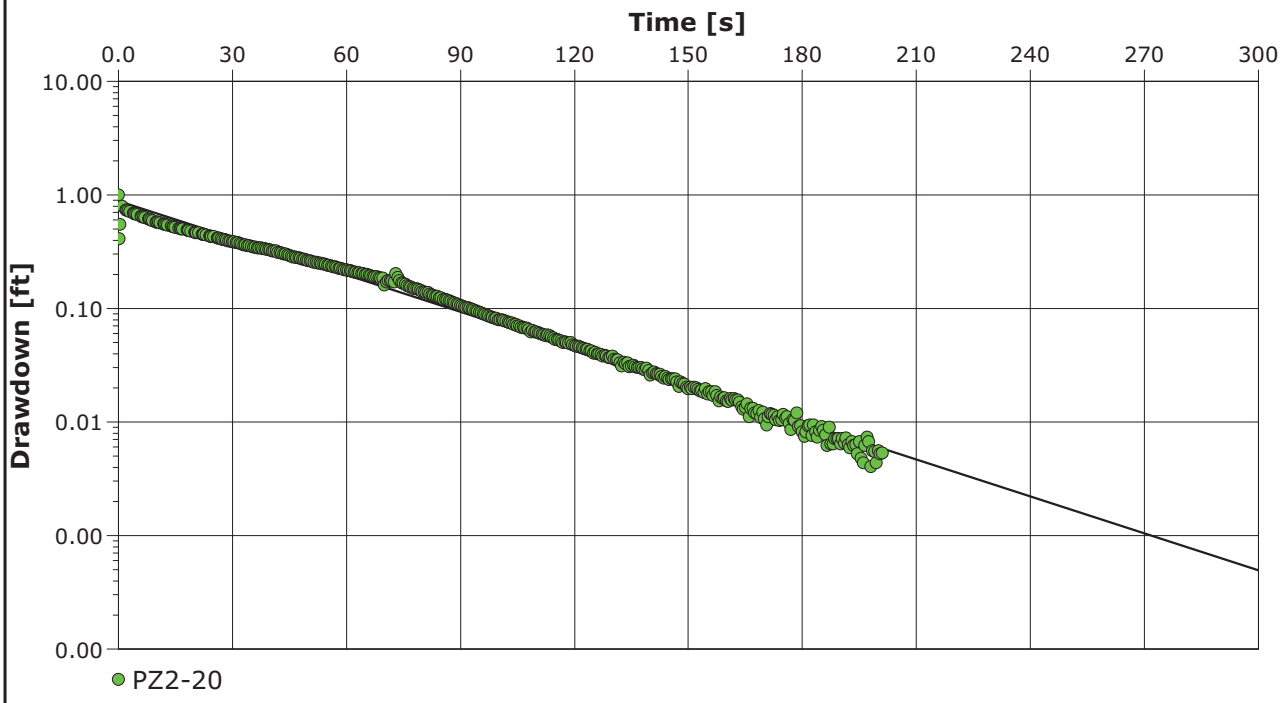
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: PZ2-20 Test 4	Test Well: PZ2-20
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 18.00 ft		



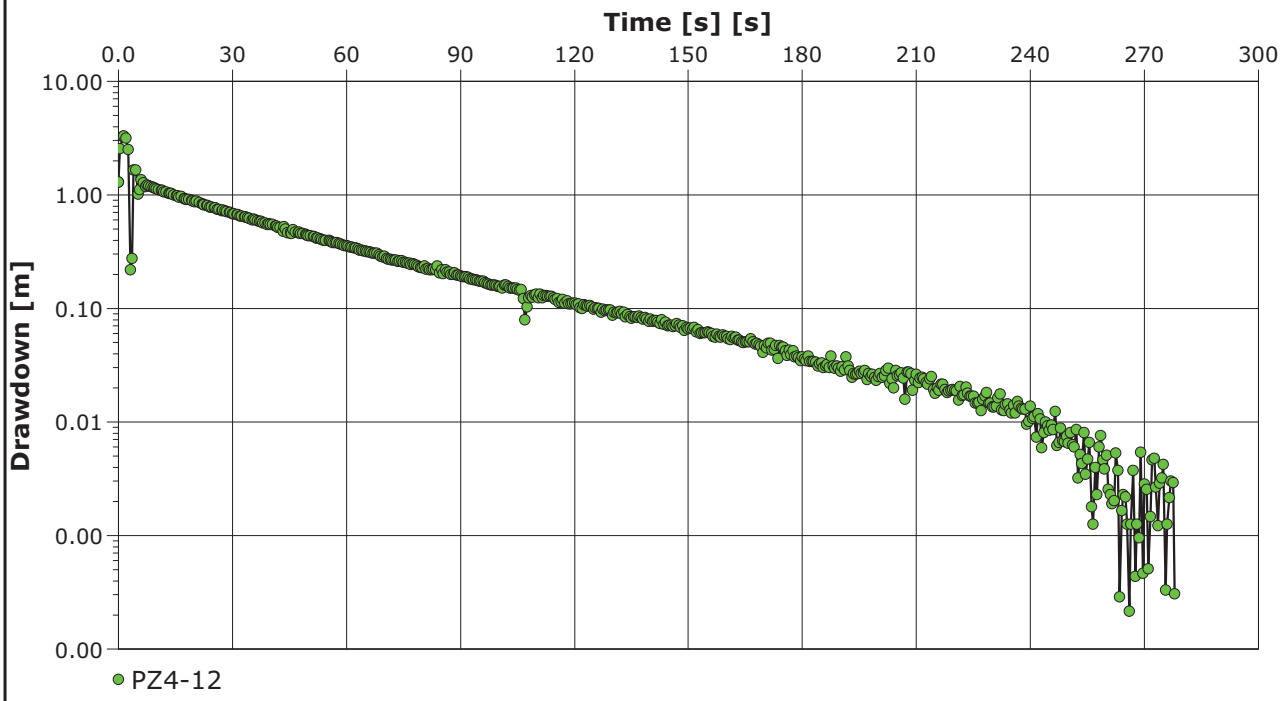
Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PZ2-20	4.98×10^{0}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

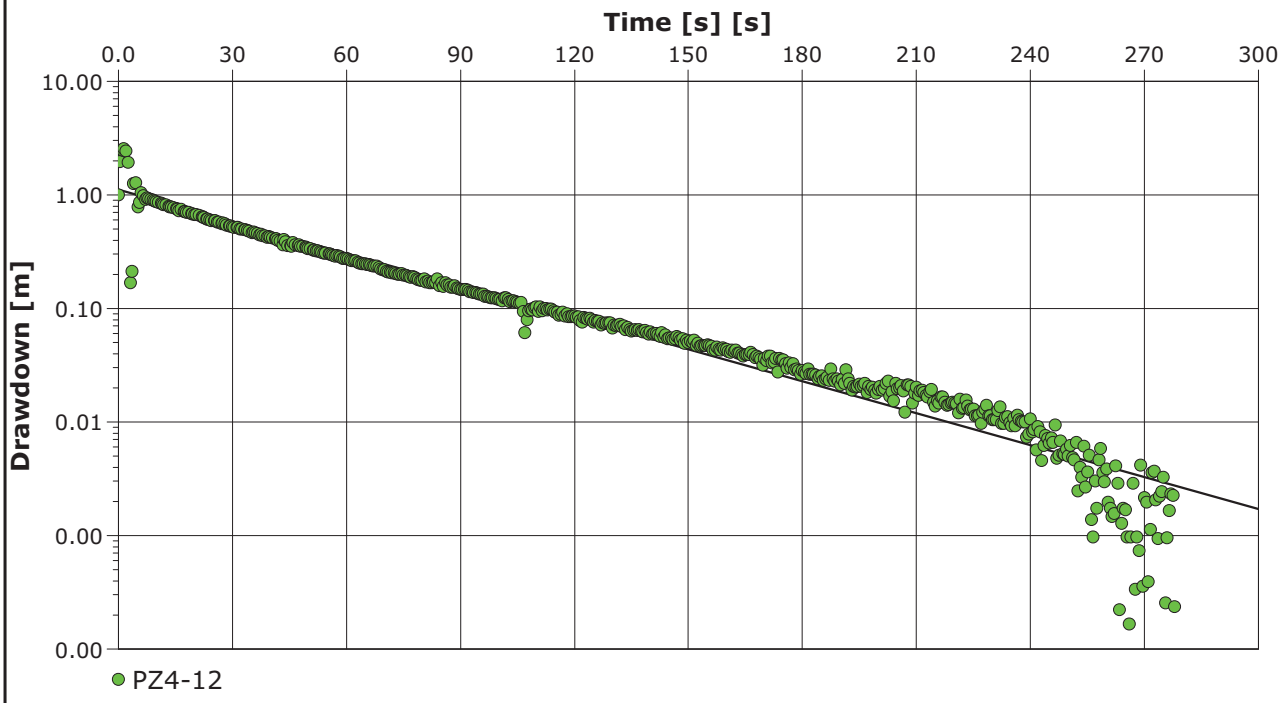
Location: Portland, Oregon	Slug Test: PZ4-12 Test 1	Test Well: PZ4-12
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 11.40 ft		



City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: PZ4-12 Test 1	Test Well: PZ4-12
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 11.40 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PZ4-12	4.06×10^{0}	

ANCHOR QEA
City, State/Province
Address 6650 SW Redwood Lane, Suite 333
Portland, Oregon 97224
Contact Info Phone 503.670.1108
Fax 503.670.1128
Company Name

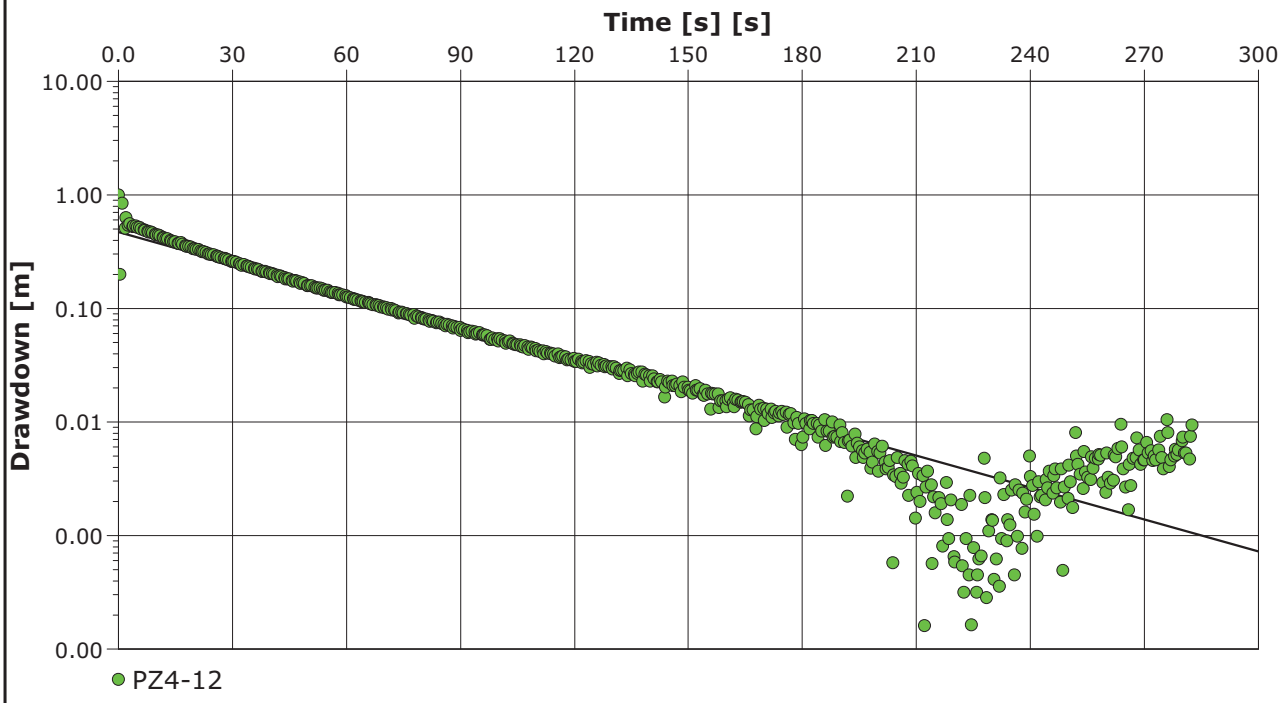
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: PZ4-12 Test 2	Test Well: PZ4-12
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 11.40 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PZ4-12	4.06×10^{0}	

ANCHOR QEA
City, State/Province
Address 6650 SW Redwood Lane, Suite 333
Portland, Oregon 97224
Contact Info Phone 503.670.1108
Fax 503.670.1128
Company Name

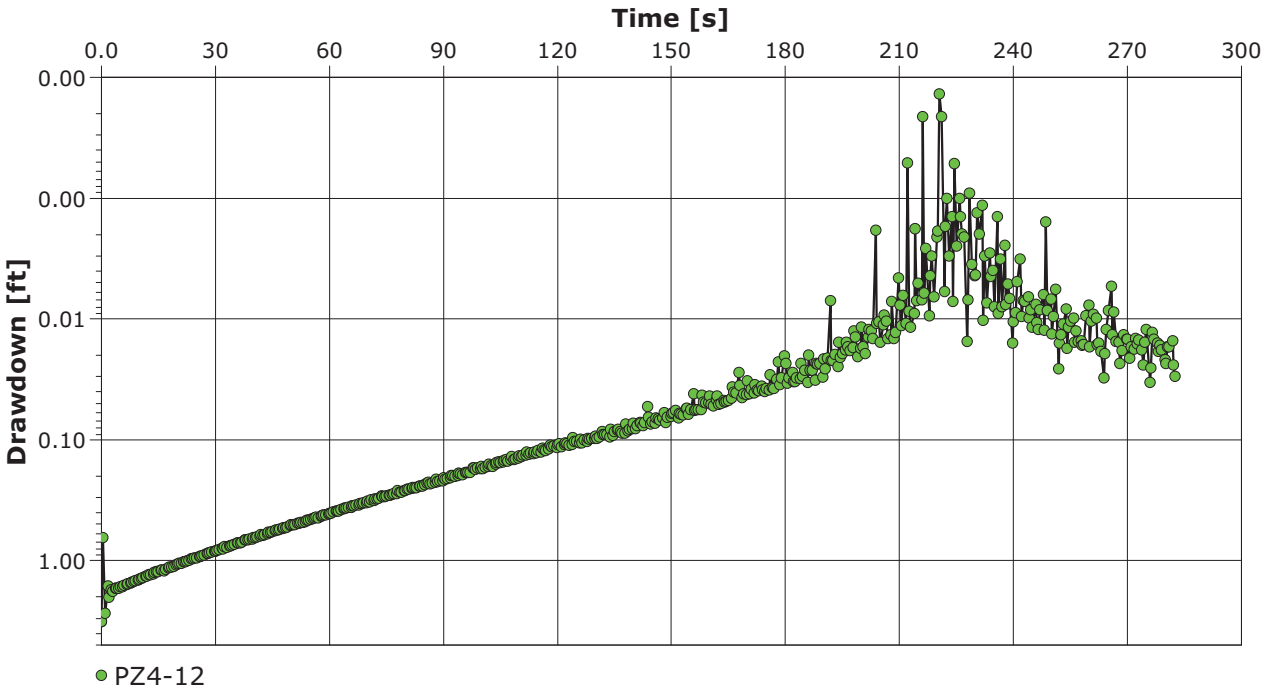
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

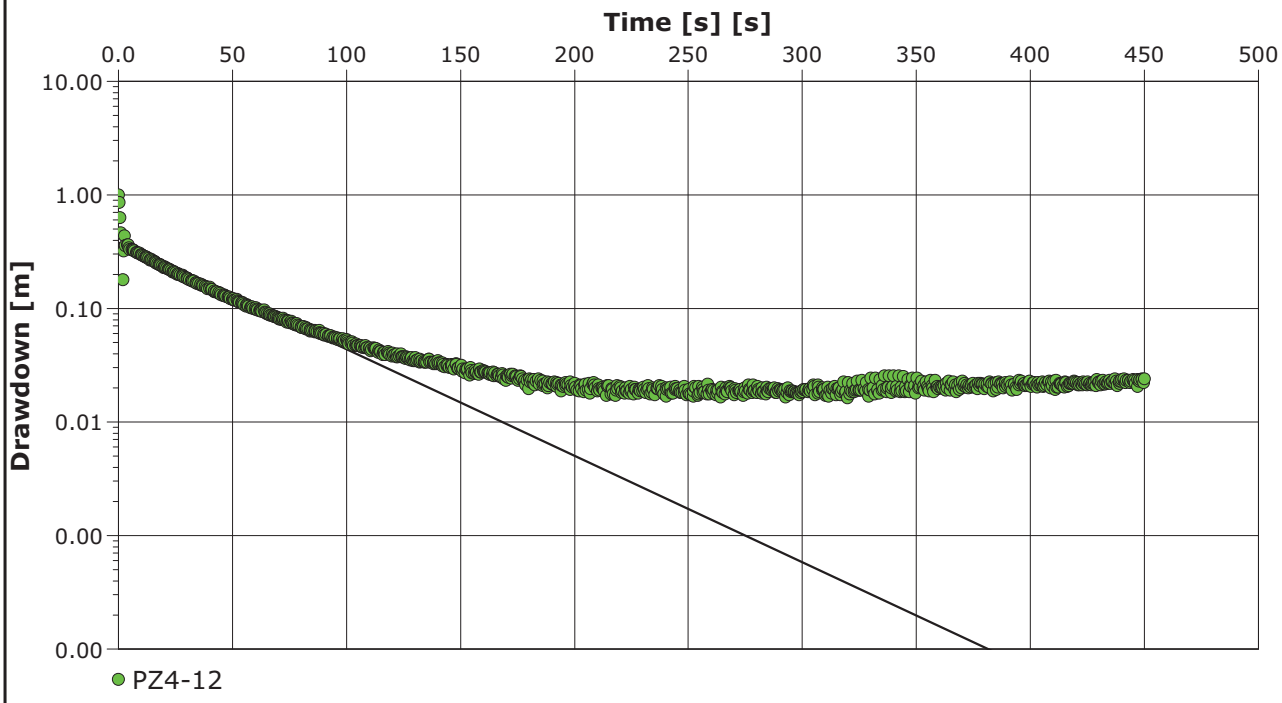
Client: NW Natural

Location: Portland, Oregon	Slug Test: PZ4-12 Test 2	Test Well: PZ4-12
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 11.40 ft		



ANCHOR QEA **City, State/Province** **Address** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 **Contact Info** Phone 503.670.1108 Fax 503.670.1128 **Company Name**	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: PZ4-12 Test 3	Test Well: PZ4-12
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 11.40 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PZ4-12	4.06×10^{0}	

ANCHOR QEA
City, State/Province
Address
Contact Info
Company Name
6650 SW Redwood Lane, Suite 333
Portland, Oregon 97224
Phone 503.670.1108
Fax 503.670.1128

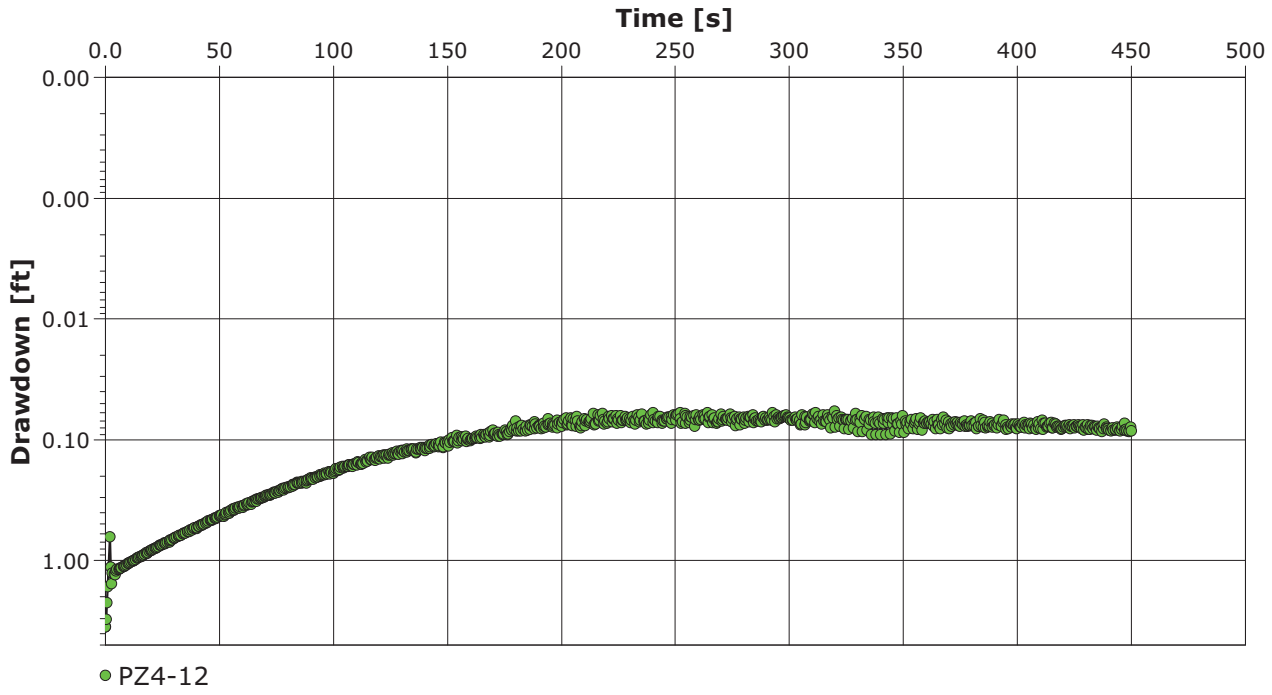
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

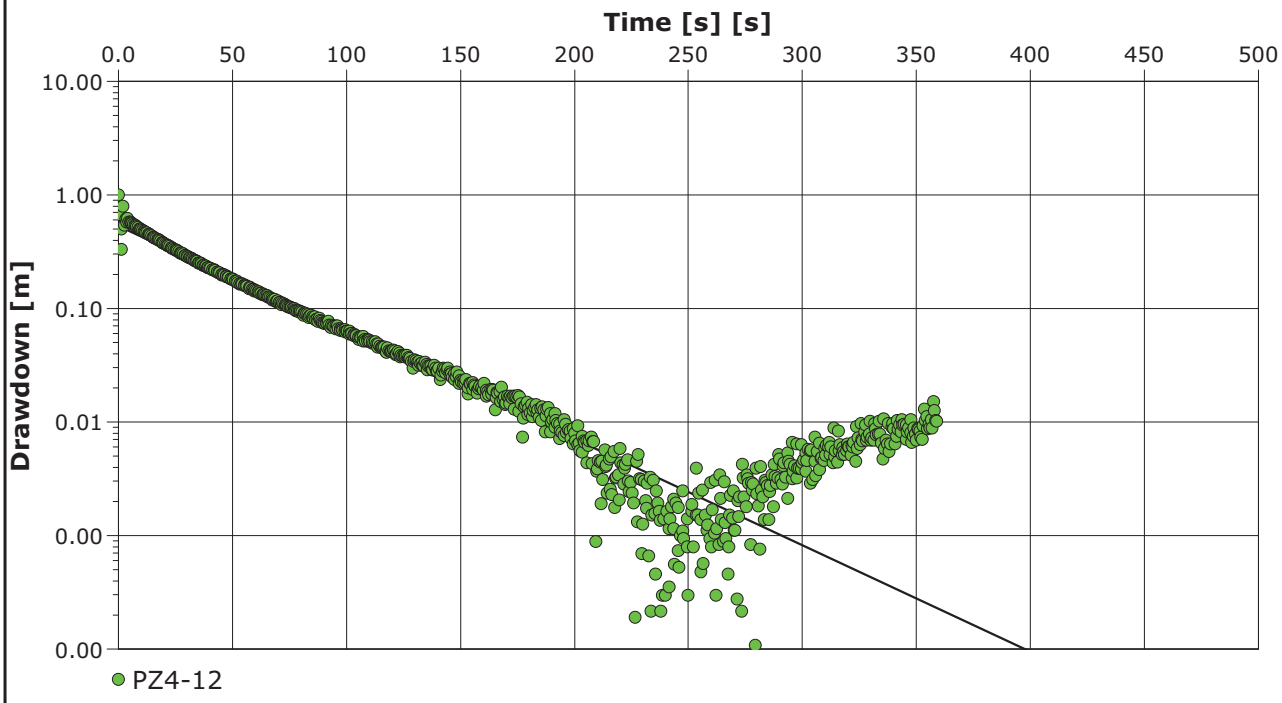
Client: NW Natural

Location: Portland, Oregon	Slug Test: PZ4-12 Test 3	Test Well: PZ4-12
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 11.40 ft		



ANCHOR QEA **City, State/Province** **Address** **Contact Info** **Company Name** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: PZ4-12 Test 4	Test Well: PZ4-12
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 11.40 ft		

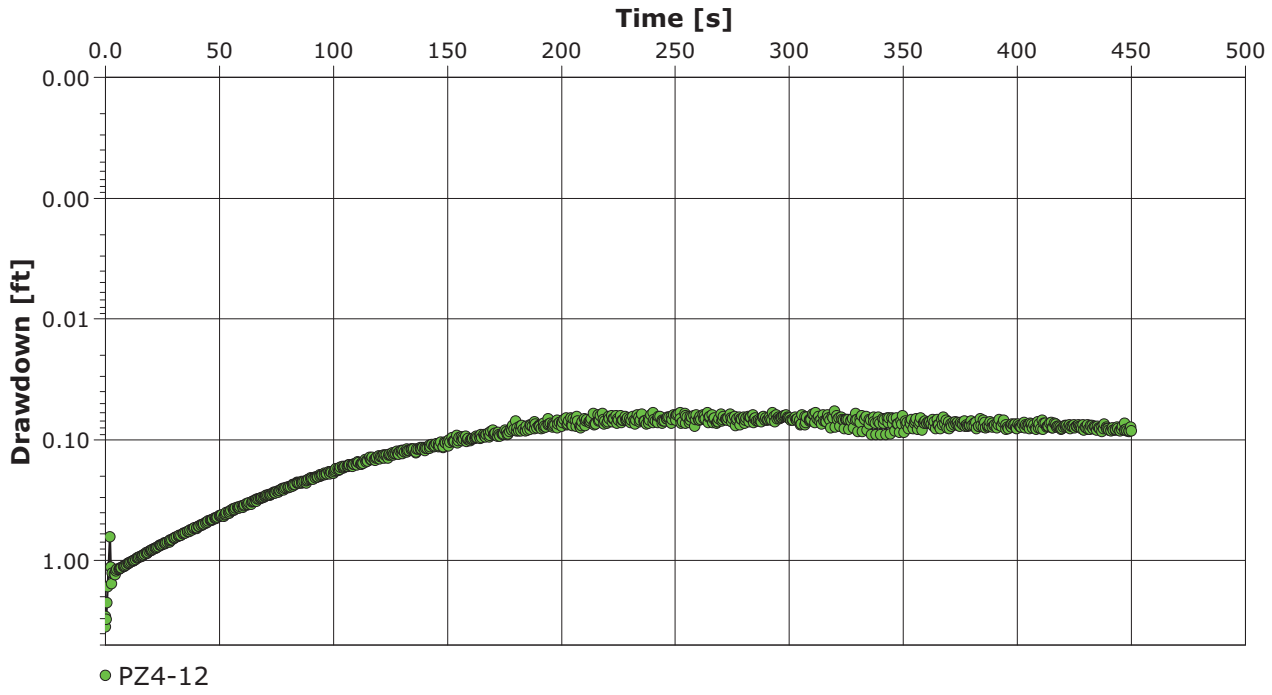


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PZ4-12	4.06×10^{0}	

ANCHOR QEA	**City, State/Province** **Address** 6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 **Contact Info** Phone 503.670.1108 Fax 503.670.1128 **Company Name**	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

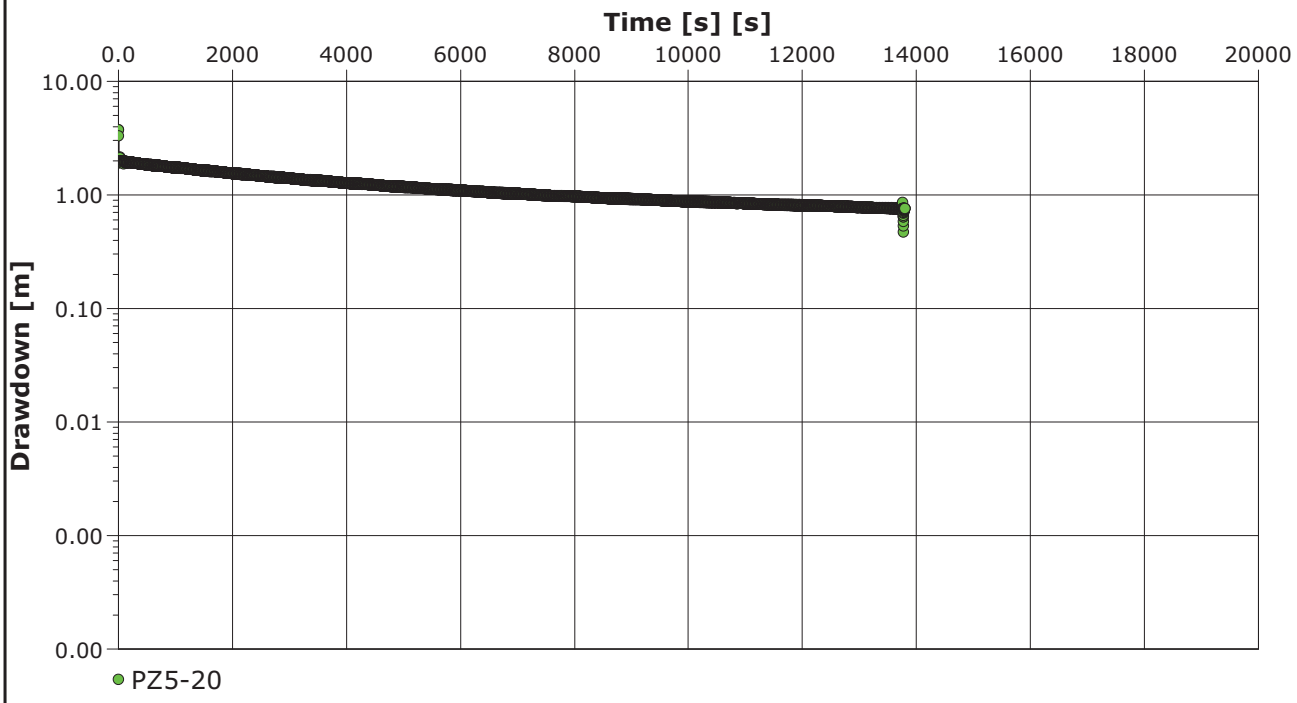
Location: Portland, Oregon	Slug Test: PZ4-12 Test 4	Test Well: PZ4-12
Test conducted by: MWilson/DLaffoon		Test date: 1/13/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 11.40 ft		



City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

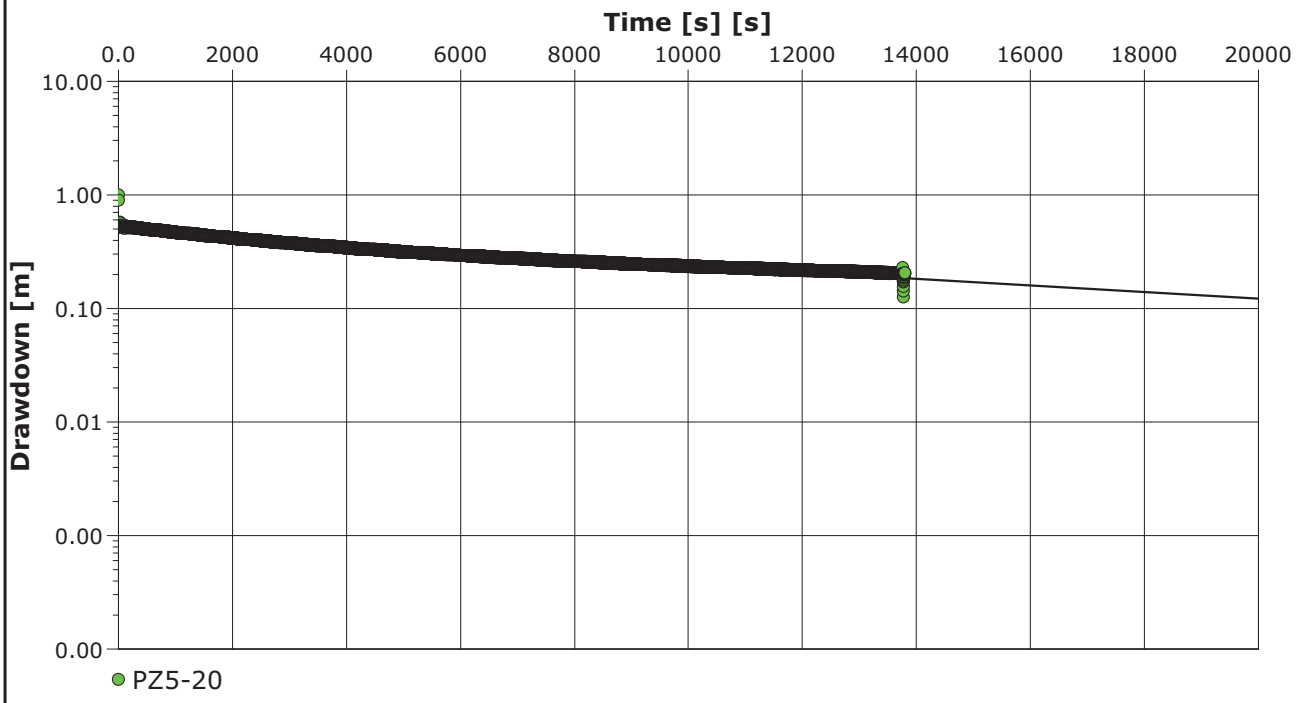
Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: PZ5-20 Test 1	Test Well: PZ5-20
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 36.00 ft		



ANCHOR QEA **City, State/Province** **Address** **Contact Info** **Company Name**	1655 SW Skyline Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: PZ5-20 Test 1	Test Well: PZ5-20
Test conducted by: MWilson/DLaffoon		Test date: 1/12/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 36.00 ft		



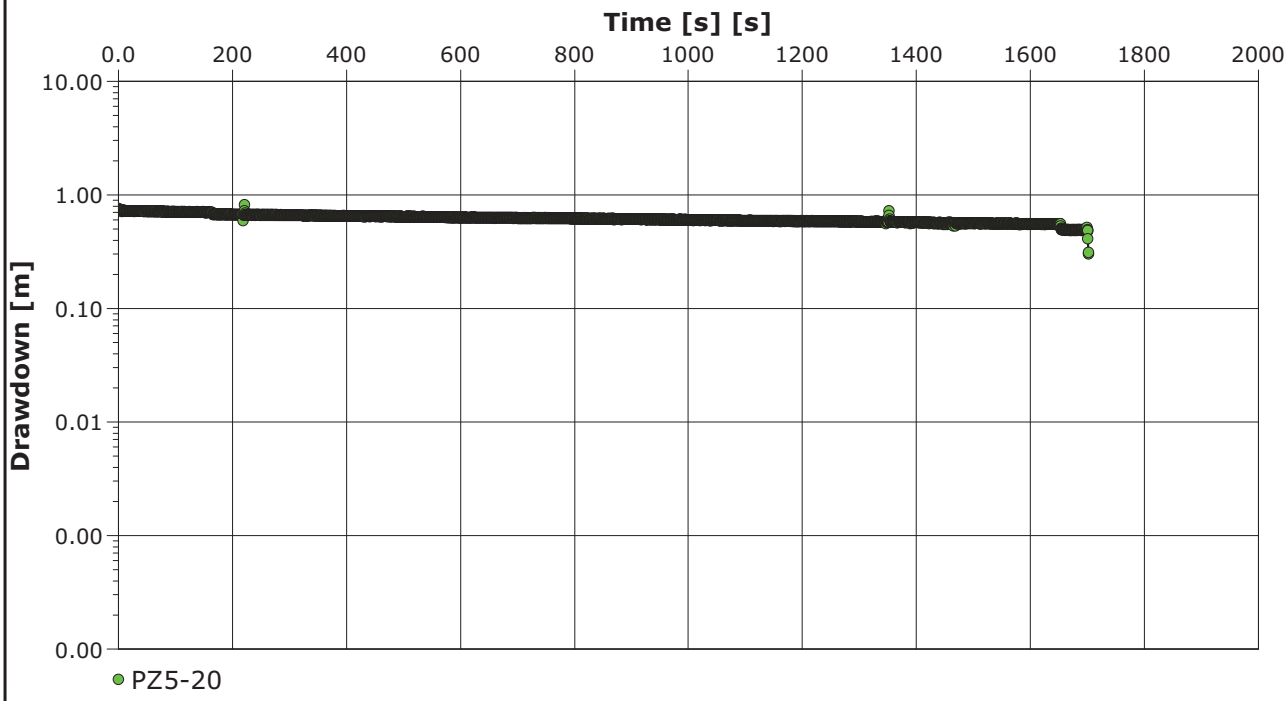
Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PZ5-20	1.25×10^{-2}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

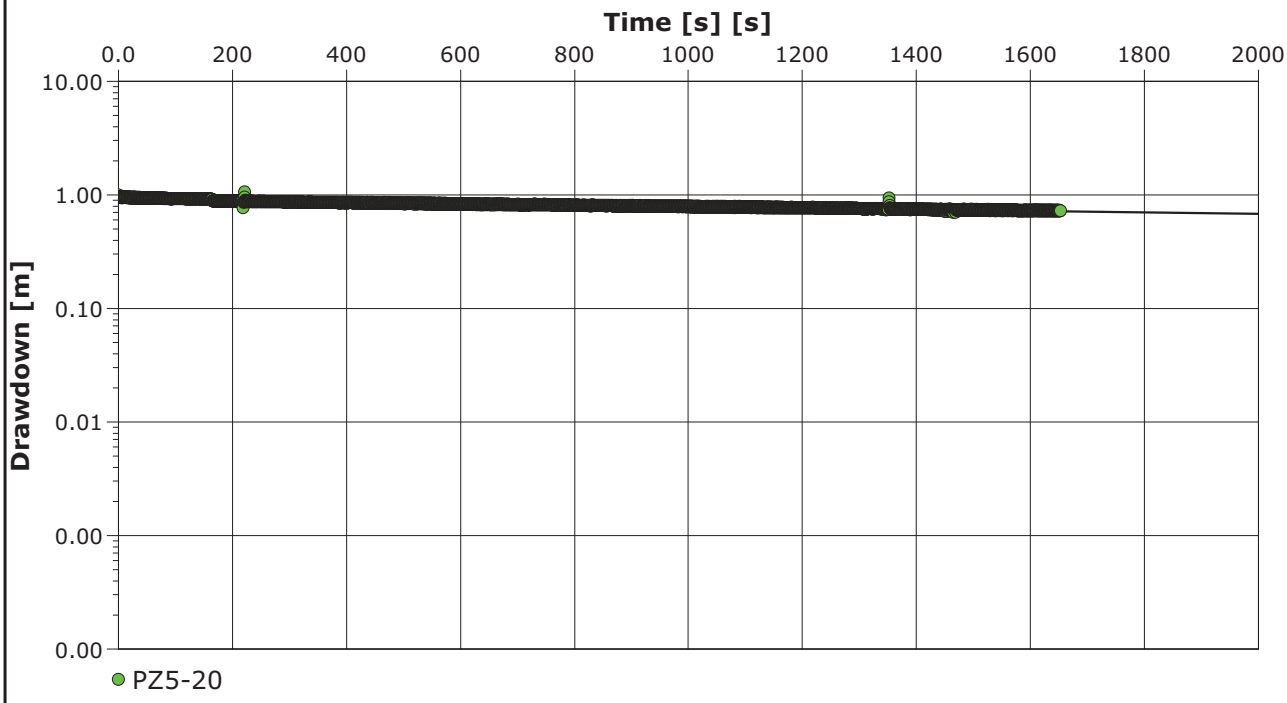
Location: Portland, Oregon	Slug Test: PZ5-20 Test 2	Test Well: PZ5-20
Test conducted by: MWilson/DLaffoon		Test date: 1/14/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 36.00 ft		



ANCHOR QEA	City, State/Province Address Contact Info Company Name	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128

Slug Test Analysis Report	
Project:	Gasco Ground Water Source Control
Number:	000029-02.28 task 3A
Client:	NW Natural

Location: Portland, Oregon	Slug Test: PZ5-20 Test 2	Test Well: PZ5-20
Test conducted by: MWilson/DLaffoon		Test date: 1/14/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 36.00 ft		

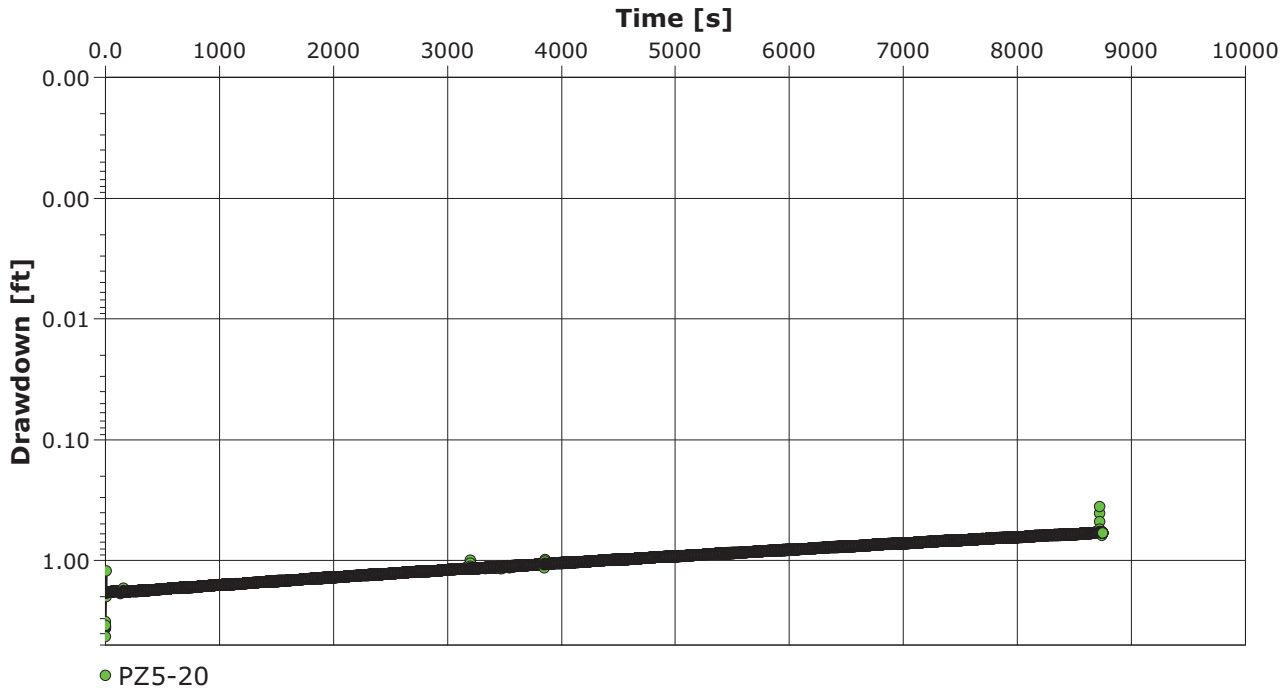


Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PZ5-20	2.78×10^{-2}	

City, State/Province **Address** **Contact Info** **Company Name**	6650 SW Redwood Lane, Suite 333 Portland, Oregon 97224 Phone 503.670.1108 Fax 503.670.1128	**Slug Test Analysis Report** Project: Gasco Ground Water Source Control Number: 000029-02.28 task 3A Client: NW Natural

Location: Portland, Oregon	Slug Test: PZ5-20 Test 3	Test Well: PZ5-20
Test conducted by: MWilson/DLaffoon		Test date: 1/14/2011
Analysis performed by: Matt Wilson	Time vs Change in Water Level	Date: 1/18/2011
Aquifer Thickness: 36.00 ft		



ANCHOR QEA
City, State/Province
Address 6650 SW Redwood Lane, Suite 333
Portland, Oregon 97224
Contact Info Phone 503.670.1108
Fax 503.670.1128
Company Name

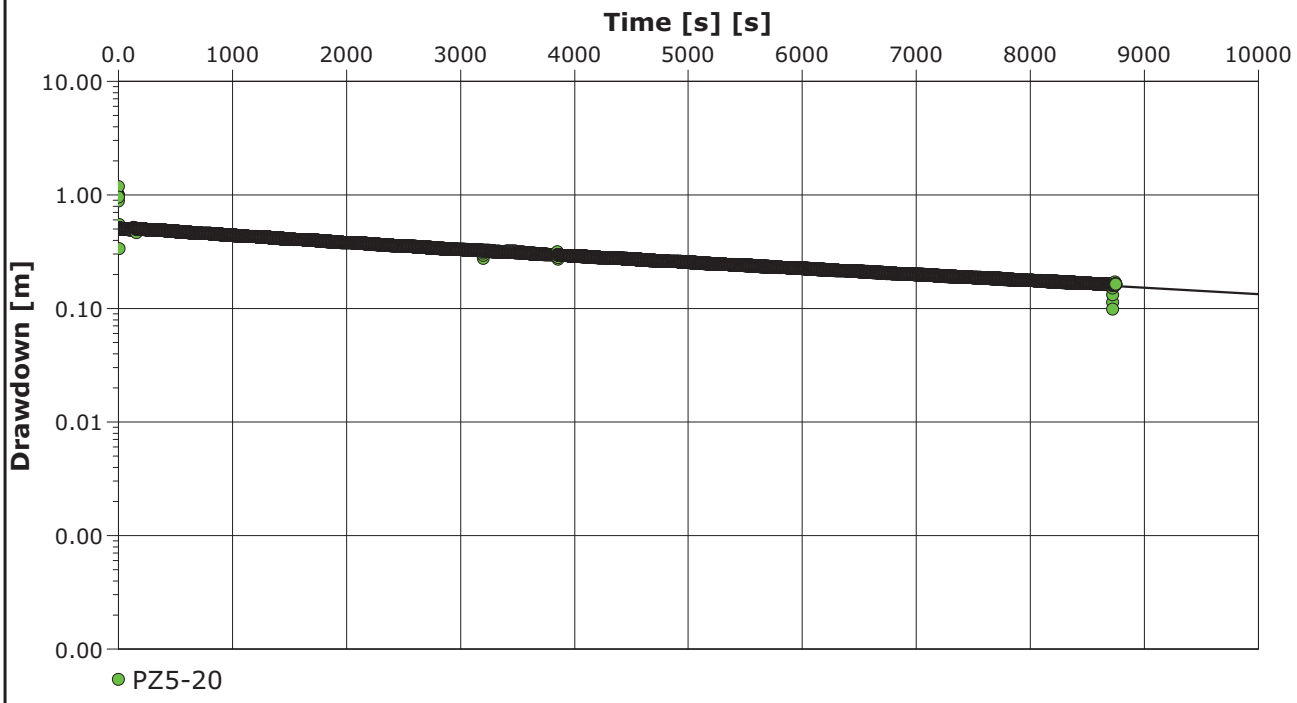
Slug Test Analysis Report

Project: Gasco Ground Water Source Control

Number: 000029-02.28 task 3A

Client: NW Natural

Location: Portland, Oregon	Slug Test: PZ5-20 Test 3	Test Well: PZ5-20
Test conducted by: MWilson/DLaffoon		Test date: 1/14/2011
Analysis performed by: Matt Wilson	Bouwer & Rice	Date: 1/17/2011
Aquifer Thickness: 36.00 ft		



Calculation after Bouwer && Rice

Observation well	K [ft/d]	
PZ5-20	2.47×10^{-2}	

APPENDIX D
AQUITARD GEOLOGY DATA TABLE

Well	Northing	Easting	GS elevation	Depth to Top of Deep Aquitard	Depth to Bottom of Deep Aquitard	Elevation of Top of Deep Aquitard	Elevation of Bottom of Deep Aquitard	Thickness of Deep Aquitard	Total Deep Aquitard Thickness	
MW-5-175			25.20	NA	NA	NA	NA	NA	NA	Boring omitted from data set - no sample recovery from study interval.
MW-16-125			30.49	Boring does not reach -100 ft elevation		NA	NA	NA	NA	
MW-21-165	705626.2	7623661.8	20.50	121	125	-100.5	-104.5	4	12.5	
			20.50	125.5	132	-105	-111.5	6.5		
			20.50	135	137	-114.5	-116.5	2		
MW-18-180	705444.0	7623930.0	31.70	140	156	-108.3	-124.3	16	16	
MW-19-180	705298.0	7624240.0	27.28	129	130	-101.72	-102.72	1	2.8	
			27.28	131	131.1	-103.72	-103.82	0.1		
			27.28	131.5	131.6	-104.22	-104.32	0.1		
			27.28	132	132.1	-104.72	-104.82	0.1		
			27.28	132.5	132.6	-105.22	-105.32	0.1		
			27.28	135	136	-107.72	-108.72	1		
			27.28	138.5	138.9	-111.22	-111.62	0.4		
MW-20-120			25.63	128	128.3	-102.37	-102.67	0.3	1	Several thin silt layers total 1 foot in thickness
			25.63	129	129.4	-103.37	-103.77	0.4		
			25.63	133.5	133.8	-107.87	-108.17	0.3		
WS-11-161	705147.4	7624628.3	31.94	146.5	147	-114.565	-115.065	0.5	3	
			31.94	150	152	-118.065	-120.065	2		
			31.94	153	153.5	-121.065	-121.565	0.5		
WS-12-161	704998.6	7624836.7	33.13	134	135.5	-100.873	-102.373	1.5	7	
			33.13	137	141	-103.873	-107.873	4		
			33.13	144	145.5	-110.873	-112.373	1.5		
WS-13	704633.3	7624575.1	33.43	132	139	-98.57	-105.57	7	18	
WS-13	704633.3	7624575.1	33.43	139.5	142	-106.07	-108.57	2.5		
WS-13	704633.3	7624575.1	33.43	142	142.5	-108.57	-109.07	0.5		
WS-13	704633.3	7624575.1	33.43	142.5	143	-109.07	-109.57	0.5		
WS-13	704633.3	7624575.1	33.43	143	144	-109.57	-110.57	1		
WS-13	704633.3	7624575.1	33.43	144.5	145.5	-111.07	-112.07	1		
WS-13	704633.3	7624575.1	33.43	148	151	-114.57	-117.57	3		
WS-13	704633.3	7624575.1	33.43	151.5	154	-118.07	-120.57	2.5		
WS-14-161	705182.5	7624485.7	32.40	141.5	142	-109.1	-109.6	0.5	6.5	
			32.40	143	148.5	-110.6	-116.1	5.5		
			32.40	149	149.5	-116.6	-117.1	0.5		
WS-15-140	704727.6	7624438.4	34.66	136	137	-101.34	-102.34	1	13.5	
			34.66	142.5	143.5	-107.84	-108.84	1		
			34.66	144.5	147.5	-109.84	-112.84	3		
			34.66	147.5	154	-112.84	-119.34	6.5		
			34.66	154	156	-119.34	-121.34	2		
WS-16-161	704964.3	7624326.3	34.61	136.5	137	-101.89	-102.39	0.5	10	
WS-16-161			34.61	139	143	-104.39	-108.39	4		
WS-16-161			34.61	144	146	-109.39	-111.39	2		
WS-16-161			34.61	149.5	153	-114.89	-118.39	3.5		
TG-1	705521.3	7623806.0	19.60	118.5	139	-98.9	-119.4	20.5	20.5	

Well	Northing	Easting	GS elevation	Depth to Top of Deep Aquitard	Depth to Bottom of Deep Aquitard	Elevation of Top of Deep Aquitard	Elevation of Bottom of Deep Aquitard	Thickness of Deep Aquitard	Total Deep Aquitard Thickness	
TG-2	705401.7	7623941.3	32.50	133	135	-100.5	-102.5	2	14	measured from CPT log
TG-2	705401.7	7623941.3	32.50	138	150	-105.5	-117.5	12		deep aquitard unit extends below bottom of boring for unknown depth
TG-3	705336.2	7624102.0	32.50	138	139	-105.5	-106.5	1	3	
			32.50	142	143	-109.5	-110.5	1		
			32.50	152	153	-119.5	-120.5	1		
TG-4	705276.1	7624230.2	28.60	132	134.5	-103.4	-105.9	2.5	3.5	
			28.60	143	144	-114.4	-115.4	1		
TG-5A	705187.5	7624332.5	25.30	132.5	134	-107.2	-108.7	1.5	1.5	
TG-6	705594.2	7623523.2	21.50	122.6	123.3	-101.1	-101.8	0.7	1.7	measured from CPT log
TG-6			21.50	124.1	124.5	-102.6	-103	0.4		
TG-6			21.50	125.4	126	-103.9	-104.5	0.6		
TG-7	705316.3	7623879.7	33.70	131	135	-97.3	-101.3	4	5	measured from CPT log
			33.70	145	150	-111.3	-116.3	5		deep aquitard layer extends below bottom of boring for unknown depth
TG-8	705110.4	7624222.5	36.70	135	137.5	-98.3	-100.8	2.5	2.5	The 2 silt layers are too far apart, so only the lower unit is included in the aquitard
TG-8			36.70	150	152.5	-113.3	-115.8	2.5		
TG-9	705454.6	7623852.7	31.40	137	138.5	-105.6	-107.1	1.5	8.5	
			31.40	143	146	-111.6	-114.6	3		
			31.40	147	151	-115.6	-119.6	4		
TG-10	705258.1	7624361.7	25.00	145	146.5	-120	-121.5	1.5	1.5	
TG-11	705189.6	7624150.2	36.90	138	140	-101.1	-103.1	2	4	
TG-11			36.90	142	144	-105.1	-107.1	2		
TG-12	705032.5	7624318.8	27.00	125.5	129.5	-98.5	-102.5	2.5	6	
TG-12			27.00	133	136.5	-106	-109.5	3.5		
TG-15	705332.3	7623961.9	33.60	133.8	139	-100.2	-105.4	5.2	9.9	
TG-15	705332.3	7623961.9	33.60	142.9	144.7	-109.3	-111.1	1.8		
TG-15	705332.3	7623961.9	33.60	149.7	152.6	-116.1	-119	2.9		deep aquitard unit extends below bottom of boring
TG-16	705157.6	7623823.8	35.60	146	147.5	-110.4	-111.9	1.5	1.5	
TG-1S	705123.1	7624613.2	35.20	142.4	143.7	-107.2	-108.5	1.3	3	measured from CPT log
TG-1S			35.20	146.2	147	-111	-111.8	0.8		
TG-1S			35.20	150	150.9	-114.8	-115.7	0.9		
TG-2S	704953.2	7624856.6	35.70	136.9	138.8	-101.2	-103.1	1.9	5.7	measured from CPT log
TG-2S	704953.2	7624856.6	35.70	142.4	144.1	-106.7	-108.4	1.7		
TG-2S	704953.2	7624856.6	35.70	149.2	151.3	-113.5	-115.6	2.1		
TG-3S	704877.7	7624265.5	35.00	132	139.5	-97	-104.5	4.5	10	
TG-3S			35.00	141	144	-106	-109	3		
TG-3S			35.00	146	148.5	-111	-113.5	2.5		
TG-4S	705112.8	7624436.7	33.60	136.5	139.5	-102.9	-105.9	3	5.5	
TG-4S			33.60	144	146.5	-110.4	-112.9	2.5		
TG-5S	704719.1	7624443.6	34.50	136	136.9	-101.5	-102.4	0.9	10.7	measured from CPT log
TG-5S			34.50	138.1	144.9	-103.6	-110.4	6.8		Same location as WS-15
TG-5S			34.50	146.2	149.2	-111.7	-114.7	3		
TG-6S	704598.5	7624577.8	34.60	133.7	136.9	-99.1	-102.3	3.2	10	measured from CPT log
TG-6S			34.60	140.7	142	-106.1	-107.4	1.3		Same location as WS-13

Well	Northing	Easting	GS elevation	Depth to Top of Deep Aquitard	Depth to Bottom of Deep Aquitard	Elevation of Top of Deep Aquitard	Elevation of Bottom of Deep Aquitard	Thickness of Deep Aquitard	Total Deep Aquitard Thickness	
TG-6S			34.60	142.8	148.3	-108.2	-113.7	5.5		
TG-7S	705069.4	7624690.9	35.30	143.2	145.3	-107.9	-110	2.1	3.1	measured from CPT log
TG-7S			35.30	151	152	-115.7	-116.7	1		
TG-8S	704895.4	7624770.2	35.20	132.7	137.4	-97.5	-102.2	4.7	10	measured from CPT log
TG-8S			35.20	138.5	142.6	-103.3	-107.4	4.1		
TG-8S			35.20	146.1	147.3	-110.9	-112.1	1.2		
TG-12S	705195.5	7624494.2	34.00	148.4	149.4	-114.4	-115.4	1	2.6	measured from CPT log
TG-12S			34.00	152.3	153.9	-118.3	-119.9	1.6		
GS-03	705918.0	7623381.0	5.50	108.5	109	-103	-103.5	0.5	7	
GS-03			5.50	111	117.5	-105.5	-112	6.5		
GS-04	705808.0	7623569.0	4.40	110	114	-105.6	-109.6	4	4	
GS-10	705235.0	7624654.0	2.50	119	120	-116.5	-117.5	1	6.5	
GS-10			2.50	122	129	-119.5	-126.5	5.5		
GS-12	705008.0	7624999.0	5.20	123	132.5	-117.8	-127.3	9.5	9.5	
GP-25	705241.9	7624678.5	1.40	118.7	119	-117.3	-117.6	0.3	0.3	
GP-26	705316.2	7624625.1	-8.10	88	93	-96.1	-101.1	5	7	
GP-26			-8.10	96	98	-104.1	-106.1	2		
GP-27	705325.8	7624736.8	-32.10	75.5	78	-107.6	-110.1	2.5	2.5	
GP-28	705168.7	7624798.9	3.40			3.4	3.4	0	0	
GP-33	704911.0	7624993.0	32.90	140	140.5	-107.1	-107.6	0.5	3.7	
GP-33			32.90	143.2	144	-110.3	-111.1	0.8		
GP-33			32.90	148.2	150.6	-115.3	-117.7	2.4		
GP-36	704836.0	7625091.0	32.90	128.5	134	-95.6	-101.1	5.5	22.3	
GP-36			32.90	135	136.5	-102.1	-103.6	1.5		
GP-36			32.90	136.7	140	-103.8	-107.1	3.3		
GP-36			32.90	140.5	141	-107.6	-108.1	0.5		
GP-36			32.90	142	145	-109.1	-112.1	3		
GP-36			32.90	145	150.5	-112.1	-117.6	5.5		
GP-36			32.90	151	151.5	-118.1	-118.6	0.5		
GP-36			32.90	152.5	155	-119.6	-122.1	2.5		
SIL-01			33.00	140	143	-107	-110	3	3	
SIL-02			35.00	149	156	-114	-121	7	7	
SIL-03			35.00						NA	TD @ -95 ft msl
RP-11-216			34.04	144	154	-109.96	-119.96	10	10	
P-5			34.22						NA	TD @ -66 ft msl
P-6			35.38						NA	TD @ -30 ft msl
P-7			34.98						NA	TD @ -29 ft msl

ANCHOR QEA

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MEMORANDUM

To:	Project File 000029-02	**Date:**	January 28, 2011
From:	Matthew Wilson	**Project:**	000029-02
Cc:			
Re:	Correlation of cone-penetrometer logs to traditional logging methods concerning occurrence of lower silt aquitard		

In their letter dated March 26, 2010, DEQ preliminarily concurred with NW Natural's interpretation of the presence of a lower silt aquitard presented in Section 2.1.2.1 of the Interim Design Report. However, DEQ acknowledged that several of the detections of the lower aquitard unit were based on analysis of cone-penetrometer (CPT) logs and requested that NW Natural analyze the correlation of CPT logging data of subsurface geology to subsurface geologic data obtained by traditional soil sampling methods, specifically concerning the occurrence of the lower silt aquitard unit.

Logs from three pairs of closely spaced borings were compared for correlation of CPT logs to traditional soil sampling methods. The results presented in the attached table and plots of CPT log data on geologic cross sections bear out that data from CPT logs are sufficient in determining the presence of the lower silt aquitard unit. The attached table shows that the CPT logs not only detected the presence of the lower silt aquitard, but the aquitard was also detected within a few vertical feet of the interval where it was described using traditional soil sampling methods.

Table
Lower Aquitard Occurrence
from Cone Penetrometer Logs and Traditional Soil Sampling Methods
NW Natural Gasco Site

Well or Boring ID	Linear distance between locations	Ground Surface elevation (COP)	Depth to top of silt unit	Depth to bottom of silt unit	Elevation of top of silt unit	elevation of bottom of silt unit
	feet	feet, COP	feet	feet	feet, COP	feet, COP
MW-18-180[1]	43.7	31.7	140	156	-108.3	-124.3
TG-2[2]		32.5	139	153	-106.5	-120.5
WS-14-161[1]	15.5	33.8	143	149.5	-109.2	-115.7
TG-12S[2]		34.0	149	154	-115.0	-120.0
MW-19-180[1]	24.0	27.3	135	136	-107.7	-108.7
TG-4[2]		28.6	132.2	134.5	-103.6	-105.9

Notes: [1] Boring logged using traditional soil sampling methods
[2] Boring logged using cone penetrometer methods
COP = City of Portland vertical datum

APPENDIX E
TREATMENT SYSTEM DESIGN REPORT

NW Natural Gas Company

NW Natural and Siltronic
Wastewater Treatment Final Design Report

April 2011

Sevenson Environmental Services, Inc.

NW Natural/Siltronic
Wastewater Treatment Final Design Report
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April 2011

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Process Design—NW Natural Site

The final treatment process is largely designed to remove iron and manganese, cyanide, heavy metals, VOCs and SVOCs. The plant will be situated inside a secondary containment area containing crushed stone over a 40-mil liner. The berm will be incorporated into the building footing to contain wastewater, residual, or chemical spills. The facility will be operated under a site-specific Health and Safety Plan (HASP), submitted under separate cover. The site-specific HASP will address spill prevention and countermeasures to be taken and emergency contacts in the event of a spill.

The NW Natural plant is designed to operate at a maximum hourly flow rate of 663 gpm. Treated effluent from the Siltronic plant (maximum hourly flow of 142 gpm) will be blended into the NW Natural plant for a maximum hourly influent flow rate of 805 gpm, operating on a continuous basis. Discharge will be to the Willamette River.

All backwash water will be recirculated to the influent equalization tanks for re-treatment. All plant residuals (bag filters, sedimentation tank solids, and spent carbon) will be properly disposed of to a permitted facility.

Process Design—Siltronic Site

The proposed treatment process is largely designed to remove iron and manganese, cyanide, heavy metals, and chlorinated solvents including vinyl chloride. The oil-water separator, air stripping tank, equalization tank and influent pump will be situated inside a secondary containment area on the NW Natural site at the NW Natural-Siltronic property line. The containment area will contain crushed stone over a 40-mil liner, with berms around the entire plant site to contain wastewater, residual, or chemical spills.

The preliminary Siltronic treatment train will be located approximately 500 feet away from the main plant.

Basis of Plant Design

Design Flows

The design flows for the treatment plant have been based upon further hydrogeological investigation and modeling by Anchor QEA. The Average-Day flow values for the Northwest Natural Gas and Siltronic sites were obtained from the modeling results. These flows were not used directly for plant design, but are useful in establishing annual operating costs.

The Maximum-Day flows for each site were obtained by applying a peaking factor to the Average-Day flows. The Maximum-Day flow is the maximum sustained flow that will occur in the plant. The Maximum-Day flows were used in sizing most of the unit processes, chemical feed systems, piping and valves.

The Maximum-Hour flows were obtained by applying a peaking factor resulting from tidal fluctuation in the river to the Maximum-Day flow values. The Maximum-Hour flow is the maximum flow rate experienced at the plant for one hour, likely as a result of maximum river stage variation from the site groundwater level. The Maximum-Hour flows were used to size all process pumps within the plant, to ensure that all flows can be accommodated by the design.

A summary of design flows for the plant is shown in Table 1.

Wastewater Characteristics

Sevenson has based the wastewater characteristics in this design document on the results of a 6-week pilot plant test, completed in September 2009, and a 1-week air stripping bench-scale study conducted in Sevenson's Wastestream laboratory.,

The Wastewater Pilot Plant Testing Plan (Sevenson, April, 2009) was provided to DEQ on May 4, 2009. DEQ provided a preliminary comment letter on October 13 and Sevenson prepared a May 21 response letter addressing DEQ's comments. The findings from operating the pilot treatment plant have been incorporated into the final design of the treatment system. The Pilot Plant report was submitted to DEQ prior to this report.

Table 1: Summary of Treatment Plant Design Flows

Average Day, gpm	
NW Natural, gpm	378
Siltronic, gpm	81
Total Average Day Flow, gpm	**459**
Maximum Day Flow, gpm	
NW Natural, gpm	510
Siltronic, gpm	109
Total Maximum-Day Flow, gpm	**619**
Maximum Hour Flow, gpm	
NW Natural, gpm	663
Siltronic, gpm	142
Total Maximum-Hour Flow, gpm	**805**

The approach and sizing data contained in this Final Design Report are based upon the groundwater monitoring and modeling studies, the pilot plant data, the Wastestream Technology air stripping studies, and prior treatability studies that established the processes as effective in cost-effectively meeting Oregon DEQ's discharge standards.

Sevenson has included its wastewater treatment plant design and materials balance in Attachment A for both the NW Natural and Siltronic sites. The Final Design drawings for the plant are included in Attachment B.

Influent Wells

In the full scale extraction system the NW Natural treatment plant will draw from a number of wells on the NW Natural Site, and wells from the Siltronic site. The well locations are described elsewhere in the Design Report.

Flow from the well pumps will be controlled from the central Supervisory Control and Data Acquisition (SCADA) system to ensure that all contaminated groundwater from the site will be intercepted and conveyed to the treatment plant.

Water level transducers in the river and key monitoring wells will be used for real time measurement of river and groundwater elevations. The well discharge rates will be adjusted to maintain average groundwater elevation below average river elevation and thereby achieve containment of groundwater at the shoreline.

Because of daily river tidal influences on the near shore groundwater levels, the well flow rates will be adjusted concurrently with groundwater level fluctuations through the use of variable frequency drives which will control the well pumping rates. The system will be constructed for remote monitoring of groundwater elevations and well discharge rates. The extraction well pumping rates will be monitored from the SCADA control panel. Flow from each well will be indicated and totalized within the SCADA system.

NW Natural Pretreatment Facilities

The pretreatment facilities are dedicated to Segment 2 wells and a portion of Segment 1 wells. The purpose of the NW Natural pretreatment facilities is to remove most or all DNAPL that may be present, particularly in the PW wells, and to reduce volatile organic compounds (VOCs) present, and to provide partial removal of semi-volatile organic compounds (SVOCs) before entering the Combined Treatment Plant. The NW Natural pretreatment facilities include:

- An oil-water separator;
- A sodium hydroxide feed system;
- Air stripping tanks; and

- An activated carbon air-treatment system.

These systems are described in further detail in the following sections.

NW Natural Oil-Water Separator (OWS)

The NW Natural wells will discharge into an oil-water separator prior to entering the treatment plant. The OWS will be elevated to permit gravity flow into the downstream air strippers. The purpose of the OWS is to capture DNAPL from the incoming wells prior to further treatment.

The oil-water separator is the coalescing-plate type, designed to remove heavy DNAPL concentrations. Collected DNAPL will be pumped to a storage tank and reused off-site to the extent possible.

NW Natural Sodium Hydroxide Feed Pumps

Two sodium hydroxide (caustic) feed pumps, pH meters and controllers will be installed between the oil-water separator and air strippers, in order to increase the influent pH to 9.5-10.0. The rates of iron and manganese oxidation are both greatly accelerated at higher pH.

The sodium hydroxide system will feed 25% sodium hydroxide from a 7,500-gal tank into a static mixer to permit in-line mixing before entering the air strippers. Two pumps (one duty, one standby) will be provided. The duty feed pump will be paced by an in-line pH set-point controller, which is tied to the plant's SCADA system.

NW Natural Air Stripping Tanks

Prior to entering the air stripping tanks, the wastewater pH will be adjusted to 9.5-10.0 to facilitate the ultimate precipitation of iron, manganese, and other metals in the downstream settling process.

Two 21,000-gallon closed-top tanks will be provided. The purpose of the air stripping tanks is twofold:

1. To volatilize the small quantity of volatile organic compounds (VOCs) present, and to provide partial stripping of semi-volatile organic compounds (SVOCs); and

2. To oxidize incoming iron and manganese which are both in their soluble, reduced forms.

Two 1,200 standard-cubic-feet-per-minute (scfm) positive-displacement blowers will be provided, one per tank, but manifolded to permit either blower to operate with either tank. The blowers will have variable-frequency drives to adjust the blower speed and output as desired. The blowers have been designed to provide a minimum air: water ratio of 30: 1 at the maximum-day flow rate. At lower flows, the air: flow ratio will be higher. Laboratory data from the Wastestream results (to be submitted in the Pilot Plant Report) indicated that virtually complete removal of VOCs and 50% removal of SVOCs were achievable at the design air: water ratio.

The tanks are designed with baffles to also collect any floating light solids and oil that may be present. The accumulated solids and floatables in the tanks will be periodically removed as required using a trash pump.

NW Natural Air Stripper Carbon System

A vapor-phase activated carbon system will be used to collect stripped organics from the stripper air prior to discharge to the atmosphere.

Siltronic Pretreatment Facilities

The pretreatment facilities are dedicated to Siltronic wells and three wells on NW Natural property (P3U, P3L, and P11), which may contain F002 listed wastes: volatile chlorinated hydrocarbons. The purpose of the Siltronic pretreatment facilities is to remove most or all DNAPL that may be present, particularly in the PW wells, and to reduce volatile organic compounds (VOCs) present to levels at which the water no longer contains F002 waste, and to provide partial removal of semi-volatile organic compounds (SVOCs) before entering the main treatment plant. The Siltronic pretreatment facilities include:

- An oil-water separator;
- A sodium hydroxide feed system;

- Air stripping tank; and
- An activated carbon air-treatment system.

These systems are described in further detail in the following sections.

Siltronic Oil-Water Separator (OWS)

The Siltronic wells, as well as three wells (P3U, P3L and P11) that might contain F002-listed wastes, will discharge into an oil-water separator prior to entering the pretreatment plant. The purpose of the OWS is to capture DNAPL from the incoming wells prior to further treatment. The Siltronic OWS will be elevated to permit gravity flow into the downstream air stripper.

The oil-water separator is the coalescing-plate type, designed to remove heavy DNAPL concentrations. Collected DNAPL will be pumped to a storage tank and reused off-site to the extent possible, or taken to a suitable disposal facility in the event it contains F002 waste.

Siltronic Sodium Hydroxide Feed Pumps

Two sodium hydroxide (caustic) feed pumps, pH meters and a pH controller will be installed between the oil-water separator and air strippers, in order to increase the influent pH to 9.5-10.0. The rates of iron and manganese oxidation are both greatly accelerated at higher pH.

The sodium hydroxide system will feed 25% sodium hydroxide from a 2,500-gal tank into a static mixer to permit in-line mixing before entering the air stripper. Two pumps (one duty, one standby) will be provided. The duty feed pump will be paced by an in-line pH set-point controller, which is tied to the plant's SCADA system.

Siltronic Air Stripping Tank

Prior to entering the Siltronic air stripping tank, the wastewater pH will be adjusted to 9.5-10.0 to facilitate the ultimate precipitation of iron, manganese, and other metals in the main plant settling process.

One 21,000-gallon tank will be provided to handle all Siltronic flows. The purpose of the air stripping tank is twofold:

1. To volatilize the various chlorinated solvents (vinyl chloride, trichloroethylene, and the various forms of dichloroethylene) present in the Siltronic wells, and to provide partial stripping of SVOCs; and
2. To oxidize incoming iron and manganese which are both in their soluble, reduced forms.

Two 600 standard-cubic-feet-per-minute (scfm) positive-displacement blowers will be provided. The blowers will have variable-frequency drives to adjust the blower speed and output as desired. The blowers have been designed to provide a minimum air: water ratio of 30: 1 at the maximum-day flow rate. At lower flows, the air: flow ratio will be higher. Laboratory data from the Wastestream results (to be submitted in the Pilot Plant Report) indicated that virtually complete removal of VOCs and 50% removal of SVOCs were achievable for the Siltronic wastewater at the design air: water ratio, and that air stripping easily attained Oregon DEQ's identified "contained-in" levels for F002 waste as follows in Table 2. Sampling will be performed on the tank effluent on a daily basis initially to establish that the effluent is free of F002 waste before introducing the flow to the NW Natural stream.

The tank is designed with baffles to also collect any floating light solids and oil that may be present. Any accumulated solids and floatables in the tank will be periodically removed as required using a trash pump. These solids will be tested for F002 waste and disposed of accordingly.

Table 2: Proposed F002 Contained-In Determination Threshold Values[1]

F002-Related Constituent	Liquid F002 Contained-In Threshold, µg/L	Soil F002 Contained-In Threshold, mg/kg
Trichloroethene (TCE)	**5**	**3.9**
Cis-1,2 Dichloroethene (cis 1,2 DCE)	**70**	**10,000**
Trans-1,2 Dichloroethene (Trans 1,2 DCE)	**100**	**9,200**
1,1 Dichloroethene (1,1 DCE)	**7**	**27,000**
Vinyl chloride	**2**	**3.9**

Siltronic Air Stripper Carbon System

A vapor-phase activated carbon system will be used to collect stripped organics from the stripper air prior to discharge to the atmosphere. The spent carbon will be evaluated for F002 characteristics and be disposed of accordingly.

Siltronic Transfer Pumps

Two transfer pumps, one duty, one standby, are provided to pump the Siltronic flow directly to the main treatment plant. The duty pumping rate will be controlled off of level in the air stripper wet well. The pump will discharge through a 4-inch HDPE pipe approximately 500 feet to the Combined Treatment Plant (NW Natural Air Stripper Wet

[1] These proposed levels for a contained-in determination of threshold values for liquids and soils were proposed in March 5, 2008 letter from Rob Ede of Hahn and Associates, Inc. to Dana Bayuk, Oregon DEQ. Liquid contained-in threshold values proposed were USEPA Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act. Soils contained-in threshold values proposed are DEQ's Risk-Based Concentrations (RBCs) for the protection of an "Occupational Worker."

Wells and Spent Backwash Storage Tank), where it will combine with the other NW Natural flows for further treatment.

Siltronic Flow Meter

Flow from the Siltronic Pretreatment Plant will be measured by a 4-inch magnetic flow meter and totalized on the plant SCADA system.

Combined Treatment Plant

The Combined Treatment Plant will treat all flows from NW Natural and Siltronic Pretreatment facilities, as well as all recycled process flows. The primary purpose of the combined treatment plant is to remove suspended solids, heavy metals including iron and manganese, cyanide, and remaining organic compounds below the NPDES permit values still being reviewed by Oregon DEQ.

To achieve these treatment goals, the Combined Treatment Plant consists of the following processes:

- Chemical coagulation/sedimentation in Inclined-Plate Clarifiers
- Cyanide destruction through the use of sodium hypochlorite or hydrogen peroxide
- Bag filtration
- Granular activated carbon adsorption
- Secondary bag filtration
- Effluent cooling as required
- Solids thickening and dewatering

These processes are described in more detail in the following sections.

Inclined-Plate Clarifier (IPC) Feed Pumps

Two 850-gpm centrifugal IPC feed pumps will be provided (one duty, one standby), each sized for the design Maximum-Hour flow. The IPC Feed Pumps lift the flow from the Air Stripper Wet Well to the IPC units.

The pumps are equipped with variable frequency drives (VFD) adjustable speed control, to allow for different flow rates to the plant. The IPC Feed Pump output will be controlled by a level controller in the Air Stripper Wet Well.

IPC Flow Meter

A 4-inch flow meter will be provided to control the downstream polymer feed unit. The flow meter will read the combined NW Natural and Siltronic flows, and control the feed rate of the polymer addition unit downstream.

Polymer Addition

A polymer addition system will be installed to feed polymer to the wastewater prior to introduction into the inclined-plate clarifiers, in order to facilitate settling of solids in the IPCs.. The polymer will be injected into the pipeline prior to the IPC flash-mix chambers. The polymer feed rate will be paced by the flow meter to the IPCs.

Inclined-Plate Clarifiers (IPCs)

Two inclined-plate clarifiers (IPCs) will receive the flow from the Air Stripper Wet Wells from both NW Natural and Siltronic. The principal purpose of the IPCs is to remove the oxidized iron and manganese generated in both upstream processes.

In addition, heavy metals will be removed via iron co-precipitation in the clarifier. Each tank will be equipped with a mechanical flash-mix chamber, and a mechanical flocculation chamber to facilitate settling of the chemical flocs. Each tank will be equipped with 2,500 square feet of settling area. The flash mixer and flocculator motors will be equipped with VFDs to allow for variability in mixing intensity, as required by operating conditions.

Settled sludge will be removed via two air-operated diaphragm pumps located between the IPCs, and designed to work off an adjustable timer programmed in the SCADA system. The pumps will discharge to two gravity thickener tanks for storage, thickening, and ultimate dewatering via a filter press. The resulting filter cake will be stored in a proper container within the containment area, will be tested for F002 waste characteristics, and will be properly disposed of periodically.

Cyanide Destruct Chemical Feed System

A chemical feed system will be supplied to provide for cyanide destruction. The chemical feed pumps and control system will be capable of feeding either 50% hydrogen peroxide or 12.5% sodium hypochlorite, both of which proved to be effective in reducing cyanide in previous pilot and bench-scale tests.

An ORP meter and controller will be installed on the cyanide destruct reactor to destroy cyanide as described below. The feed pumps will take suction from a 5,000-gallon chemical storage tank of either 50% hydrogen peroxide solution, or 12.5 % sodium hypochlorite solution.

Cyanide Destruct Reactor

Two 21,000-gallon reactor tanks will be used for cyanide destruction via the alkaline oxidation process. The alkaline oxidation process uses either hydrogen peroxide (H_2O_2) or sodium hypochlorite (NaOCl) to break the cyanide bond at high pH in two steps.

1. Cyanide (CN-) oxidized to cyanate (CNO-);
2. Cyanate is further oxidized to carbon dioxide and nitrogen gas,

Both of these reactions will occur in the cyanide destruct tanks. The addition of either hydrogen peroxide or sodium hypochlorite (both strong oxidizers) is made ahead of the destruct tank. The oxidizer feed rate is automatically controlled by Oxidation-Reduction Potential (ORP), measured in millivolts by probes in the tanks. Adding the oxidant raises ORP in the wastewater. An ORP controller will control the addition of the oxidant to the desired level to destroy cyanide.

The tanks are sized for a minimum detention time of 60 minutes at the Maximum-Day flow rate, based upon the results in the treatability and pilot tests. A constant water level will be maintained in the tanks via level controls and variable-speed pumping.

Sulfuric Acid Feed System

A sulfuric acid feed pump, a pH meter and a controller will be installed on the combined pipe from the cyanide destruct tanks to reduce the wastewater pH to approximately 8.5.

Two acid pumps (one duty, one standby) will be provided. The sulfuric acid feed pumps will take suction from a tote, containing approximately 240 gallons of sulfuric acid. The acid will be injected upstream of a 4-inch in-line static mixer.

Filter Feed Pumps

Following the cyanide reactor tanks will be two 850-gpm electric centrifugal pumps (one duty, one standby), sized to accommodate Maximum-Hour flow. The pumps are automatically controlled, using a set level in the cyanide destruct tank. The flow rate will be adjusted with the use of variable-frequency drives on the pump motors.

The Filter Feed Pumps will pump the combined flows through the primary bag filters, the granular activated carbon (GAC) vessels, and the secondary bag filters, before discharging into the Effluent/Backwash Storage Tanks.

Primary Bag Filters

Six pressure bag filters (3 trains of 2 filters) will be provided to remove remaining particulates from the wastewater prior to the GAC units. The three trains of bag filters will be set up to operate in series to filter precipitated iron and other solids prior to introduction into the GAC vessels. Each bag filter has a capacity of 500 gpm.

The upstream and downstream filters will be fitted with 10-micron and 5-micron bags, respectively. The vessels are fitted with inlet and outlet pressure transmitters. When the selected pressure differential is reached, the train will automatically shift to the other train and the SCADA system will alert the operator to changes filter bags before putting the train back on line.

Granular Activated Carbon Vessels

The waste stream then flows through two trains of two, 10-foot diameter Granular Activated Carbon (GAC) vessels (4 total), piped in series, with differential pressure measured across each vessel. The GAC units will remove volatile organics and semi-volatile organics in the effluent from the filter units. Twelve thousand five hundred pounds of carbon will be loaded into each vessel, for an overall total of 50,000 pounds of carbon.

The lead-lag system design is intended to continue to remove all organics in the lag vessel after breakthrough in the lead vessel. Breakthrough will be determined by frequent sampling of volatile and semi-volatile organics between the columns. After breakthrough, volatile and semi-volatile organics will be monitored from the lag column. No work will continue if the lag vessel becomes exhausted. The amount of carbon in each vessel has been calculated to give the process water adequate contact time at Maximum Day flow rate plus recycle flows.

The GAC filters will be provided with backwashing capability to allow continuous operation. A single train will be shut down for backwashing and the other train will continue processing the entire flow. Spent backwash water will be returned to the Spent Backwash Tank for re-processing through the plant.

Secondary Bag Filters

A final filtration step will be accomplished using three secondary bag filters arranged in parallel. The filters are intended to remove any carbon fines and adsorbed organics escaping the GAC vessels.

The vessels are each sized for 500 gpm, and are fitted with inlet and outlet pressure transmitters. The filters are capable of handling the Maximum-Hour flow rate plus recycle flows, with one unit out of service for bag changes.

The bag filters will be equipped with either 1.0-micron or 0.5-micron bags. The bags will be changed at an appropriate pressure differential.

Effluent/Backwash Storage Tanks

Treated effluent will be discharged into two 21,000-gallon backwash storage tanks. The tanks will serve as clean water holding tanks for backwash water, and for sampling effluent prior to discharge.

Effluent/Backwash Pumps

Two electric centrifugal pumps (one duty, one standby) will be provided, each with a capacity of 942 gpm, to allow for a suitable backwash rate for the GAC vessels and to discharge the Maximum-Hour flow.

Flow Meter Rate/Totalizer

All treated wastewater discharged from the plant will pass through a magnetic flow meter. Discharge flow rates and totalized volumes will be recorded by the SCADA system.

In addition, a backwash flow meter will be installed on the backwash line. Backwash flow and duration will be controlled by SCADA.

Effluent Discharge

The effluent will be discharged under pressure past the Effluent Bag Filters to the discharge point to the river. As an alternative, flow may be diverted to the Backwash Storage Tank as necessary.

Effluent Heat Exchanger

Prior to discharge, the plant effluent will pass through a heat exchanger, if required, to reduce the plant effluent temperature to the NPDES requirement.

Effluent Sampler

A refrigerated composite effluent sampler will be provided to collect a representative effluent sample for monitoring and compliance. The sampler will obtain a flow-proportioned effluent sample controlled off the outputs of the effluent flow meter and totalizer.

Combined Plant Residuals Handling and Disposal

All residuals from both the NW Natural and Siltronic treatment plants: settled solids, GAC media, and spent bag filters, will be properly disposed of in a hazardous or nonhazardous landfill, depending upon their characteristics. The residuals will be analyzed for F002 characteristics, and will be disposed of accordingly.

Gravity Sludge Thickeners

Settled sludge from the IPC units will be pumped to two gravity thickeners by an air-operated diaphragm pump. The purpose of the gravity thickeners is to concentrate the sludge to the maximum extent possible prior to dewatering with a filter press.

Two 20,000-gallon storage tanks will be provided and piped either in common or individually. The tanks allow for up to 3.5 days of storage of sludge under normal conditions, to accommodate weekend and holiday periods. Each tank will be equipped with a steep, cone bottom and decanting valves to permit thickening.

The decanted water from the thickeners will be piped to a recycle pump station for return to the Air Stripper Wet Wells.

Filter Press, Feed Pump and Polymer Addition

Two filter press feed pumps will be provided to pump thickened sludge from the gravity thickeners to the filter press. The pumps are air-operated diaphragm pump, are each sized at 100 gpm, to handle the required sludge flow at nominal pressure up to the maximum filter press pressure of 100 psi. A polymer feed system will be used to pump polymer into the pump suction lines prior to the filter press to improve the press' dewatering performance.

The filter press is sized at 100 cubic feet. With an estimated cycle time of 2 hours, this allows for approximately 3 drops per day. The filter press is expected to produce a cake with a solids content of 50-60%. Filtrate from the filter press will be returned under pressure to the Air Stripper Wet Wells.

Dried filter cake will be analyzed for F002 characteristics, heavy metals, cyanides and organics and a determination made as to its nature, whether hazardous or nonhazardous. An appropriate disposal site for the sludge cake will be selected after the determination.

Air Compressor and Storage Tank

An air compressor and storage tank will be provided to operate the IPC and Filter press sludge pumps, the filter press pneumatic valves, the filter press system, and to blow down the filter press.

Instrumentation

Supervisory Control and Data Acquisition

A Supervisory Control and Data Acquisition (SCADA) system provides overall monitoring and control of the treatment facilities. The SCADA system comprises Programmable Logic Controllers (PLC), a Personal Computer (PC) and Variable Frequency Drives (VFD) interconnected by an Industrial EtherNet/IP™ Local Area Network (LAN).

Operation of the Siltronic Pretreatment Facility (SPTF) is monitored and controlled by a remote PLC. This PLC communicates over fiber-optic data communication cables with a central PLC and a PC in the Combined Treatment Facility. The SCADA system for the groundwater extraction wells communicates with the treatment system SCADA system by an EtherNet/IP™ link. There are also several discrete, i.e. point-to-point, interlocks for critical functions such as a well field shutdown required by a treatment system process shutdown.

Field instruments and process control components within the treatment facilities are shown on the Process Piping and Instrumentation Diagrams (P&IDs) included as Drawings FD-2—FD-5. Field instruments, such as tank level transmitters and flow meters, are connected directly to PLC analog input modules. Pump control VFDs are monitored and controlled digitally by EtherNet/IP™ connections to the SCADA LAN.

Siltronic Pretreatment Facility

Drawing FD-2 shows the P&ID for Siltronic pretreatment facility located at the northeast corner of NW Natural property adjacent to the Siltronic property line. Groundwater is pumped from two extraction wells on the Siltronic property into an oil-water separator and then flows by gravity into an aeration tank with underflow baffle and overflow weir discharging into a flow equalization wet well.

A pH probe in the pipeline between the separator and aeration tank measures the pH and controls the output of a chemical metering pump feeding sodium hydroxide to raise the process pH to a predetermined set point.

The aeration blower is controlled manually by start-stop pushbuttons in the locally mounted blower control panel. Blower operational status, i.e. on or off, is monitored by the SCADA system.

An ultrasonic transducer and level transmitter system measures the liquid level in the flow equalization wet well. The level transmitter output signal is the process variable input to a loop controller in the SCADA PLC. The PLC will be programmed to provide proportional band control of the flow equalization discharge pump. The pump speed will increase as the liquid level increases and will decrease as the level decreases. The controller gain will be selected to provide maximum attenuation of influent flow rate variations.

Pretreatment discharge flow rate will be measured and communicated to the main plant. Provision will be made for intermittent addition of hydrogen peroxide to the pretreatment discharge force main. An insertion-type oxidation-reduction potential (ORP) probe will be available to control the peroxide feed in a proportional plus integral (PI) control loop.

Flow Equalization and Aeration

The Siltronic Pretreatment Facility discharges to the Combined Plant's Spent Backwash Storage Tank and the Air Stripper Wet Wells, which are hydraulically connected. Filtrate discharge from the filter press and the sump pump discharge from the sludge storage/decant tanks are also returned to these tanks along with backwash from the carbon filters.

Influent flow meters measure flow from the individual NW Natural extraction wells. Transmitter outputs are summed with the pretreatment flow meter in the SCADA system for a total plant flow.

If the pretreatment flow is combined with the NW Natural extraction wells, the well flow is computed by subtracting the pretreatment flow from the influent flow meter flow. This well flow is a check on the sum of the flows from the individual wells.

A pH probe controls a sodium hydroxide chemical metering pump to raise the well flow pH to a predetermined set point suitable for metal hydroxide precipitate formation. The air stripper blowers are controlled manually by start-stop pushbuttons in the locally mounted blower control panels. Blower operational status, i.e. on or off, is monitored by the SCADA system.

A level transmitter in one of the Air Stripper Wet Wells controls the IPC Feed Pumps. A second transmitter in the other wet well is a backup. Discharge rate of the pumps is measured by a magnetic flow meter.

Flocculation and Settling

Flocculation and settling processes are shown on Drawing FD-4. The feed pump discharge flow meter output flow-paces a chemical feed pump that feeds polymer necessary for flocculation/coagulation and settling.

The flocculation basin is integral to the Inclined Plate Clarifier (IPC). Energy input for flocculation and coagulation is controlled by an adjustable-speed flocculator drive motor. The operator manually adjusts the mixer speed at the VFD.

Precipitated solids settled in the IPCs are removed by a gravity blow-off to either of two sludge storage tanks. A solenoid valve controlled by the SCADA PLC will actuate one of two air-operated sludge pumps to regulate sludge wasting.

IPC Effluent Clearwell and Cyanide Destruction

Drawing FD-4 also diagrams the cyanide destruction process. Overflow from the IPC flows by gravity to the Cyanide Destruct Reactors. ORP probes in the reactors controls a chemical metering pump, feeding either hydrogen peroxide or sodium hypochlorite.

The cyanide reactors also serve as an IPC clearwell. An ultrasonic level transmitter system in the reactor tanks controls the Filter Feed Pump discharge to the primary bag

filters, GAC vessels, and secondary bag filters, in order to maintain adequate hydraulic residence time (HRT) in the cyanide destruct reactors.

Primary and Secondary Bag Filters

Suspended solids remaining after the IPCs and suspended solids formed by oxidation reactions in the cyanide destruction process are removed in the primary bag filters. Pressure transmitters ahead, after and between the primary and secondary bag filters transmit line pressures to the SCADA system. The gauge pressures at these points are used to continuously calculate differential pressure across the filters and indicate when cleaning is required.

Granular Activated Carbon Filtration

Drawing FD-5 diagrams the Granular Activated Carbon (GAC) filters. Operation and cleaning (backwashing) of the GAC filters will be controlled manually. The GAC filters are normally operated in two parallel trains of two vessels.

Pressure transmitters on the influent and effluent piping allow the SCADA system to compute differential head-loss across the GAC system.

The SCADA system will use a supplemental pressure transmitter between the GAC filters to determine individual head losses when the filters are operated in series. A final bag filter system is provided after the GAC filters to capture any charcoal fines that may be flushed through. A pressure transmitter downstream of the final bag filters allows the SCADA system to compute head loss and indicate when the bag filters need cleaning.

Final Effluent Filter Backwash System

Effluent from the GAC vessels and secondary bag filters is discharged to Effluent/Backwash Storage Tanks. These tanks accumulate enough clean water for backwashing of the GAC filters, which is an entirely manual operation.

The operator manually closes valves around the selected GAC vessel to isolate it from the process flow, and opens the backwash supply and drain valves. He then manually operates the adjustable-speed backwash pump at the VFD to provide the appropriate

backwash flow rate for the prescribed duration. Waste backwash flow is returned to the Spent Backwash Storage Tank. Effluent from the Effluent/Backwash Storage Tank is pumped to a heat exchanger as required, and then to the Willamette River. Effluent instrumentation includes a flow meter, temperature sensor and pH probe.

Sludge Thickening and Dewatering

The sludge thickening and dewatering system is also shown on Drawing FD-4. Two cone-bottom sludge storage/decant tanks are manually alternated for gravity sludge thickening and storage. Ultrasonic transmitters in each tank will alarm before overfilling. The filter press dewatering system is operated manually from a local control panel. The PLC in the dewatering control panel is networked to the SCADA system.

Buildings and Other Appurtenances

The facilities will be enclosed within a pre-engineered building to shield the facilities and the operators from cold and rainy weather. The building will be equipped with inside and outside lighting, and will be provided with heating and ventilation systems. An electrical control room will be located outside of building.

The chemical storage and feed structure will also be located outside of the building. The chemical facility will be equipped with a chemical shower and eyewash, with a drain for both to the recycle pump station.

Electrical service equipment and an emergency power system comprising a diesel generator and automatic transfer switch will be exterior-mounted south of the building as shown on the site drawings.

A Connix™ box will be used to store spare pumps, blowers, chemical feed pumps, and assorted spare parts.

Storage, Handling and Disposal of Hazardous Chemicals and Wastes

All site personnel working at the treatment plant will have required OSHA training and certification for management of potentially hazardous chemicals and waste materials. The

minimum training for onsite personnel is described in the Sevenson HASP to be submitted under separate cover.

A decon area will be provided within the lined, bermed area to permit decontamination of equipment, vehicles, etc.

Attachment A: Plant Design and Materials Balance

01-Apr-11				
NW NATURAL DESIGN DATA AND MATERIALS BALANCE				
DESIGN DATA	mg/L	INITIAL	DESIGN	COMMENTS/ ASSUMPTIONS
NW INFLUENT MAX DAY FLOW-MW-1, GPM		149	153	Characteristics from pilot plant
				Includes NWN Miscellaneous flows
VOLATILE ORGANIC COMPOUNDS, LBS/DAY	0.001	0.002	0.002	
SEMI-VOLATILE ORGANIC COMPOUNDS, LBS/DAY	0.060	0.107	0.110	
TOTAL SUSPENDED SOLIDS, LBS/DAY	185.0	331	339	
FREE CYANIDE, LBS/DAY	0.01	0.018	0.018	
TOTAL IRON, LBS/DAY	270.0	482.9	495.0	
TOTAL MANGANESE, LBS/DAY	10.0	17.9	18.3	
NW INFLUENT MAX DAY FLOW-PW-1, GPM		149	153	Characteristics from pilot plant
				Includes NWN Miscellaneous flows
VOLATILE ORGANIC COMPOUNDS, LBS/DAY	8.5	15.2	15.6	
SEMI-VOLATILE ORGANIC COMPOUNDS, LBS/DAY	10.0	17.9	18.3	
TOTAL SUSPENDED SOLIDS, LBS/DAY	150	268.3	275.0	
FREE CYANIDE, LBS/DAY	0.01	0.018	0.018	
TOTAL IRON, LBS/DAY	16	28.6	29.3	
TOTAL MANGANESE, LBS/DAY	1.8	3.22	3.30	
SILTRONIC INFLUENT MAX DAY FLOW, GPM		74	109	Includes Miscellaneous Flows + two Add'l Siltronic wells
				Characteristics from pilot plant
VOLATILE ORGANIC COMPOUNDS, LBS/DAY	5.0	4.4	6.6	
SEMI-VOLATILE ORGANIC COMPOUNDS, LBS/DAY	0.25	0.22	0.33	
TOTAL SUSPENDED SOLIDS, LBS/DAY	70	62.0	91.8	
FREE CYANIDE, LBS/DAY	0.01	0.009	0.013	
TOTAL IRON, LBS/DAY	36	31.9	47.2	
TOTAL MANGANESE, LBS/DAY	1.8	1.59	2.36	
US MOORINGS INFLUENT MAX DAY FLOW, GPM		0	81	Assumed similar to MW-1 characteristics
VOLATILE ORGANIC COMPOUNDS, LBS/DAY	0.001	0.000	0.001	
SEMI-VOLATILE ORGANIC COMPOUNDS, LBS/DAY	0.060	0.000	0.058	
TOTAL SUSPENDED SOLIDS, LBS/DAY	185.0	0.000	180	
FREE CYANIDE, LBS/DAY	0.01	0.000	0.010	
TOTAL IRON, LBS/DAY	270.0	0.000	262.8	
TOTAL MANGANESE, LBS/DAY	10.0	0.000	9.7	
DNAPL WELLS MAX DAY FLOW, GPM		0	68	Assumed similar to PW-1 characteristics
VOLATILE ORGANIC COMPOUNDS, LBS/DAY	8.5	0.0	6.9	
SEMI-VOLATILE ORGANIC COMPOUNDS, LBS/DAY	10.0	0.0	8.1	
TOTAL SUSPENDED SOLIDS, LBS/DAY	150	0.0	121.7	
FREE CYANIDE, LBS/DAY	0.01	0.0	0.008	
TOTAL IRON, LBS/DAY	16	0.0	13.0	
TOTAL MANGANESE, LBS/DAY	1.8	0.0	1.5	
LNG BASIN MAX DAY FLOW, GPM		30	30	Assumed similar to PW-1 characteristics
VOLATILE ORGANIC COMPOUNDS, LBS/DAY	8.5	3.0	3.0	
SEMI-VOLATILE ORGANIC COMPOUNDS, LBS/DAY	10.0	3.6	3.6	
TOTAL SUSPENDED SOLIDS, LBS/DAY	150	53.5	53.5	
FREE CYANIDE, LBS/DAY	0.01	0.004	0.004	
TOTAL IRON, LBS/DAY	16	5.7	5.7	
TOTAL MANGANESE, LBS/DAY	1.8	0.6	0.6	
INTERCEPTOR TRENCH MAX DAY, GPM		27	27	Assumed similar to PW-1 characteristics
VOLATILE ORGANIC COMPOUNDS, LBS/DAY	8.5	2.8	2.8	
SEMI-VOLATILE ORGANIC COMPOUNDS, LBS/DAY	10.0	3.2	3.2	
TOTAL SUSPENDED SOLIDS, LBS/DAY	150	48.7	48.7	
FREE CYANIDE, LBS/DAY	0.01	0.003	0.003	
TOTAL IRON, LBS/DAY	16	5.2	5.2	
TOTAL MANGANESE, LBS/DAY	1.8	0.6	0.6	
SPENT BACKWASH RETURN FLOW, GPM		35	35	
VOLATILE ORGANIC COMPOUNDS, LBS/DAY	0.0	0.0	0.0	
SEMI-VOLATILE ORGANIC COMPOUNDS, LBS/DAY	0.0	0.0	0.0	
TOTAL SUSPENDED SOLIDS, LBS/DAY	0.0	0.0	0.0	Negligible
FREE CYANIDE, LBS/DAY	0.0	0.0	0.0	
TOTAL IRON, LBS/DAY	0.0	0.0	0.0	Negligible
TOTAL MANGANESE, LBS/DAY	0.0	0.0	0.0	Negligible

FLOW AND LOAD SPLIT				
NW NATURAL PRETREATMENT PLANT				
MW FLOW, GPM		149	153	
PW FLOW, GPM	85%	127	130	P3U, P3L, P11 wells to Siltronic pretreatment facility
US MOORINGS FLOW, GPM		0	81	
DNAPL WELLS		0	68	
LNG BASIN, GPM		30	30	
INTERCEPTOR TRENCH, GPM		27	27	
SPENT BACKWASH RETURN, GPM		35	35	
TOTAL MAX DAY FLOW TO NW NATURAL PRETREATMENT FACILITY, GPM		367	522	
NW NATURAL PRETREATMENT PLANT				
VOLATILE ORGANIC COMPOUNDS, LBS/DAY		18.7	25.9	
SEMI-VOLATILE ORGANIC COMPOUNDS, LBS/DAY		22.1	30.7	
TOTAL SUSPENDED SOLIDS, LBS/DAY		661.2	976.8	
FREE CYANIDE, LBS/DAY		0.040	0.059	
TOTAL IRON, LBS/DAY		518.2	806.6	
TOTAL MANGANESE, LBS/DAY		21.8	33.6	
SILTRONIC PRETREATMENT PLANT				
SILTRONIC WELLS, GPM		74	109	
PW FLOW, GPM	15%	22	23	P3U, P3L, P11 wells to Siltronic pretreatment facility
TOTAL MAX DAY FLOW TO SILTRONIC PRETREATMENT FACILITY, GPM		96	132	
SILTRONIC PRETREATMENT PLANT				
VOLATILE ORGANIC COMPOUNDS, LBS/DAY		6.7	8.9	
SEMI-VOLATILE ORGANIC COMPOUNDS, LBS/DAY		2.9	3.1	
TOTAL SUSPENDED SOLIDS, LBS/DAY		102.2	133.1	
FREE CYANIDE, LBS/DAY		0.0	0.0	
TOTAL IRON, LBS/DAY		36.2	51.6	
TOTAL MANGANESE, LBS/DAY		2.1	2.9	
NW NATURAL PRETREATMENT FACILITIES				
NW NATURAL OIL-WATER SEPARATORS				Crane mats above air strippers to allow gravity flow
TYPE		COALESCING PLATE		
NUMBER OF UNITS		1	1	
UNIT RATE, GPM		367	522	
DIMENSIONS, FT				
LENGTH		14.1	14.1	
WIDTH		7.9	7.9	
HEIGHT		6.7	6.7	
NW NATURAL CAUSTIC FEED PUMPS				pH Adjustment as required
TYPE		DIAPHRAGM		
CONTROL		pH		
NUMBER OF UNITS		2	2	
PROJECTED USAGE, GALS/DAY		529	752	Treatability using 25%
PROJECTED USAGE, LBS/DAY		6,871	9,780	
, GALS/HOUR		22.0	31.3	
UNIT CAPACITY, GALS/HR		0-40	0-40	
TOTAL CAPACITY, GALS/HOUR		0--80	0--80	
STORAGE PROVIDED, GALS		7,500	7,500	Plastic tank
STORAGE PROVIDED, DAYS		14.2	10.0	
NW NATURAL PRETREATMENT AIR STRIPPERS				
NUMBER OF TANKS		2	2	Baffled over/under closed 21K frac tank
UNIT VOLUME, GALS		21,000	21,000	Air to all compartments
TOTAL VOLUME GALS		42,000	42,000	
DETENTION TIME, MINS		114	80	
AIR: WATER RATIO	**30: 1**	49	34	Wastestream results
NW NATURAL PRETREATMENT BLOWERS				
NUMBER OF UNITS		2	2	Manifolded
TYPE		POSTIVE DISPLACEMENT		
CONTROL		VFD		
AIR FLOW RATE, SCFM		1,200	1,200	
ESTIMATED STATIC HEAD, PSI		3.0	3.0	7-foot submergence
ESTIMATED DYNAMIC LOSSES, PSI		1.5	1.5	
TOTAL BLOWER TDH, PSI		4.5	4.5	
EST BHP		34	34	@ 2,600 RPM
EST MOTOR HP		40	40	

NW NATURAL PRETREATMENT EQUALIZATION TANK ACTIVATED CARBON				
TYPE		VAPOR PHASE		
NO OF UNITS INSTALLED		2	2	
UNIT CARBON, LBS		1,000	1,000	
TOTAL CARBON, LBS		2,000	2,000	
SILTRONIC PRETREATMENT FACILITIES				
SILTRONIC OIL-WATER SEPARATOR				
TYPE		COALESCING PLATE		
NUMBER OF UNITS		1	1	
UNIT RATE, GPM		96	132	
DIMENSIONS, FT				
LENGTH		7.8	7.8	
WIDTH		3.3	3.3	
HEIGHT		6.6	6.6	
SILTRONIC CAUSTIC FEED PUMPS				pH Adjustment as required
TYPE		DIAPHRAGM		
CONTROL		pH		
NUMBER OF UNITS		2	2	
PROJECTED USAGE, GALS/DAY		138	190	Treatability using 25%
PROJECTED USAGE, LBS/DAY		1,798	2,472	
, GALS/HOUR		5.8	7.9	
UNIT CAPACITY, GALS/HR		0-40	0-40	
TOTAL CAPACITY, GALS/HOUR		0--80	0--80	
STORAGE PROVIDED, GALS		2,500	2,500	Plastic tank
STORAGE PROVIDED, DAYS		18.1	13.1	
SILTRONIC AIR STRIPPER				
NUMBER OF TANKS		1	1	Baffled over/under closed 21K tank
UNIT VOLUME, GALS		21,000	21,000	Air to all compartments
TOTAL VOLUME GALS		21,000	21,000	
DETENTION TIME, MINS		285	192	
AIR: WATER RATIO	**30: 1**	47	34	Wastestream results
SILTRONIC AIR STRIPPER BLOWERS				
NUMBER OF UNITS		2	2	per tank
TYPE		POSTIVE DISPLACEMENT		
CONTROL		VFD		
AIR FLOW RATE, SCFM		600	600	
ESTIMATED STATIC HEAD, PSI		3.0	3.0	7-foot submergence
ESTIMATED DYNAMIC LOSSES, PSI		1.5	1.5	
TOTAL BLOWER TDH, PSI		4.5	4.5	
EST BHP		20	20	@ 1,800 rpm
EST MOTOR HP		30	30	
SILTRONIC PRETREATMENT EQUALIZATION TANK ACTIVATED CARBON				
TYPE		OVER/UNDER WEIR		
NO OF UNITS INSTALLED		1	1	
UNIT CARBON, LBS		1,000	1,000	
TOTAL CARBON, LBS		1,000	1,000	
NW NATURAL AIR STRIPPING EFFLUENT, GPM		367	522	
VOLATILE ORGANIC COMPOUNDS, LBS/DAY @ REMOVAL =	98%	0.374	0.519	Wastestream results
SEMI-VOLATILE ORGANIC COMPOUNDS, LBS/DAY @ REMOVAL =	50%	11.1	15.3	Wastestream results
TOTAL SUSPENDED SOLIDS, LBS/DAY		661.2	976.8	
FREE CYANIDE, LBS/DAY @ REMOVAL =		0.040	0.059	
TOTAL IRON, LBS/DAY		518.2	806.6	
TOTAL MANGANESE, LBS/DAY		21.8	33.6	

SILTRONIC AIR STRIPPING EFFLUENT, GPM		96	132	
VOLATILE ORGANIC COMPOUNDS, LBS/DAY @ REMOVAL =	98%	0.134	0.178	Wastestream results
SEMI-VOLATILE ORGANIC COMPOUNDS, LBS/DAY @ REMOVAL =	50%	1.452	1.539	Wastestream results
TOTAL SUSPENDED SOLIDS, LBS/DAY		102.2	133.1	
FREE CYANIDE, LBS/DAY		0.012	0.016	
TOTAL IRON, LBS/DAY		36.2	51.6	
TOTAL MANGANESE, LBS/DAY		2.1	2.9	
SILTRONIC TRANSFER PUMP				
TYPE		CENTRIFUGAL		
NO OF UNITS INSTALLED		2	2	
PUMP CAPACITY		200	200	Sized for Max Hour Flow
PIPE DIAMETER, IN		4	4	
PIPE DISTANCE, FT		500	500	
STATIC HEAD, FT		10	10	
EST TDH, FT		20	21	
EST BHP		1.3	1.4	
MOTOR HP		2	2	
COMBINED TREATMENT FACILITIES				
TOTAL MAX DAY FLOW TO COMBINED PLANT				
NW NATURAL FLOW, GPM		367	522	
SILTRONIC FLOW, GPM		96	132	
RECYCLE PUMP STATION		4	6	
FILTER PRESS FILTRATE		4	6	
TOTAL MAX DAY FLOW, GPM		**471**	**666**	
TOTAL MAX DAY LOADS TO COMBINED PLANT				
VOLATILE ORGANIC COMPOUNDS, LBS/DAY		0.509	0.697	
SEMI-VOLATILE ORGANIC COMPOUNDS, LBS/DAY		12.514	16.877	
TOTAL SUSPENDED SOLIDS, LBS/DAY		1,044	1,538	Incl solids fm recycle PS & FP filtrate
FREE CYANIDE, LBS/DAY		0.051	0.074	
TOTAL IRON, LBS/DAY		554.3	858.2	
TOTAL MANGANESE, LBS/DAY		23.9	36.4	
IPC FEED PUMPS				Controlled off reactor level
TYPE		CENTRIFUGAL		
NO OF UNITS		2	2	
UNIT CAPACITY, GPM		850	850	Sized for Max Hour Flow
TDH, FT		25	25	
UNIT BHP		7.2	7.2	
UNIT HP		10	10	with VFD
INFLUENT FLOW METER				
TYPE		MAGNETIC		
NO OF UNITS		1	1	
SIZE, INCHES		6	6	
ANIONIC POLYMER FEED PUMP				Settling Aid
TYPE		Diaphragm		
CONTROL		FLOW PACED		
NUMBER OF UNITS		1	1	With uninstalled spare
PROJECTED USAGE @ 8.6 LBS/GAL, LBS/DAY		29.4	41.6	@ 5 mg/L
PROJECTED USAGE @ 8.6 LBS/GAL, GALS/DAY		3.4	4.8	20-Gallon Carboy
, GALS/HOUR		0.29	0.40	
UNIT CAPACITY, GALS/HR		0-1	0-1	
TOTAL CAPACITY, GALS/HOUR		0-2	0-2	
DILUTION WATER @ 0.25%, GALS/DAY		1,368	1,936	
, GALS/HOUR		114	161	
, GALS/MIN		0.95	1.34	

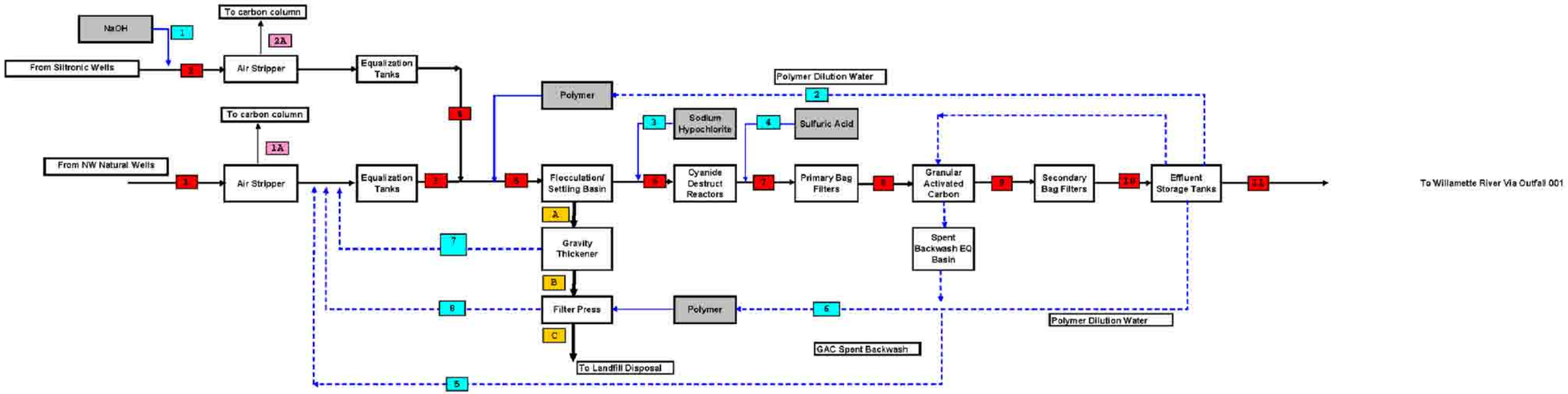
FLASH MIX TANKS				
NUMBER		2	2	
TYPE		MECHANICAL w VFD		
G FACTOR		500	500	
MIXER BHP		0.6	0.6	@ 50 deg F
MIXER HP		1.5	1.5	
DIMENSIONS, FT				
LENGTH		3.0	3.0	
WIDTH		3.0	3.0	
DEPTH		4.0	4.0	
UNIT VOLUME, GALS		269	269	
TOTAL VOLUME, GALS		539	539	
DETENTION TIME, MINS		1.1	0.8	
FLOCCULATION TANK				
NUMBER		2	2	
TYPE		MECHANICAL w VFD		
G FACTOR		50	50	
MIXER BHP		0.12	0.12	@ 50 deg F
MIXER HP		1.0	1.0	
DIMENSIONS, FT				
LENGTH		9.0	9.0	
WIDTH		9.0	9.0	
DEPTH		9.0	9.0	
UNIT VOLUME, GALS		5,453	5,453	
TOTAL VOLUME, GALS		10,906	10,906	
DETENTION TIME, MINS		23.2	16.4	
INCLINED-PLATE CLARIFIER				
TYPE		INCLINED PLATE		
NUMBER		2	2	
DIMENSIONS, FT				
LENGTH		7	7	
WIDTH		6.5	6.5	
HEIGHT		10	10	
UNIT SETTLING AREA, SQ FT		2,500	2,500	Each @ 500 gpm
TOTAL SETTLING AREA, SQ FT		5,000	5,000	
LOADING RATE, GPM/SQ FT		0.09	0.13	
SOLIDS PRODUCTION				
INFLUENT SOILIDS,		940	1,384	@ 90% Removal of Influent
CHEMICAL SOLIDS		1,940	3,004	@ 3.5 X Influent Iron
TOTAL SOLIDS, LBS/DAY		2,880	4,388	
, CONCENTRATION @		3%	3%	
, GALS/DAY		11,285	17,193	
, GALS/MIN @ 10 MINS/HR		47.0	71.6	
SLUDGE PUMPS				
TYPE		DIAPHRAGM--DUAL FEED		Sandpiper SB2
NUMBER		2	2	
CAPACITY, GPM		75	75	
TDH, FT		25	25	
REQUIRED AIR, CFM		70	70	
AIR COMPRESSOR				Also provides air to filter press & filter press pump
CAPACITY, CFM		250	250	
PRESSURE, PSI		100	100	
SODIUM HYPOCHLORITE FEED PUMPS				CYANIDE OXIDATION
TYPE		Diaphragm		pH = 10.5
CONTROL		Paced off ORP		ORP = 250 mv
NUMBER OF UNITS		2	2	
PROJECTED USAGE, GALS/DAY		271	384	Treatability & Estimate
PROJECTED USAGE, LBS/DAY		2,712	3,838	Estimate
, GALS/HOUR		11	16	
UNIT CAPACITY, GALS/HOUR		0-40	0-40	
TOTAL CAPACITY, GALS/HOUR		0-80	0-80	
STORAGE PROVIDED, GALS		5,000	5,000	Plastic tank
STORAGE PROVIDED, DAYS		18.4	13.0	
FLASH MIX				
TYPE		IN-LINE STATIC		
SIZE, IN		6	6	

CYANIDE REACTOR				
DESIRED DETENTION TIME, MINS		50-60	50-60	Oxidation to Cyanate
TYPE		FRAC TANK		
NUMBER OF UNITS		2	2	
UNIT VOLUME, GALS		21,000	21,000	
TOTAL VOLUME, GALS		42,000	42,000	
DETENTION TIME, MINS		89	63	
SULFURIC ACID FEED PUMPS				pH Adjustment 8-8.5
TYPE		Diaphragm		
CONTROL		Paced off pH		
NUMBER OF UNITS		2	2	
PROJECTED USAGE @ 28 mg/L, LBS/DAY		238	336	Estimate
, GALS/HOUR		0.8	1.1	
, GALS/DAY		18.3	25.9	
UNIT CAPACITY, GALS/HOUR		0-4	0-4	
TOTAL CAPACITY, GALS/HOUR		0-8	0-8	
STORAGE PROVIDED, GALS		240	240	Tote
STORAGE PROVIDED, DAYS		13.1	9.3	
FILTER/GAC FEED PUMPS				
TYPE		CENTRIFUGAL		
NO OF UNITS		2	2	
UNIT CAPACITY, GPM		850	850	Sized for Max Hour Flow
TDH, FT		185.0	185.0	80 psi
UNIT BHP		53	53	
UNIT HP		75	75	
BAG FILTERS				Metals/solids removal
NO OF UNITS		6	6	Three trains in series
BAG MEDIA, MICRONS		10-->5	10-->5	
GRANULAR ACTIVATED CARBON VESSELS				Organics Removal
DESIGN PARAMETERS				
CONTACT TIME, MINS		15		
LOADING RATE, GPM/SQ FT		4		
NO OF UNITS		4	4	Trains In Series; 1 Train in backwash
UNIT DIAMETER, FT		10	10	
UNIT HEIGHT, FT		12	12	
CARBON DEPTH, FT		5.0	5.0	
UNIT AREA, SQ FT		79	79	
TOTAL AREA, SQ FT		314	314	
EFFECTIVE UNIT VOLUME, CU FT		393	393	
TOTAL EFFECTIVE VOLUME, CU FT		1,570	1,570	
HYDRAULIC LOADING, GPM/SQ FT, ALL UNITS ON-LINE		1.5	2.1	
, ONE TRAIN IN BACKWASH		3.0	4.2	
LBS CARBON/UNIT @ 32 LBS/CU FT		12,560	12,560	
TOTAL AVAILABLE CARBON, LBS		50,240	50,240	
EMPTY BED CONTACT TIME , MINS ALL UNITS ON-LINE		24.9	17.6	
TOTAL ORGANICS TO CARBON UNITS, LBS/DAY		9.8	13.2	Assumes 25% VOC/SVOC reduction in CN reactor
% TOTAL ORGANICS REMOVAL		99%	99%	
EFFLUENT ORGANICS, LBS/DAY		0.10	0.13	
, mg/L		0.02	0.02	
UTILIZATION RATE, LBS TOCr/LB CARBON		0.15	0.15	
UTILIZATION RATE, LBS/CARBON/DAY		64	87	
, LBS/YEAR		23,529	31,751	
EFFECTIVE BED LIFE, DAYS		779	578	
EFFLUENT STORAGE TANK				
TYPE		FRAC TANK		
NO OF UNITS INSTALLED		2	2	
VOLUME, GALS		21,000	21,000	
TOTAL VOLUME, GALS		42,000	42,000	
SINGLE BACKWASH VOLUME, GALS		14,130	14,130	15 minutes/backwash
TOTAL BACKWASH VOLUME PER DAY, GALS		28,260	28,260	Backwash 2 vessels/day
STORED BACKWASHES		3.0	3.0	

GAC BACKWASH/EFFLUENT PUMPS				
TYPE		CENTRIFUGAL		
NO OF UNITS INSTALLED		2	2	
UNIT CAPACITY, GPM		942.0	942.0	Backwash Rate = 12 gpm/sq ft
TDH, FT		60	60	
UNIT BHP		19.0	19.0	
MOTOR HP		30.0	30.0	
SPENT BACKWASH STORAGE TANK				
TYPE		FRAC TANK		
NO OF UNITS INSTALLED		1	1	
VOLUME, GALS		21,000	21,000	
TOTAL VOLUME, GALS		21,000	21,000	
STORED BACKWASHES		1.5	1.5	
SPENT BACKWASH RETURN PUMPS				
TYPE		CENTRIFUGAL		
NO OF UNITS INSTALLED		2	2	
UNIT CAPACITY, GPM		35.0	35.0	From routing analysis
TDH, FT		25	25	
UNIT BHP		0.3	0.3	
MOTOR HP		1.0	1.0	
BAG FILTERS				
NO OF UNITS		3	3	Carbon fines removal removal
BAG MEDIA, MICRONS		1.0	1.0	In parallel
EFFLUENT FLOW METER				
TYPE		MAGNETIC		
SIZE, INCHES		6.0	6.0	
RESIDUALS HANDLING (NW NATURAL & SILTRONIC)				
NW NATURAL SILTRONIC SLUDGE THICKENER/STORAGE				
NO OF UNITS		2.0	2.0	
TYPE		POLY--V-BOTTOM		
UNIT VOLUME, GALS		20,000	20,000	With decant capability
TOTAL VOLUME, GALS		40,000	40,000	
SLUDGE FEED, GALS/DAY		11,285	17,193	
STORAGE CAPACITY, DAYS		3.5	2.3	
THICKENED SLUDGE, LBS/DAY		2,736	4,168	@ 95% Solids capture
THICKENED SLUDGE, 2 x INFLUENT		6%	6%	
THICKENED SLUDGE, GALS		5,308	8,087	
RECYCLE FLOWS				Gravity flow
SUPERNATANT SOLIDS, LBS/DAY		144	219	
SUPERNATANT RETURN, GALS/DAY		5,977	9,106	
, GPM @ 15 MINS		199	304	2 decants per day
ASSUMED RETURN RATE, GPM (SHORT DURATION) @ 24 HRS		4	6	
SOLIDS HANDLING POLYMER FEED PUMP				Filter Aid
TYPE		DIAPHRAGM		
CONTROL		FLOW PACED		Discharge to sludge pump suction side
NUMBER OF UNITS		1	1	With uninstalled spare
PROJECTED USAGE @ 8.6 LBS/GAL, LBS/DAY		4.89	7.45	@ 50 mg/L
PROJECTED USAGE @ 8.6 LBS/GAL, GALS/DAY		0.57	0.87	20-Gallon Carboy
, GALS/HOUR		0.09	0.14	6 hours
UNIT CAPACITY, GALS/HR		0-1	0-1	
TOTAL CAPACITY, GALS/HOUR		0-2	0-2	
DILUTION WATER @ 0.25%, GALS/DAY		228	347	
, GALS/HOUR		19	29	
, GALS/MIN		0.63	0.96	6 hours
NW NATURAL SILTRONICSLUDGE FILTER PRESS & PUMP				
TOTAL SLUDGE TO PRESS, LBS/DAY		2,736	4,168	
, GALS/DAY		5,308	8,087	

FILTER PRESS FEED PUMP				
PUMP TYPE		AIR-OPERATED DIAPHRAGM		
NO OF UNITS		2	2	
PUMP OUTPUT, GPM		59	90	30 minute fill
PUMP PRESSURE PSI AT MAX PUMP FLOW, PSI		15	15	35 feet
PUMP HP @ MAX PUMP FLOW, BHP		0.7	1.0	
PUMP OUTPUT AT MAX PRESSURE, PSI		6	9	
MAX PUMP PRESSURE, PSI AT MIN FLOW		100	100	231 feet
PUMP HP @ MIN PUMP FLOW, BHP		0.5	0.7	
TOTAL HP		2.5	2.5	Worst case is high flow - lower pressure
SLUDGE FILTER PRESS				
MAX PRESSURE, PSI		100	100	
ESTIMATED CYCLE TIME, HRS		2	2	
EST CYCLES/DAY		3	3	
DEWATERED CAKE, DRY LBS/DAY		2,599	3,960	
, WET LBS/DAY @ 60%		4,332	6,600	
, CU FT/DAY		124	189	@ 35 LBS/CU FT
, CU FT/CYCLE		41	63	
PRESS VOLUME, CU FT		75	75	
DIMENSIONS, FT				
LENGTH		23	23	1200 mm (4 ft x 4 ft plates)
WIDTH		5	5	
HEIGHT		6.2	6.2	
APPROX NUMBER OF CHAMBERS		83	83	
ASSUMED SOLIDS CAPTURE, %		95%	95%	
FILTRATE SOLIDS, LBS/DAY		137	208	
, GALS/DAY		5,292	8,062	
, GALS/MIN		15	22	
ASSUMED RETURN RATE, GPM (SHORT DURATION) @ 24 HRS		4	6	Filtrate returned under pressure

Attachment B: Treatment Plant Design Drawings



Process Flows–Maximum Day											
Process Stream	1	2	3	4	5	6	7	8	9	10	11
Description	Influent From NW Natural Wells	Influent From Siltronic Wells	Equalized Flow From NW Natural Wells	Equalized Flow From Siltronic Wells	Settling Basin Influent	Settling Basin Effluent	Cyanide Reactor Effluent	Primary Bag Filter Effluent	GAC Vessel Effluent	Secondary Bag Filter Effluent	Final Effluent to Willamette River
Flow, Gals/day	752,281	190,339	798,056	190,339	990,331	976,976	977,002	977,002	977,002	977,002	946,459
VOCs, lbs/day	25.9	8.9	0.52	0.18	0.70	0.70	0.52	0.52	0.01	0.01	0.01
SVOCs, lbs/day	30.7	3.1	15.3	1.5	16.9	16.9	12.7	12.7	0.13	0.13	0.13
TSS, lbs/day	976.8	133.1	1,404.7	133.1	1,537.7	153.8	153.8	7.7	3.8	0.19	0.19
Free CN, lbs/day	0.059	0.016	0.059	0.016	0.074	0.074	0.001	0.001	0.001	0.001	0.001
Total Fe, lbs/day	806.6	51.6	806.6	51.6	858.2	85.8	85.8	4.3	2.1	0.11	0.11
Total Mn, lbs/day	33.6	2.9	33.5	2.9	36.4	3.6	3.6	0.18	0.09	0.005	0.005

Chemical and Recycle Flows								
Process Stream	1	2	3	4	5	6	7	8
Description	Caustic Addition	Water Treatment Polymer Dilution Water	Sodium Hypochlorite Addition	Sulfuric Acid Addition	Spent GAC Vessel Backwash Water	Solids Treatment Polymer Dilution Water	Gravity Thickener Overflow	Filter Press Filtrate
Flow, Gals/day	216	1,936	3,838	26	28,260	347	9,106	8,062
VOCs, lbs/day	0	0	0	0	0	0	0	0
SVOCs, lbs/day	0	0	0	0	0	0	0	0
TSS, lbs/day	0	0	0	0	0	0	219	269
Free CN, lbs/day	0	0	0	0	0	0	0	0
Total Fe, lbs/day	0	0	0	0	0	0	0	0
Total Mn, lbs/day	0	0	0	0	0	0	0	0

Solids Flows			Air Flows	
Process Stream	A	B	C	1A	2A
Description	Settling Basin Solids	Gravity Thickener Underflow	Filter Cake	NW Natural Air Stripper	Siltronic Air Stripper
Flow, Gals/day	17,193	8,087	25	0	0
VOCs, lbs/day	0	0	0	25.4	8.7
SVOCs, lbs/day	0	0	0	15.3	1.5
TSS, lbs/day	4,388	4,168	3,960	0	0
Free CN, lbs/day	0	0	0	0	0
Total Fe, lbs/day	772	734	697	0	0
Total Mn, lbs/day	33	31	30	0	0

LEGEND

- 1 Forward process flow
- 3 Chemical and recycle flows
- A Solids flow
- 1A Air flow

Sevenson Environmental Services, Inc.
2749 LOCKPORT ROAD
NIAGARA FALLS, NY 14305

ADA
APONOWICH, DRISCOLL & ASSOCIATES, INC.

TS JONES CONSULTING

NW NATURAL GASCO SITE SOURCE CONTROL

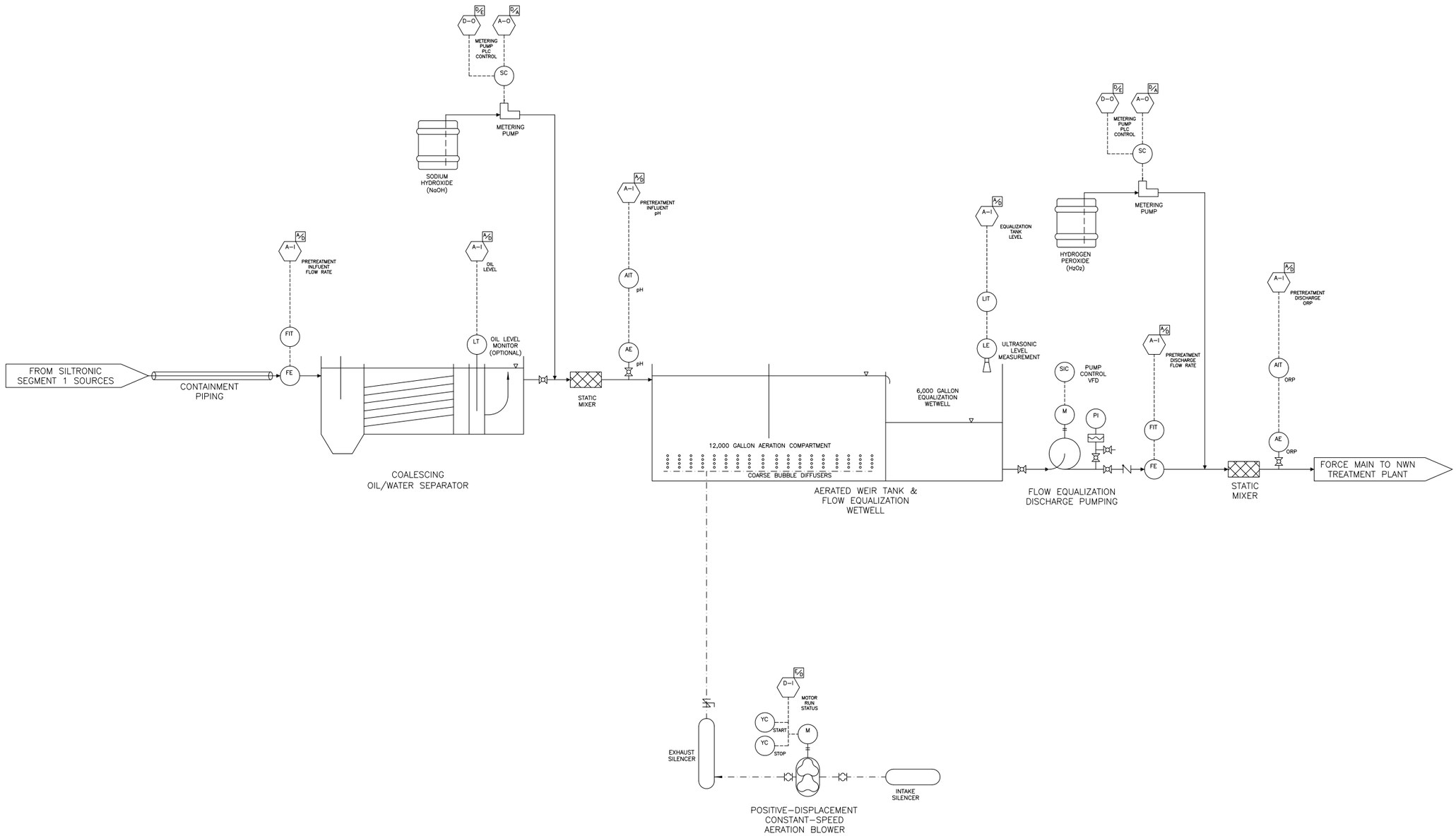
FINAL DESIGN REPORT
GROUNDWATER TREATMENT FACILITY
PROCESS FLOW DIAGRAM & MATERIALS BALANCE

CADD NO.	SCALE:	CONTRACT:	JOB NO. SES-E975	DRN.BY TSJ	DSN.BY TPD/TSJ	CHK.BY TPD	APP.BY MDC
		-					

FD-1

FILE NO.

4/04/2011



SILTRONIC PRETREATMENT

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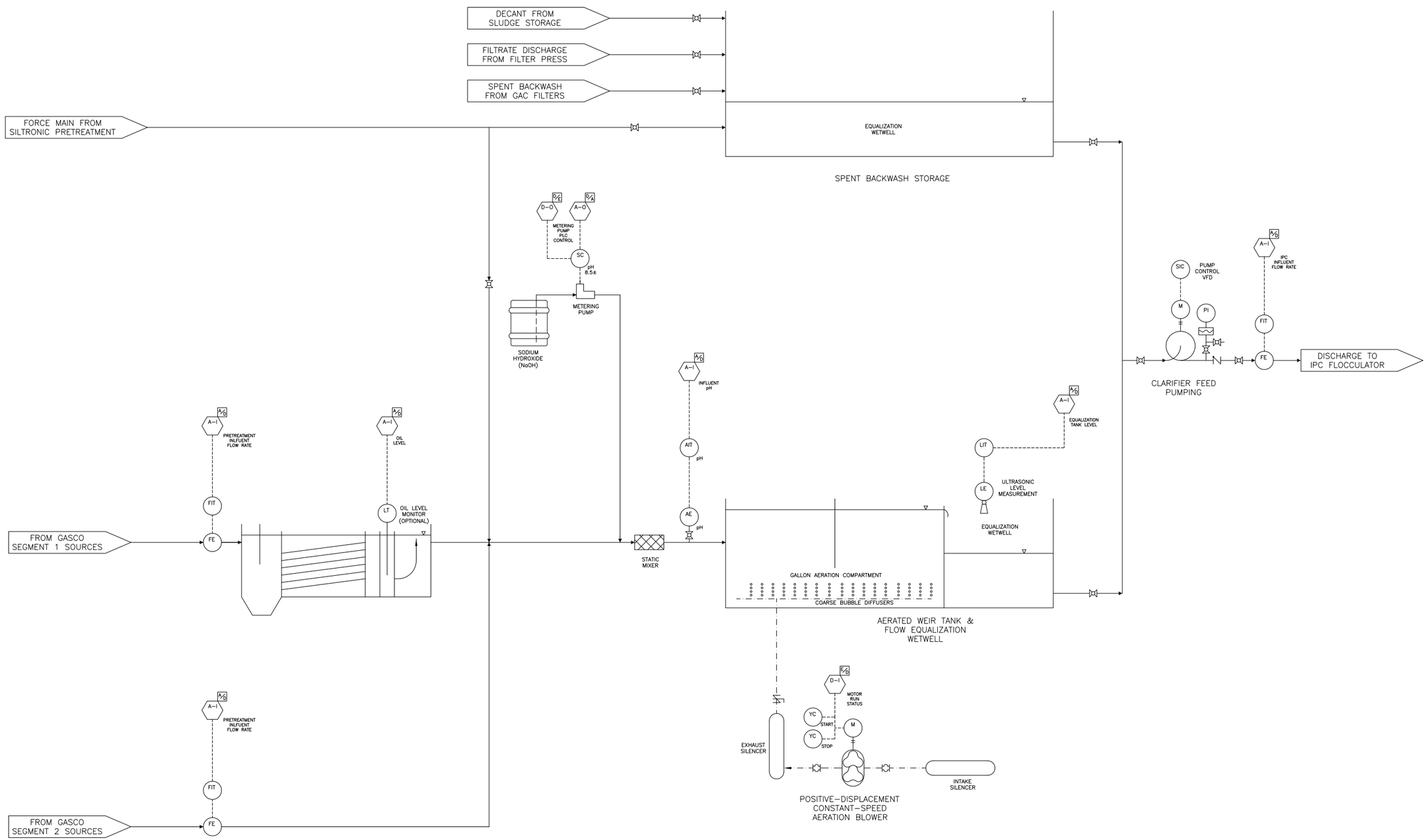
NW NATURAL GASCO SITE SOURCE CONTROL
FINAL DESIGN REPORT
GROUNDWATER TREATMENT FACILITY
PIPING & INSTRUMENTATION DIAGRAM (P&ID)

CADD NO.	SCALE:	CONTRACT:	JOB NO.	DRN.BY	DSN.BY	CHK.BY	APP.BY
		–	SES-E975	TSJ	TPD/TSJ	TPD	MDC

FD-2

FILE NO.

4/04/2011



P&ID #2
(NW NATURAL)

Sevenson Environmental Services, Inc.
2749 LOCKPORT ROAD
NIAGARA FALLS, NY 14305

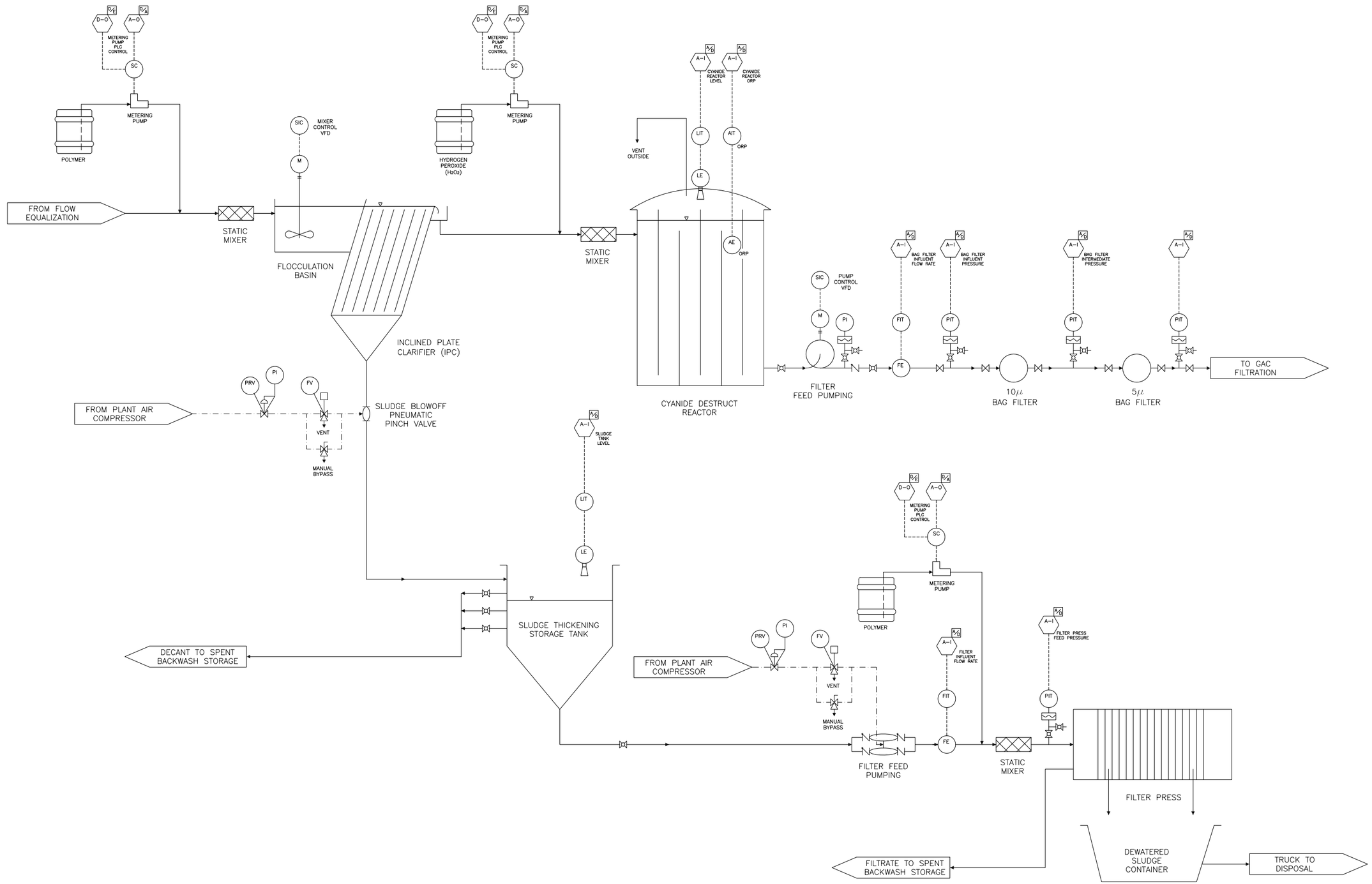
ADA
APONOWICH, DRISCOLL & ASSOCIATES, INC.
TS JONES CONSULTING

NW NATURAL GASCO SITE SOURCE CONTROL
FINAL DESIGN REPORT
GROUNDWATER TREATMENT FACILITY
PIPING & INSTRUMENTATION DIAGRAM (P&ID)

CADD NO.	SCALE:	CONTRACT:	JOB NO.	DRN.BY	DSN.BY	CHK.BY	APP.BY
		–	SES-E975	TSJ	TPD/TSJ	TPD	MDC

FILE NO. FD-3

4/04/2011



P&ID #3
(NW NATURAL)

Sevenson Environmental Services, Inc.
2749 LOCKPORT ROAD
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ADA
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TS JONES CONSULTING

NW NATURAL GASCO SITE SOURCE CONTROL
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PIPING & INSTRUMENTATION DIAGRAM (P&ID)

CADD NO.	SCALE:	CONTRACT:	JOB NO.	DRN.BY	DSN.BY	CHK.BY	APP.BY
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FD-4

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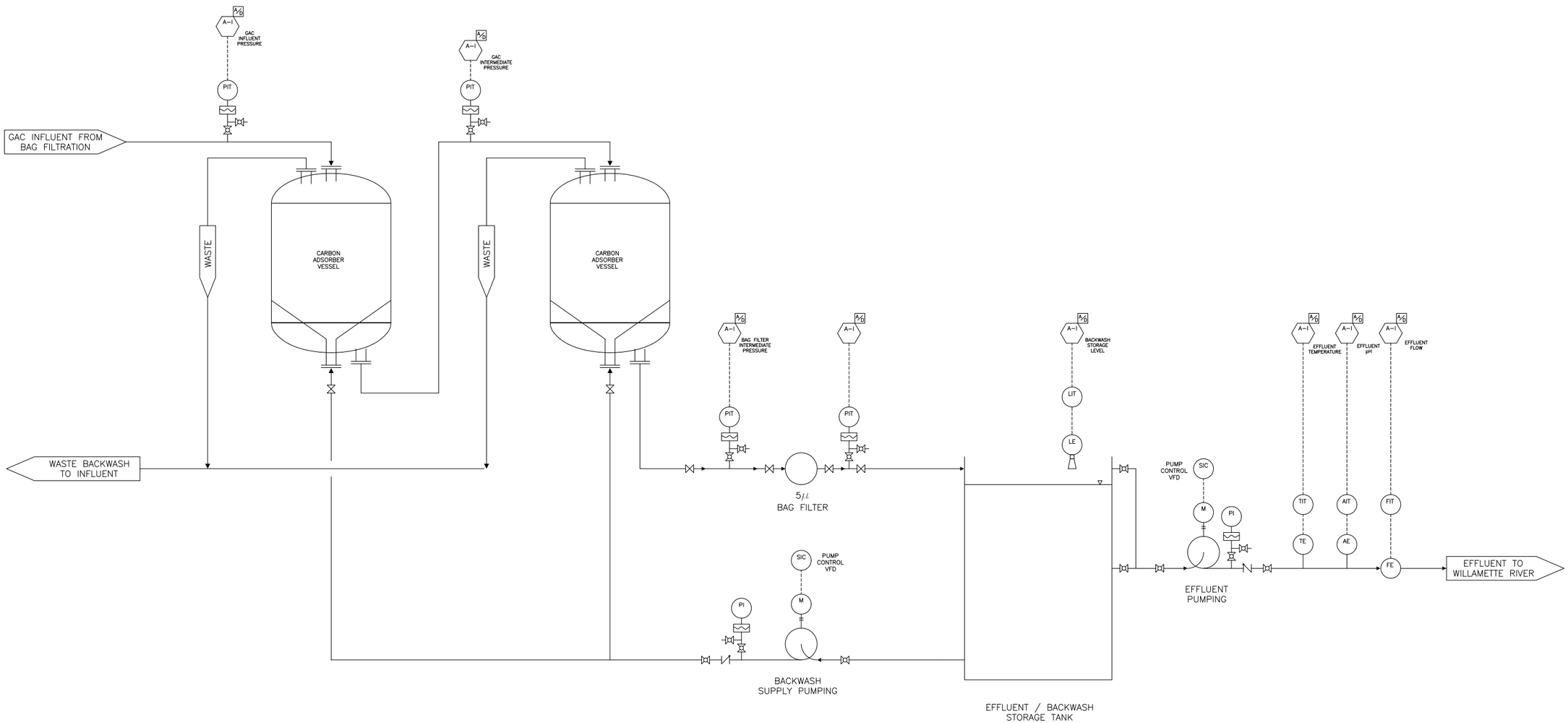

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FD-5

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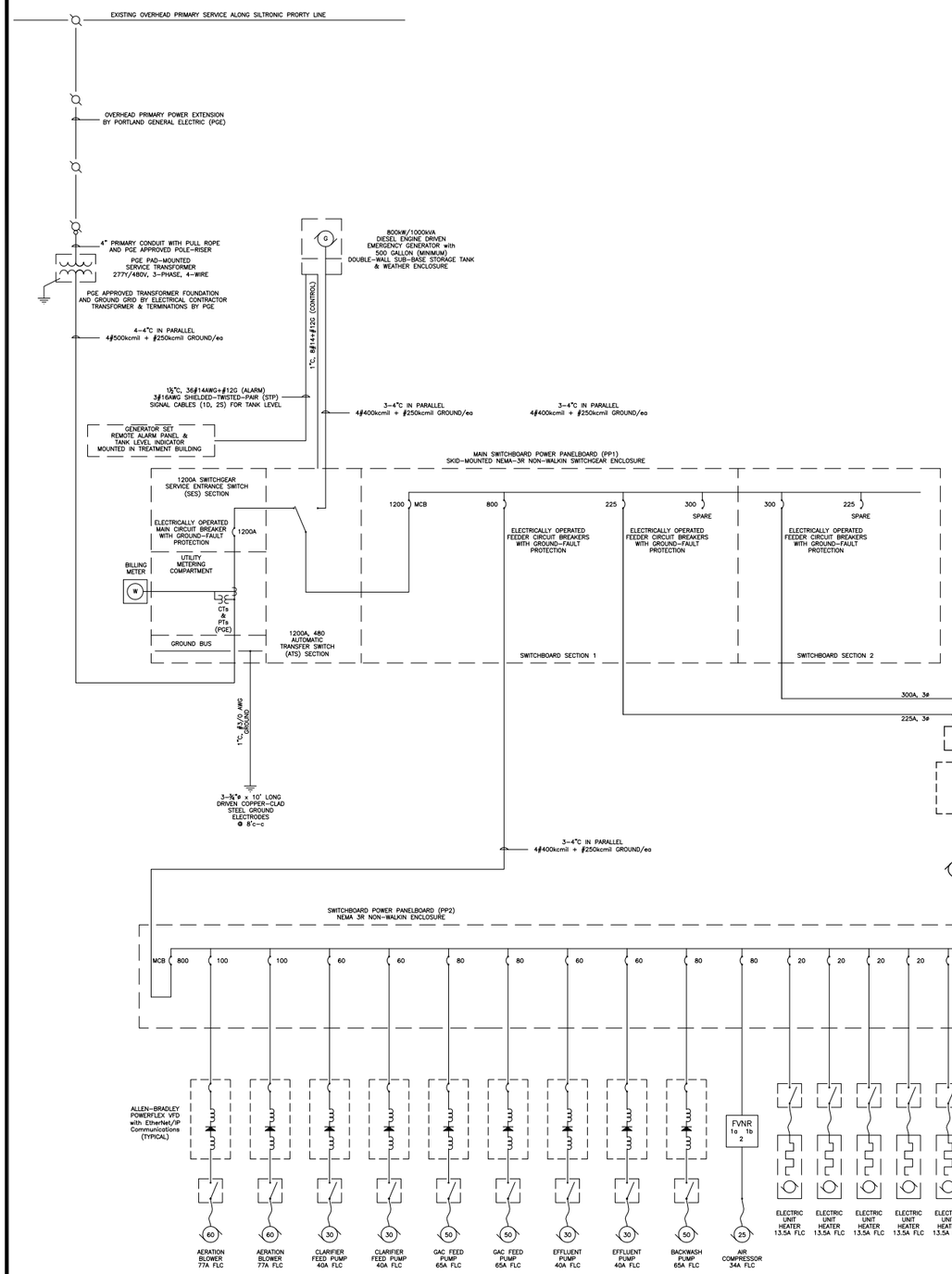
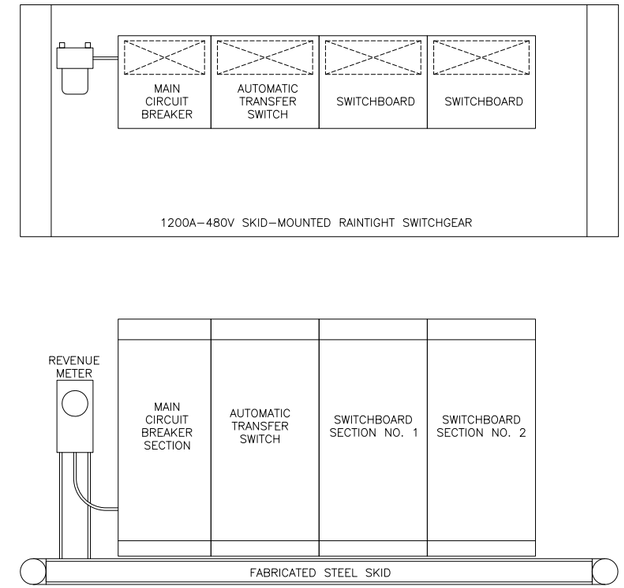
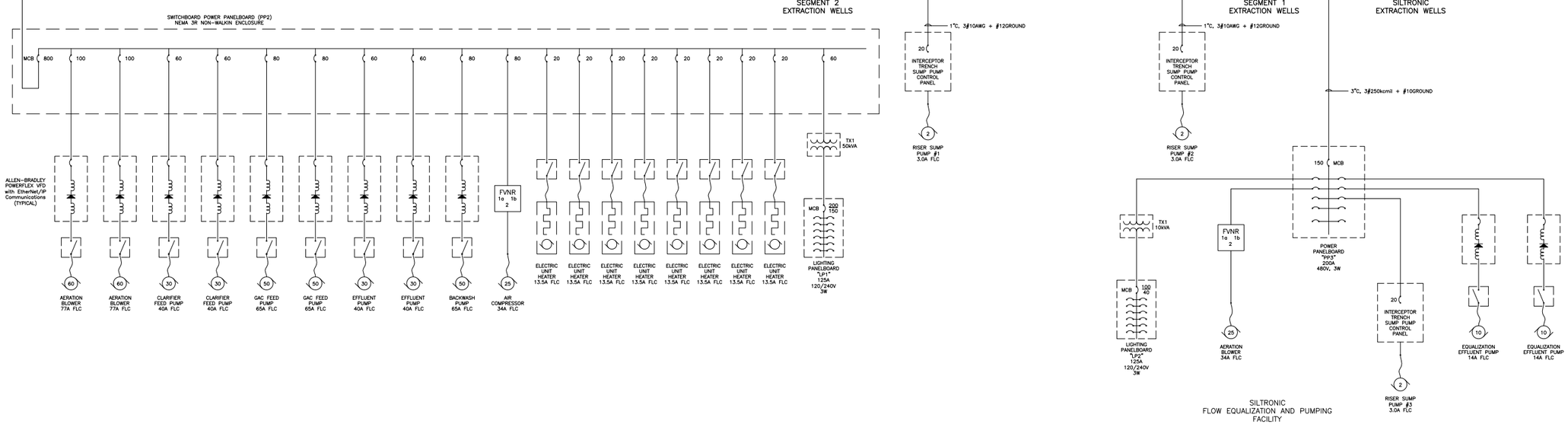




EXTERIOR SWITCHGEAR LAYOUT

SCALE IN INCHES

12 0 12 24



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FINAL DESIGN REPORT
GROUNDWATER TREATMENT FACILITY
ELECTRICAL SINGLE-LINE DRAWING

CADD NO.	SCALE:	JOB NO. SES-E975	DRN.BY TSJ	DSN.BY TPD/TSJ	CHK.BY TPD	APP.BY MDC
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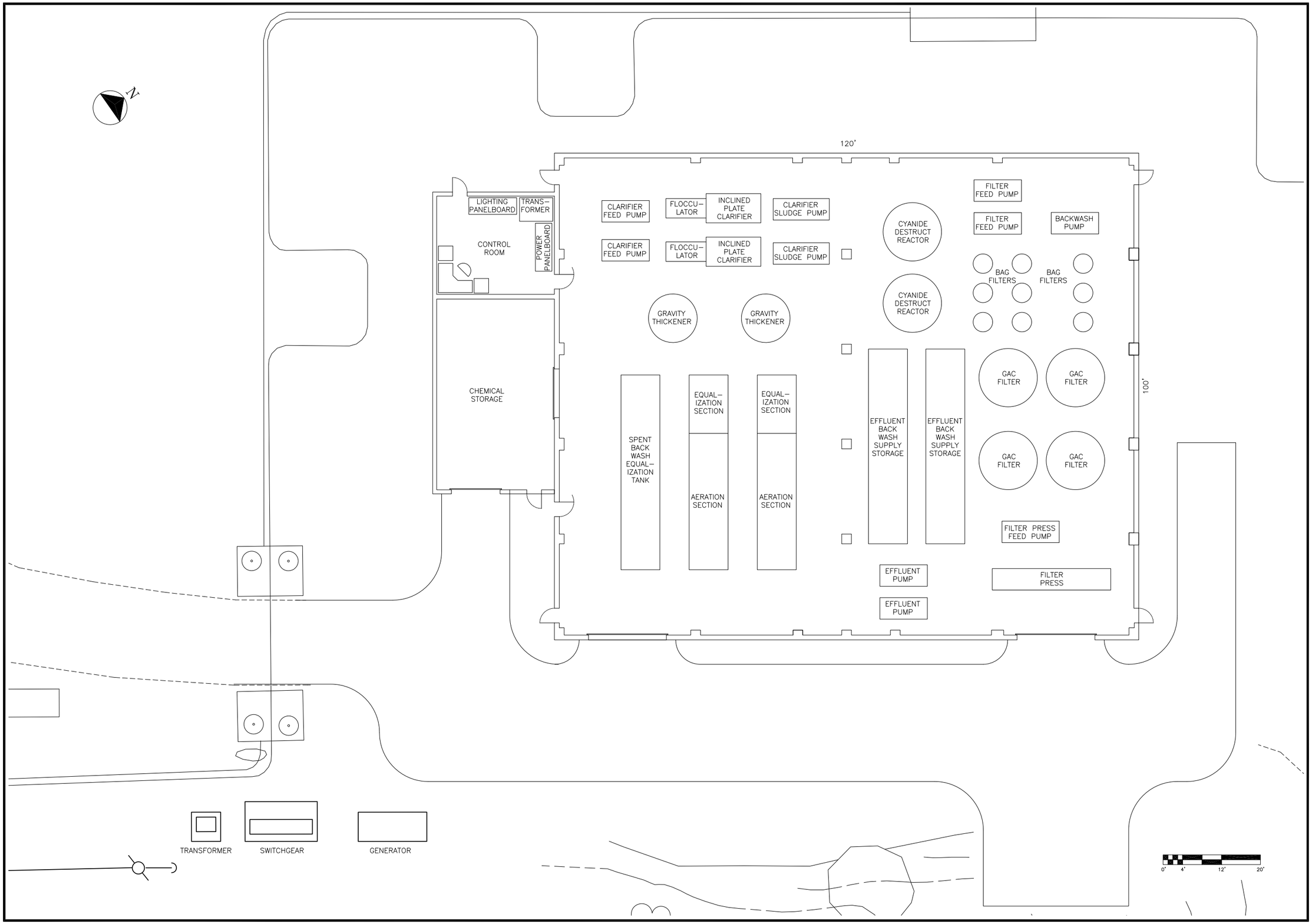
4/04/2011



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NW NATURAL GASCO SITE SOURCE CONTROL

FINAL DESIGN REPORT
GROUNDWATER TREATMENT FACILITY
TREATMENT BUILDING LAYOUT

CADD NO.	SCALE:	CONTRACT:	JOB NO.	DRN.BY	DSN.BY	CHK.BY	APP.BY
		–	SES-E975	TSJ	TPD/TSJ	TPD	MDC

FILE NO. FD-7

4/04/2011

APPENDIX F
GROUNDWATER MODEL DOCUMENTS

S.S. PAPADOPULOS & ASSOCIATES, INC.
ENVIRONMENTAL & WATER-RESOURCE CONSULTANTS

Memorandum

Date: April 25, 2008

From: Michael J. Riley, Christopher J. Neville

To: John Edwards, Anchor Environmental

Subject: NW Natural Gasco, Pump Test Analysis and MODFLOW Model Summary

An October 30, 2007 version of this memorandum was included as Appendix E to the *Groundwater/DNAPL Source Control Focused Feasibility Study, NW Natural, Gasco, Site* (Anchor Environmental, LLC). In a letter dated March 21, 2008, Oregon DEQ asked NW Natural to provide further information on the following five issues.

1. Additional documentation that basalt is a no flow boundary
2. Using independent methods to confirm total groundwater flux
3. Explain contradiction between rapid draw down in PW-04 and complete capture conclusion
4. Evaluate increase in hydraulic conductivity with depth as cause of above
5. Provide hydraulic property assignments not previously provided

This memo provides further information on issues 1 and 5. Items 2, 3, and 4 are addressed in the memorandum *NW Natural, Gasco: Additional Groundwater Flow Analysis* (SSPA, April 25, 2008).

As described on page 22 of this memo, the basalt is not a no-flow boundary. The basalt contributes flow to the model through the upgradient specified head boundary. Definition of flow through this boundary is supported by the USGS Portland Basin model and the seepage meter analysis as described in the Additional Groundwater Flow analysis memo. In response to issue 5, the table of aquifer parameters on the bottom of page 23 is expanded and a new subsurface profile Figure 4-6 is included. The profile shows the subsurface extent of the different aquifer parameter zones.

Summary of Results

Three lines of investigation were conducted to determine aquifer properties. Water level data from extraction well PW-4 pump tests were evaluated using several analytical methods. Tide lag data measured in the shoreline monitoring wells were used to calculate hydraulic conductivity. Potentiometric surface gradient data were also used to evaluate hydraulic conductivity. The results of these analyses were incorporated into a groundwater flow model used to predict the effectiveness of nearshore extraction wells to contain site groundwater.

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Analysis of pump test data produced estimates of hydraulic conductivity that are significantly lower in the nearshore shallow alluvium than in the nearshore intermediate and deep alluvium. The pump test data indicate that the shallow alluvium has an estimated hydraulic conductivity on the order of 10 ft/d while the intermediate and deep alluvium has a hydraulic conductivity on the order of 200 ft/d.

Analysis of tidal fluctuations at nearshore shallow, intermediate and deep wells showed that hydraulic conductivity in intermediate and deep alluvium is 20 to 50 times greater than the hydraulic conductivity in the shallow alluvium.

An analysis of gradients was conducted as another line of evidence to compare hydraulic conductivity in upland alluvium to nearshore alluvium. This analysis showed a marked contrast between hydraulic conductivity in upland alluvium compared to alluvium closer to the river. Combining this information with the pump test and tidal analysis shows that the upland alluvium and shallow nearshore alluvium have similar low hydraulic conductivity compared to the nearshore intermediate and deep alluvium.

A groundwater flow model was developed and calibrated to site water levels. Model calibration to nearshore wells was attained by using significantly higher hydraulic conductivity values in the intermediate and deep nearshore alluvium than in the shallow and upland alluvium. This is consistent with pump test analyses, analysis of tidal fluctuations, and analysis of groundwater gradients across the site.

1.0 Pump Test Analyses

The PW-4 pump test consisted of pumping the shallow screen interval (PW-4-85) and intermediate screen interval (PW-4-118) both individually and together. The test included separate step-drawdown tests on each screen interval and a combined constant rate test on both screen intervals. The tests were conducted in July 2007 and included extensive continuous (one-minute frequency) monitoring of water levels in the pumping wells and observations wells for extended periods before, during, and after pumping. A summary of the rate and duration of tests is provided in the following table.

Test	Pumping Rate (gpm)	Duration (minutes)
PW-4-85 Step-Drawdown Test		
Step 1	20	240
Step 2	30	251
Step 3	40	954
PW-4-118 Step-Drawdown Test		
Step 1	30	240
Step 2	40	240

Step 3	50	521
Constant Rate Test		
PW-4-85	40	420
PW-4-118	50	420

Water levels during the tests were affected by river stage changes, which were primarily due to tidal fluctuations during the test period. Determining ambient water levels to determine drawdown at the test wells proved to be challenging.

1.1 PW-4-85 Step-drawdown Test

For this test, it was observed that water levels at PW-4-85, PW-4-118 and MW-20-120 were nearly identical prior to the test. During pumping, the water levels at PW-4-118 and MW-20-120 were identical and neither showed any significant change in water level due to pumping of PW-4-85 (Figure 1-1). Consequently, water levels at PW-4-118 were used as static water levels for computing drawdown at PW-4-85 (Figure 1-2).

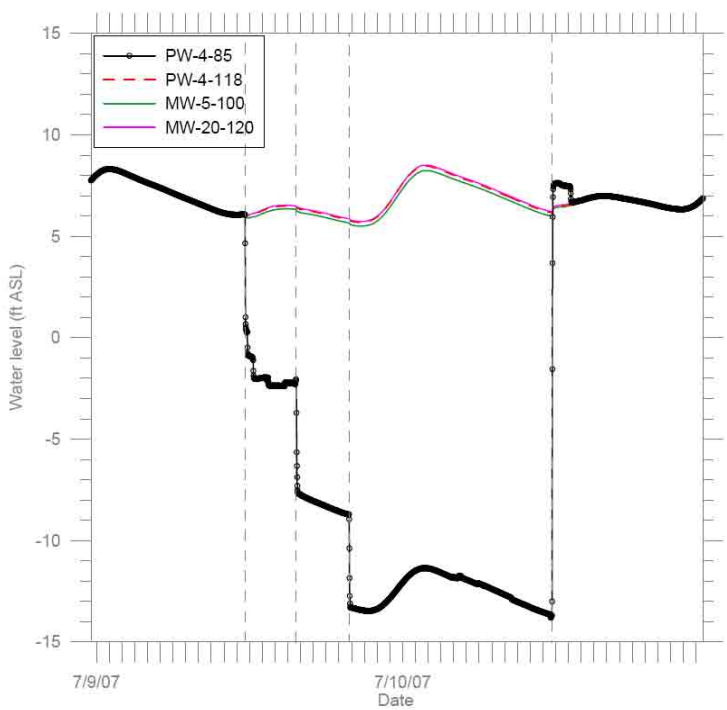

Figure 1-1 Water levels measured during the PW-4-85 Step-drawdown Test

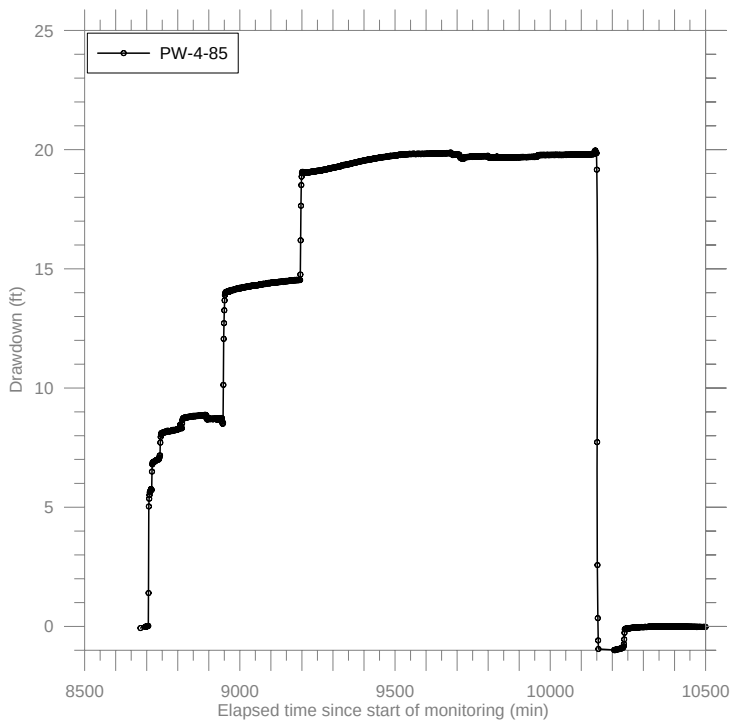

Figure 1-2 Drawdown computed during the PW-4-85 Step-drawdown Test

Drawdown during the PW-4-85 step-drawdown test was analyzed by several methods to estimate transmissivity: specific capacity and Theis analyses both including and neglecting nonlinear well losses. The specific capacity test assumes a specific capacity and discharge relationship given by (Jacob, 1947):

$$\frac{s_w}{Q} = B + CQ$$

Where: s_w is drawdown at a pump rate step (ft);
Q is the pump rate (gpm);
B is the inverse of the specific capacity (SC^{-1}); and
C is a well loss coefficient given by the slope of the line.

A plot of this relationship is shown on Figure 1-3. The intercept is 0.365, which gives a specific capacity of 2.74 gpm/ft, and the slope (well loss, C) is 0.0036 ft/gpm^2.

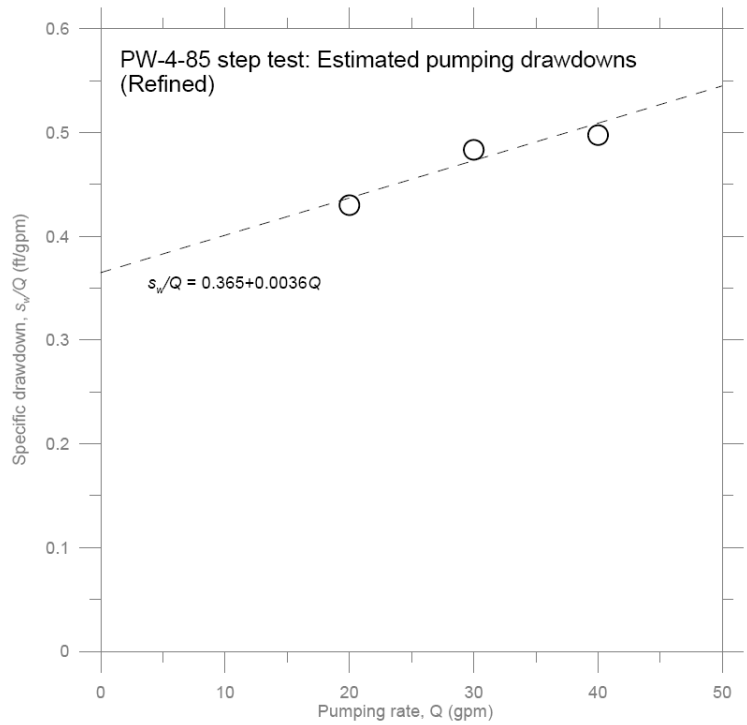

Figure 1-3 Regression analysis for specific capacity analysis with well loss

The low value of the well loss coefficient indicates that the specific capacity can be approximated as a constant value given by the average value over the three steps, which is approximately 2.3 gpm/ft.

In both cases, transmissivity was computed from the relationship (Driscoll, 1986):

$$T = 270\frac{Q}{s_w}$$

Where: T is transmissivity in ft^2/d; and
Q/s_w is specific capacity, SC, in gpm/ft.

Transmissivity was estimated with the generalized Theis (1935) analysis for various combinations of storage coefficient, skin loss factor, and well loss coefficient. The best combination of parameters included storage coefficient of 10^{-4} (confined), well loss of 0.0036 ft/gpm^2 (from the specific capacity analysis), and skin loss of 0.2823. This yielded a transmissivity estimate of 5900 ft^2/d. A plot of this Theis analysis is shown in Figure 1-4.

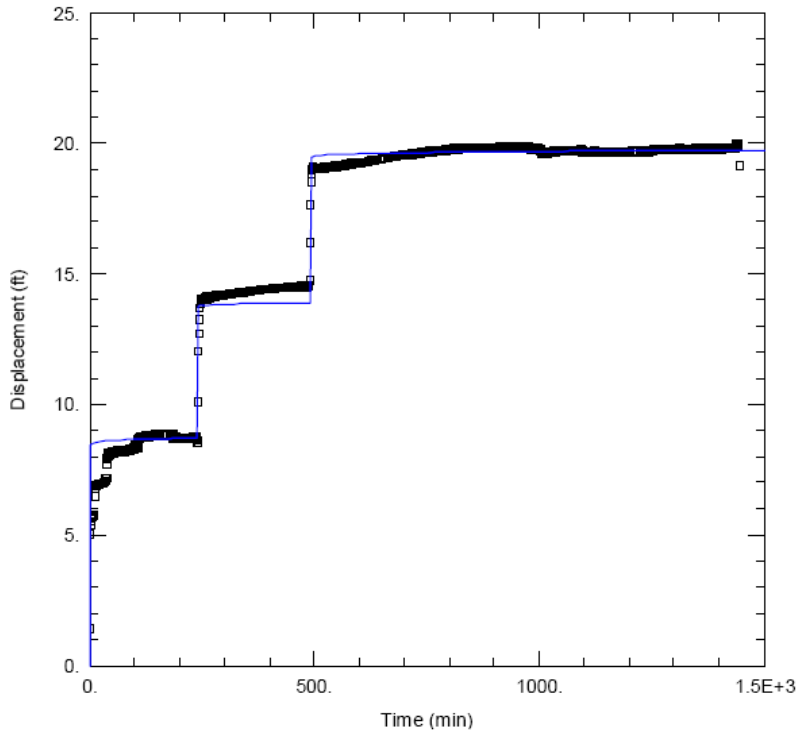

Figure 1-4 Theis analysis (blue line) compared to data (black symbols)

The results of the analyses of the PW-4-85 step-drawdown test are presented on the following table.

Analysis	**Transmissivity (ft^2/d)**	**Thickness[1] (ft)**	**Hydraulic Conductivity (ft/d)**
Specific capacity with well loss considered	730	10	73
Specific capacity without considering well loss	570	10	57
Theis solution	5900	70	84

1) For specific capacity calculations, the appropriate thickness is the screen interval since the screen is short relative to aquifer thickness. The Theis solution included a skin loss term and consequently the aquifer thickness is the appropriate value to use.

1.2 Constant Rate Test: PW-4-85 Analysis

As in the step-drawdown test, the initial problem was determining an ambient water level for computing drawdown. Water level data from MW-5-100, MW-20-120 and MW-5-175 were compared to water level data from PW-4-85 and PW-4-118 before, during and after pumping. MW-5-175 was the least affected by pumping (Figure 1-5).

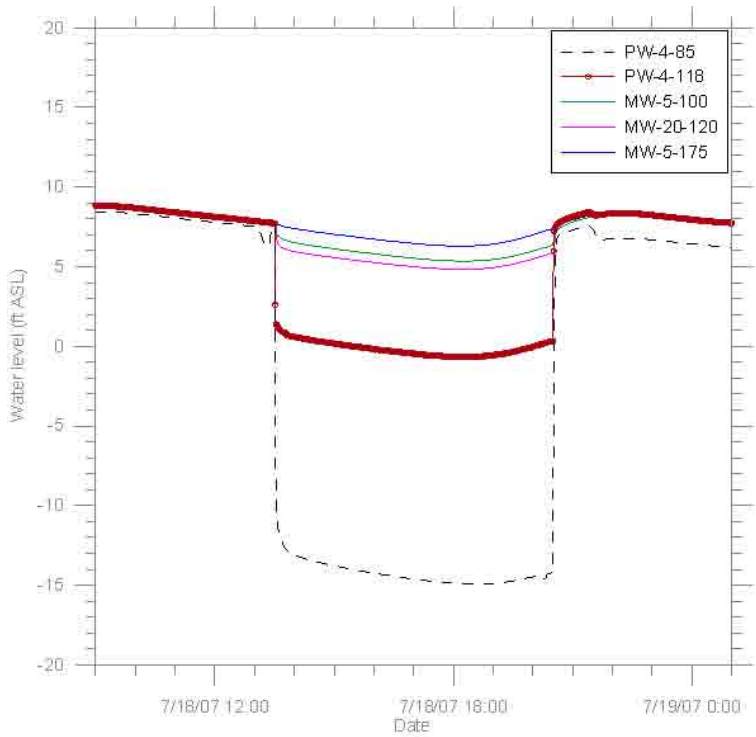

Figure 1-5 Water level response during PW-4 constant rate test

Consequently, water levels from this well were assumed to represent the water levels at PW-4-85 that would have been observed if the well had not been pumped, and were used to estimate the drawdowns caused by pumping the well. The estimated drawdowns are plotted in Figure 1-6.

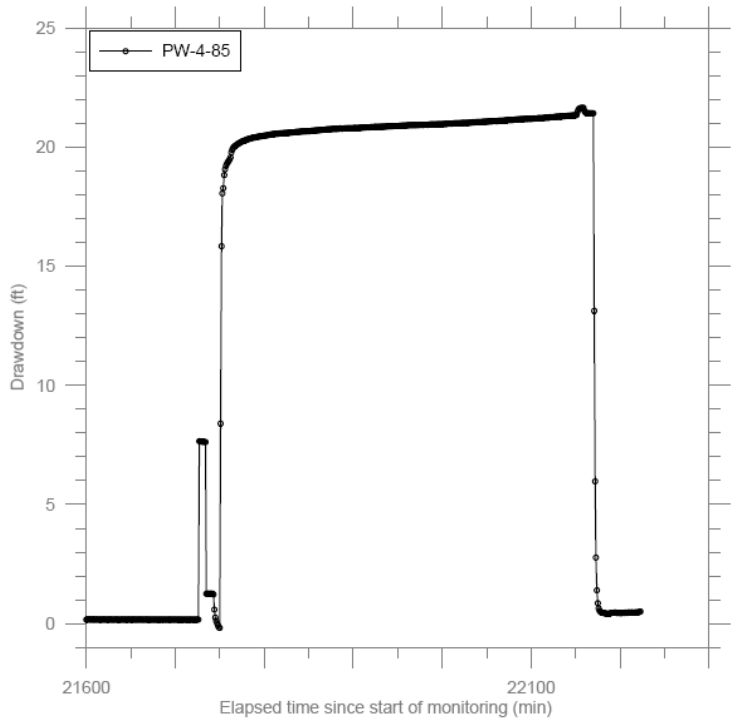

Figure 1-6 Drawdown at PW-4-85 during the constant rate test

Drawdown at PW-4-85 during the constant rate test was used to compute transmissivity using several approaches. First, the drawdown at the end of pumping was added to the specific capacity data used in the step-drawdown test and the transmissivity was recomputed. The results of the constant rate pumping test were consistent with the results from the step test. Consequently, including the constant rate test in the specific capacity analysis did not change the previously estimated transmissivity of 730 ft^2/d.

A second set of analyses was conducted using the Cooper-Jacob straight line method using early time and late time data. These analyses are shown in Figure 1-7. The flatter slope in the late time data may be an effect from the nearby river boundary and consequently, the early time data may be more representative of aquifer transmissivity.

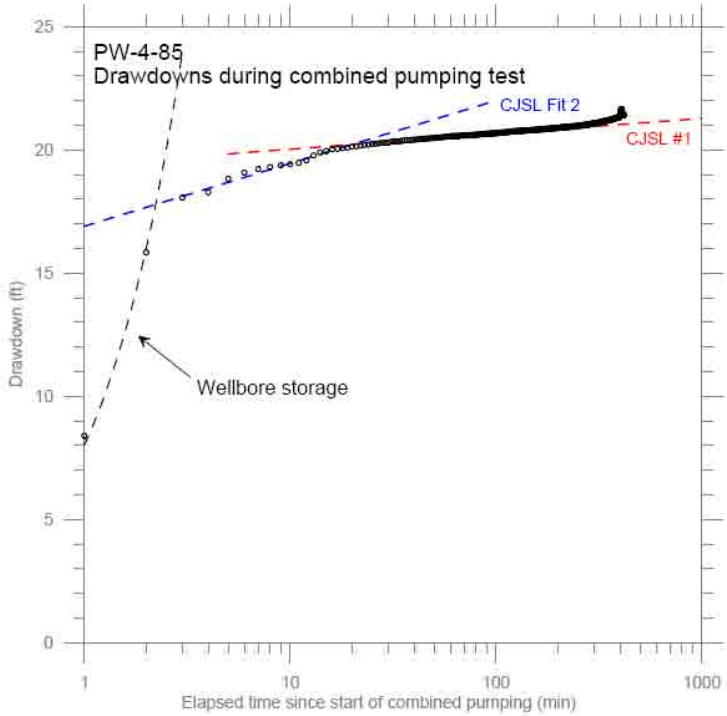

Figure 1-7 Time periods used for the Cooper-Jacob analysis

The results from the PW-4-85 constant rate test analyses are presented on the following table.

Analysis	**Transmissivity (ft^2/d)**	**Thickness[1] (ft)**	**Hydraulic Conductivity (ft/d)**
Specific capacity	730	10	73
Cooper-Jacob late time	2300	70	33
Cooper-Jacob early time	550	70	8

1) For specific capacity calculations, the appropriate thickness is the screen interval since the screen is short relative to aquifer thickness.

The Cooper-Jacob analysis showed significantly different results between the early time and late time analyses. The higher transmissivity in the late time may indicate an effect from the river boundary; therefore, the early time data (first 10 minutes of pumping) is a better representation of the response to pumping of the aquifer in the immediate vicinity of the well. Because the aquifer equilibrates so quickly and the time periods for the step test are long relative the equilibration time, it is likely that the specific capacity results are also affected by the river boundary.

1.3 PW-4-118 Step-drawdown Test

As in the case of the PW-4-85 test, the initial tasks were to identify a well that was not affected by pumping at the test well, relate those water levels to ambient water levels at the test well, and

then use that relationship to compute drawdown during the test. Water levels at MW-5-100 and MW-20-120 showed an effect from pumping of PW-4-118, while MW-5-175 did not. The water levels at MW-5-175 are almost identical to water levels at PW-4-118 before and after the test. Therefore, the water levels at MW-5-175 during the test period were used directly to compute drawdown at the test well. Water level data from the PW-4-118 step-drawdown test is shown in Figure 1-8 and interpreted drawdowns are shown in Figure 1-9.

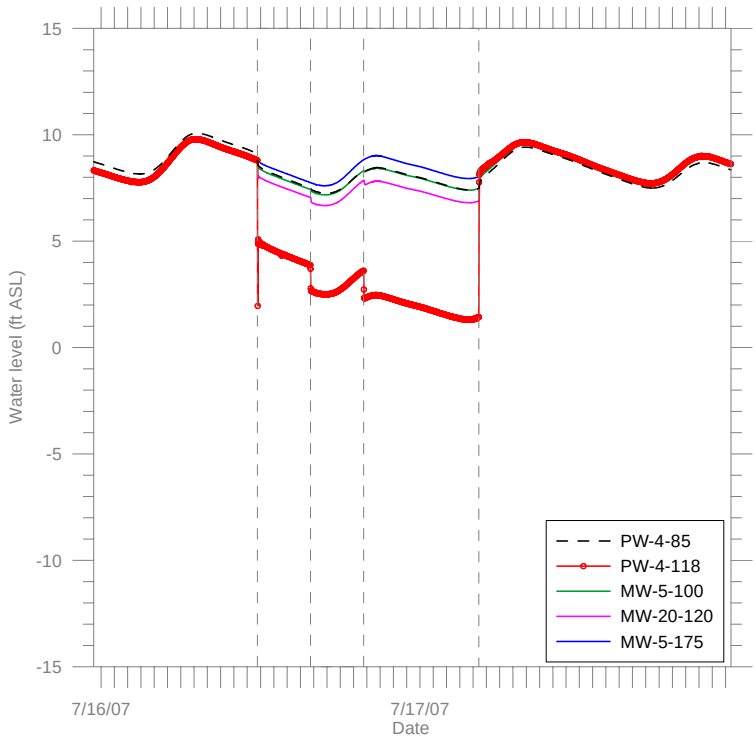

Figure 1-8 Water level data at the PW-4-118 test well and monitoring wells

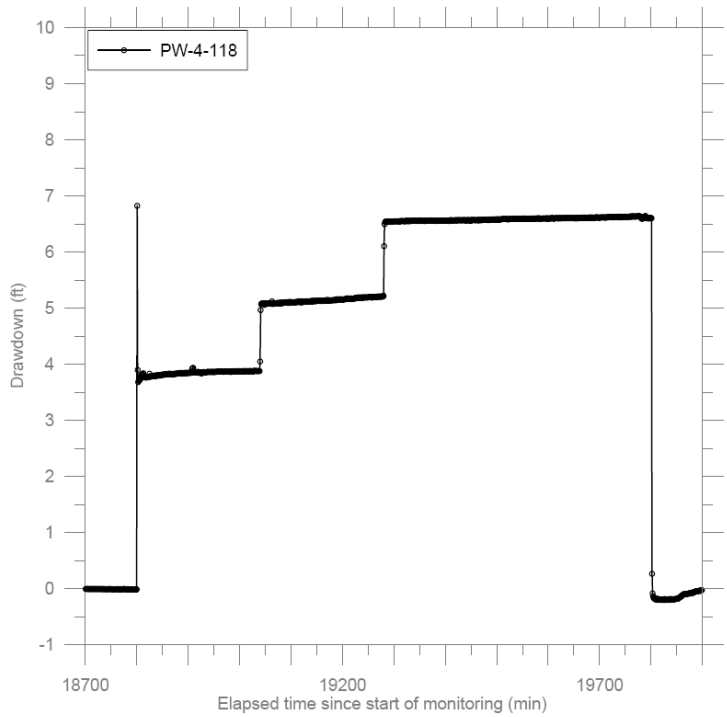

Figure 1-9 Computed drawdown at PW-4-118

Drawdown at PW-4-118 was analyzed using two methods: specific capacity analysis and Theis analysis. In contrast to the results from the PW-4-85 step testing, the results from PW-4-118 suggested that the specific capacity did not change with the pumping rate. Specific capacity at each step was approximately 7.8 gpm/ft, which translates to a transmissivity of about 2,100 ft^2/d.

The Theis analysis was conducted with a storage coefficient of 10^{-4} (confined). The specific capacity results indicate that the well loss coefficient is negligible so this was not included in the analysis. The estimated transmissivity is 16,000 ft^2/d. A plot of the results of the Theis analysis is shown in Figure 1-10.

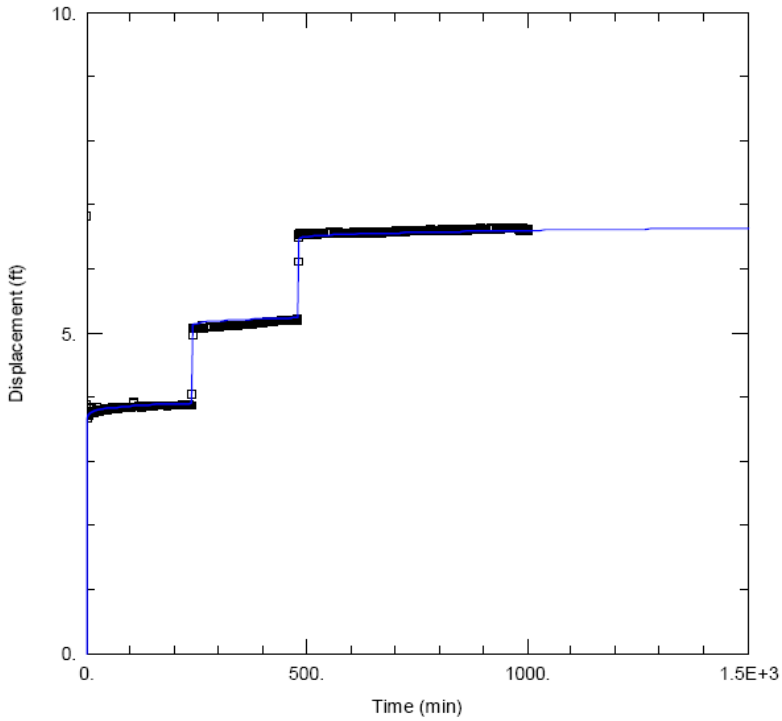

Figure 1-10 Theis analysis (blue line) compared to data (black symbols)

The results from the analysis of PW-4-118 step-drawdown test are summarized on the following table.

Analysis	**Transmissivity (ft^2/d)**	**Thickness[1] (ft)**	**Hydraulic Conductivity (ft/d)**
Specific capacity	2100	10	210
Theis solution	16000	100	160

1) For specific capacity calculations, the appropriate thickness is the screen interval since the screen is short relative to aquifer thickness. For the Theis analysis the aquifer thickness is the appropriate value to use.

1.4 Constant Rate Test: PW-4-118 Analysis

Drawdown was computed from water levels at MW-5-175 (see Section 1.2). The resulting drawdown at PW-4-118 is shown in Figure 1-11.

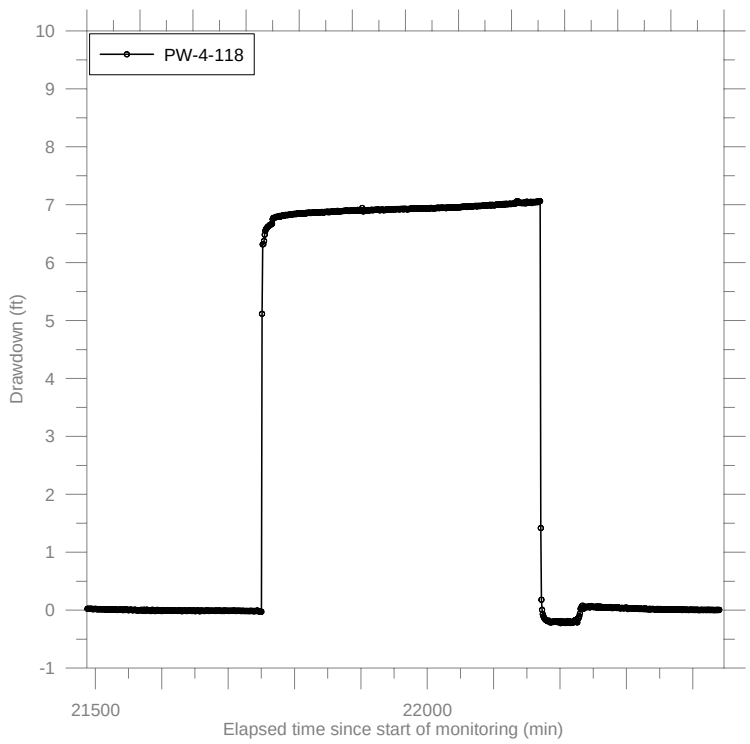

Figure 1-11 Drawdown at PW-4-118 during the constant rate pump test

Drawdown at PW-4-118 was analyzed using the specific capacity analysis and Theis analysis. The specific capacity for this pump test is 7.092 gpm/ft, which is close to the specific capacity from the step-drawdown test of 7.481 gpm/ft. The specific capacity yields a transmissivity of 1,900 ft^2/d.

The Theis analysis was conducted using the Cooper-Jacob straight line method as shown in Figure 1-12. This produced a transmissivity of 6,200 ft^2/d, but with a storage coefficient of 3×10^{-20}, which is unreasonably low. This suggests that the Cooper-Jacob analysis does not capture all the processes controlling drawdown at the well. Consequently, the analysis was conducted assuming a more reasonable storage coefficient of 10^{-4} and including skin loss in the analysis. This analysis produced a negative value for the skin loss, which is also not physically realistic.

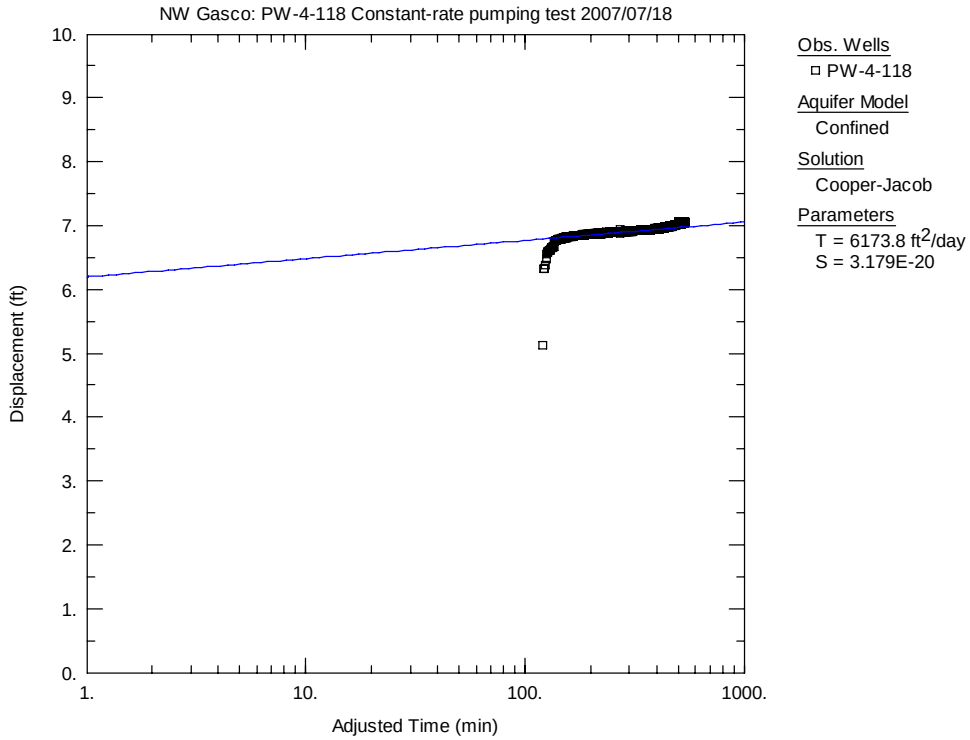

Figure 1-12 Results of Cooper-Jacob analysis on PW-4-118 constant rate test

The non-physical parameter estimates obtained from the transient analyses suggests that the analysis is affected by the influence of the Willamette River. The river is close to the pumping well, and leakage from the river may be induced relatively quickly, causing drawdown to stabilize. The 'true' transient may indeed be the relatively rapid response that is observed within about the first 20 minutes of pumping. In this case, the transient analysis is in effect being used to match quasi-steady drawdown. If this is the case, and in our opinion it is likely, the most representative estimate of transmissivity is developed from the specific capacity data, T = 1,900 ft^2/d.

The estimation of the transmissivity from the specific capacity assumes that the pumping well is open across the entire thickness of the aquifer. The well screen of PW-4-118 is 10 feet long. The aquifer is significantly thicker, and the transmissivity may therefore not be representative of the properties of the full thickness of the tested formation. For a stratified aquifer, as a working hypothesis, we assume that the "effective" thickness of the formation is the length of the well screen (Cooper, Bredehoeft, and Papadopulos, 1967).

$$K_H \approx \frac{T}{L_{eff}}$$

The horizontal hydraulic conductivity of the sediments in the vicinity of the PW-4-118 well screen is estimated by dividing the estimated transmissivity by the length of the well screen:

$$K_H \approx \frac{1{,}900 \text{ ft}^2/\text{d}}{10 \text{ ft}} = 190 \text{ ft/d}$$

1.5 Conclusions

Analysis of the constant rate test at PW-4-85 shows two responses: an early time response and a later time response. The early time response is indicative of conditions close to the pumping well before the influence of the river boundary becomes significant. The later time response is likely influenced by the river boundary. From this, the shallow alluvium is estimated to have a hydraulic conductivity on the order of 10 ft/d while the deeper alluvium has a hydraulic conductivity on the order of 200 ft/d.

Analyses of the PW-4-85 and PW-4-118 step-drawdown and constant rate tests show a considerable difference in the hydraulic conductivity in the shallow and deep alluvium. In both tests, the influence of the river boundary appears to affect the pump tests as seen in the rapid equilibration of the water levels with time.

2.0 Tidal Fluctuation Analysis

Water level data collected by transducers after the PW-4 pump test are show in Figure 2-1. This figure illustrates the tidal efficiencies at the various wells. Water levels at the wells follow the stage fluctuations in the river, but are attenuated and delayed in time compared to the river stage fluctuation. The attenuated fluctuation in the wells compared to the river tidal fluctuation is referred to as the tidal efficiency and is usually reported as a percentage of the river stage fluctuation. The delay in the peak water levels in the well compared to the timing in the river is referred to as the lag time.

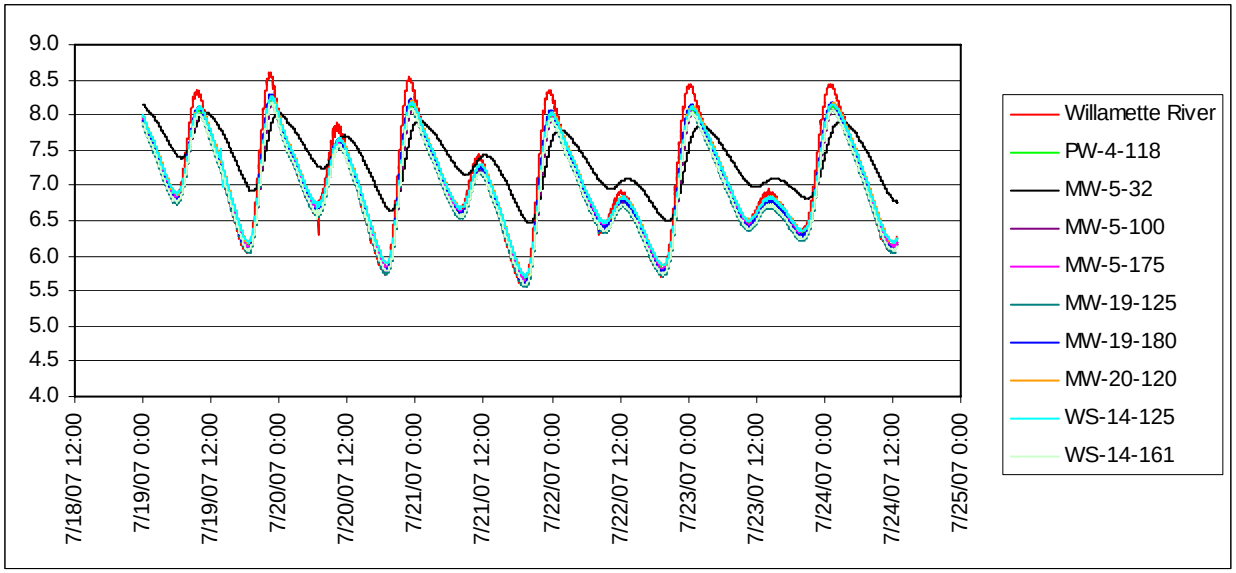

Figure 2-1 Water level and stage record at selected wells and on the Willamette River

Figure 2-1 shows that most wells track the river tidal stage very closely and with little lag time. Only MW-5-32 shows a markedly lower tidal efficiency and longer lag time. The intermediate and deep wells have tidal efficiencies ranging from 86 to 91 percent while the tidal efficiency at MW-5-32 is only 55 percent. The intermediate and deep wells have similar lag times on the order of 20 to 30 minutes, while the lag time at MW-5-32 is on the order of 90 minutes. The tidal efficiencies and lag times suggests that the shallow alluvium has a lower hydraulic conductivity than the intermediate and deep alluvium and that the hydraulic conductivity of the intermediate and deep alluvium are very similar.

Several methods have been developed to calculate hydraulic conductivity from tidal signals (Jacob 1950, Ferris 1951, Carr and van der Kamp 1969). However, tidal calculations can only be used to estimate the ratio of hydraulic conductivity and specific storage, known as the hydraulic diffusivity. The hydraulic conductivity cannot be estimated unless the specific storage is known or computed independently. Carr and van der Kamp (1969) developed a methodology for computing specific storage independently using tidal efficiency and then computing hydraulic conductivity using the time lag of the tidal signal at a well. The tidal efficiency is computed as the ratio of the standard deviation of water level measurements in a well to the standard deviation of stage measurements in the surface water body.

The relationship between specific storage and tidal efficiency is given by:

$$S_s = \frac{\theta\beta\gamma}{1 - TE_{true}}$$

Where: θ is porosity;
β is the compressibility of water;
γ is the specific weight of water; and
TE_{true} is the tidal efficiency corrected from the lag time.

$$TE_{true} = TE_{app} * \exp\left[\frac{2\pi * lag}{t_0}\right]$$

Where: TE_{app} is the measured tidal efficiency at a well;
lag is the measured tidal lag time at a well; and
t_0 is the tidal period.

It is clear from this relationship that TE_{true} must be less than one and that as it approaches one, S_s goes to infinity. This also means that the hydraulic conductivity K must also go to infinity since the ratio K/S_s is a constant in the tidal equation. If TE_{true} is greater than one, S_s becomes negative, which cannot be correct as a negative specific storage has no physical meaning. Unfortunately, this often happens for wells with high tidal efficiency and indeed happens in the present case.
Despite the unrealistic tidal efficiency, an estimate of K can still be made by substituting TE_{app} for TE_{true} in the equation for S_s above. Since TE_{true} is always greater than TE_{app}, the value of K will be under-estimated. Estimates of K are shown in the following table for different values of distance from the shoreline and porosity for deep and shallow wells.

Parameter	**Deep Case 1**	**Deep Case 2**	**Shallow Case 1**	**Shallow Case 2**
Lag time (minutes)	30	30	90	90
Tidal efficiency (dimensionless)	.90	.90	.55	.55
Specific gravity, γ (N/m^3)	9800	9800	9800	9800
Compressibility of water, β (m^2/N)	4.60E-10	4.60E-10	4.60E-10	4.60E-10
Porosity, θ	0.3	0.2	0.3	0.2
Specific storage, S_s (m^{-1})	1.4E-5	9.0E-6	3.0E-6	2.0E-6
Specific storage, S_s (ft^{-1})	4.1E-6	2.8E-6	9.2E-7	6.1E-7
Distance from Shore (ft)	280	305	280	305
Hydraulic conductivity, K (ft/d)	31	24	0.8	0.6

The *K* values shown on the table represent minimum values of *K* based on the tidal analysis. The tidal computation of *K* presented above depends on several parameters. Predicted *K* increases with increasing distance from shore, porosity and TE_{true} and with decreasing lag time. The distance from shore is the distance at which the tidal boundary acts on the aquifer, which may not be at the shoreline, but could be some distance offshore. TE_{true} is not actually known, and for high values of $\underline{TE}_{app}$ the TE_{true} correction can produce values close to one and raise the predicted *K* substantially. Consequently, computing *K* from TE_{app} carries a substantial caveat that the actual *K* could be considerably higher, but it does provide a lower bound estimate of *K*. However, comparing the computed *K* for the deep alluvium aquifer to the computed *K* for the shallow alluvium aquifer, the *K* of the deep alluvium is estimated to be 30 to 50 times greater than the *K* of the shallow alluvium. Results showing that *K* is substantially higher in the deep alluvium than in the shallow alluvium are consistent with the pump test analysis and are discussed further in the next section.

3.0 Analysis of Water Level Gradients

Water level gradients cannot be used to compute hydraulic conductivity or transmissivity unless the groundwater flow rate is known. However, the change in gradient can be directly related to the change in *K* if the groundwater flow rate is assumed to be constant and aquifer thickness is known. That is, if there are no significant changes in groundwater flow across the site, then changes in gradient can be related to changes in transmissivity and the aquifer thickness allows the transmissivity to be converted to an estimate of *K*.

Water level gradients were analyzed along a transect from MW-12-36 to MW-4-57 using time-averaged water level data collected from November 1998 through December 2005 (Figure 3-1).

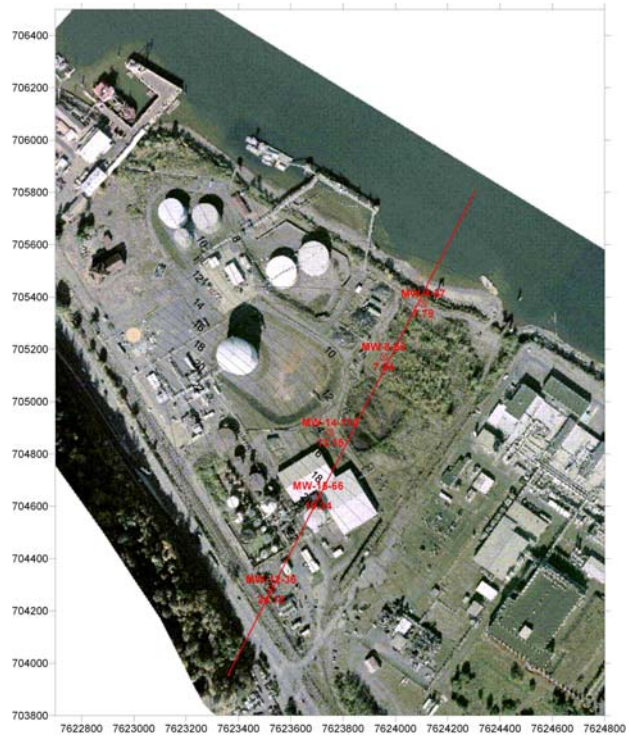

Figure 3-1 Location of Transect for Gradient Analysis

The time-averaged water level profile along this transect is shown on Figure 3-2.

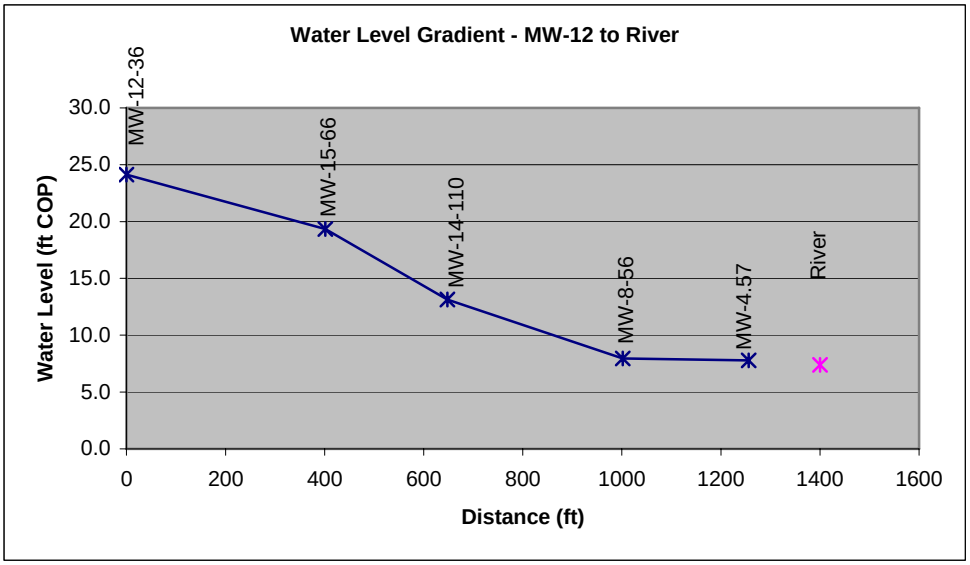

Figure 3-2 Water Level Profile from MW-12 to the River

The change in the water level profile is a function of the groundwater flow rate and the transmissivity. If the groundwater flow is assumed to be constant along the flow transect and the transect is approximately parallel to the groundwater flow direction, then the following relationship applies:

$$(Kbi)_1 = (Kbi)_2$$

where $(Kbi)_1$ is the product of the hydraulic conductivity, thickness and gradient between a pair of wells and $(Kbi)_2$ is the hydraulic conductivity, thickness and gradient between a second pair of wells.

The pair of wells do not need to be adjacent to each other and index notation is arbitrary so the upgradient well can be 1 and the downgradient well 2 or the reverse. The previous equation can be rearranged to:

$$\frac{K_2}{K_1} = \frac{(bi)_1}{(bi)_2}$$

This equation shows that the change in gradient can be used to relate the change in hydraulic conductivity along the transect. The results of this analysis are presented in the following table.

Well ID	Ave WL (City Datum)	Thickness (ft)	Distance (ft)	Average Thickness *b* (ft)	Gradient *i*	*bi*	K_2/K_1	Well Pairs
MW-12-36	24.12	17	401	24	0.011925	0.292172	0.30	MW-12 to MW-15 and MW-15 to MW-14
MW-15-66	19.34	32	246	38	0.025115	0.954353	0.70	MW-15 to MW-14 and MW-14 to MW-8
MW-14-110	13.15	44	354	92	0.014698	1.352237	14	MW-14 to MW-8 and MW-8 to MW-4
MW-8-56	7.94	140	254	154	0.000617	0.095271		
MW-4-57	7.79	169						

From this analysis, the hydraulic conductivity close to the river should be on the order of 20 to 45 times greater than the hydraulic conductivity upland from the river. However, from the pump test and tidal analyses, we saw a similar difference between the hydraulic conductivity of the nearshore shallow alluvium and the nearshore intermediate and deep alluvium. Putting all the information together, it is clear that the upland alluvium and the nearshore shallow alluvium

have relatively low hydraulic conductivity while the nearshore intermediate and deep alluvium has a substantially higher hydraulic conductivity.

It is also worth noting in Figure 3-2 that the water level at MW-4-57 is very close to the river stage. This indicates that there is a strong connection between the river and the aquifer, which is also evident in the tidal response. This suggests that contact between the river and the aquifer is through higher *K* sandy material and that nearshore silt or silt lenses in the aquifer do not significantly affect the connection between the river and the aquifer. If silty sediments affected the connection between the river and the aquifer, there would be a greater water level drop between the aquifer and the river.

4.0 Groundwater Model Analysis

A groundwater flow model has been developed to evaluate groundwater flow in greater detail and to provide a tool for evaluation of Feasibility Study (FS) alternatives. The modeling approach has been presented to DEQ, so only an overview of the model setup and calibration is presented here.

The model extends from the BNSF bridge to the downstream end of the Gasco property and from the bluff west of the property to the east side of the navigation channel in the Willamette River. The overall model area is shown in Figure 4-1.

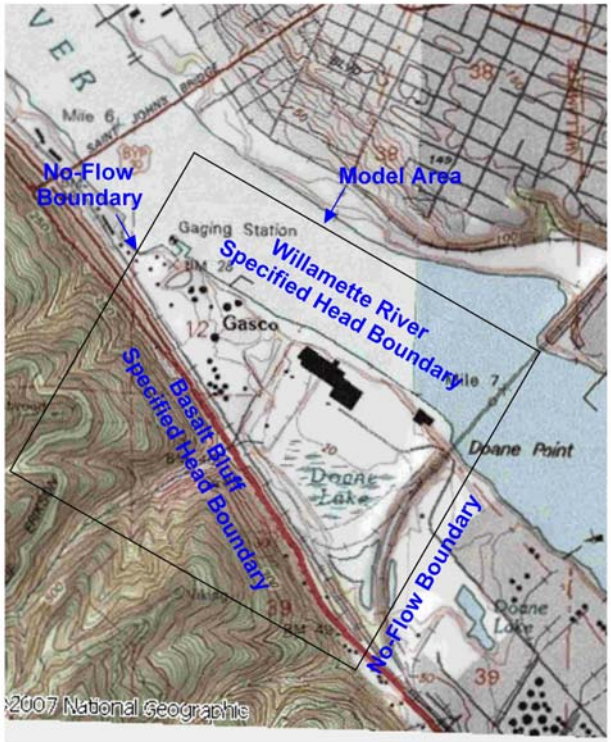

Figure 4-1 Groundwater model area

The model grid consists of 107 rows, 116 columns, and 14 layers. The rows and columns are uniformly spaced with 40 feet on a side. The 14 layers consist of one unconfined fill layer, which includes the Willamette River constant head, two silt layers and 11 layers in the alluvium. The layers in the alluvium were set up to test various FS alternatives with shoreline walls and/or extraction wells completed at different depths. Model cross sections are shown in Figures 4-3 and 4-4. Cross section locations are shown in Figure 4-2

Model boundary conditions are shown in Figure 4-1. Specified heads are used for the river boundary and in the fill and shallow alluvium along the southwest model boundary. No-flow boundaries are applied to the northwest and southeast. The top model boundary is a recharge boundary, which is discussed below. The model extends vertically to the basalt, which contributes flow to the model through the upgradient specified head boundary in the fill and shallow alluvium.

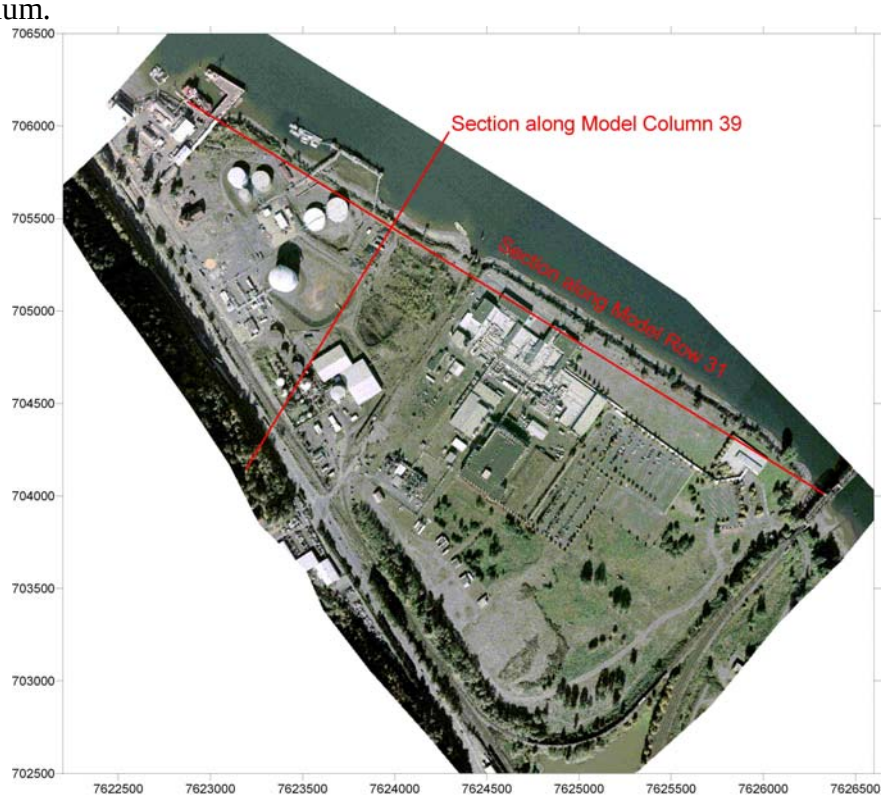

Figure 4-2 Location of model cross sections

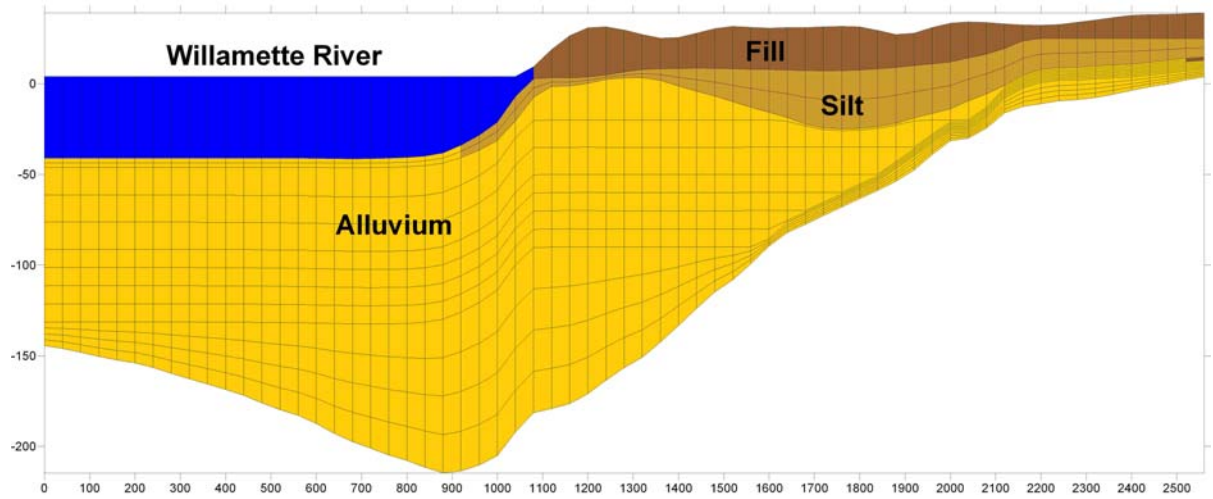

Figure 4-3 Cross section through model column 39

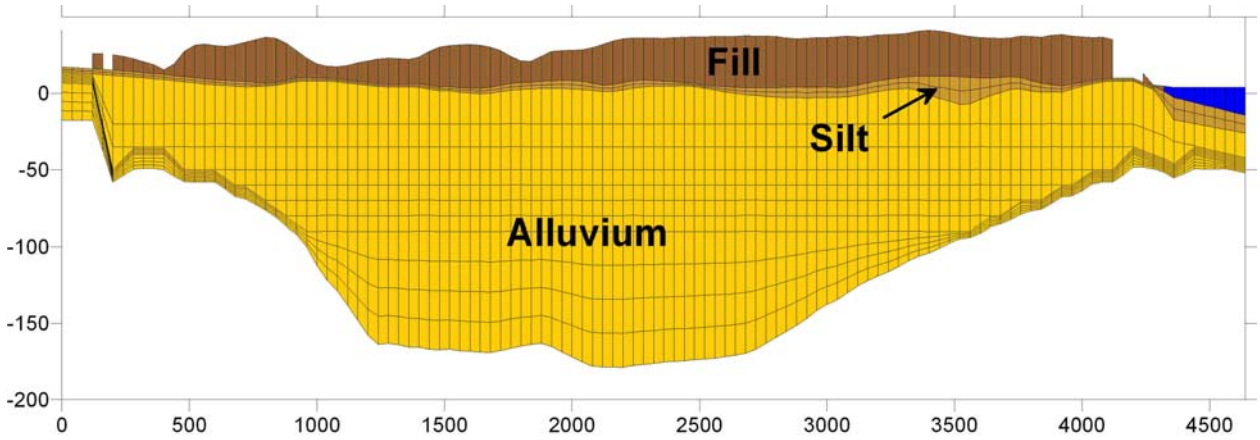

Figure 4-4 Cross section through model row 31

The model was calibrated to water level data averaged over the period from November 1998 to December 2005. Hydraulic conductivity values in the fill, silt and alluvium were adjusted during calibration as were the upgradient constant head boundary condition and areal recharge.

Recharge primarily affected water levels in the fill, which limits the range of recharge. The calibrated recharge was approximately 10 inches per year or about 25 percent of annual

precipitation. A comparison of model results to average water levels on the site is shown in Figure 4-5.

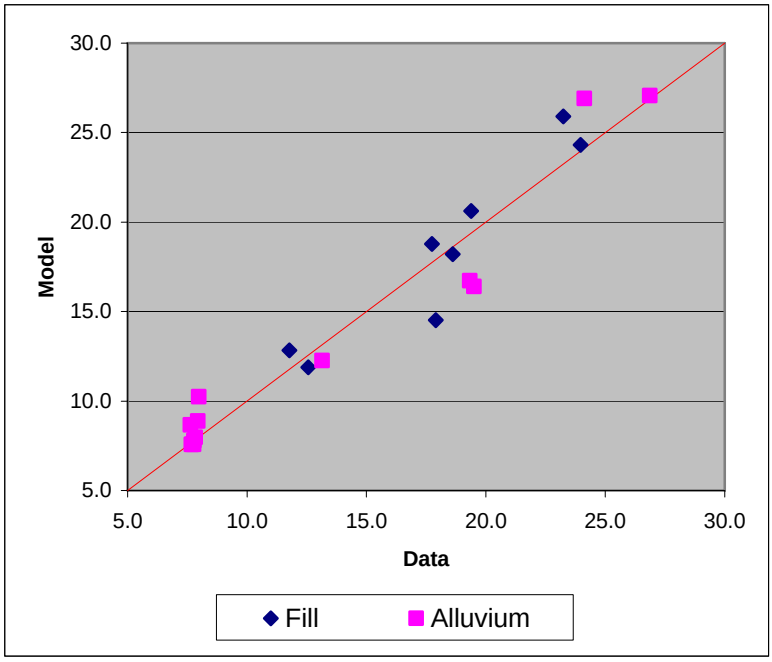

Figure 4-5 Model to data comparison for model calibration

The most difficult water levels to match between the model and data are the cluster of wells near the river. These wells have approximately the same water levels although they range in location from approximately 150 feet to over 400 feet from the river. The low gradient between these wells and the river indicates a high hydraulic conductivity zone between nearshore wells and the river. Consequently, a high hydraulic conductivity zone between the intermediate level wells and the river was incorporated in the model with a lower hydraulic conductivity zone upland in the shallow alluvium. A list of model parameters is given in the following table.

Parameter	**Value**
Recharge (in/yr)	10.5
Hydraulic conductivity – Fill (K_h:K_v ft/d)	10 : 0.1
Hydraulic conductivity – Silt (K_h:K_v ft/d)	0.5 : 0.005
Hydraulic conductivity – Shallow upland alluvium (K_h:K_v ft/d)	10 : 2[1]
Hydraulic conductivity – Deep alluvium upland and under the River (K_h:K_v ft/d)	300 : 60

[1] Analysis of groundwater flux rates described in SSPA memorandum "Northwest Natural, Gasco: Additional Flow Analysis", April 23, 2008, resulted in the hydraulic conductivity of the shallow alluvium being revised to 15 ft/day.

The distribution of the hydraulic conductivity zones is shown on Figure 4.6. The shallow alluvium extends upland to the basalt and extends under the river close to the shoreline. The deep alluvium extends under the river and horizontally upgradient until it intersects the basalt at depth.

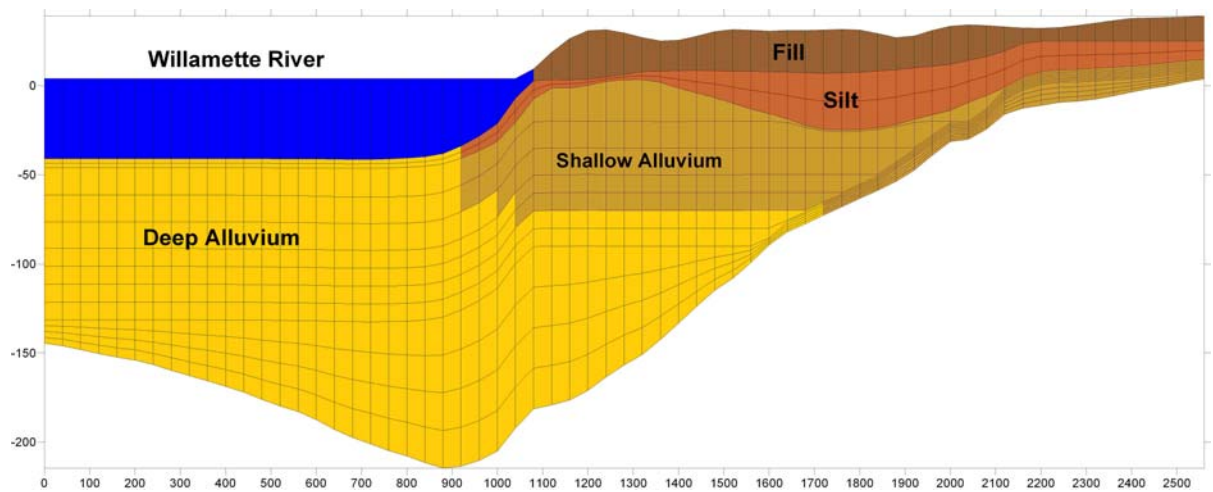

Figure 4-6 Cross section through model column 39 showing the distribution of hydraulic conductivity zones

The model is reasonably calibrated and suitable for evaluating FS alternatives. The model has presently been used to evaluate the following alternatives:

- groundwater pumping without a wall
- groundwater pumping with a wall completed to 65 feet below ground surface
- groundwater pumping with a wall completed to 90 feet below ground surface

The model was setup with 10 wells along the shore line (Figure 4-6) with each well pumping at 20 gpm. The wall simulations were conducted with low permeability cells between the wells and river.

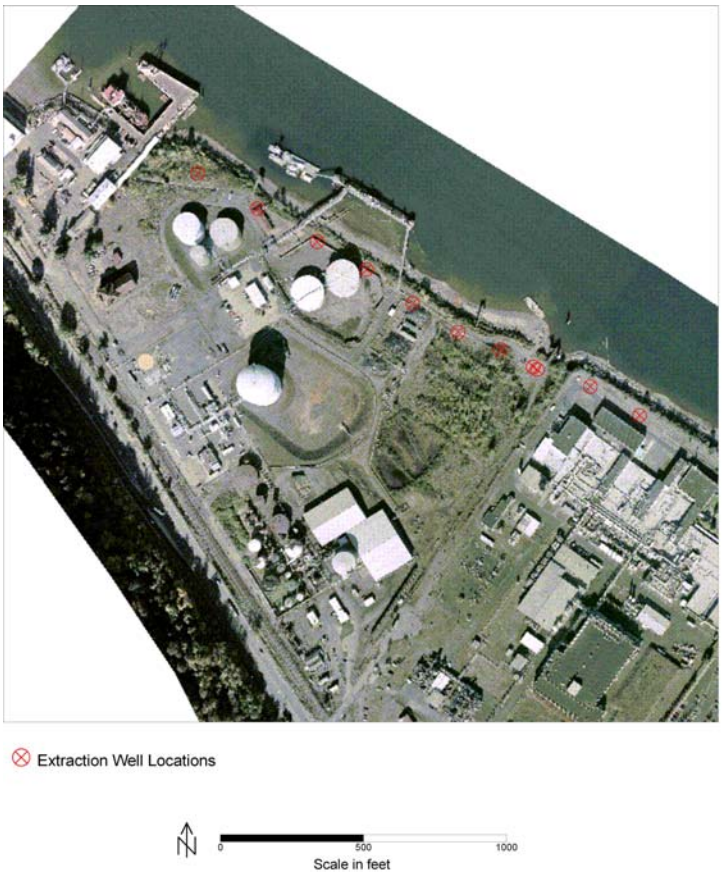

Figure 4-7 Location of wells in the containment analysis

Nearshore walls were simulated by changing the hydraulic conductivity in a row of model cells between the extraction wells and the shoreline. The wall is represented by a hydraulic conductivity of 0.01 ft/d. A model cross section showing the orientation of the wall and extraction wells is shown in Figure 4-7.

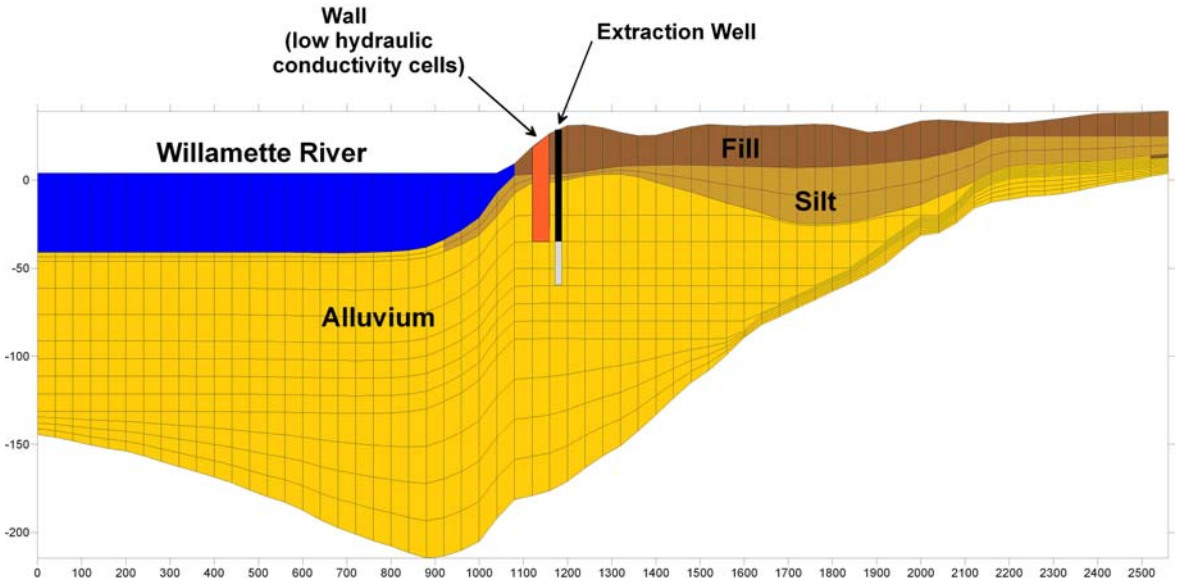

Figure 4-8 Model cross section showing relationship between extraction wells, nearshore wall, and model layers.

Containment was evaluated using the particle tracking code, Path3D (Zheng 1988; SSPA 2001). Particles were started at shallow, intermediate and deep elevations to evaluate the vertical as well as the horizontal extent of capture. In each of the above cases, containment was achieved at 20 gpm per well. Particle path lines in a containment analysis are shown in Figure 4-8. Containment is indicated by all particles reaching a well instead of the river.

Figure 4-9 Example of successful containment

To evaluate the significance of the wall and wall depth on pumping, the pump rate was systematically reduced until containment was no longer achieved. In all three cases particle breakthrough occurs between 12 and 14 gpm. The narrow range in pump rates for breakthrough indicates that the wall does not have a significant effect on groundwater containment. This is due to the considerable saturated thickness below even the deepest wall simulated.

The capture zone analysis was also used to evaluate the depth of capture. One of the objectives of the modeling analysis was to determine the pump rate necessary to capture to approximately 130 feet bgs based on the vertical extent of contamination in the aquifer. The capture zone analysis showed that a pump rate of 20 gpm per well with 10 wells along the shoreline for a total pumping rate of 200 gpm was sufficient to capture the full vertical extent of the aquifer and that fine tuning the pump rate to only capture to a specific vertical zone was not practical. This is due to the tendency for breakthrough to occur horizontally around the edges of the wellfield even though the capture zone extends to the base of the aquifer in the center of the wellfield.

Cost Considerations

The capital costs and operation and maintenance costs for a 200 gpm extraction system consisting of 10 shoreline wells was analyzed for the Focused Feasibility Study. The analysis showed that costs did not make the extraction system infeasible.

Analysis of the effect of higher ambient groundwater flux rate showed that pump rates of 220 to 240 gpm may be necessary to maintain capture. Cost analysis of pump rates in this range did not change the feasibility of the system.

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S.S. PAPADOPULOS & ASSOCIATES, INC.
ENVIRONMENTAL & WATER-RESOURCE CONSULTANTS

Memorandum

Date: April 25, 2008

From: Michael J. Riley

To: John Edwards

Subject: NW Natural, Gasco: Additional Groundwater Flow Analysis

On behalf of Anchor Environmental, LLC (Anchor), S.S. Papadopulos & Associates, Inc. (SSPA) prepared the memorandum *NW Natural Gasco, Pump Test Analysis and MODFLOW Model Summary* (SSPA, October 30, 2007). The 2007 Model Summary was in Appendix E of the *Groundwater/DNAPL Source Control Focused Feasibility Study, NW Natural GASCO Site* (Anchor, November, 2007). At a January 24, 2008 meeting with DEQ, NW Natural was asked to further evaluate three issues related to the 2007 Model summary.

- Develop model with an alternative hydrogeologic CSM in which the deeper alluvial sand with a higher hydraulic conductivity extends upgradient until it intercepts bedrock
- Reality check on estimate of upgradient groundwater flow into model
- Evaluation of "zero" drawdown in MW-05-175

In a letter from Oregon DEQ dated March 21, 2008, NW Natural was asked to further evaluate five issues listed below.

1. Additional documentation that basalt is a no flow boundary
2. Using independent methods to confirm total groundwater flux
3. Explain contradiction between rapid draw down in PW-04 and complete capture conclusion
4. Evaluate increase in hydraulic conductivity with depth as cause of above
5. Provide hydraulic property assignments not previously provided

Items 1 and 5 have been addressed with a recent revision of the NW Natural Gasco, Pump Test Analysis and MODFLOW Model Summary (April, 2008).

The three bullet items identified by DEQ in the January 24 meeting, and items 2, 3, and 4 identified in the March 21 letter, are further evaluated and answered in this memorandum *Additional Groundwater Flow Analysis*.

This memo presents results from a number of analyses conducted in response to the above issues raised by DEQ. These analyses include:

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- Evaluation of hydraulic conductivity from grain size data at MW-18, MW-19, and MW-20
- Interpolation of seepage rate from seepage meters
- Modification of the groundwater flow model
- Groundwater model simulation of PW-4-85 and PW-4-118 pump test.

Grain Size Analysis

Grain size data from MW-18, MW-19, and MW-20 were used to compute hydraulic conductivity values using methods developed by Hazen and Shepherd presented in Fetter (1994)[1]. Hazen developed a formula based on the D_{10} of the grain size distribution, which is a measure of the finest 10 percent particle sizes. Shepherd based his analysis on the D_{50} size. Both follow the same general formula:

$$K = CD_i^j$$

Where: K is hydraulic conductivity
C is a coefficient
D is a representative particle size, *i* (10 percentile for Hazen and 50 for Shepherd)
j is an exponent (2 for Hazen and varies from 1.5 to 2 for Shepherd)

Both methods are somewhat subjective as the coefficient is estimated based on how well sorted the sample is and other subjective factors. For Shepherd, the exponent as well as the coefficient must be estimated.

Hazen's use of D_{10} as the representative particle size results in very low estimates for hydraulic conductivity at the site since many of the samples contain 10% silt and clay size particles, however the average grain size is significantly larger. As a result, more reasonable values were computed using the Shepherd formulation. For the analysis, the shallow alluvium was represented as channel deposits (less well sorted) and the deeper alluvium was treated as beach deposits (more sorted). Results of this analysis are presented in the following tables.

MW-18		K (ft/d)	
Depth (ft bgs)	D_{50} (inches)	Channel Deposits[1]	Beach Deposits[2]
30	0.0037	9.1	25.7
40	0.0438	537	1930
50	0.0002	0.05	0.09
60	0.0028	5.9	16.0

[1] Fetter, C. W. 1994 Applied Hydrogeology. Third edition. Prentice-Hall, Inc. Upper Saddle River, NJ

70	0.0019	3.1	8.1
80	0.0042	11.0	31.3
90	0.0020	3.3	8.8
100	0.0063	22.0	65.2
110	0.0075	28.9	87.1
120	0.0076	29.6	89.3
130	0.0062	21.3	62.9
140	0.0044	12.3	35.2
150	0.0033	7.6	21.0
160	0.0038	9.3	26.3
170	0.0064	22.4	66.5
180	0.0055	17.5	51.3

1) C = 450, j = 1.65
2) C = 1600; j = 1.75

MW-19		K (ft/d)	
Depth (ft bgs)	D_{50} (inches)	Channel Deposits[1]	Beach Deposits[2]
30	0.0029	6.0	16.4
40	0.0035	8.4	23.5
50	0.0017	2.6	6.7
60	0.0001	0.04	0.07
70	0.0001	0.03	0.07
80	0.0044	12.1	34.5
90	0.0057	18.3	53.6
100	0.0001	0.04	0.09
110	0.0074	28.7	86.4
120	0.0073	27.8	83.4
130	0.0070	26.1	78.1
140	0.0036	8.7	24.2
150	0.0127	69.9	222
160	0.0034	8.0	22.3
170	0.0065	23.1	68.7
180	0.0070	26.3	78.6

1) C = 450, j = 1.65
2) C = 1600; j = 1.75

MW-20		K (ft/d)	
Depth (ft bgs)	D_{50} (inches)	Channel Deposits[1]	Beach Deposits[2]
30	0.0025	4.6	12.5

40	0.0037	8.9	25.0
50	0.0001	0.03	0.06
60	0.0043	11.5	32.8
70	0.0037	9.2	26.0
80	0.0057	18.5	54.1
90	0.0001	0.03	0.06
100	0.0001	0.03	0.07
110	0.0075	28.9	87.0
120	0.0072	27.4	82.2
130	0.0056	17.8	52.1
140	0.0065	23.2	68.8
150	0.0053	16.6	48.3
160	0.0044	11.9	34.0
170	0.0036	8.5	23.8
180	0.0064	22.4	66.3

1) C = 450, j = 1.65
2) C = 1600; j = 1.75

The analysis shows a distinct break between less permeable material above 100 ft bgs and more permeable material with depth. The less permeable material corresponds to the depth of material defined as shallow alluvium in the Gasco site groundwater flow model. The hydraulic conductivity value of 10 ft/d used in the model is similar to the values computed here. The grain size analysis for deeper alluvium, although higher in hydraulic conductivity, is not as high as the 300 ft/day used in the model. The higher hydraulic conductivity in the model will produce a higher groundwater flow rate and therefore is a more conservative choice of parameters than the deep alluvium hydraulic conductivity presented here.

Seepage Analysis

Seepage meter data collected in sediments offshore from the Gasco site shows a range of values, The variability in seepage rates is likely due to differences in hydraulic conductivity of the interbedded shallow alluvial sands and silts. Several methods were used to assign seepage meter data to offshore areas. In the present analysis, the location of the seepage meters were digitized and a sector grid extending 3 sectors offshore and 10 sectors along shore was used to interpolate the seepage results to offshore areas. The interpolation used kriging to project the seepage meter data to the center of each sector. Both linear and exponential kriging were used. The linear kriging interpolation produced a seepage rate of 225 gpm and the exponential kriging produced a seepage rate of 253 gpm. Both agree favorably with upgradient boundary flows extrapolated from the U.S.G.S. Portland Basin model of approximately 200 gpm. The seepage analysis is further described in Section 4.4 of the *Offshore Investigation Report, NW Natural Gasco Site* (Anchor, February, 2008)

Modification of the Groundwater Flow Model

The groundwater flow model was modified in two ways:

- The high hydraulic conductivity zone in the deep alluvium was extended upgradient to the basalt contact
- The hydraulic conductivity of the shallow alluvium was modified to determine how this affects the upgradient boundary flow.

Previously, the high hydraulic conductivity zone of the deep alluvium was limited to an area between the pilot boring wells and the river. In the modified model, this zone was extended throughout the deep alluvium. Based on the grain size analysis of MW-18, MW-19 and MW-20 presented above, 100 ft bgs (elevation of approximately -70 feet) was used to extend the deep alluvium hydraulic conductivity to bedrock in the upgradient direction. That is, the deep alluvium below an elevation of -70 ft was set to a hydraulic conductivity of 300 ft/d. This resulted in an increase in upgradient boundary flow from 154 gpm to 172 gpm.

The shallow alluvium was previously set with a hydraulic conductivity value of 10 ft/d. This value agrees with the average value for the shallow alluvium in the grain size analysis, if the very low values and the extremely high value at MW-18-40 are not used. However, as a sensitivity analysis, the shallow alluvium hydraulic conductivity was increased to 15 ft/d. This change was made with the high hydraulic conductivity zone of the deep alluvium extending to bedrock as described above. Changing the hydraulic conductivity of the shallow alluvium resulted in an increase in the upgradient boundary flow from 172 gpm to 245 gpm.

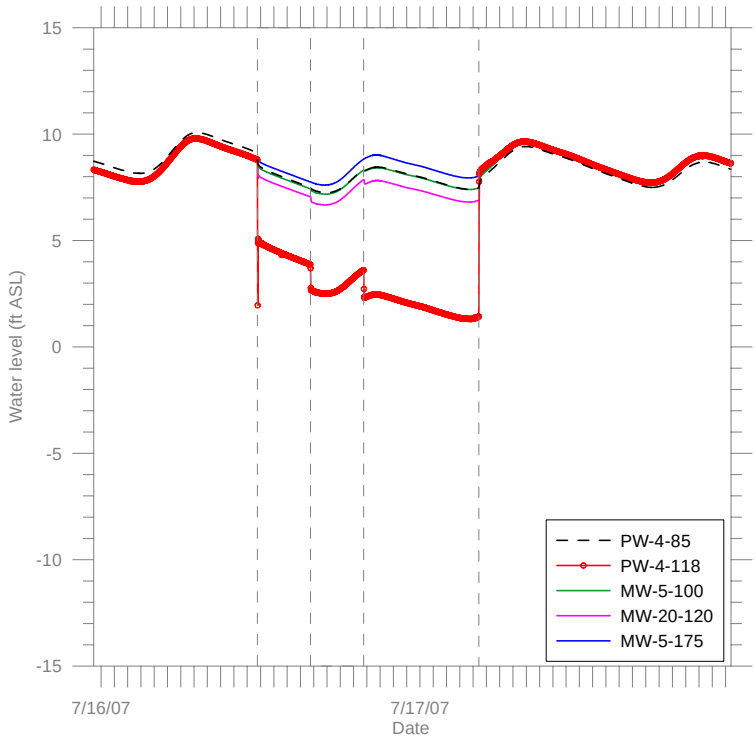
Increasing the hydraulic conductivity of the shallow alluvium and extending the high hydraulic conductivity zone of the deep alluvium to all of the deep alluvium increases the boundary flow closer to the value estimated with the U.S.G.S. model. Higher boundary flow rates can be reached by increasing the hydraulic conductivity of the shallow alluvium. While the original value of 10 ft/d agrees well with pump test analysis and grain size analysis, representing a higher flow rate in the model is more conservative with respect to capture zone design as it will result in higher design pump rates for a groundwater extraction system. Therefore, it is recommended to use a hydraulic conductivity of 15 ft/d for the shallow alluvium in design-related simulations.

Simulation of PW-4 Pump Test

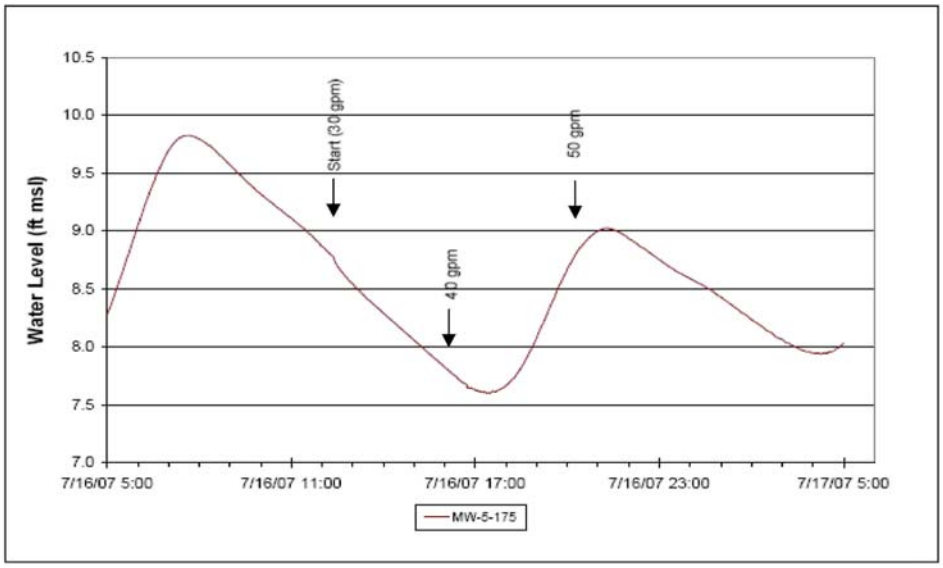
In the analysis of the PW-4-118 step test (Anchor, November, 2007), a simplifying assumption was made that water levels at MW-5-175 were not affected by the pumping. This raised a

concern from DEQ that a high flow interval between the screen of the pumping well and MW-5-175 may prevent capture of groundwater in the vicinity of this well.

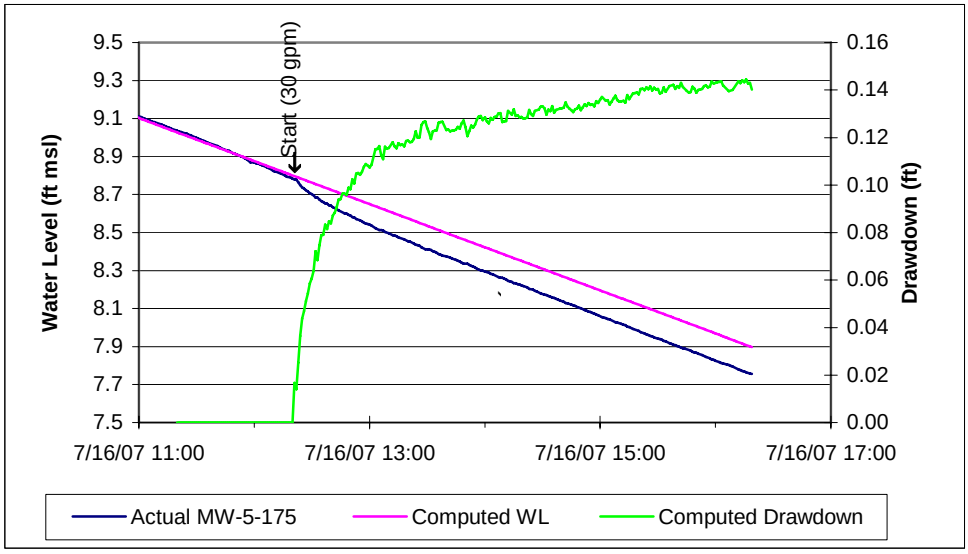
The measured water level data at MW-5-100, MW-5-175 and MW-20-120 during the PW-4-118 step test are shown in the following figure. During that test, PW-4-118 was pumped at three steps with discharge rates of 30, 40, and 50 gpm.



At the scale shown above, the water level at MW-5-175 appears to be unaffected by pumping. Consequently, the water levels at MW-5-175 were used to compute drawdown for the other wells. A closer examination of the water levels at MW-5-175 is shown in the following figure.



The first step shows a very slight change in water level, but the second and third steps are too close to the low and high tide level to discern a change in water level. To compute drawdown, water levels prior to the start of the test (from 9:00 to 12:15) were extrapolated by linear regression through the first step (from 12:20 to 16:20). The measured and computed water level and drawdown are shown on the following graph.

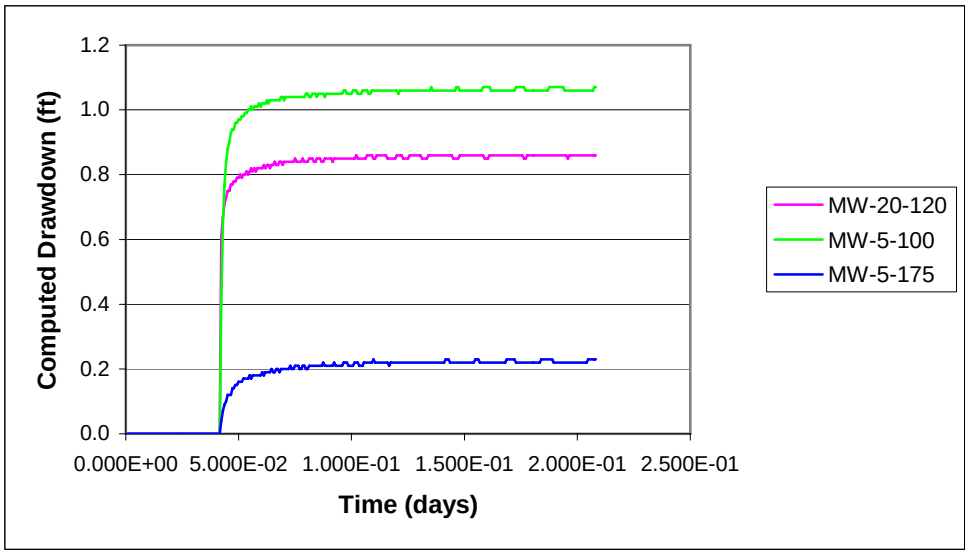


Computed drawdown levels off at about 0.14 ft. The slow steady increase in drawdown from 0.12 to 0.14 ft is a result of extrapolating the computed water level. Taking drawdown as linear with pump rate, the drawdown at 50 gpm would be approximately 0.20 to 0.23 ft. Although the

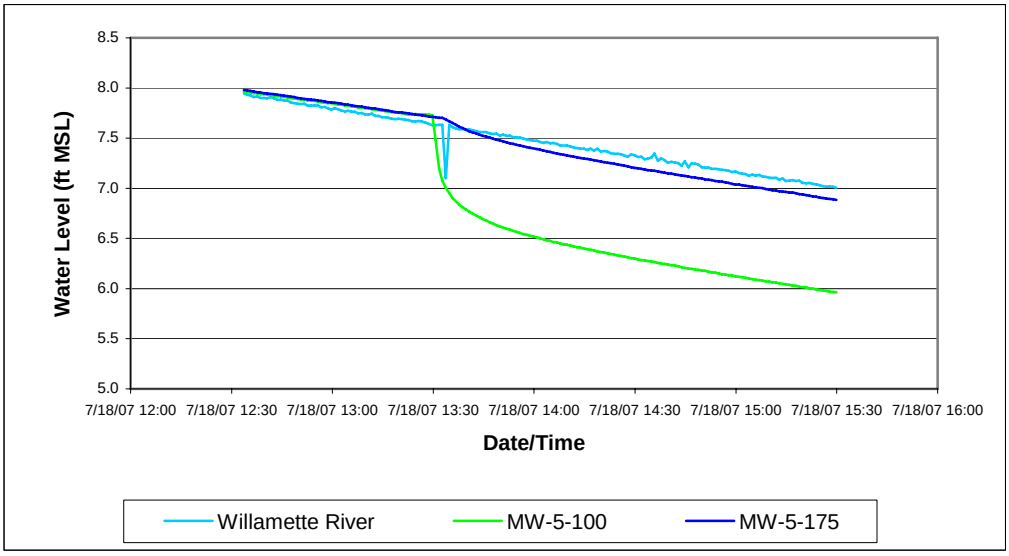
PW-4-118 step drawdown analysis was based on an assumption of zero drawdown at MW-5-175, the actual drawdown of 0.20 to 0.23 ft is small enough that it does not significantly affect the findings of the pump test analysis described in Appendix E of the 2007 Model Summary.

For this modeling analysis, the model was set up to simulate the PW-4-85 and PW-4-118 combined constant rate test conducted September 18, 2007. This test was selected because the higher pump rate and the dual pumping wells provide a greater aquifer stress for simulating drawdown. During that test, PW-4-85 was pumped at 40 gpm and PW-4-118 was pumped at 50 gpm. The model with the high hydraulic conductivity zone throughout the deep alluvium and the shallow alluvium hydraulic conductivity set at 15 ft/d, as described above, was used in the analysis.

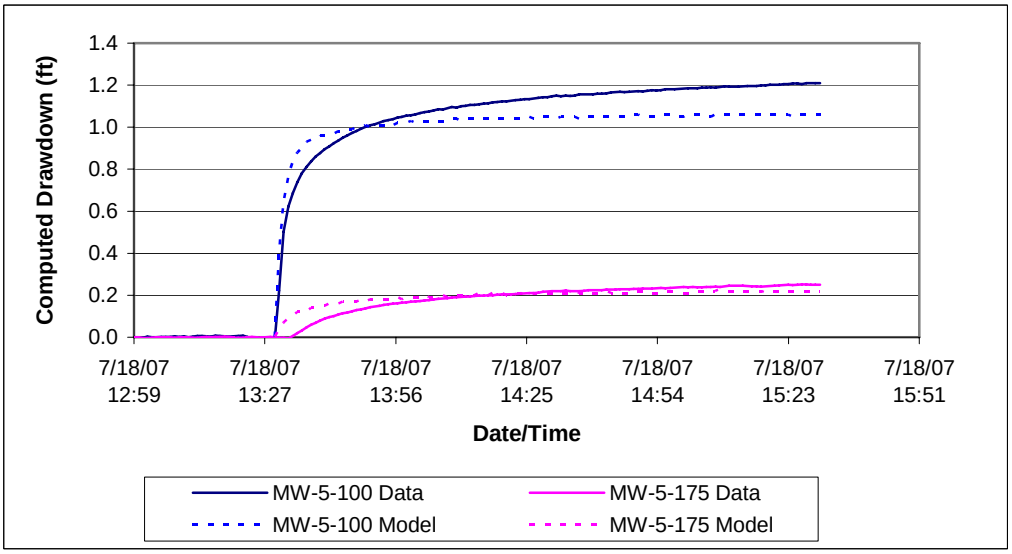
The model was used to simulate a four hour pumping period first without pumping and then with pumping. Drawdown was computed by subtracting the water levels in the pumping simulation from the water levels in the non-pumping simulations. This method keeps all boundary conditions the same for each case so that the only stress affecting drawdown is the pumping. Results of the simulation are presented on the following graph.



The computed drawdown shows a similar pattern to the drawdown in the PW-4-118 step test with substantially greater drawdown at MW-20-120 and MW-5-100 than at MW-5-175. The actual water levels at MW-5-100 and MW-5-175 during the combined PW-4 pump test are shown in the following figure.



Water levels prior to pumping can be extrapolated and used to compute drawdown during pumping. A comparison between drawdown computed from the data and drawdown computed from model results is shown in the following figure.



Drawdown computed from data and from model results show a very good match. The slightly higher drawdown computed from the data is partially explained by the trend in the data before pumping begins as the well data diverges slightly from the trend in the river stage.

Conclusion

Several additional lines of analysis are presented here that support the conceptual site model and groundwater flow model for the Gasco site.

- The analysis of grain size data indicates distinct hydraulic conductivity values for the shallow and deep alluvium.
- The hydraulic conductivity value originally used in the groundwater flow model for the shallow alluvium of 10 ft/d is consistent with the grain size analysis. However, using a higher hydraulic of 15 ft gives a higher groundwater flow rate through the site and is more consistent with estimated groundwater flow rates based on seepage meter analysis and analysis of the U.S.G.S. Portland Basin model.
- The hydraulic conductivity value of 300 ft/d used in the groundwater flow model for the deep alluvium is conservatively higher than the grain size analysis.
- Seepage rate analysis indicates that groundwater flow to the Willamette River is on the order of 225 to 253 gpm.
- Model changes to the hydraulic conductivity of the shallow alluvium and the distribution of hydraulic conductivity between the shallow and deep alluvium result in upland boundary flow that is consistent with the U.S.G.S. Portland Basin model.
- Higher boundary flows can be achieved by increasing the hydraulic conductivity of the shallow alluvium, but values quickly become out of range of the data. A hydraulic conductivity value of 15 ft/day for the shallow alluvium is not inconsistent with the data while providing a better match to estimates of groundwater flow rates from seepage meter analysis and previous modeling by the U.S.G.S. and was incorporated into the model.
- The groundwater flow model was able to simulate the PW-4 pump test and show about 0.2 ft drawdown at MW-5-175 as observed during the PW-4-118 step test and PW-4-85 and PW-4-118 combined pump test when PW-4-118 was pumped at 50 gpm.
- Considering the findings of the PW-4 pumping test, the MODFLOW model with the change described above, and the offshore seepage analysis, it is reasonable to use 250 gpm as the design basis flow rate for the shoreline extraction well system. The groundwater extraction and treatment system will be designed to handle a flow rate higher than 250 gpm to provide a factor of safety and potentially allow for treatment of water from other upland source control measures. The amount of incremental flow increase above 250 gpm will be determined in conjunction with DEQ during design of the system.

GROUNDWATER FLOW MODEL AND DNAPL EVALUATION SUPPLEMENTAL REPORT

NW NATURAL GASCO SITE

Prepared for

NW Natural

Prepared by

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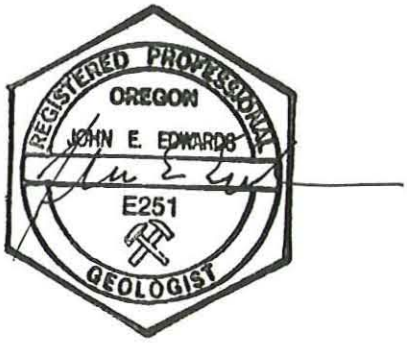

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1 INTRODUCTION

This supplemental report summarizes the work completed and findings of groundwater model and dense non-aqueous phase liquid (DNAPL) evaluations completed as part of source control design at the NW Natural Gasco Site. Chapter four of the *Preliminary Design Report, Groundwater Source Control* (Anchor 2008) identified groundwater flow modeling tasks to be completed, including extraction well design-related issues and the impact of shutdowns and river flow variations. In previous meetings and correspondences, the Oregon Department of Environmental Quality (DEQ) has also requested evaluation of DNAPL mobility as it relates to design of the proposed vertical barrier. This report responds to all of the above technical issues, with the exception of the analysis of the impact of shutdowns. That analysis can more efficiently be addressed after DEQ and NW Natural have conferred on the findings in this report.

NW Natural proposes to meet with DEQ to present the findings of these studies, and this supplemental report is intended to provide DEQ with information to prepare for the meeting. The following sections describe development of reasonable worst case flow conditions, model recalibration, reasonable worst case scenarios, nearshore dredge scenarios, and potential effect on DNAPL.

2 REASONABLE WORST CASE HYDRAULIC GRADIENT DATA ANALYSIS

At DEQ's request a reasonable worst hydraulic gradient case condition was developed by analyzing existing site groundwater level data and comparing the water level data to measured river stage. The greatest difference between water levels at wells and river stage occurred at various times from well to well. However, the greatest difference occurred for 11 wells in the March 27, 2000, monitoring event. Consequently, the water level data from this event were selected as the reasonable worst case condition. More detail on this analysis is presented in Appendix B.

3 MODEL RECALIBRATION

The model was recalibrated to the selected worst case water level data from March 27, 2000. The river boundary condition was changed to the measured stage of 6.82 feet. Model calibration consisted of changing the upland boundary head and the aerial recharge rate to match the March 27, 2000, water level data. The only physical change to the model structure was addition of the MODFLOW Drain Package to represent groundwater seepage to the extraction system in the LNG Basin. This addressed the relatively low water level in MW-10-25, a well completed in the fill near the LNG Basin.

In the model recalibration, the recharge rate changed from the average base case of 0.029 inches per day to 0.054 inches per day. The higher rate yields 1.67 inches of recharge in the March 2000 calibration, which is over 50 percent of the precipitation recorded for March 2000. . This is a relatively high recharge rate and consequently quite conservative with respect to groundwater flow.

The upland boundary head changed in the alluvium from 33 feet in the average base case to 37 feet for the March 2000 calibration. The boundary head did not change in the fill as the calibration to water levels in the fill was accomplished by changing the recharge rate.

Following recalibration, the model was adjusted by extending the deep high hydraulic conductivity zone in the alluvium upland until it intersected bedrock. This same adjustment was done for the average base case to address DEQ's concerns that the model was under-representing groundwater flow from the upland boundary. This upland boundary flow to the alluvium is interpreted as being flow from the underlying basalt west of the Site.

Overall, the calibration to March 2000 worst case conditions with the change in the upland boundary head, recharge rate, and adjustment of the deep alluvium hydraulic conductivity zone increases the overall groundwater flow in the model by 30 percent from the average base case condition. This higher groundwater flow rate represents a transient condition that may only last for a few weeks during winter conditions. For instance, the gradients recorded in March 2000 were not observed in other February or March monitoring events. Therefore, using the model calibrated to the March 2000 data in a steady-state analysis of groundwater containment is a very conservative approach.

4 REASONABLE WORST CASE SCENARIOS

The recalibrated reasonable worst case MODFLOW model was used to simulate five source control scenarios. In all scenarios with the vertical barrier, it is constructed to a bottom elevation of -60 feet along the reach of shoreline recommended in the preliminary design report. The source control scenarios simulated are:

1. Base case with no vertical barrier or pumping.
2. Vertical barrier with no pumping.
3. Barrier with pumping from shallow extraction wells.
4. Barrier with pumping from intermediate depth extraction wells completed near the bottom of the barrier.
5. Barrier with combination of shallow and intermediate depth extraction wells.

The map on Figure 1 shows the locations of subsurface profiles A-A′ and B-B′. Results from all of the model runs are shown along profile A-A′ (Appendix A, Figures A-1 through A-7). Profile A-A′ extends from the river edge across the location of proposed Extraction Well PW-1 and extends approximately 700 feet upland of the shoreline. Results from one model run are also shown along profile B-B′, to assess gradients between extraction wells (Appendix A, Figure A-8).

The first two source control scenarios were analyzed for hydraulic gradients under ambient conditions and with the wall in the absence of pumping, such as in a situation where pumps were turned off. The groundwater gradients near the river and extending upland beyond the proposed location of the wall for these two scenarios are shown on the subsurface profiles in Figures 2 and 3. Figures 2 and 3 display the horizontal and vertical groundwater hydraulic gradients that are predicted when wells are not pumping, both with and without a vertical barrier.

Source control scenarios 3 through 5 were analyzed for the effect on hydraulic gradients and to estimate the pump rate necessary to capture upland groundwater. These scenarios evaluate the different groundwater gradients that result from shallow extraction wells, intermediate depth wells, and paired wells. A summary of the horizontal and vertical hydraulic gradients in the vicinity of and landward from the wall are presented on the subsurface profile in Figure 4. Subsurface profiles showing the detailed distributions of hydraulic gradients that underlie the

data on Figure 4 are provided in Appendix A. Combined pumping rates for all ten extraction well locations predicted to attain capture of groundwater from the Site are presented in the following table.

Model Scenario Current Bathymetry	Estimated Pump Rate (gpm)
Shallow wells	290
Intermediate Wells	250
Combined shallow and intermediate wells	252[1]

1) Pump rate evenly divided between shallow and intermediate wells

5 NEARSHORE DREDGE SCENARIOS

At DEQ's request, the reasonable worst case flow model was modified to represent an additional worst case possibility in which sediment offshore from the Site is dredged to a depth of 20 feet below existing mudline with no backfill material to fill the dredge prism. The assumption was made that the 20-foot dredge segment would extend along the entire alignment of the extraction wells (approximately 2,300 feet) and approximately 300 feet offshore.

The same five scenarios discussed above were analyzed under this condition. A summary of gradients is presented on the subsurface profile in Figure 5. Detailed gradient distributions for these scenarios are presented on the subsurface profiles in Appendix A. Combined pumping rates for all 10 extraction well locations predicted to attain capture of groundwater from the Site are presented in the following table.

Model Scenario Dredge Bathymetry	Estimated Pump Rate (gpm)
Shallow wells	320
Intermediate Wells	260
Combined shallow and intermediate wells	260[1]

1) Pump rate evenly divided between shallow and intermediate wells

6 POTENTIAL EFFECT ON DNAPL

One of the objectives for this evaluation is to determine if there is a potential for upward vertical migration of free-phase DNAPL product into the riverbed sediments and/or surface water as a result of the implementation of the proposed corrective measures at the Gasco Site. Specifically, DEQ asked if the installation of the proposed vertical barrier and associated pumping of groundwater extraction wells on the landward side of the barrier could induce DNAPL migration beneath the wall that could subsequently discharge into the Willamette River.

Fundamentally, the flow of DNAPL is not coincident with groundwater flow in magnitude or direction in saturated environments because of density/specific gravity differences between the two media. The three driving forces that act concurrently on subsurface DNAPL include the gravity gradient (weight of the fluids), the capillary pressure gradient (surface tension of the fluids), and the hydraulic gradient (Cohen and Mercer 1993). It is normally assumed that upward vertical hydraulic gradients associated with groundwater flow can prevent or slow the downward movement of DNAPL. For example, shallow recovery wells and drains can be used to create or increase vertical (upward) hydraulic gradients, particularly across an aquitard that separates two aquifers, and this mechanism has been considered to contain sinking DNAPL at several sites. However, reversing DNAPL flow for recovery is very difficult because of capillary effects between the fluid and surrounding aquifer matrix materials.

The equations used to evaluate the effect of hydraulic gradient and head differences required to prevent DNAPL from sinking vertically downward are given by Cohen and Mercer (1993):

$i_h = (\rho_n - \rho_w)/ \rho_w$ (equation 1.1)

and,

$\delta h = z_n(\rho_n - \rho_w)/ \rho_w$ (equation 1.2)

where:

i_h = hydraulic gradient

ρ_n = specific gravity of DNAPL

ρ_w = specific gravity of water

δh = hydraulic head difference

z_n = thickness of DNAPL body

These density driven forces would have to be overcome for upward vertical migration to occur before capillary forces could exert an additional significant effect on vertical migration tendencies. Therefore, as a first approximation, Equation 1.1 may be used to address the question of whether an upward groundwater hydraulic gradient may reverse the downward vertical migration of DNAPL at the site such that the DNAPL might be drawn to a recovery well or discharge to a surface water body.

Table 1 provides a summary of DNAPL properties at the Site (HAI 2007). This table shows that the specific gravity of DNAPL at the Gasco Site varies between 1.05 and 1.1. Solving equation 1.1 above, the upward vertical hydraulic gradient that is required to overcome or prevent the downward migration of DNAPL due to gravitational forces is between 0.05 and 0.10.

The vertical hydraulic gradients described in Sections 4 and 5 were examined at the bottom of the proposed vertical barrier to assess if upward hydraulic gradients could potentially overcome gravitational forces associated with the downward migration of DNAPL. Two areas were examined for each of the five Reasonable Worst Case scenarios outlined for the groundwater model above under existing and dredged conditions. The two areas that were evaluated are:

- The area on the landward side and adjacent to the proposed barrier—approximately at Stations 1200 to 1350 in the model grid
- The area on the river side and adjacent to the proposed barrier—approximately at Stations 1000 to 1150 in the model grid

The evaluations were performed on gradients predicted at the bottom of the proposed wall (the -60 foot elevation), and are centered on cross section A-A′. Subsurface profile B-B′ was offset from the pumping wells to evaluate how the magnitudes of predicted gradients change with distance away from the proposed pumping wells. In cases where the model well screen was located at the -60 foot level (combined and intermediate scenarios), the gradient from the -70 foot level was substituted at Station 1200.

The following conclusions can be derived from the above analysis:

- None of the modeled conditions have upward hydraulic gradients that could draw DNAPL upward towards the river on the river side of the barrier wall. The vertical gradients in this area are near zero, and mobile DNAPL in the area would tend to migrate in a downward direction since gravitational forces greatly exceed the hydraulic gradient (Figure 6).
- Based on differences between hydraulic and gravitational gradients, there is a potential that downward migration of DNAPL in the immediate vicinity of the pumping wells could be retarded or contained (Figure 7). This effect decreases rapidly moving away from extraction wells. Capillary effects may prevent the complete reversal of downward DNAPL migration in these areas, and heterogeneities in the aquifer matrix would play an important role in determining the magnitude of these effects.

7 SUMMARY OF MODEL FINDINGS

1. The groundwater elevation data for March 27, 2000, represents a reasonable worst case condition for future modeling and design purposes.
2. Overall, the calibration to March 2000 worst case conditions with the change in the upland boundary head, recharge rate, and adjustment of the deep alluvium hydraulic conductivity zone increases the overall groundwater flow in the model by 30 percent from the average base case condition for the period the worst case condition is in effect.
3. Modeled source control scenarios of shallow, intermediate, and paired extraction wells show that the use of shallow extraction wells requires the highest pump rate to achieve capture.
4. The intermediate extraction well scenario results in the highest upward vertical gradients on the landward side of the vertical barrier, but these gradients decrease more rapidly with distance from the pumping well than in the shallow extraction well scenario.
5. Model runs of the dredge bathymetry showed somewhat higher pumping rates to attain capture than the current bathymetry. However, modeling the dredge bathymetry in addition to the March 2000 reasonable worst case flow condition is believed to be overly conservative because the 20-foot dredge depth will likely be restored with engineered fill or filled in by natural river sedimentation processes. With the addition of post-dredge engineered fill or natural river sedimentation the resulting bathymetry will be close enough to current bathymetry to make the modeled groundwater flows essentially the same. Therefore, the March 2000 reasonable worst case model described in Section 4 is recommended as the worst case scenario to be considered in future design evaluations.
6. None of the modeled scenarios have upward hydraulic gradients that could draw DNAPL upward towards the river on the river side of the barrier wall. Based on differences between hydraulic and gravitational gradients, there is a potential that downward migration of DNAPL in the immediate vicinity of the pumping wells could be retarded or contained.
7. The modeling results demonstrate that the DEQ-proposed vertical barrier depth of -60 feet elevation has a large factor of safety to prevent DNAPL migration from the area upland of the vertical barrier into the river channel.

8 REFERENCES

Anchor Environmental, LLC 2008. *Preliminary Design Report, Groundwater Source Control, NW Natural GASCO Site*. Prepared for NW Natural. Portland, Oregon.

Cohen, R.M. and Mercer, J.W. 1993. *DNAPL Site Evaluation*. Office Research and Development, U.S. EPA.

HAHN and Associates, Inc. 2007. *Remedial Investigation Report, NW Natural Gasco Facility*. Prepared for NW Natural. Portland, Oregon.

TABLE

TABLE 1
Summary of DNAPL Testing Results: Physical and Chemical

Parameter	Unit of Measure	Gasco Property Wells					Siltronic Property Wells	
		Surficial Fill Unit			Alluvial Unit		Surficial Fill Unit	Alluvial Unit
		Well MW-6-32	Well MW-10-25	Well MW-11-32	Well MW-16-45	Well PW-01-80	Well WS-10-27	Well WS-11-125
		Screen: 22-32 feet bgs	Screen: 15-25 feet bgs	Screen: 22-32 feet bgs	Screen: 30-45 feet bgs	Screen: 40-80 feet bgs	Screen: 11-26 feet bgs	Screen: 110-125 feet bgs
		Sample No.2708-981214-MW6-32-01	Sample No. 2708-981214-MW10-25-02	Sample No. 2708-981214-MW11-32-03	Sample No. 2708-041011MW-16-45-Oil	Sample No. 2708-070221-PW01-Oil	Sample No. WS10070104	Sample No. WS11-125-N
Total Metals [1]	mg/kg (ppm)							
Arsenic		2.75	3.85	-	-	-	-	-
Barium		ND>0.500	0.700	-	-	-	-	-
Cadmium		ND>0.500	ND>0.500	-	-	-	-	-
Chromium		0.700	0.850	-	-	-	-	-
Lead		ND>10	ND>10	-	-	-	-	-
Mercury		0.059	ND>0.0500	-	-	-	-	-
Selenium		0.550	ND>0.500	-	-	-	-	-
Silver		ND>0.500	ND>0.500	-	-	-	-	-
Aromatic Hydrocarbons [2]	mg/kg (ppm)							
Benzene		589	14,400	2,740	ND>10.0	1,000	874	271
cis-1,2-DCE		-	-	-	ND>10	ND>764	ND>20	188
Ethylbenzene		2,220	5,320	1,760	34.4	2,228	807	925
Isopropylbenzene		-	-	-	ND>20	ND>1,590	69	ND>50
n-Propylbenzene		-	-	-	ND>10	ND>794	33	ND>50
1,2,4-Trimethylbenzene		-	-	-	54.9	976	394	434
1,3,5-Trimethylbenzene		-	-	-	16.2	ND>794	147	121
Naphthalene		-	-	-	1,720	75,400	39,500	114,000
Toluene		ND>5.00	21,900	2,950	17.8	ND>794	43	194
Trichloroethene		-	-	-	ND>10	ND>794	ND>20	59.6
Xylene		1,240	19,500	4,400	66.1	ND>1,590	664	720
PAHs [3]	mg/kg (ppm)							
Total PAHs		214,900	189,700	164,470	32,787	46,910		
Total Carcinogenic PAHs		9,300	19,490	16,210	2,647	ND		
Petroleum Hydrocarbon ID [4]	None							
Gasoline-Range (mg/kg)		Detected [12]	Detected [12]	Detected [12]	Not Detected	22,900	-	14.9
Diesel-Range (mg/kg)		Detected [12]	Detected [12]	Detected [12]	Detected [12]	545,000 [12]	-	347
Heavy Oil-Range (mg/kg)		Detected [12]	Detected [12]	Detected [12]	Detected [12]	175,000 [12]	-	73.1
Reactive Cyanide [5]	mg/kg (ppm)						-	-
		ND>0.200	ND>0.200	-	-	-	-	-
Reactive Sulfide [6]	mg/kg (ppm)						-	-
		434	ND>50.0	-	-	-	-	-
Specific Gravity [7]	gm/cc	1.05	1.05	1.09	1.084 @ 70F; 1.079 @100F; 1.080 @130F	1.1006 @ 70F; 1.0955 @10 1.0920 @130F	-	1.1
Viscosity [8]	cSt	7.2 @ 50C (122F)	14.7 @ 50C (122F)	45.7 @ 50C (122F)	105 @ 70F; 40.1@100F; 18.7@130F	65.6 @ 70F; 24.1@100F; 13.3 @130F	-	-
Ignitability [9]	degrees F	No Flash to 150 degrees F	94.0 degrees F	-	No Flash to 150 degrees F	No Flash to 150 degrees F	-	-
Heating Value [10]	BTU/lb	9,230	12,230	12,280	-	-	-	-
pH [11]	pH unit	6.26	4.30	-	8.28	7.10	-	7.01
Interfacial / Surface Tension [13]	dynes/centimeter							
Water with Air		-	-	-	66.7 @ 70F	66.9 @ 75F	-	-
DNAPL with Air		-	-	-	34.9 @ 70F	36.2 @ 75F	-	-
DNAPL with Water		-	-	-	14.2 @ 70F	15.8 @ 75F	-	-

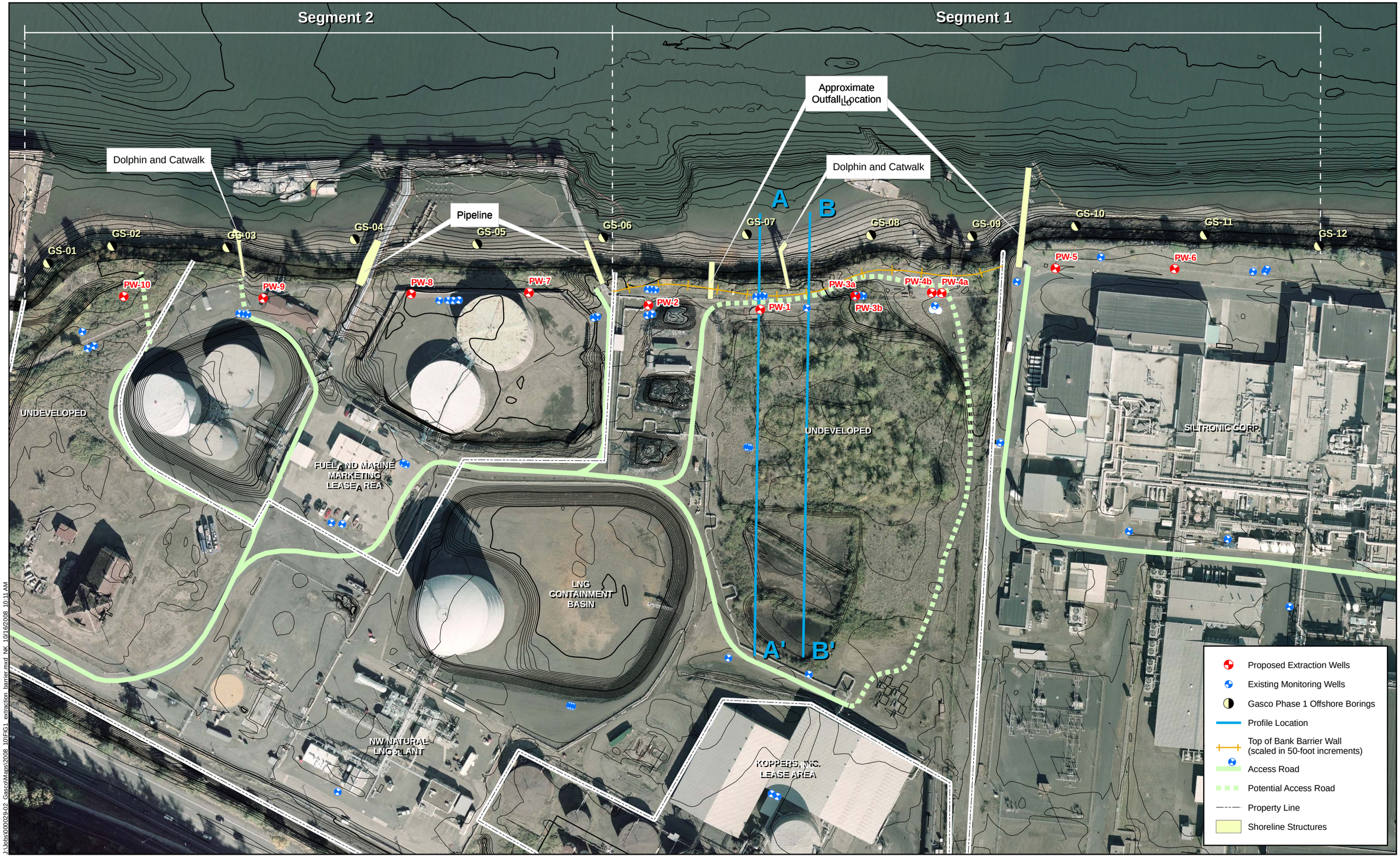
NOTE:

1 = EPA Method 6010/6020/7471
2 = EPA Method 8020A or EPA 8260B
3 = EPA Method 8270 SIM or 8270C
4 = EPA Method 8015M or NW-TPH Methodology or EPA 8015
5 = EPA Method 9010A
6 = EPA Method 9030
7 = SM 2710F
8 = ASTM Method D-445
9 = EPA Method 1010
10 = ASTM Method D2015
11 = EPA Method 150.1/9040A
12 = Laboratory reports that detected hydrocarbons have pattern and range consistent with creosotes
13 = DuNuoy Method - ASTM D971
J = Estimated concentration, results are between the Method Detection Limit (MDL) and the Method Reporting Limit (MRL).

bgs=below ground surface
cc=cubic centimeter
cSt = centistokes
BTU = british thermal unit
DNAPL = dense non-aqueous phase liquids
EPA = U. S. Environmental Protection Agency
gm = gram
lb = pound
mg/kg = milligrams/kilogram

ND = not detected above detection limit indicated
ppm = parts per million

FIGURES



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ANCHOR ENVIRONMENTAL, L.L.C.

0 150
Scale in Feet
1 inch equals 150 feet

Figure 1
Cross Section Location Map
Gasco/Siltronic
Portland, Oregon

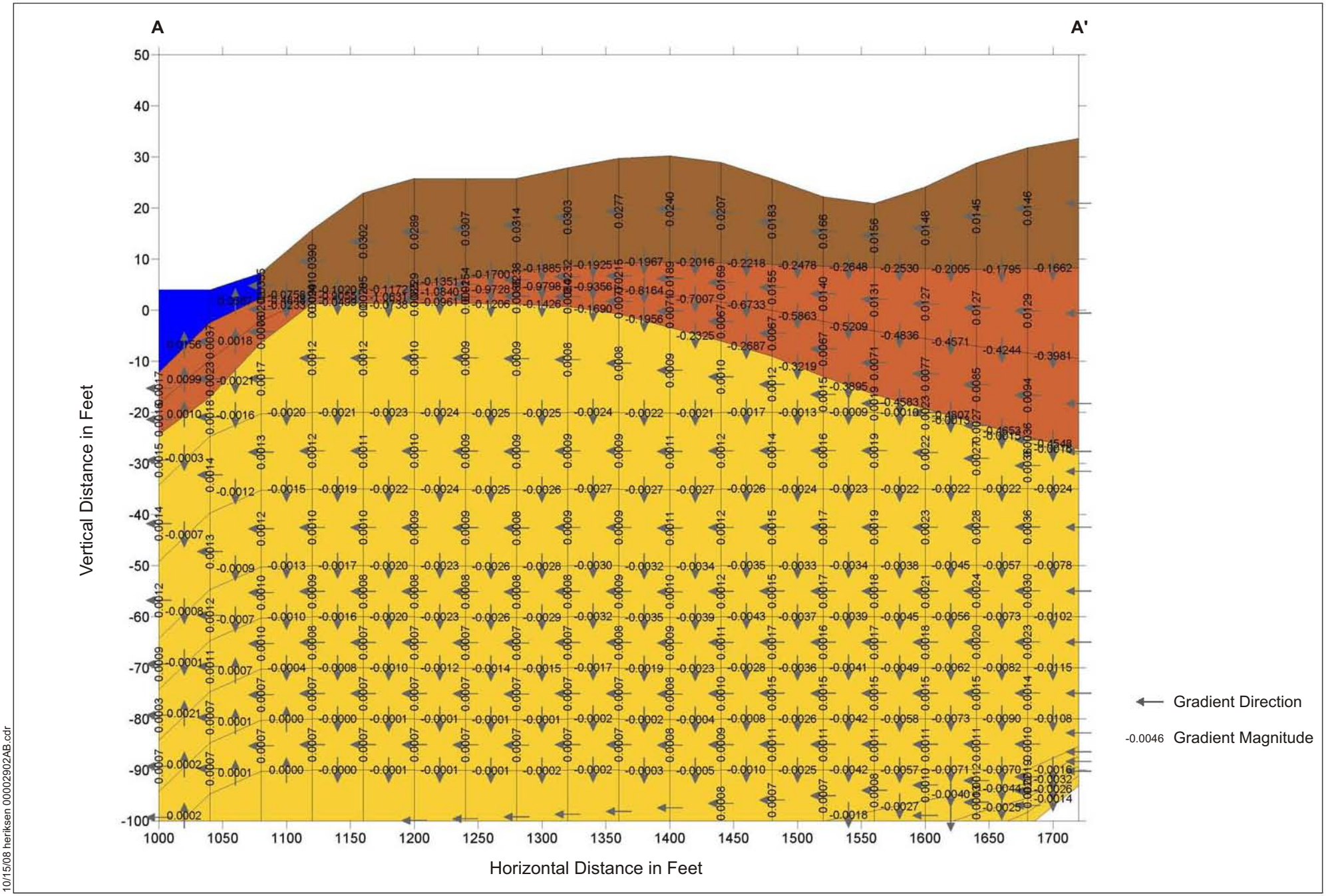

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Figure 2
Reasonable Worst Case Gradient Profile A-A' - Ambient without Vertical Barrier
NW Natural "Gasco" Site

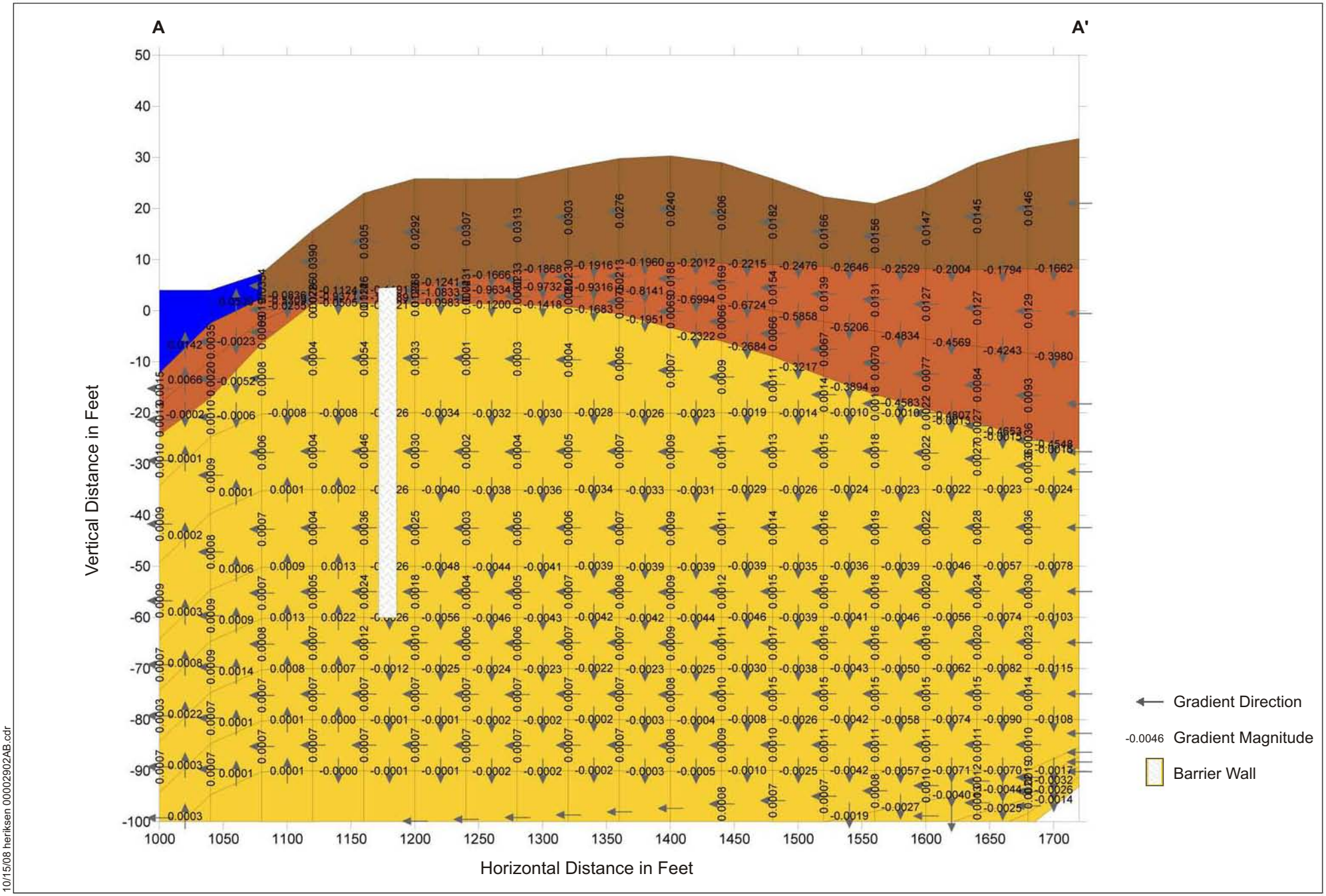

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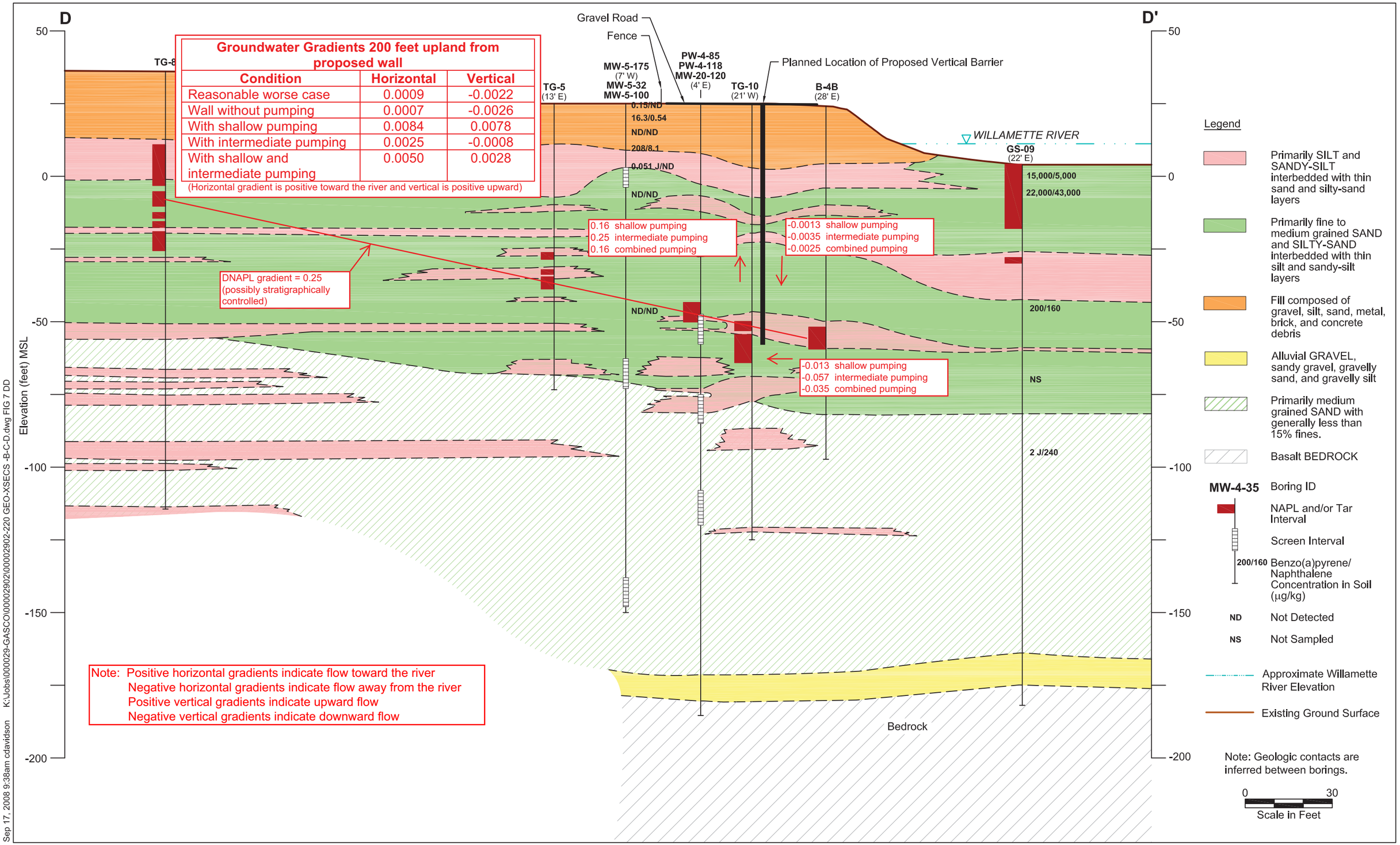
Figure 3
Reasonable Worst Case Gradient Profile A-A' - Ambient with Vertical Barrier
NW Natural "Gasco" Site



Groundwater Gradients 200 feet upland from proposed wall		
Condition	Horizontal	Vertical
Reasonable worse case	0.0009	-0.0022
Wall without pumping	0.0007	-0.0026
With shallow pumping	0.0084	0.0078
With intermediate pumping	0.0025	-0.0008
With shallow and intermediate pumping	0.0050	0.0028

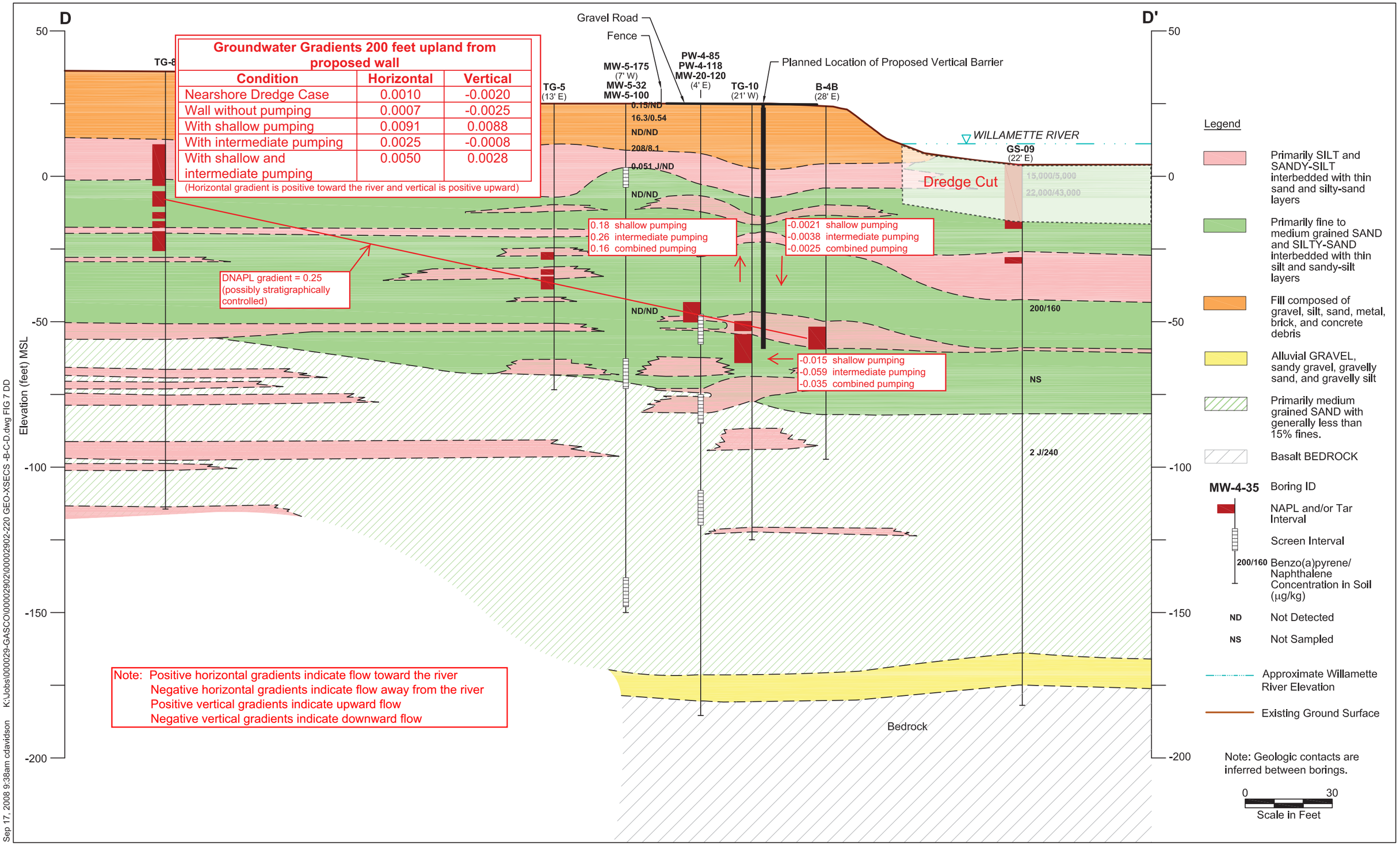
(Horizontal gradient is positive toward the river and vertical is positive upward)

Note: Positive horizontal gradients indicate flow toward the river
Negative horizontal gradients indicate flow away from the river
Positive vertical gradients indicate upward flow
Negative vertical gradients indicate downward flow

Figure 4

ANCHOR ENVIRONMENTAL, L.L.C.

$\Sigma^2\Pi$



Groundwater Gradients 200 feet upland from proposed wall		
Condition	**Horizontal**	**Vertical**
Nearshore Dredge Case	0.0010	-0.0020
Wall without pumping	0.0007	-0.0025
With shallow pumping	0.0091	0.0088
With intermediate pumping	0.0025	-0.0008
With shallow and intermediate pumping	0.0050	0.0028

(Horizontal gradient is positive toward the river and vertical is positive upward)

Note: Positive horizontal gradients indicate flow toward the river
Negative horizontal gradients indicate flow away from the river
Positive vertical gradients indicate upward flow
Negative vertical gradients indicate downward flow

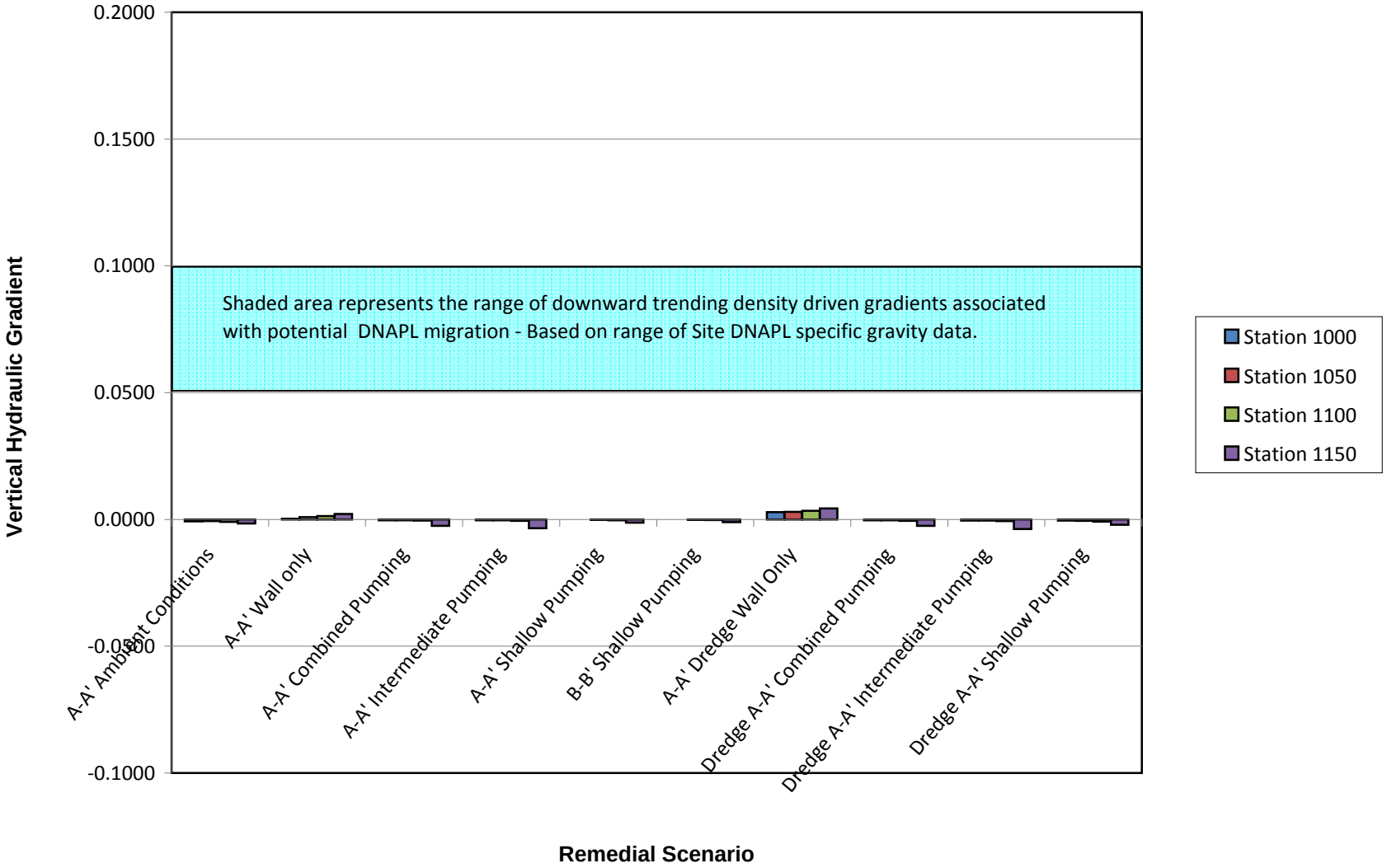
ANCHOR ENVIRONMENTAL, L.L.C.

$\Sigma^2\Pi$

DRAFT

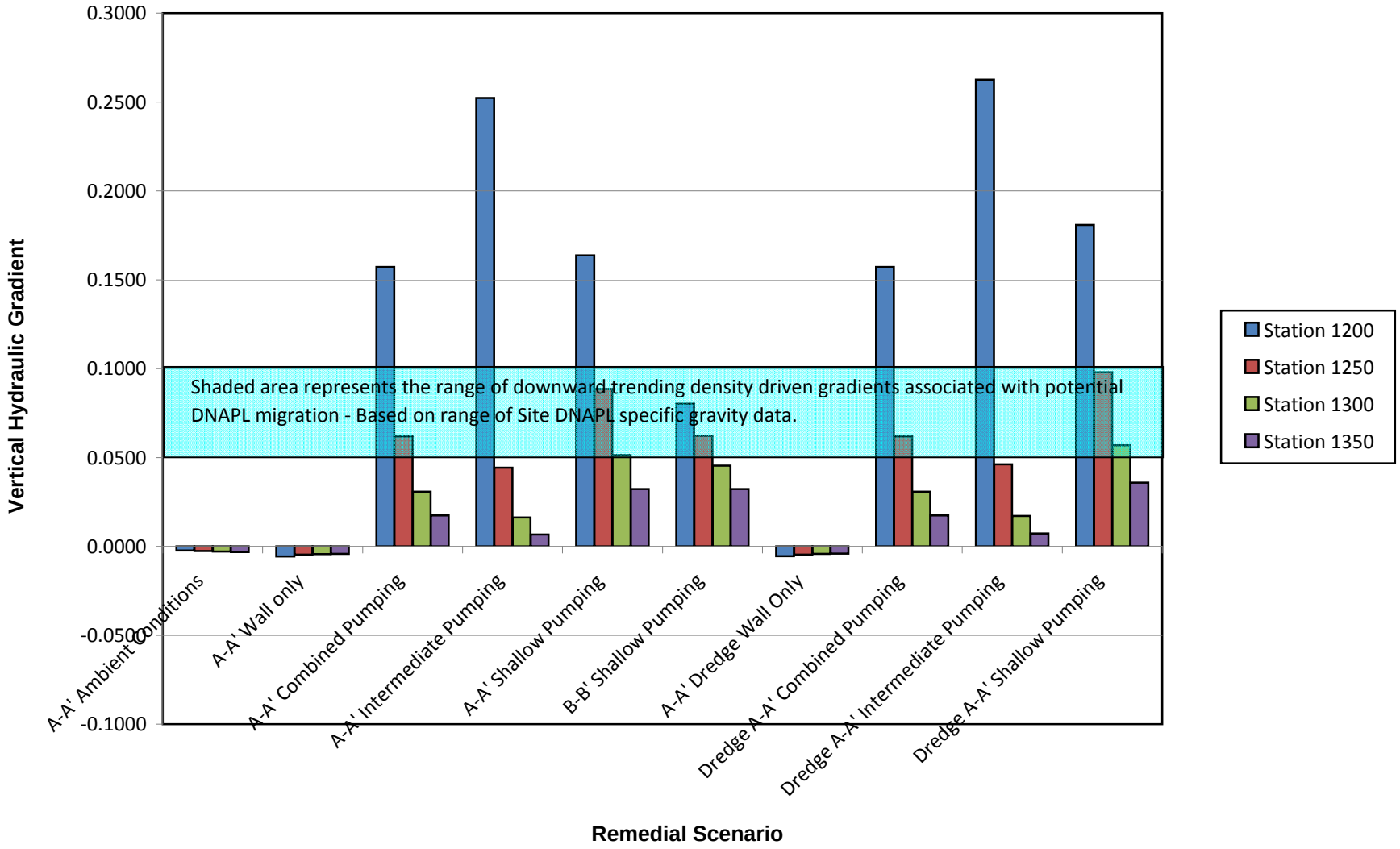
Figure 5
Geologic Profile with Gradient Summary, Nearshore Dredge Bathymetry Case

FIGURE 6
-60 foot Level Vertical Hydraulic Gradients Riverside of Proposed Barrier Wall



ANCHOR ENVIRONMENTAL, L.L.C.

FIGURE 7
-60 foot Level Vertical Hydraulic Gradients Landward of Proposed Barrier Wall



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APPENDIX A
GRADIENT PROFILES A-1 THROUGH A-8

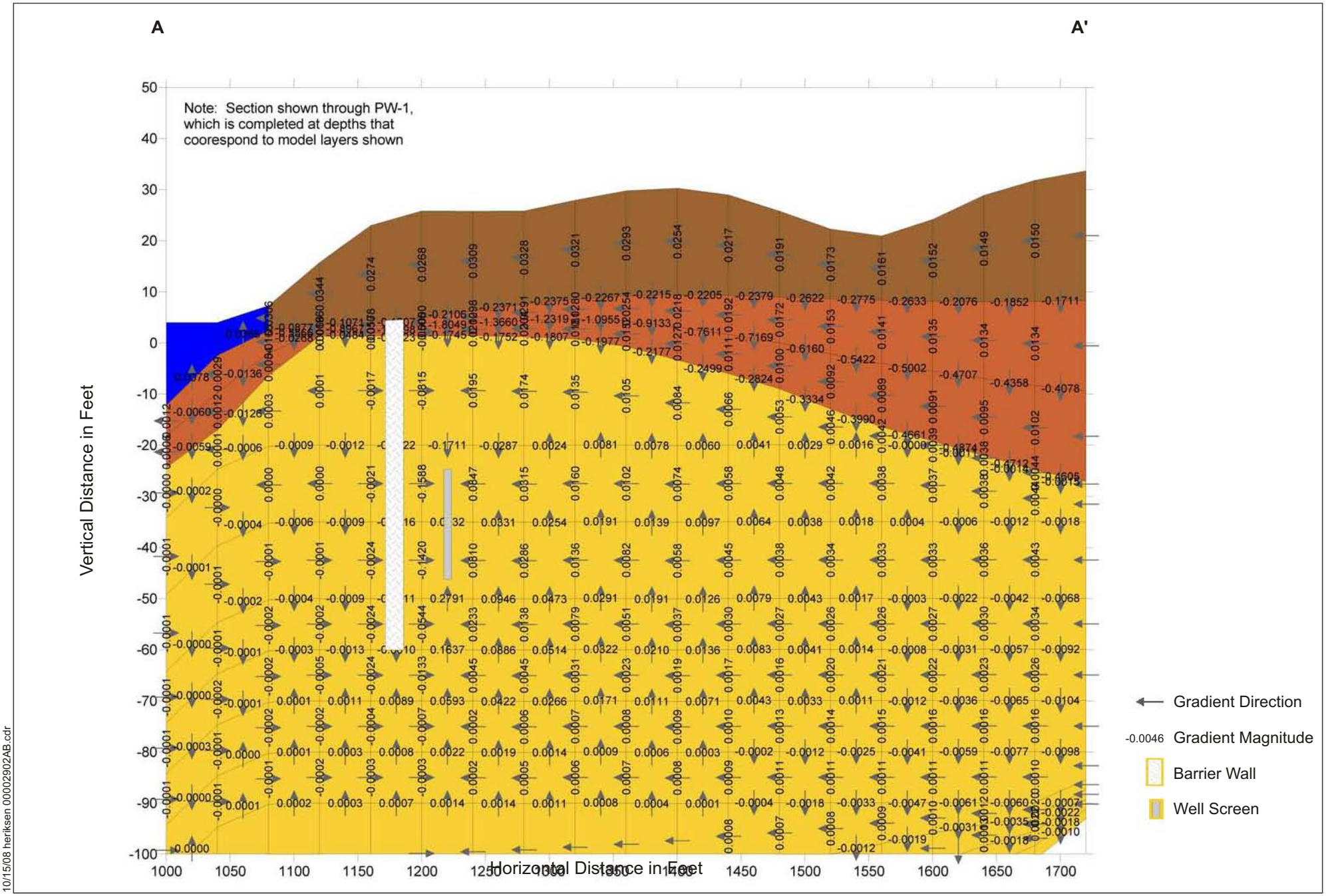

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Figure A-1
Gradient Profile A-A', Current Bathymetry, Shallow Well
NW Natural "Gasco" Site

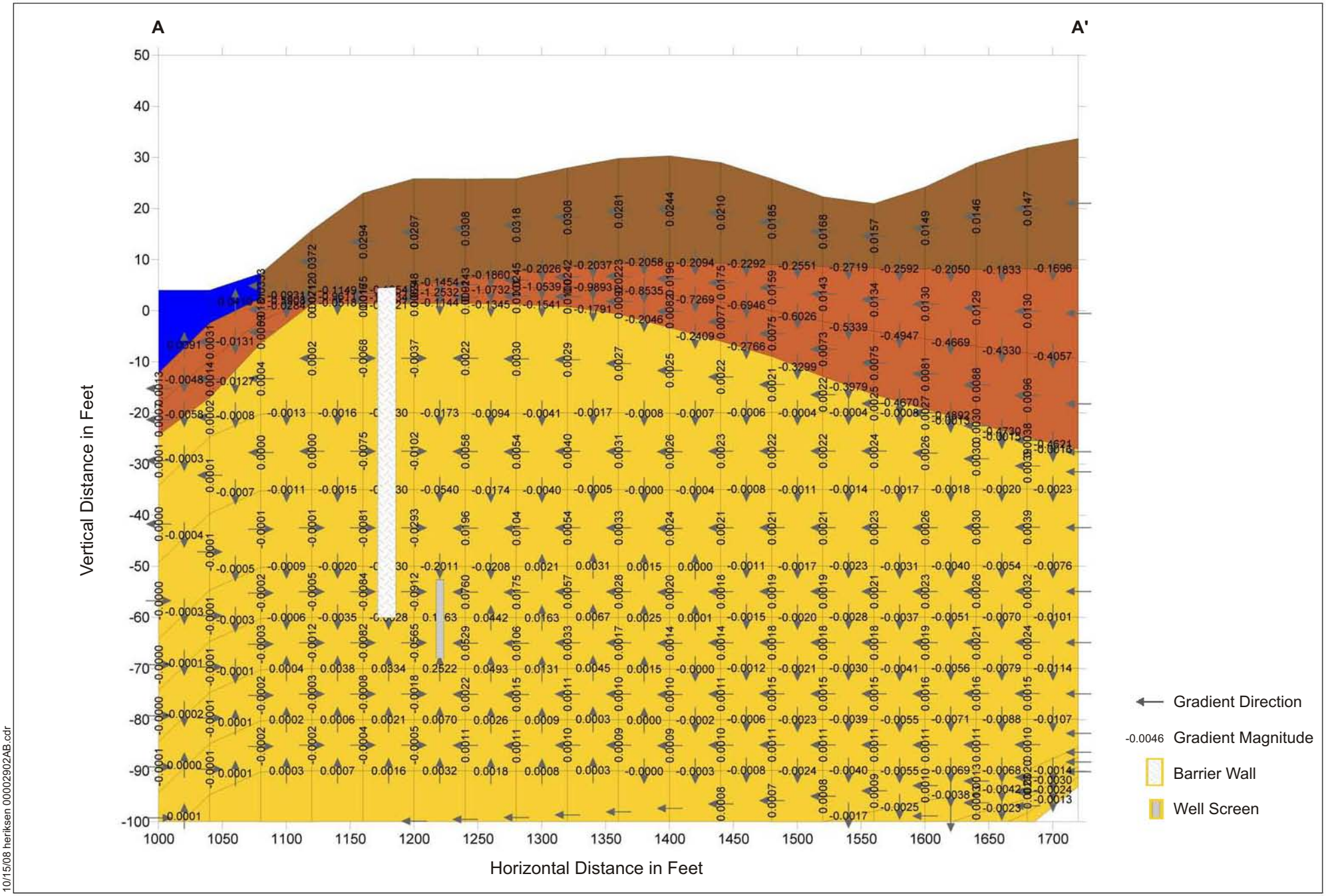

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Figure A-2
Gradient Profile A-A', Current Bathymetry, Intermediate Well
NW Natural "Gasco" Site

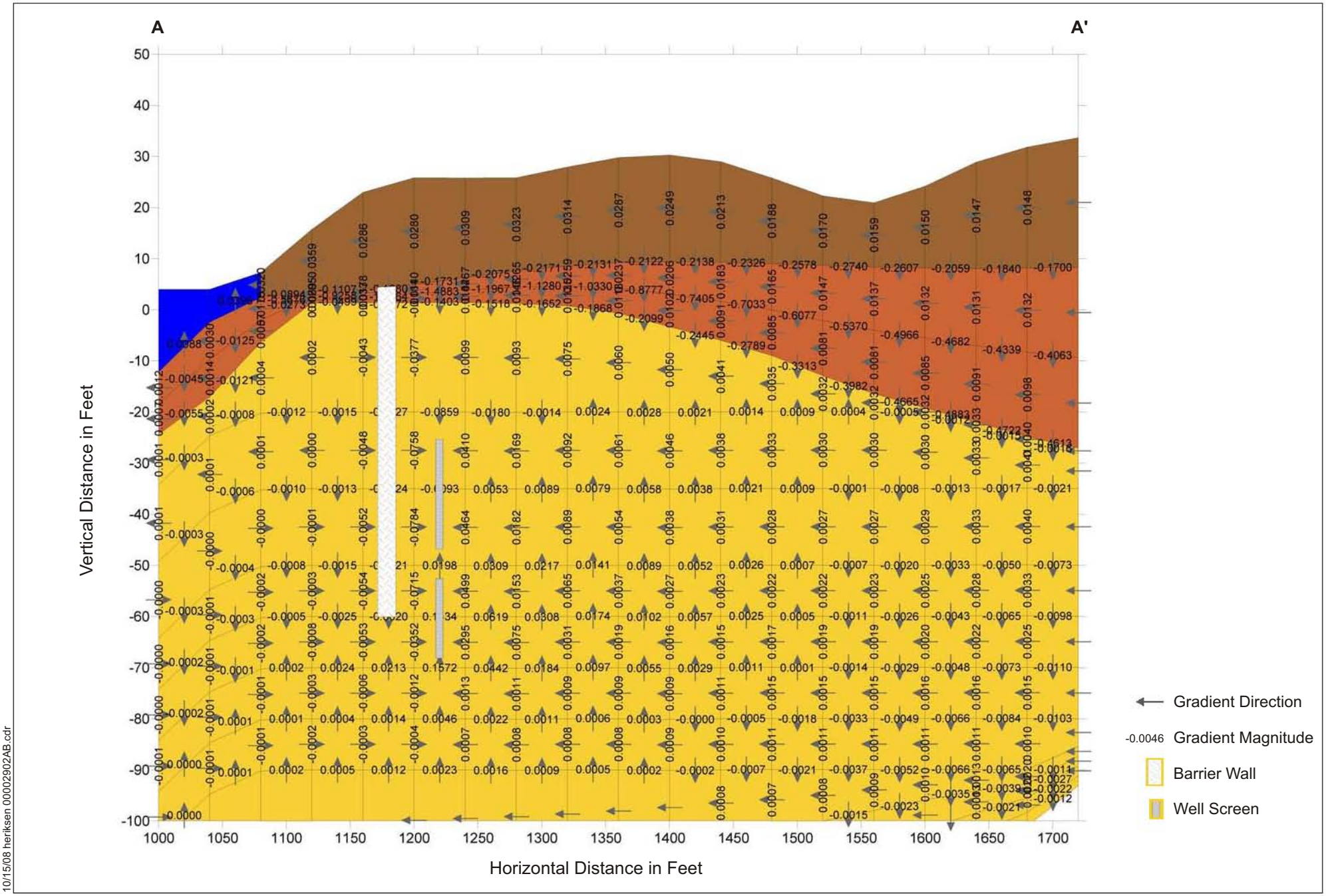

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Figure A-3
Gradient Profile A-A', Current Bathymetry, Shallow and Intermediate Wells
NW Natural "Gasco" Site

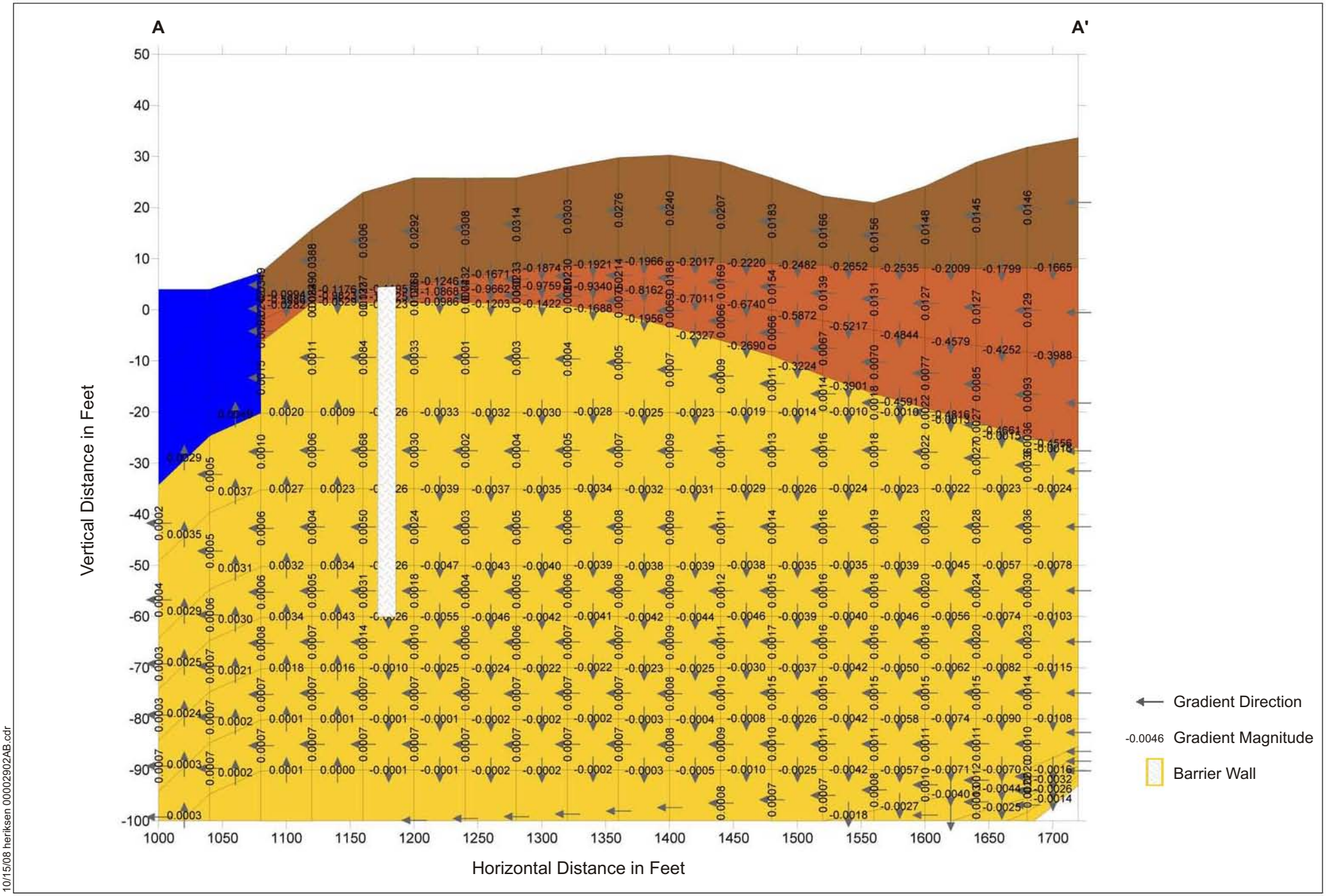

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Figure A-4
Gradient Profile A-A', Dredge Bathymetry, Vertical Barrier, No Pumping
NW Natural "Gasco" Site

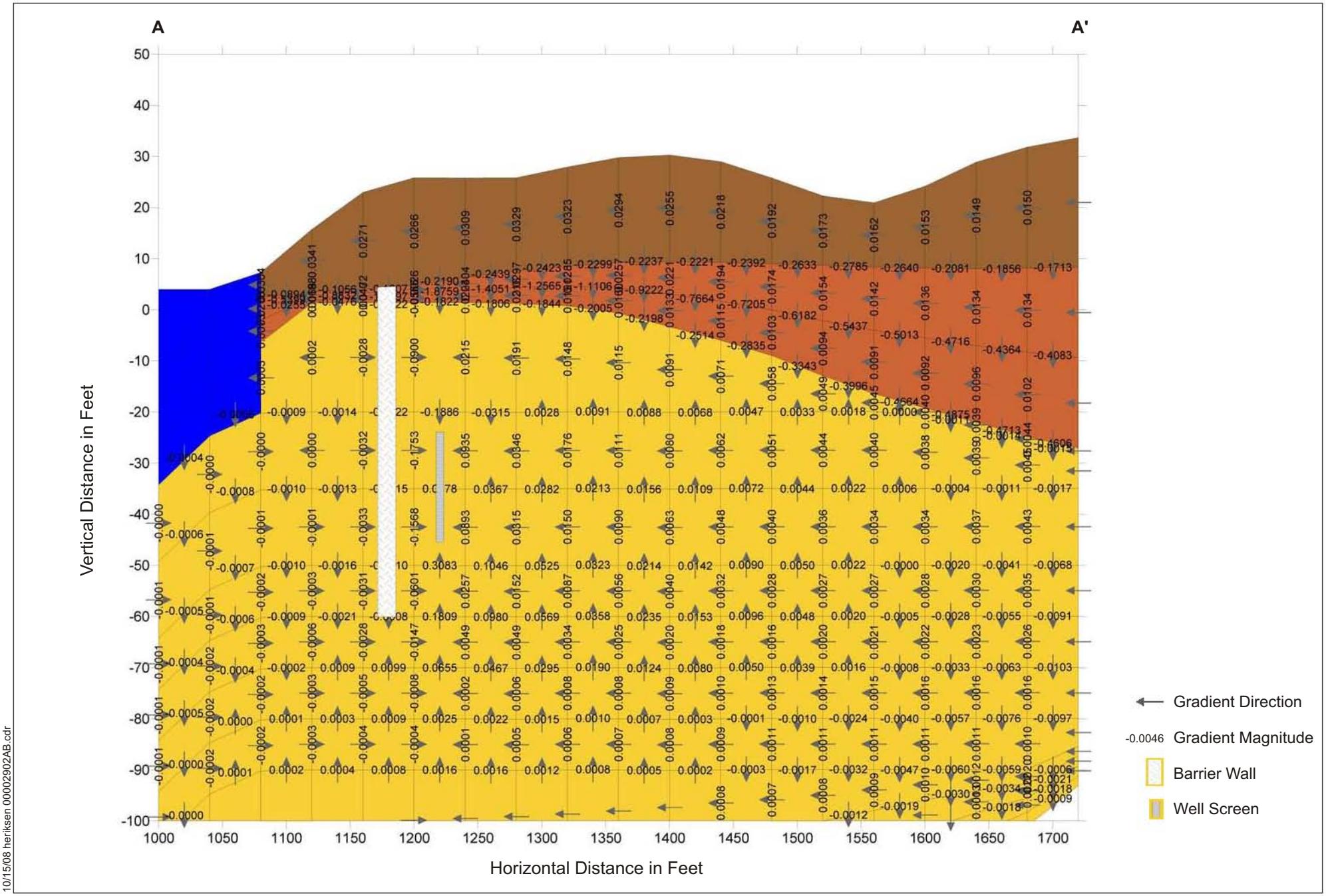

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Figure A-5
Gradient Profile A-A', Dredge Bathymetry, Vertical Barrier, Shallow Well
NW Natural "Gasco" Site

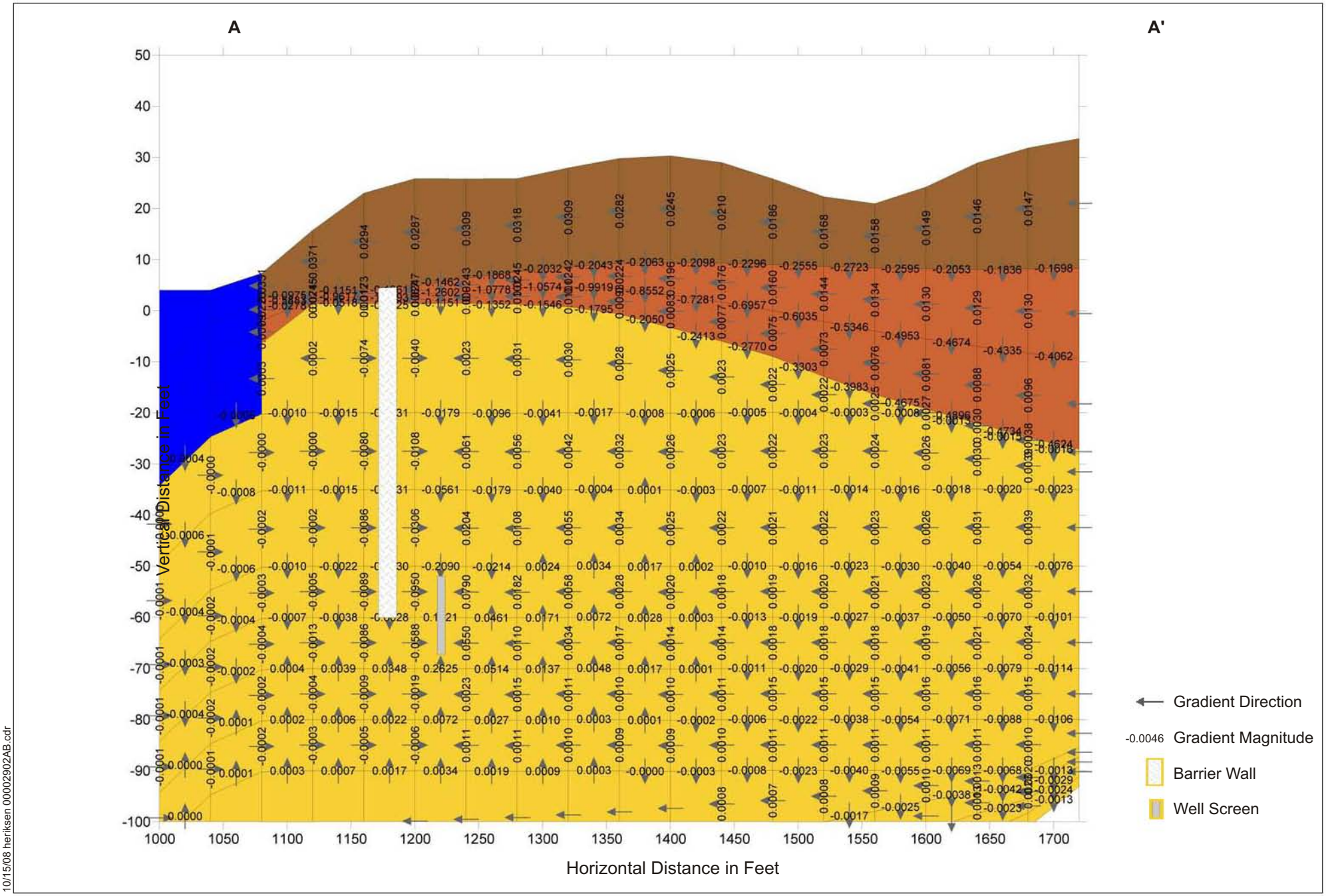

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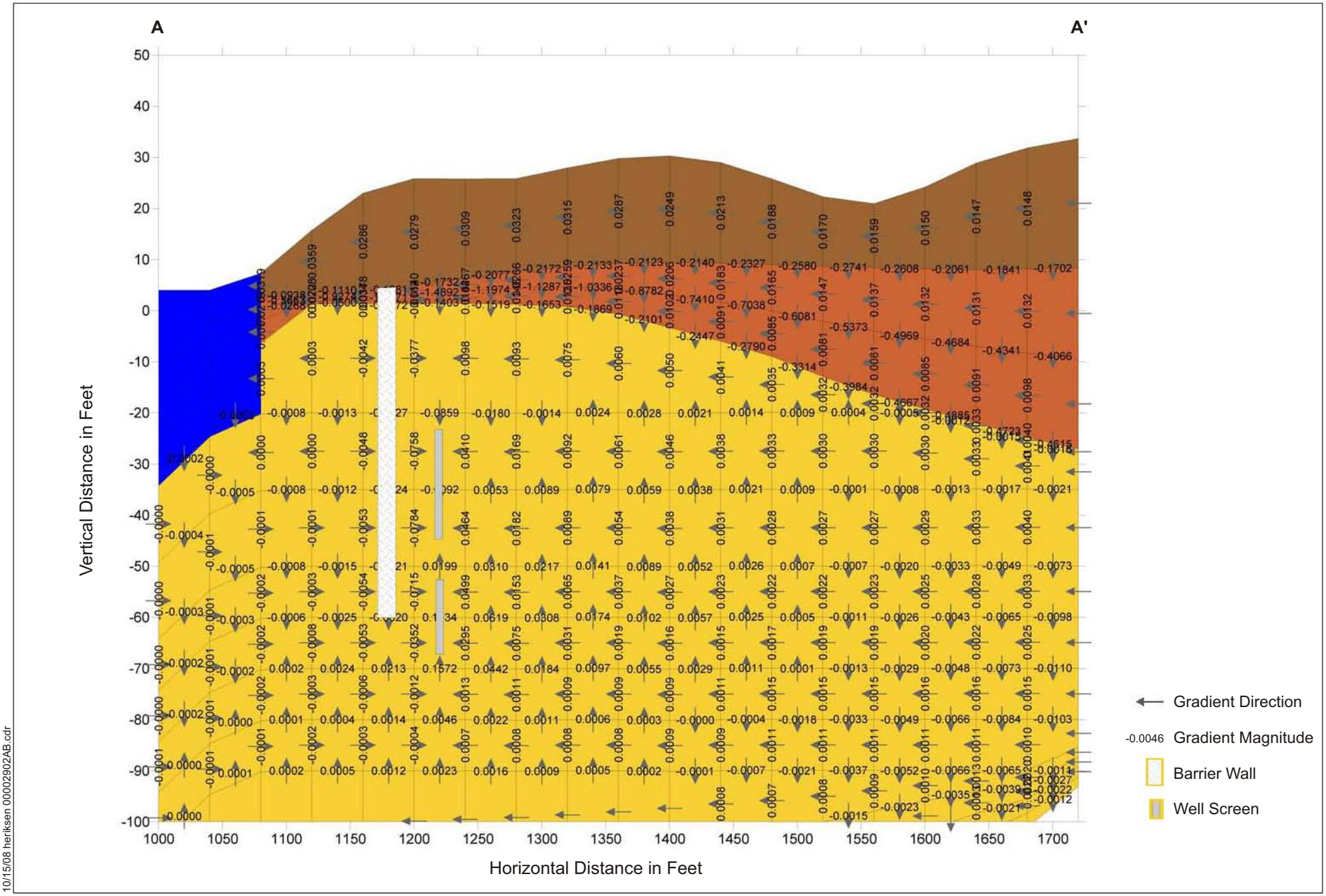
Figure A-6
Gradient Profile A-A', Dredge Bathymetry, Vertical Barrier, Intermediate Well
NW Natural "Gasco" Site



10/15/08 heriksen 00002902AB.cdr

Figure A-7
Gradient Profile A-A', Dredge Bathymetry, Vertical Barrier, Shallow and Intermediate Wells
NW Natural "Gasco" Site

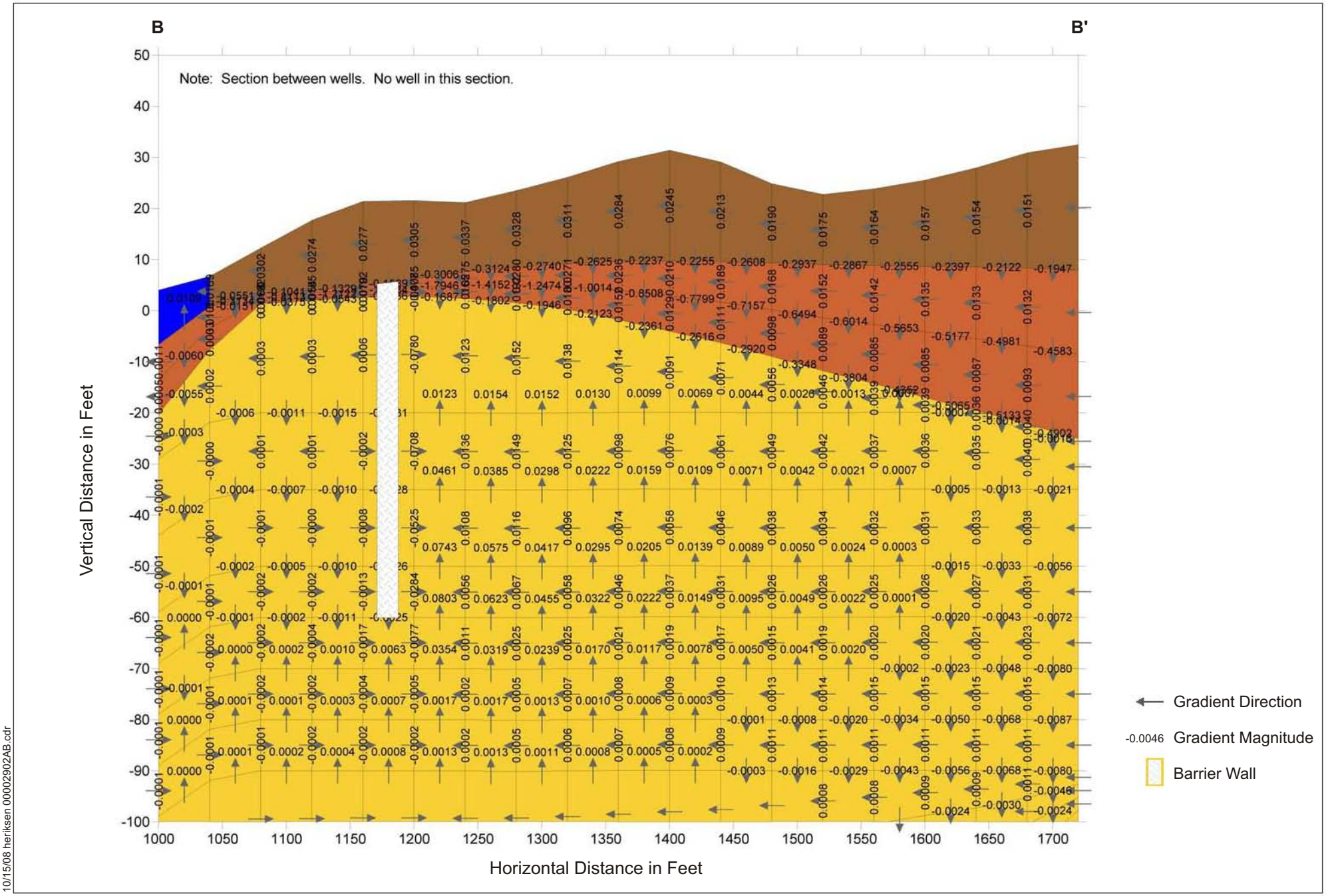


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Figure A-8
Gradient B-B', Current Bathymetry, Veritical Barrier, Shallow Well
NW Natural "Gasco" Site

APPENDIX B
SSPA MEMO ON REASONABLE WORST CASE SCENARIO

S.S. PAPADOPULOS & ASSOCIATES, INC.
ENVIRONMENTAL & WATER-RESOURCE CONSULTANTS

Memorandum

Date: October 15, 2008

From: Michael J. Riley

To: John Edwards, Anchor Environmental

Subject: NW Gasco: Groundwater Modeling, Proposed Reasonable Worst-Case Scenario

The groundwater model analysis for the Gasco shoreline wells was conducted for average water level data and river stage data presented in the site Draft Remedial Investigation Report (RI), June 30, 2006. Average water level data from 8 fill wells and 16 alluvium wells and from on-site river stage measurements were compiled for model calibration. The model was then used to evaluate groundwater extraction rates from shoreline wells to contain site groundwater.

The Oregon Department of Environmental Quality (DEQ) has requested that the groundwater model analysis be conducted for a reasonable worst-case condition rather than just of average conditions to evaluate higher groundwater extraction rates that may be necessary to contain groundwater under higher groundwater flow conditions. The following is an analysis of site groundwater and river stage data and recommendation on conditions to use for a reasonable worst-case evaluation.

Data Analysis

The difference between water level data and river stage data for fill and alluvium wells are presented in Table 1. The highlighted cells in the table indicate when the highest difference between groundwater level and river stage occur for each well.

For fill wells, the highest water level difference occurred at the March 2000 monitoring event at 5 of the 8 wells. The highest occurred at two wells during the September 2005 event and the highest occurred in November 1998 at one well. The highest water level differences exceeded the average values used in the model by approximately 2.5 to 4.5 feet.

For alluvium wells, the highest water level occurrence varied over more dates than for the fill wells. Of the 16 alluvium wells, three wells had the highest difference from the river in August 1999 while December 2004 was the highest in three other wells. Two wells had the highest difference in September 1996. Isolated maximum differences occurred in October 2001 and December 2003 at one well each. The most frequent maximum difference occurred in March 2000 when the maximum difference occurred at six wells.

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The alluvium wells showed a marked difference from well to well depending on proximity to the shoreline. For wells close to the shoreline (MW-2-61, MW-3-56, MW-4-35, MW-4-57, MW-4-101, MW-5-32, MW-5-100, MW-5-175, MW-8-56, and MW-13-61), the maximum water level difference between groundwater and the river varied less than 2 feet with the exception of MW-4-35. In addition, these wells showed negative differences indicating that the river stage was above the water level in the well.

Wells located farther from the shoreline (MW-9-29, MW-10-61, MW-12-36, MW-14-110, MW-15-50, and MW-15-66), showed much higher maximum differences ranging from 7 to 25 feet. In addition, these wells do not show negative values in the difference between water levels and river stage. In all of these wells, even the minimum difference is well above river stage.

Water level differences were compared to monthly precipitation data to aid in understanding differences between river stage and water levels. There was no correlation between precipitation and occurrence of highest water level differences. For instance, November 1998, had 11 inches of rainfall, but only one well showed a maximum water level difference that month. By contrast, 5 fill wells and 6 alluvium wells showed the highest water level data in March 2000, when only 3.2 inches of rainfall occurred. It is likely that the November 1998 rainfall partially went to moisture deficit since previous months were quite dry. However, the winter of 2000 was not particularly wet with 13.4 inches of rainfall from January through March. From 1996 to 2005, the rainfall that occurred in the three months prior to February or March monitoring events was higher in 6 of those years than in 2000. From this, there is no obvious correlation between precipitation and the highest difference between water level data and river stage.

Recommendation

A reasonable worst-case scenario can be based on the March 2000 water level and river stage data. The lack of correlation between precipitation and highest water level differences indicates that there is no value in searching precipitation data for extreme events. The likely reason for the lack of correlation is that higher precipitation generates higher runoff with little change in infiltration, especially if the soil is already saturated.

Water levels in nearshore alluvium wells are strongly correlated with river stage showing limited range between minimum and maximum water level differences. Nearshore wells in both the fill and alluvium often show negative differences between water levels and river stage, which suggests that the difference may be affected by the timing of data collection with respect to tidal fluctuations. Consequently, the differences may not be meaningful with respect to groundwater flow rates over periods of longer than a few hours.

Based on the above, it is recommended that the reasonable worst-case scenario for evaluation of capture at nearshore wells be based on water level data at upland wells and river stage data from the March 27, 2000 monitoring event. The groundwater flow model would be re-calibrated to water level data at fill wells MW-8-29, MW-10-25, MW-11-32, and MW-13-30 and alluvium

wells MW-9-29, MW-10-61, MW-12-36, MW-14-110, MW-15-50, and MW-15-66. The recalibration will likely include changes to both the recharge rate and the upland boundary head.

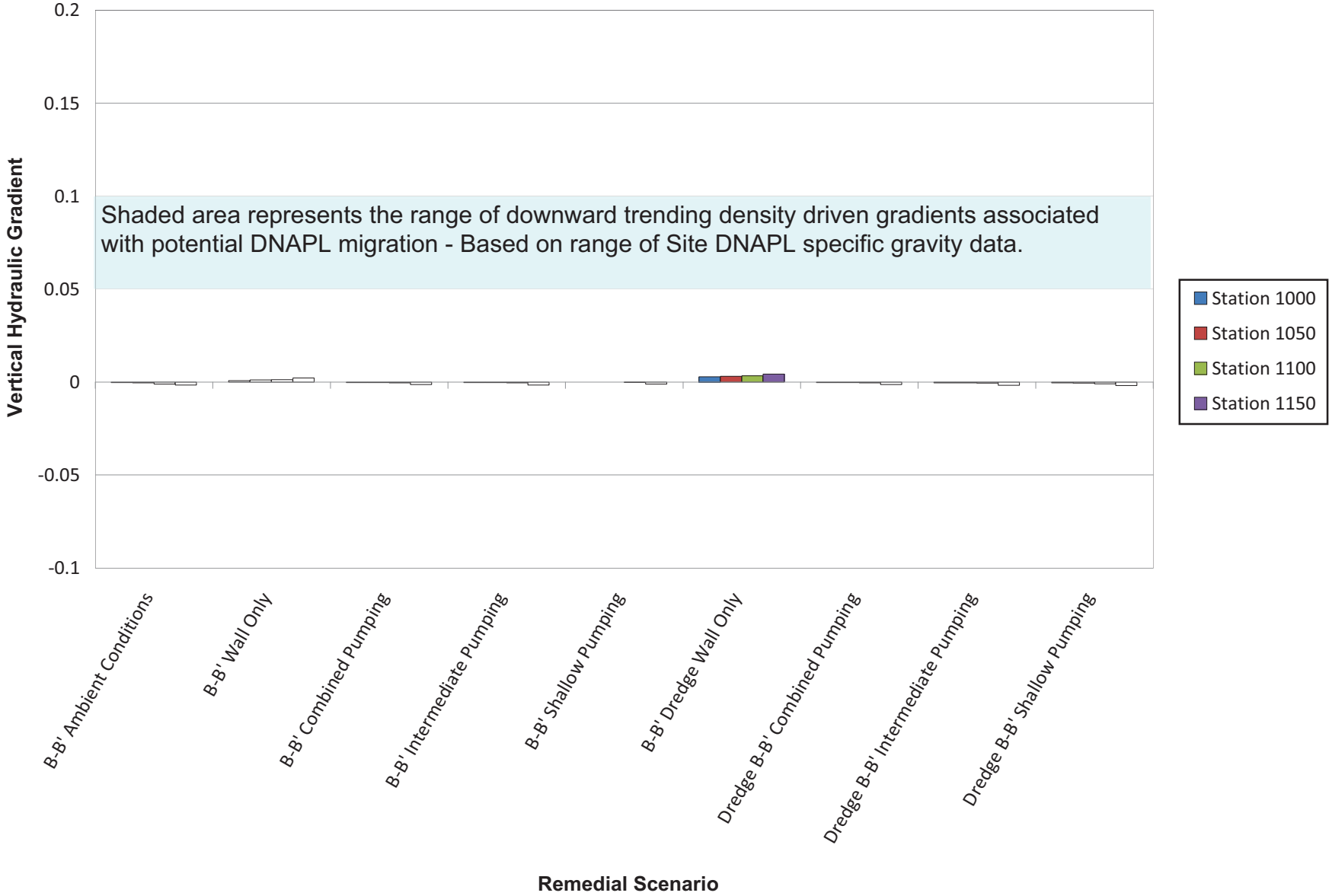
The reasonable worst-case re-calibration would be used to simulate the hypothetical intermediate and shallow well extraction systems. The pump rates developed for the reasonable worst-case scenarios will be compared to the simulations under average conditions as a means of evaluating possible seasonal fluctuations in pump rates to achieve capture.

Table 1. Difference between water level and river stage based on data presented in the Draft Remedial Investigation Report

(Highlighted values are dates of maximum difference between water levels and river at each well)

	Nearshore Fill						Upland Fill		Nearshore Alluvium										Upland Alluvium					
Date	**MW-1-22**	**MW-2-32**	**MW-3-26**	**MW-6-32**	**MW-8-29**	**MW-13-30**	**MW-10-25**	**MW-11-32**	**MW-2-61**	**MW-3-56**	**MW-4-35**	**MW-4-57**	**MW-4-101**	**MW-5-32**	**MW-5-100**	**MW-5-175**	**MW-8-56**	**MW-13-61**	**MW-9-29**	**MW-10-61**	**MW-12-36**	**MW-14-110**	**MW-15-50**	**MW-15-66**
05-Dec-95	1.70	0.33	-0.37	-0.10	0.44		5.34	6.80		-0.62	-0.48	-0.76		-0.53			-0.38		12.55	7.01	10.42			
05-Jan-96	7.85	1.99	2.21	8.24	7.65		11.59	13.77		-0.21	-0.36	-0.28		-0.17			-0.04		17.89	10.58	15.44			
12-Feb-96	0.58	-0.58	-0.84	-0.47	-4.33		1.68	3.01		-0.99	-0.98	-1.00		-1.01			-0.86		7.90	3.98	6.99			
18-Mar-96	7.90	2.02	1.83	9.00	9.46		12.86	14.56		0.00	-0.11	-0.09		0.05			0.18		17.11	10.45	15.27			
16-Apr-96	6.57	1.10	1.45	7.56	8.98		12.06	13.74		0.07	-0.25	-0.07		-0.06			0.16		16.19	9.73	14.47			
10-May-96	9.37	3.36	3.50	10.58	11.69		14.61	16.36		0.43	0.33	0.30		0.42			0.57		19.08	11.80	16.82			
17-Jun-96	5.14	1.33	0.98	6.38	7.36		9.98	11.76		0.13	0.20	0.07		0.14			0.25		16.89	9.64	12.98			
21-Aug-96	11.61	6.03	5.24	12.71	13.28		16.01	18.36		0.45	1.14	0.39		0.74			0.57		22.55	13.27	17.53			
17-Sep-96	11.89	6.60	7.70	12.77	13.16		16.62	18.57		0.25	1.59	0.20		0.76			0.70		24.33	14.23	18.03			
30-Sep-96	12.18	6.82	5.39	13.03	13.50		16.93	18.73		1.63	1.68	1.52		1.75			1.28		23.55	14.09	18.32			
15-Nov-96	11.17	5.24	6.15	11.31	11.26		15.60	16.99		0.39	0.49	0.33		0.79			0.56		23.84	13.75	17.64			
24-Feb-97	8.74	2.15	1.90	9.08	7.06		10.77	13.61		-0.01	0.12	-0.09		0.06			0.20		19.70	11.40	15.38			
10-Jun-97	2.03	0.40	0.48	1.87	0.70		3.38	6.06		0.04	0.01	0.14		0.03			0.05		12.98	7.30	10.37			
26-Aug-97	11.47	4.86	3.60	9.08	10.88		14.22	16.19		0.07	0.08	0.79		0.30			0.10		18.04	11.27	16.66			
25-Nov-97	11.61	4.24	6.14	10.50	9.52		14.14	15.79		0.71	0.68	1.01		0.88			0.56		21.08	12.72	18.18			
16-Feb-98	11.94	4.12	5.25	11.01	8.83	9.92	13.41	16.16		0.31	1.08	0.22		0.53			0.42	0.59	22.11	13.23	18.76			
01-Jun-98	2.71	-0.06	-0.05	2.21	1.49	1.62	7.04	7.99		0.01	0.09	-0.02		-0.05			-0.05	0.12	12.85	7.42	11.31			
25-Aug-98	10.73	5.32	4.03	11.38	11.80	10.90	18.50	17.70		-0.12	0.82	-0.23		0.29			0.27	0.16	18.58	11.74	17.32			
16-Nov-98	10.53	4.07	6.11	11.48	12.10	11.28	19.12	18.14	0.25	0.70	1.42	0.63	0.27	1.04	0.32	0.34	1.20	0.87	19.75	12.72	17.97	6.77		
15-Feb-99	12.60	5.26	5.66	12.98	11.25	11.64	16.63	18.18	0.29	0.69	0.42	0.64	0.43	0.90	0.41	0.47	0.98	0.98	22.36	13.81	19.00	6.88		
11-May-99	9.52	3.36	4.44	11.19	11.62	9.92	12.49	16.66	0.51	0.72	0.71	0.63	0.51	0.86	0.53	0.60	0.91	0.96	18.24	11.48	16.67	5.88		
20-Aug-99	11.06	5.98	5.87	9.39	13.12	11.36	17.90	17.82	1.14	1.44	2.24	1.40	1.17	1.78	1.19	1.25	1.77	1.65	19.29	12.55	17.97	7.16	13.78	13.67
25-Oct-99	10.64	4.10	4.08	10.88	12.63	10.71	17.19	17.16	0.01	0.39	0.89	0.41	0.29	0.64	0.32	0.45	0.72	0.52	18.16	11.55	16.55	6.10	12.60	12.45
27-Mar-00	15.05	7.55	8.05	14.64	12.84	13.59	14.70	18.67	0.65	0.98	2.03	0.91	0.63	1.65	0.66	0.73	1.23	1.25	24.58	15.19	20.22	7.48	15.10	14.56
15-Jun-00	8.07	2.86	3.68	9.04	9.14	8.62	14.06	14.61	-0.09	0.09	-0.30	-0.03	-0.16	0.01	-0.18	-0.09	0.29	0.26	17.08	10.36	15.16	4.97	11.41	10.68
04-Oct-00	10.48	5.10	5.87		12.66	11.42	19.01	18.12	-0.63	-0.47	0.40	-0.54	-0.68	-0.22	-0.69	-0.62	-0.45	-0.32	17.86	10.90	15.72	4.98	12.04	11.28
20-Dec-00	9.65	4.61	7.49		12.73	11.04	19.08	18.18	0.16	0.06	1.29	0.14	0.48	0.38	0.56	0.76	-0.11	-0.04	18.31	12.01	16.40	4.24	12.60	11.86
27-Mar-01	11.42	6.10	6.83		13.48	11.63	19.06	18.34	-0.06	0.30	1.11	0.20	-0.16	0.75	-0.16	-0.11	0.64	0.50	19.32	12.06	17.31	5.75	13.15	12.41
28-Jun-01	11.62	5.86	4.86		12.84	11.69	16.84	18.03	0.72	0.85	1.92	0.90	1.00	1.13	0.97	1.11	0.98	0.95	19.23	11.30	17.52	6.42	13.54	12.84
08-Oct-01	11.54	4.33	4.69		13.13	11.48	16.97	17.32	0.59	1.00	1.52	0.88	1.67	1.19	0.74	0.77	1.05	1.03	18.18	11.47	16.27	5.93	12.59	11.90
12-Dec-01	10.34	4.10	5.94		9.83	9.29	15.04	14.71	0.19	0.58	2.74	0.52	0.22	1.14	0.22	0.30	1.02	0.76	20.26	12.65	17.34	6.07	13.24	12.52
02-Apr-02	11.25	5.47	4.98		10.33	10.99	13.93	16.71	0.11	0.22	-0.36	0.17	0.25	0.60	0.23	0.33	0.00	0.41	21.14	12.35	17.69	5.30	12.89	12.12
10-Jul-02	8.61	3.72	3.73		9.70	8.81	14.06	15.43	0.14	0.42	0.46	0.35	0.27	0.59	0.25	0.31	0.44	0.51	17.08	10.45	15.75	5.16	11.10	11.88
23-Sep-02	11.71	4.91	4.78		13.08	11.63			0.37	0.82	1.69	0.66	0.32	1.09	0.30	0.36	1.18	1.03	18.78	11.90	16.67	6.26	13.03	12.35
17-Dec-02	5.59	0.23	4.04		7.48	6.02	13.20	11.27	-0.02	-0.80	1.11	-0.71	-0.52	-0.91	-0.53	-0.62	-1.85	-0.79	14.90	8.71	12.82	3.48	9.95	9.38
17-Mar-03	10.52	4.42	4.99		9.07	9.61	13.49	15.56	0.16	0.39	0.83	0.29	0.12	0.68	0.11	0.19	0.29	0.53	21.45	12.95	11.89	5.86	13.14	12.42
02-Jun-03	6.91	1.77	1.19		6.27	6.48	9.95	12.12	0.11	0.21	0.05	0.11	0.19	0.12	0.14	0.23	0.16	0.31	15.53	9.27	13.80	4.27	10.22	9.67
29-Sep-03	10.63	3.70	3.81		11.99	10.61	17.45	16.12	0.18	1.04	0.63	1.00	1.20	1.13	1.09	1.17	0.64	1.25	17.32	10.88	15.40	5.56	12.08	11.42
29-Dec-03	9.92	3.12	6.39		9.70	8.83	14.41	15.18	0.38	0.80	3.59	0.76	0.62	1.20	0.61	0.67	0.70	0.91	20.96	12.67	17.78	5.76	13.25	12.52
29-Mar-04	11.81	5.60	6.05		11.20	11.32			-0.50	-0.37	0.55	-0.42	-0.50	0.27	-0.49	-0.41	-0.39	-0.28	20.94	12.51	18.32	5.39	13.54	12.70
11-Aug-04	10.81	4.34	3.83		12.08	10.79	17.05	17.12	-0.07	-0.73	0.57	-0.66	-0.79	-0.20	-0.60	-0.43	-0.38	-0.69	18.08	14.16	16.30	4.80	12.66	11.69
20-Dec-04	9.51	3.03	4.88		10.50	9.41	14.96	15.84	1.43	1.24	1.82	1.19	1.21	1.70	1.25	1.36	0.99	1.30	21.07	13.04	17.35	6.17	13.37	12.27
28-Mar-05	9.00	2.50	5.47		8.90	8.15	13.28	14.15	0.76	0.56	1.81	0.55	0.57	0.65	0.55	1.23	0.59	0.78	20.84	12.09	16.42	5.33	12.34	11.67
20-Jun-05	11.43	5.92	5.20		11.55	10.43	15.66	17.25	0.18	0.58	1.34	0.56	0.32	0.94	0.28	0.35	1.08	0.73	21.59	13.48	18.37	6.58	14.07	12.91
16-Sep-05	13.36	5.90	6.04		14.31	13.17	18.37	19.15	0.41	1.04	2.38	0.80	0.29	1.49	0.35	0.39	1.69	1.31	21.39	13.80	18.47	7.25	14.63	13.81
07-Dec-05	10.81	4.52	5.87		10.56	9.79	15.52	16.43	-0.34	-0.19	0.85	-0.30	-0.51	0.53	-0.40	-0.32	-0.03	0.07	21.58	12.94	17.38	5.44	13.19	12.33
Minimum	0.58	-0.58	-0.84	-0.47	0.44	1.62	1.68	3.01	-0.63	-0.99	-0.98	-1.00	-0.79	-1.01	-0.69	-0.62	-1.85	-0.79	7.90	3.98	6.99	3.48	9.95	9.38
Maximum	15.05	7.55	8.05	14.64	14.31	13.59	19.12	19.15	1.43	1.63	3.59	1.52	1.67	1.78	1.25	1.36	1.77	1.65	24.58	15.19	20.22	7.48	15.10	14.56
Calibration Targets	10.51	4.37	5.17	11.99	11.22	10.35	15.85	16.57	0.25	0.45	1.20	0.39	0.31	0.75	0.29	0.38	0.55	0.60	19.47	12.12	16.73	5.76	12.59	11.94
Difference from Calibration Targets	4.54	3.18	2.88	2.65	3.09	3.24	3.27	2.58	1.18	1.18	2.39	1.13	1.36	1.03	0.96	0.98	1.22	1.05	5.11	3.07	3.49	1.72	2.51	2.62

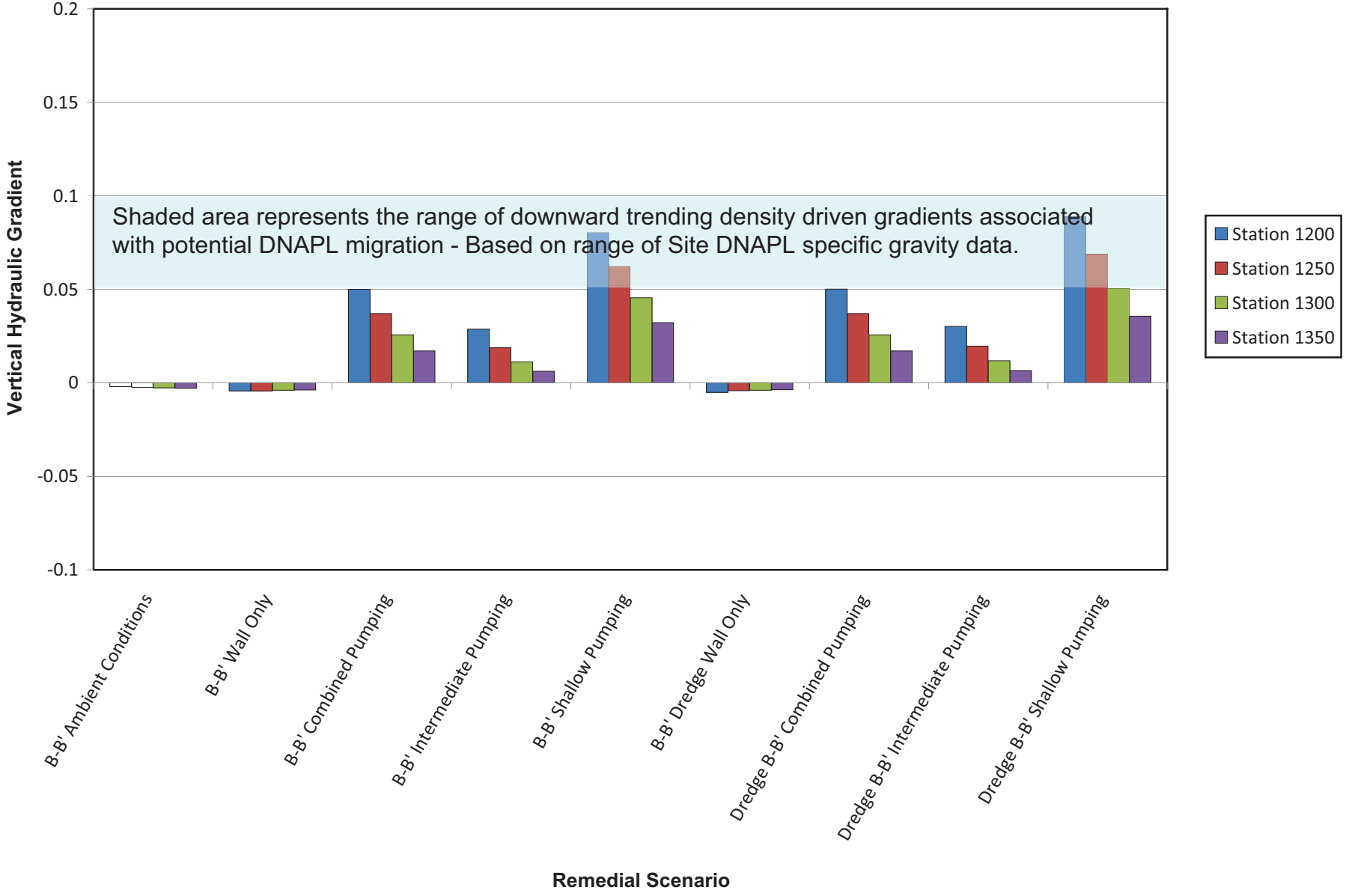
Figure 8
-60 foot Level Vertical Hydraulic Gradients Riverside of Proposed Barrier Wall



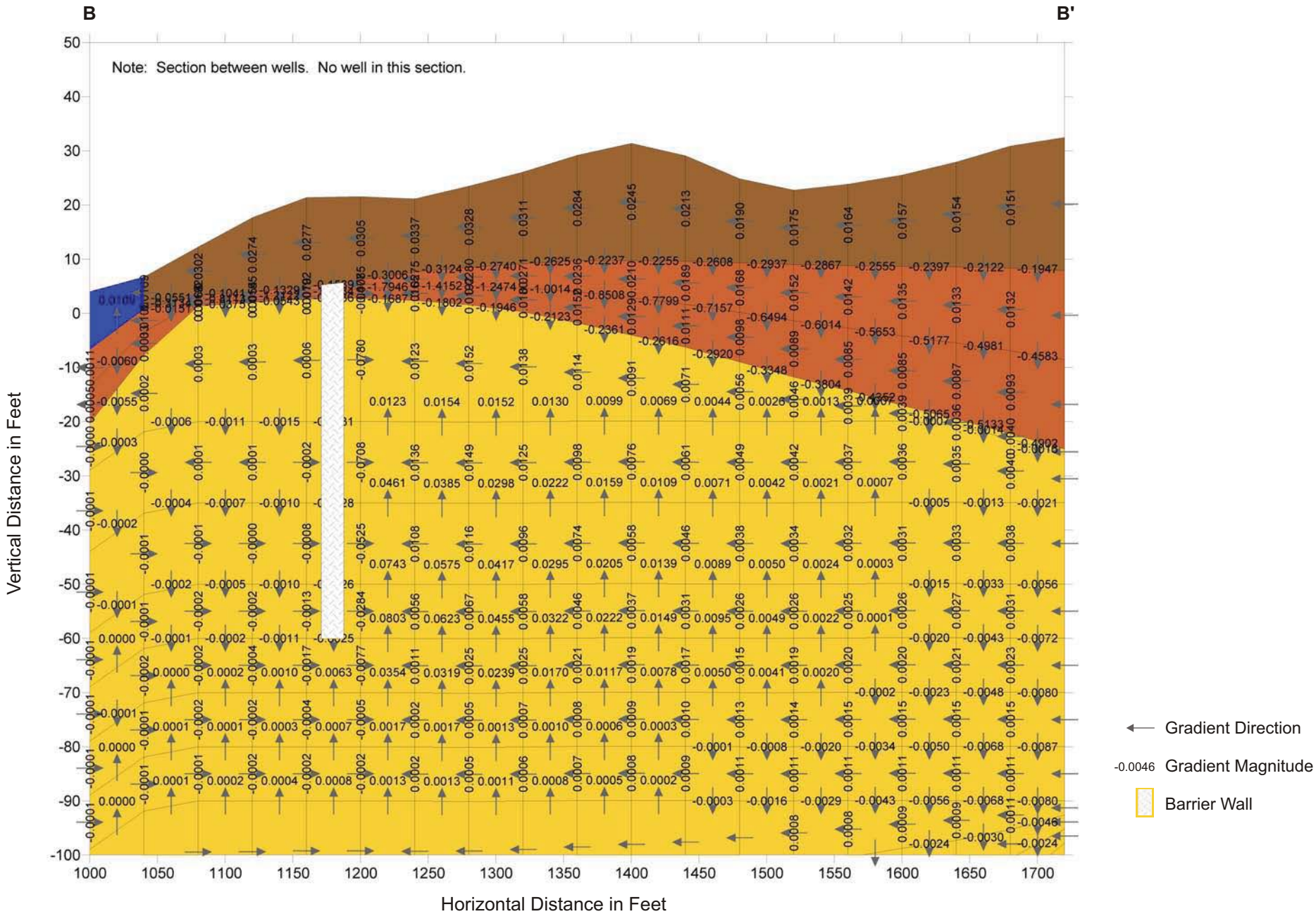
ANCHOR ENVIRONMENTAL, L.L.C.

Figure 9

-60 foot Level Vertical Hydraulic Gradients Landward of Proposed Barrier Wall



ANCHOR ENVIRONMENTAL, L.L.C.



10/15/08 heriksen 00002902AB.cdr

Figure A-8
Gradient Profile B-B', Current Bathymetry, Shallow Wells
NW Natural "Gasco" Site

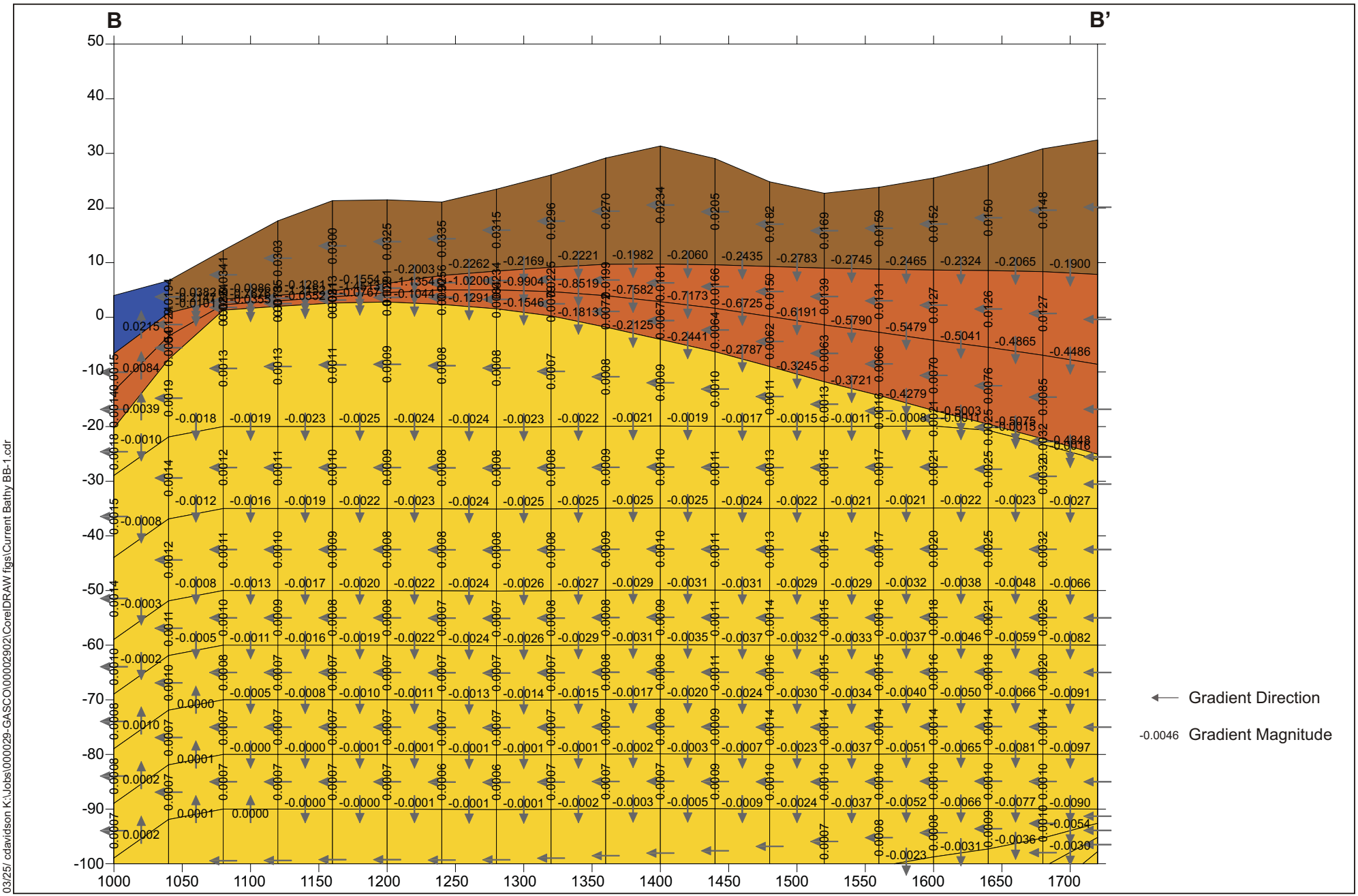
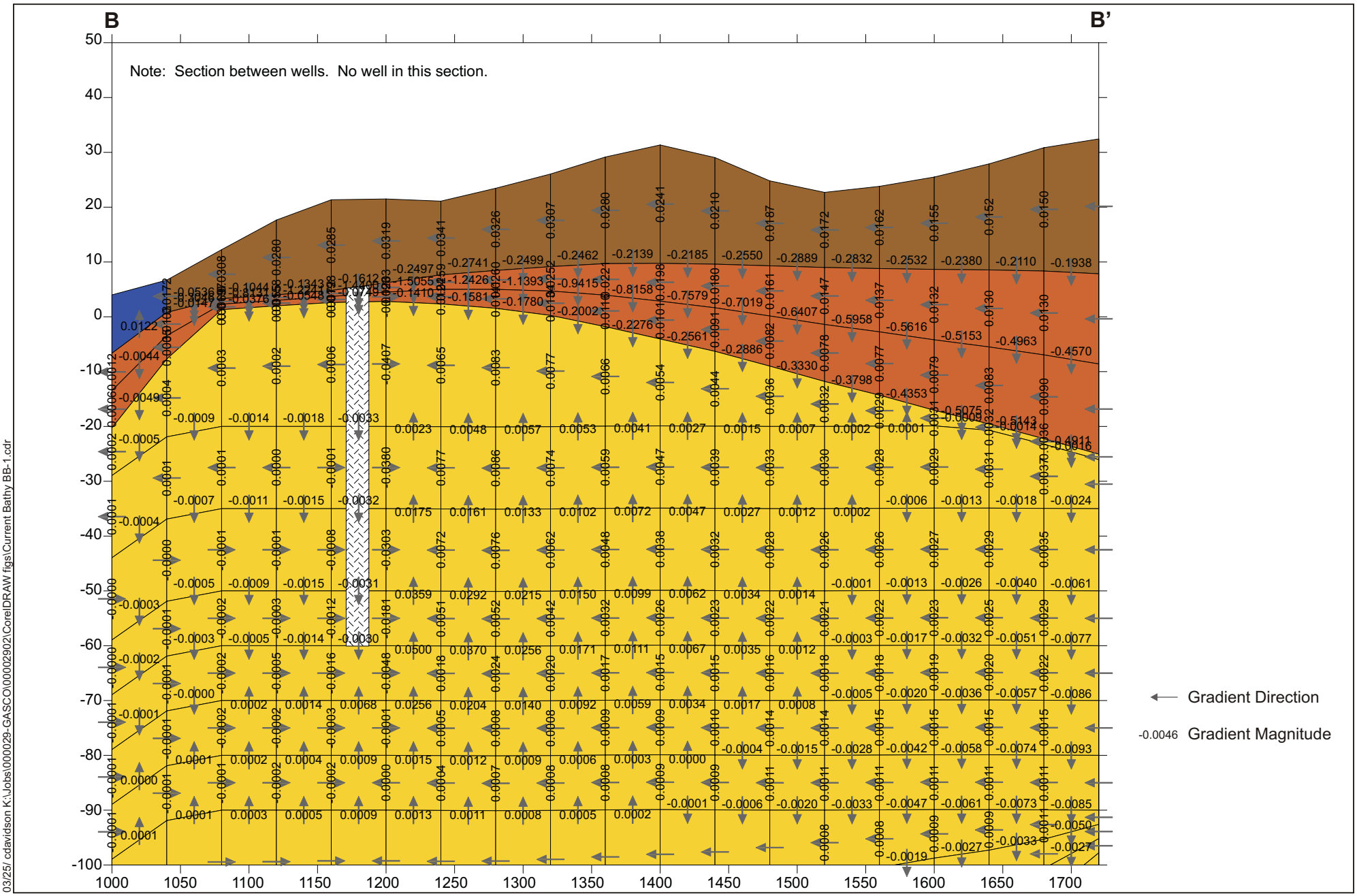


Figure A-9

Gradient Profile B-B', Current Bathymetry, No Vertical Barrier, No Pumping
NW Natural "Gasco" Site



03/25/ cdavidson K:\Jobs\000029-GASCO\00002902\CorelDRAW figs\Current Bathy BB-1.cdr

Figure A-10

Gradient Profile B-B', Current Bathymetry, Vertical Barrier, Shallow and Intermediate Wells
NW Natural "Gasco" Site

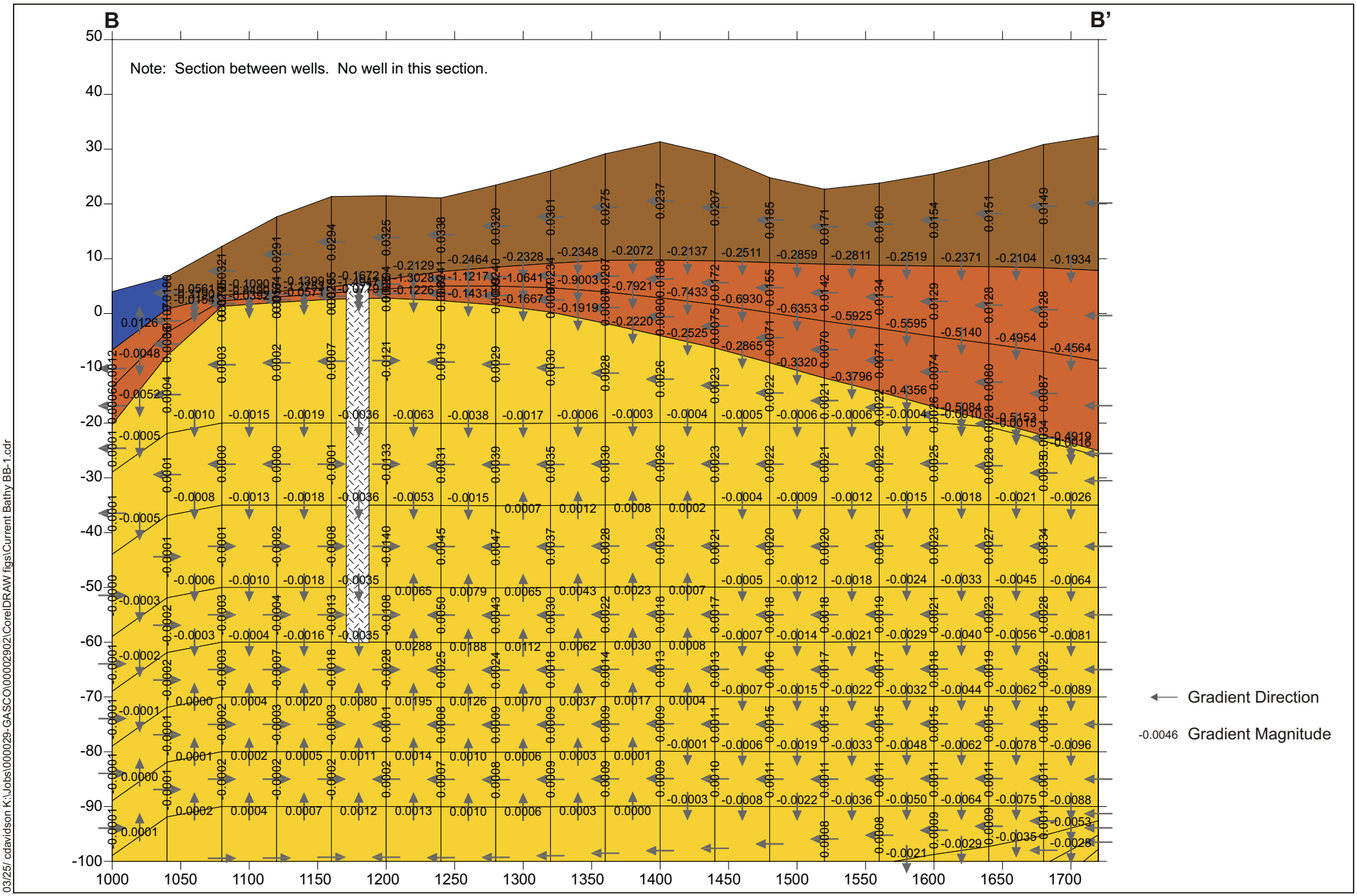


Figure A-11

Gradient Profile B-B', Current Bathymetry, Vertical Barrier, Intermediate Wells
NW Natural "Gasco" Site

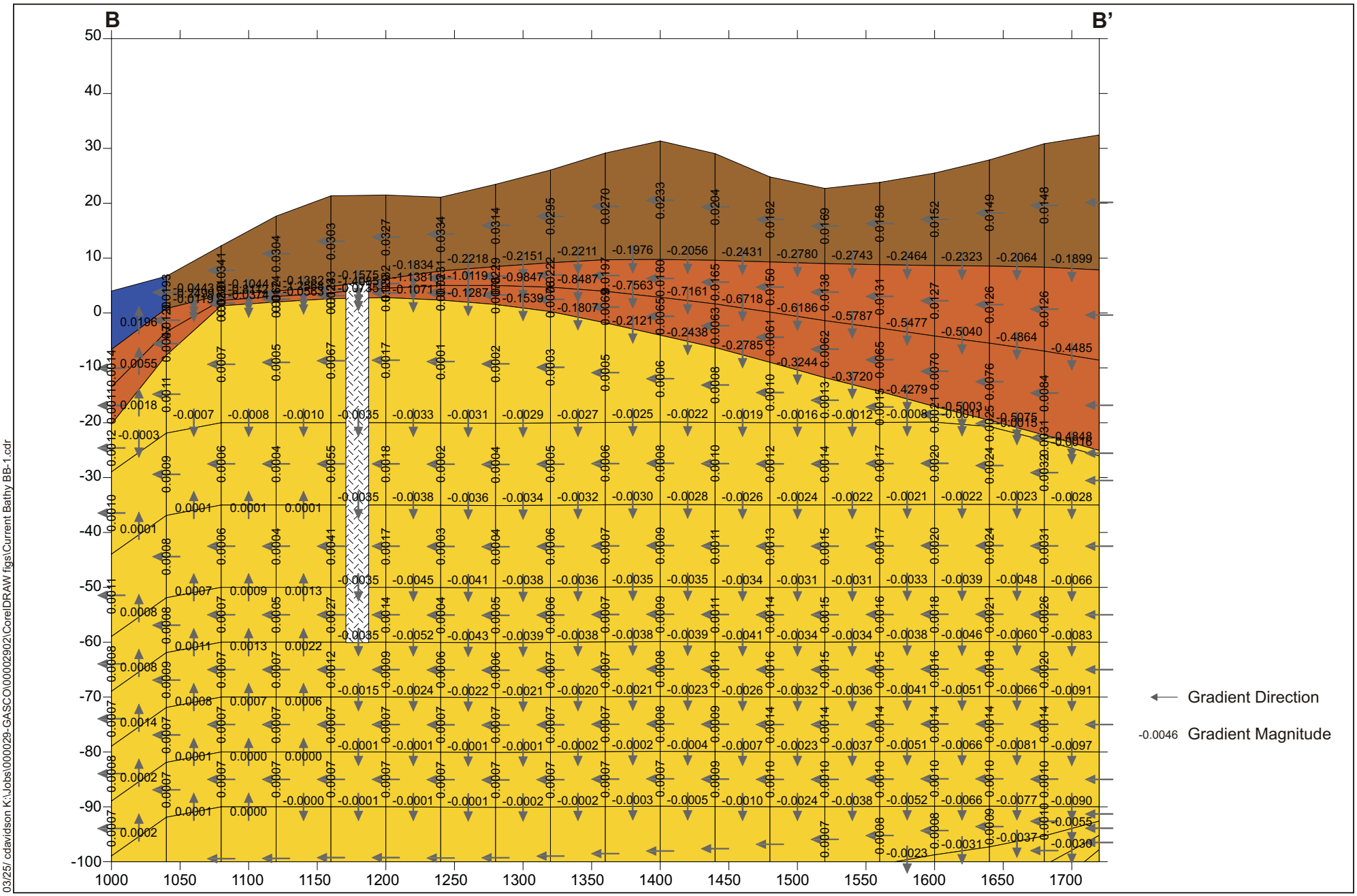


Figure A-12
Gradient Profile B-B', Current Bathymetry, Vertical Barrier, No Pumping
NW Natural "Gasco" Site

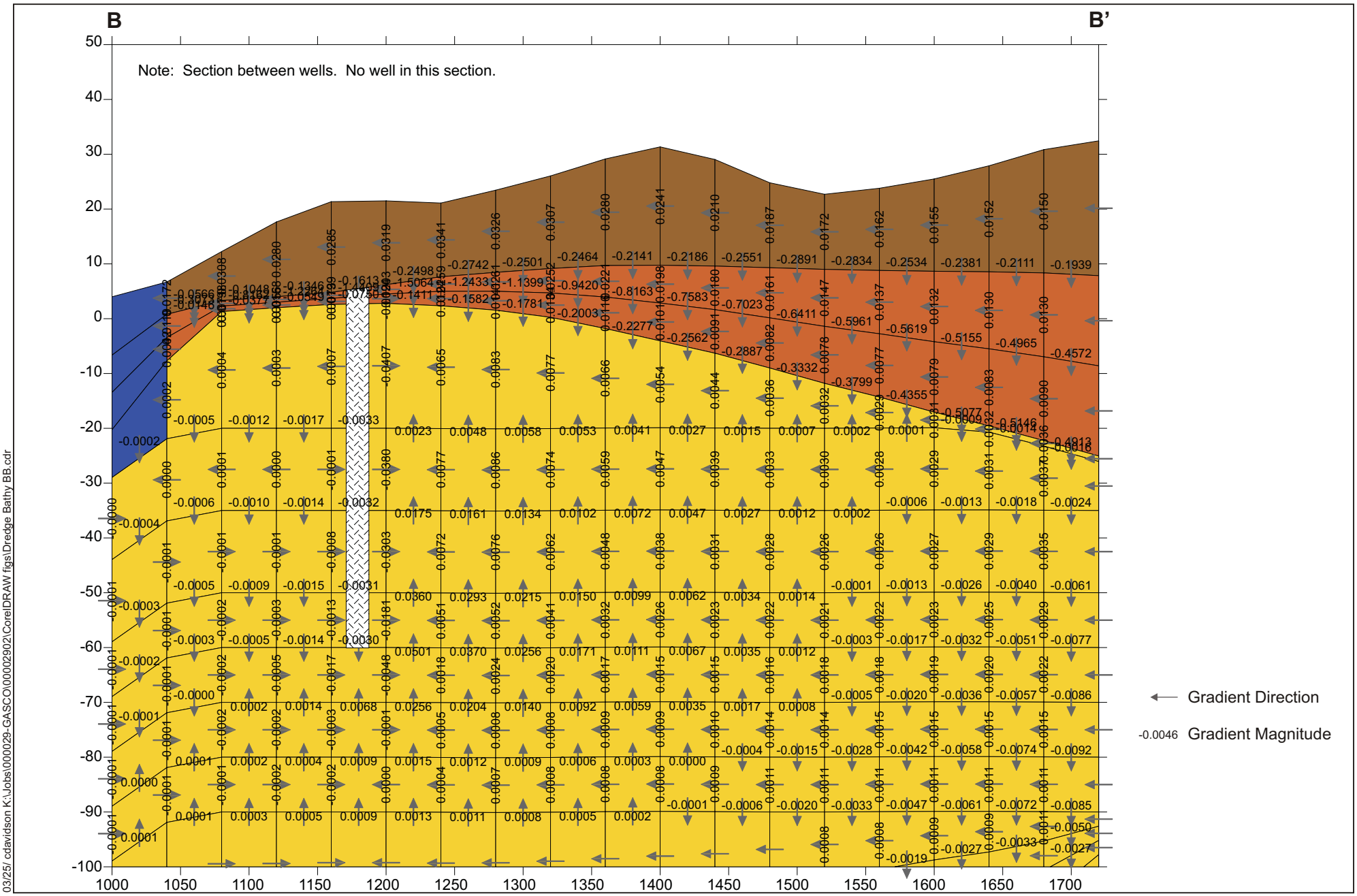


Figure A-13

Gradient Profile B-B', Dredge Bathymetry, Vertical Barrier, Shallow and Intermediate Wells
NW Natural "Gasco" Site

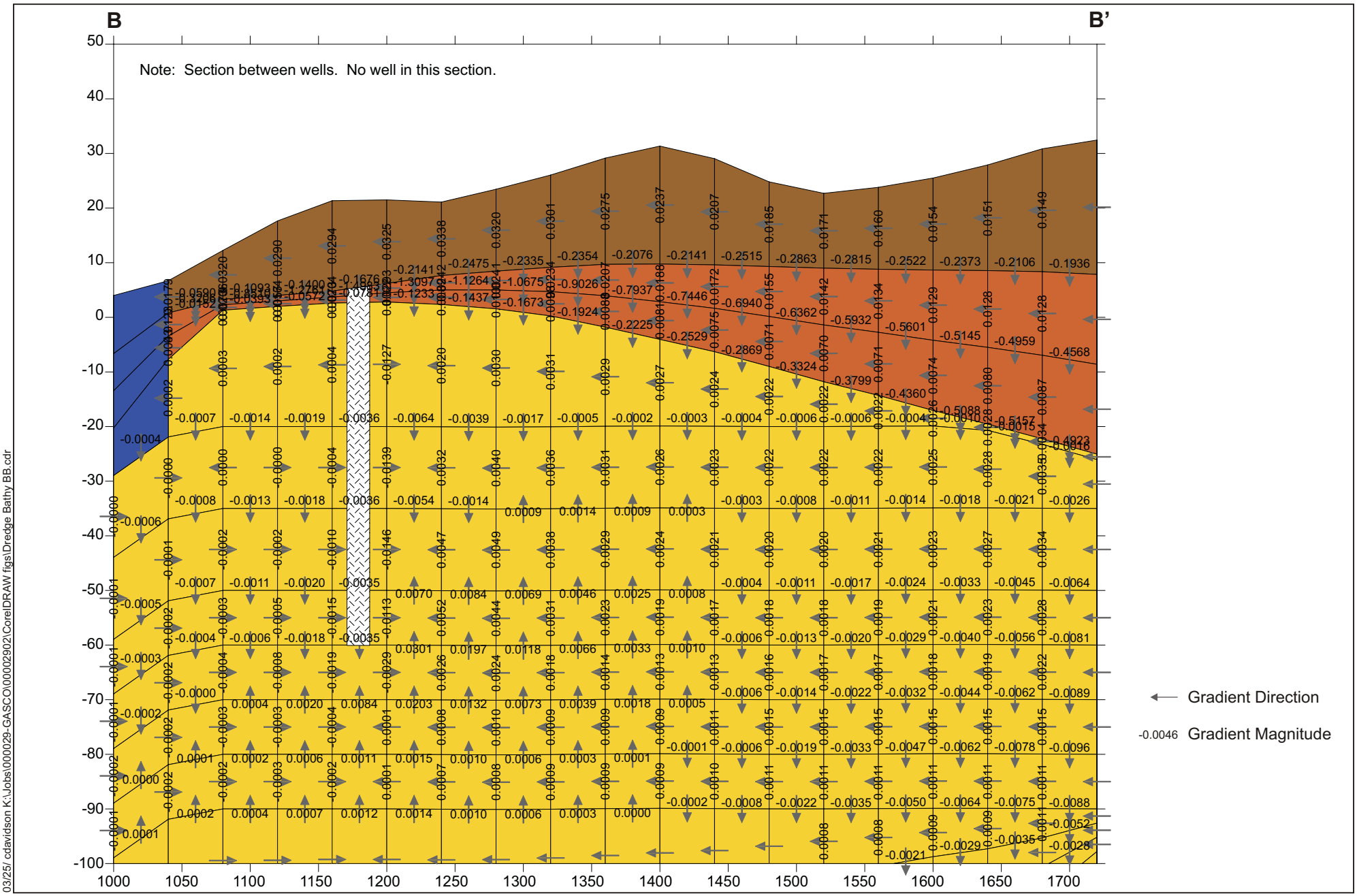


Figure A-14

Gradient Profile B-B', Dredge Bathymetry, Vertical Barrier, Intermediate Wells
NW Natural "Gasco" Site

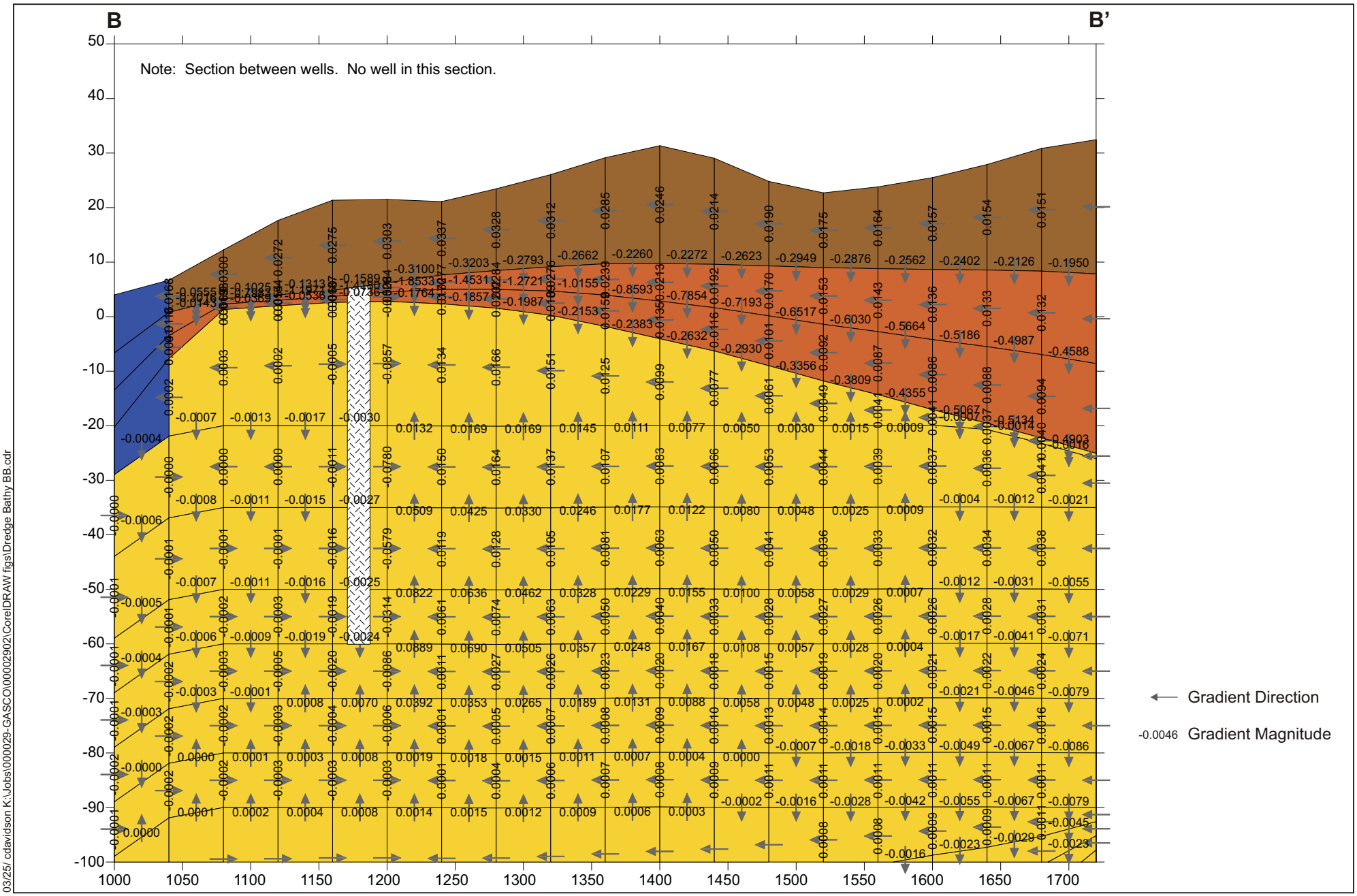
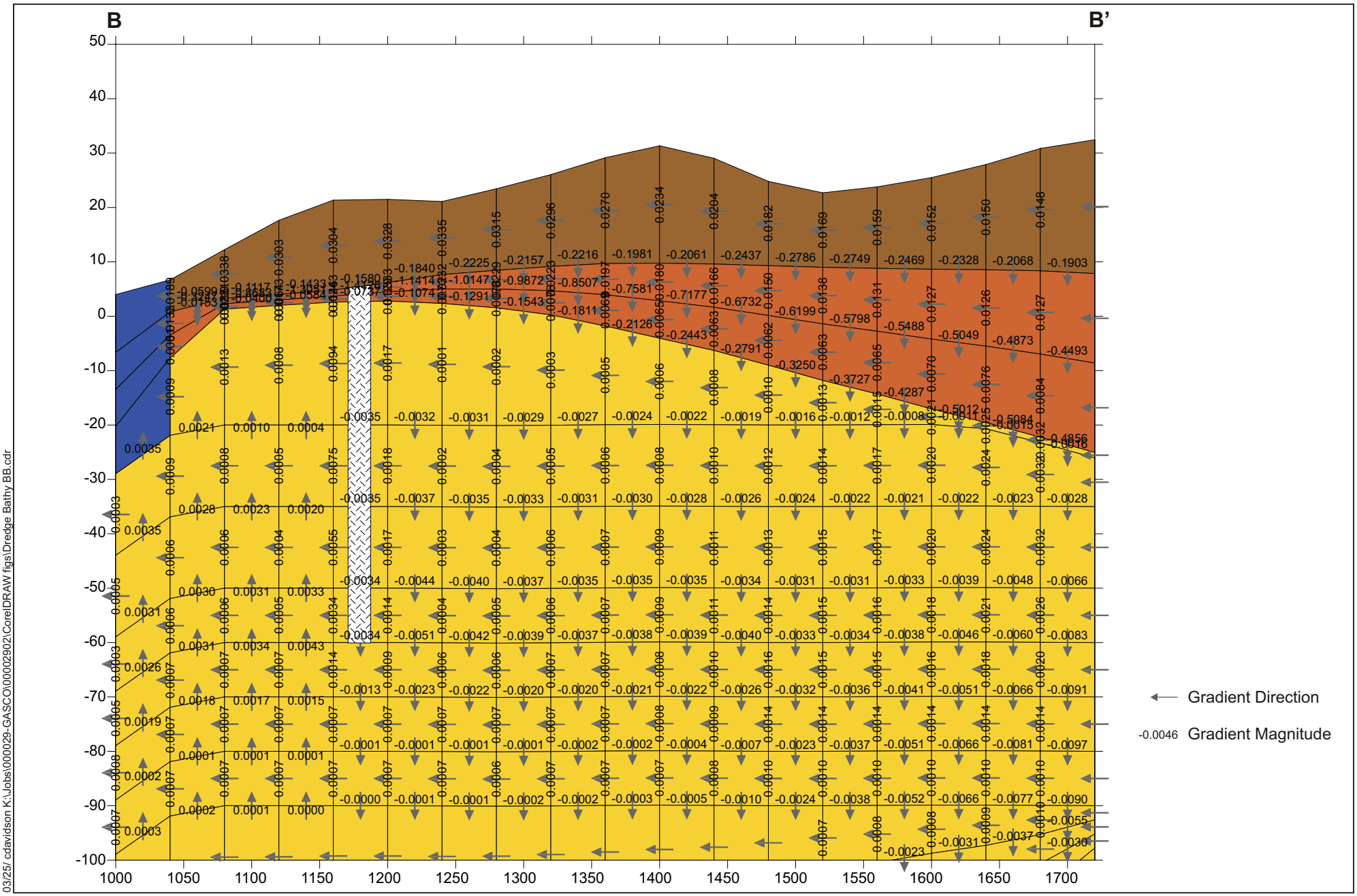


Figure A-15

Gradient Profile B-B', Dredge Bathymetry, Vertical Barrier, Shallow Wells
NW Natural "Gasco" Site



03/25/ cdavidson K:\Jobs\000029-GASCO\00002902\CorelDRAW figs\Dredge Bathy BB.cdr

Figure A-16
Gradient Profile B-B', Dredge Bathymetry, Vertical Barrier, No Pumping
NW Natural "Gasco" Site

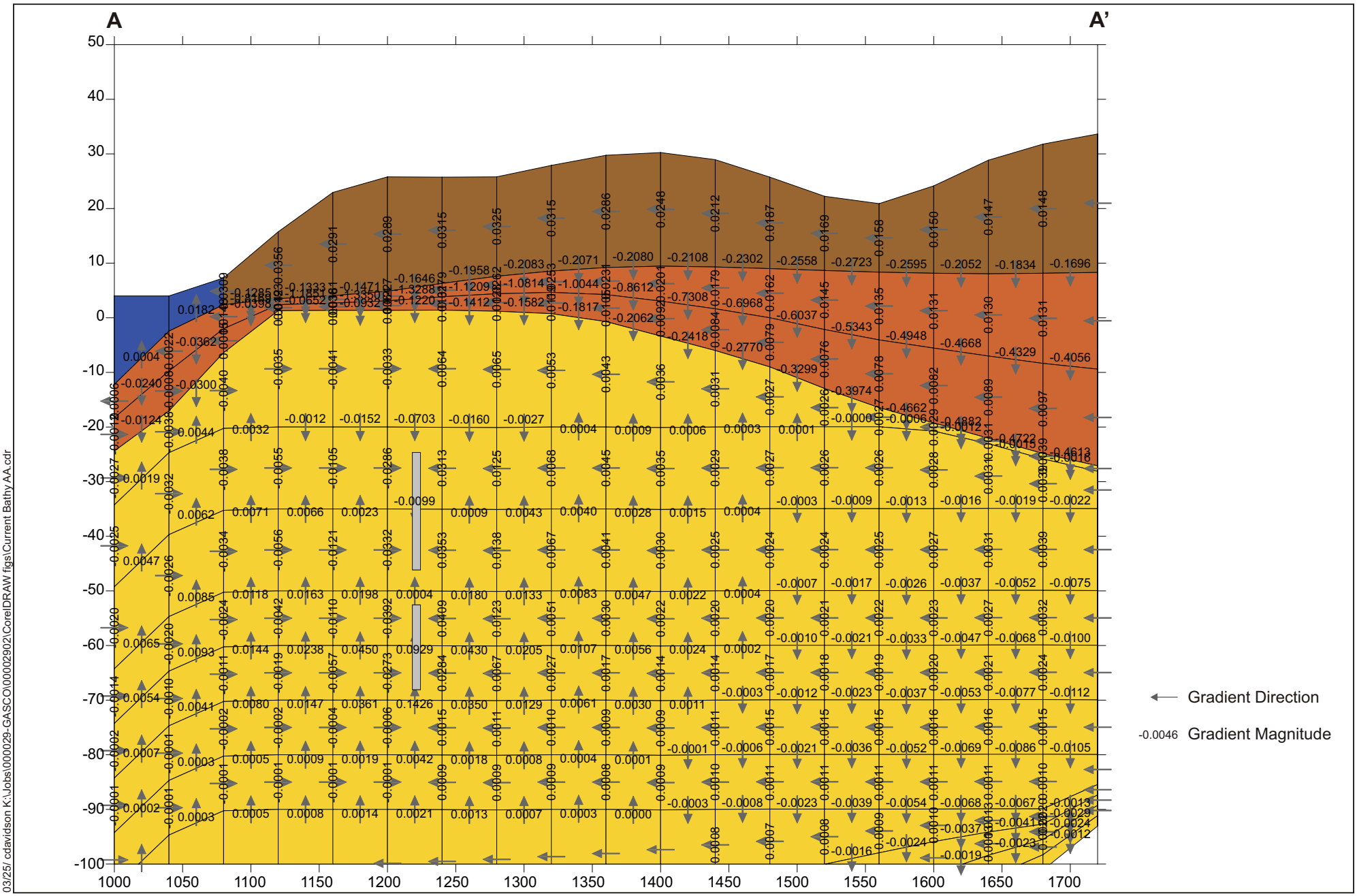


Figure A-17

Gradient Profile A-A', Current Bathymetry, No Vertical Barrier, Shallow and Intermediate Wells
NW Natural "Gasco" Site

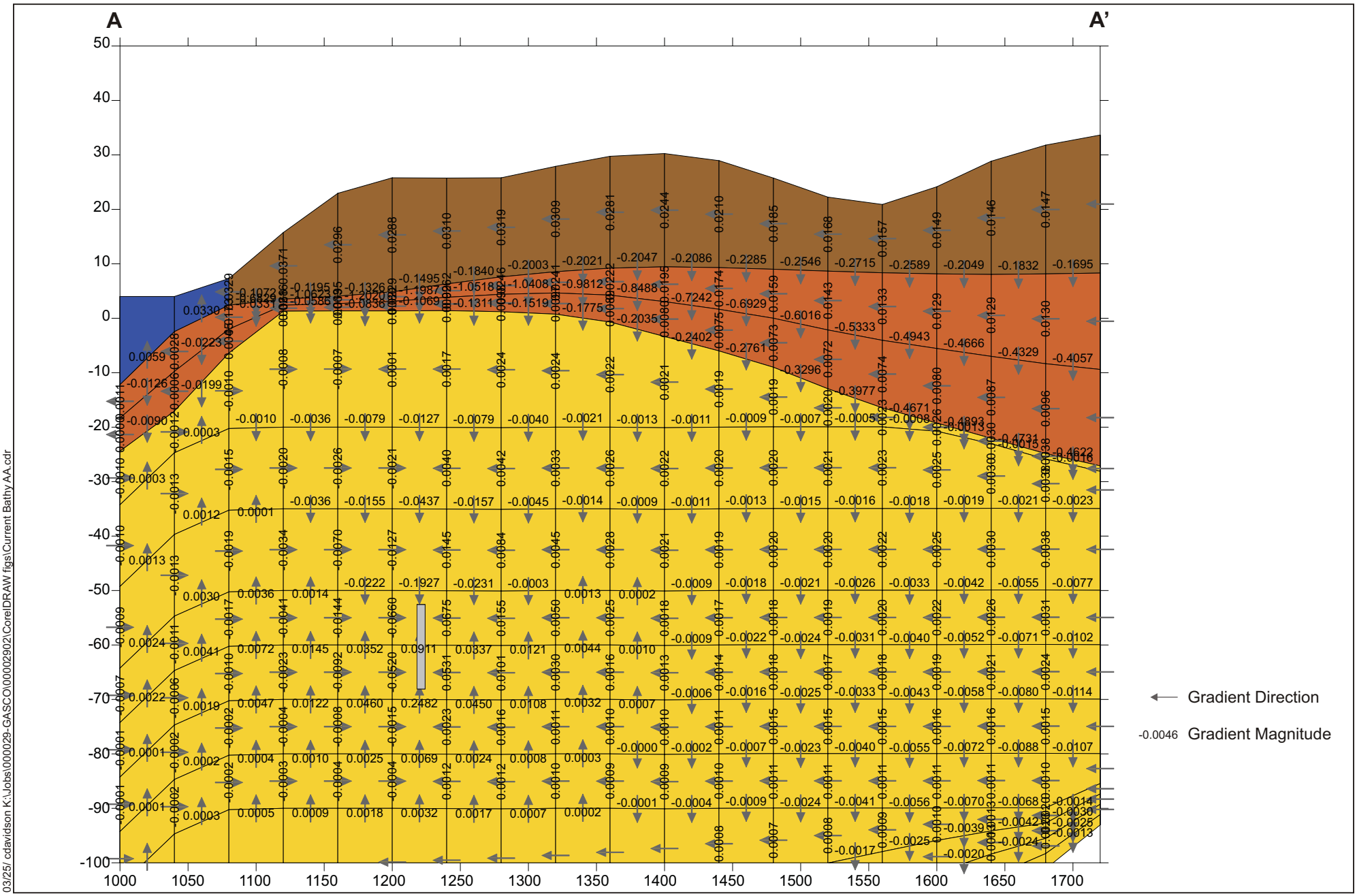


Figure A-18

Gradient Profile A-A', Current Bathymetry, No Vertical Barrier, Intermediate Wells
NW Natural "Gasco" Site

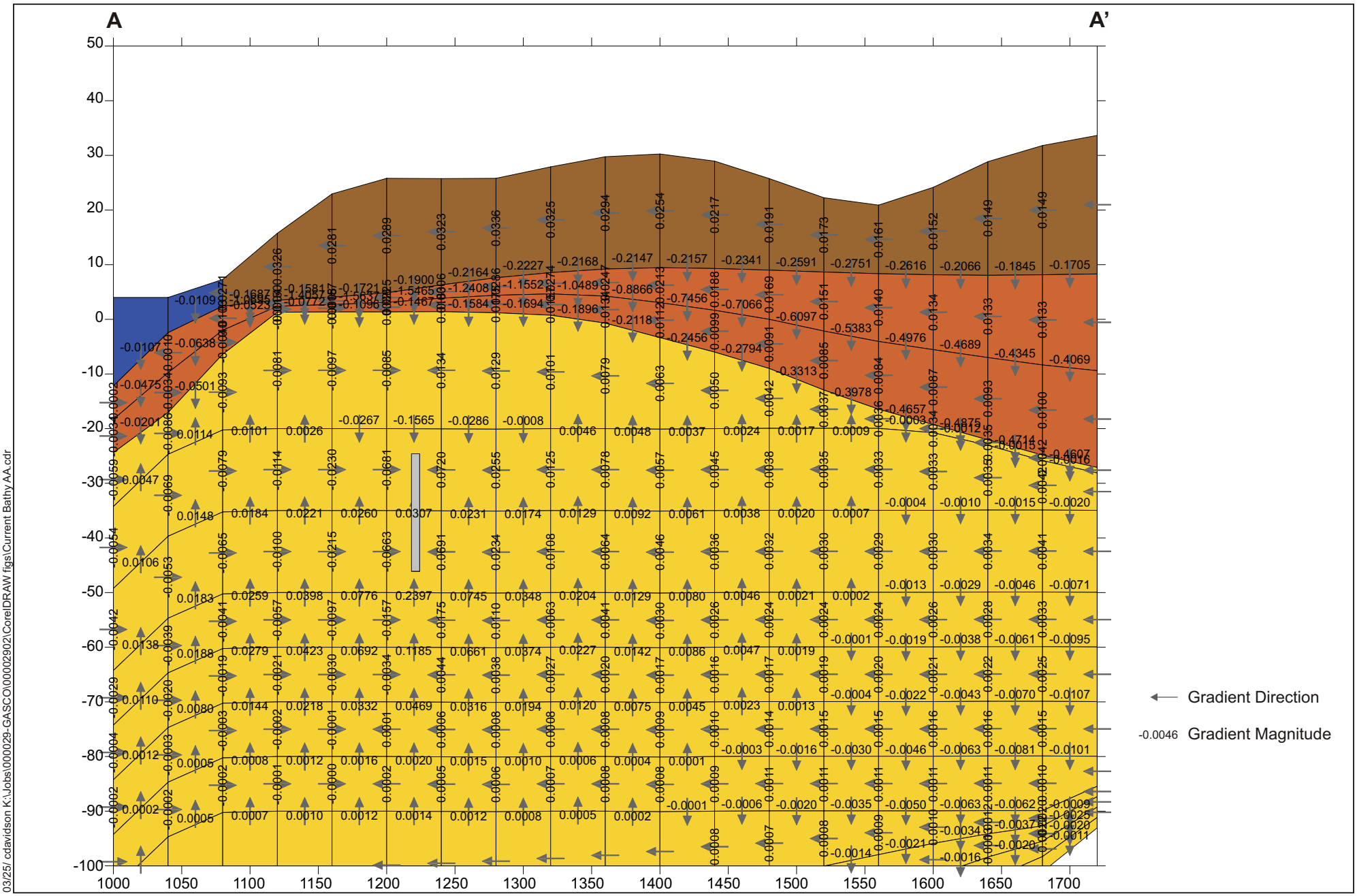


Figure A-19

Gradient Profile A-A', Current Bathymetry, No Vertical Barrier, Shallow Wells
NW Natural "Gasco" Site

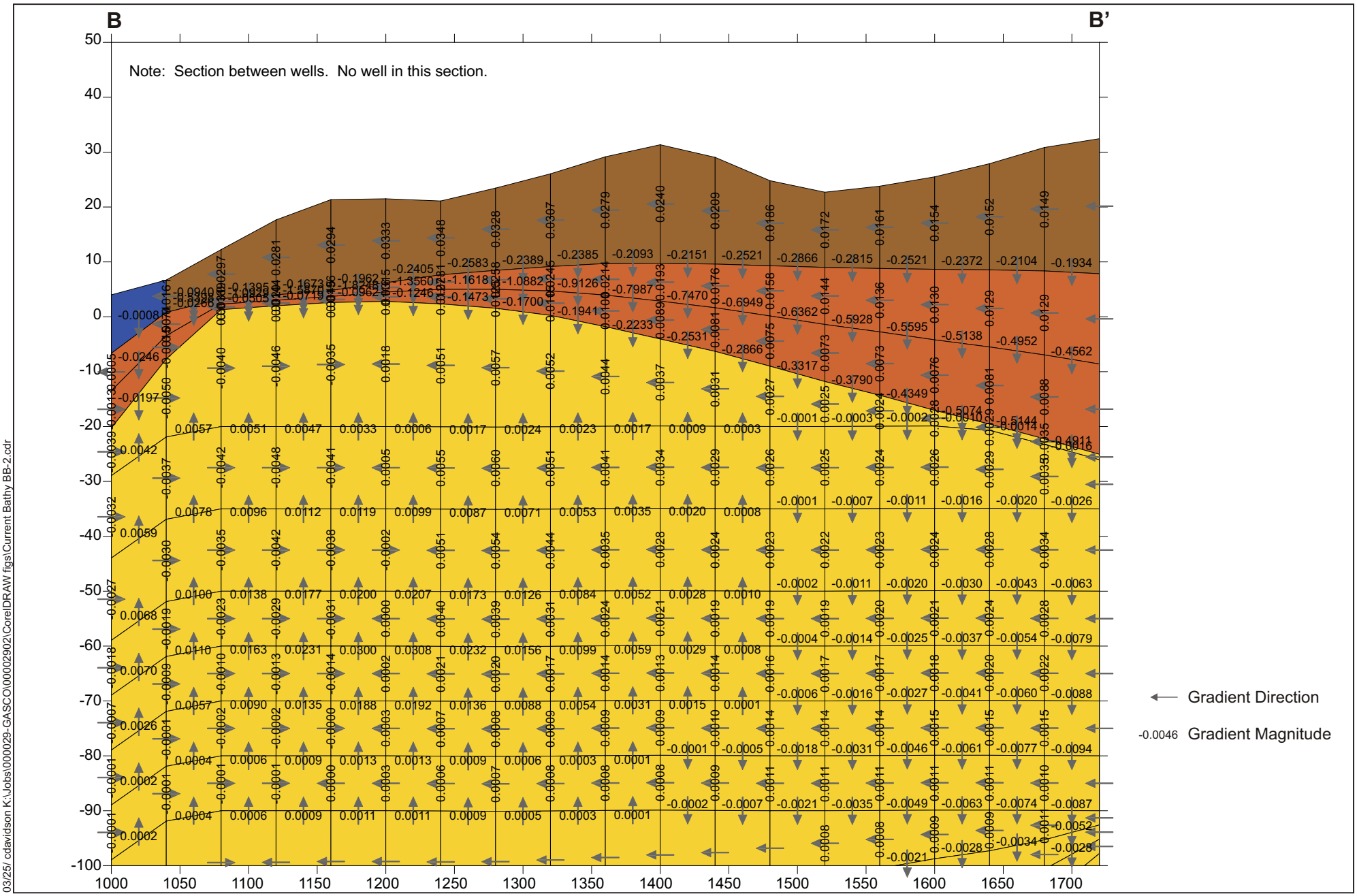


Figure A-20

Gradient Profile B-B', Current Bathymetry, No Vertical Barrier, Shallow and Intermediate Wells
NW Natural "Gasco" Site

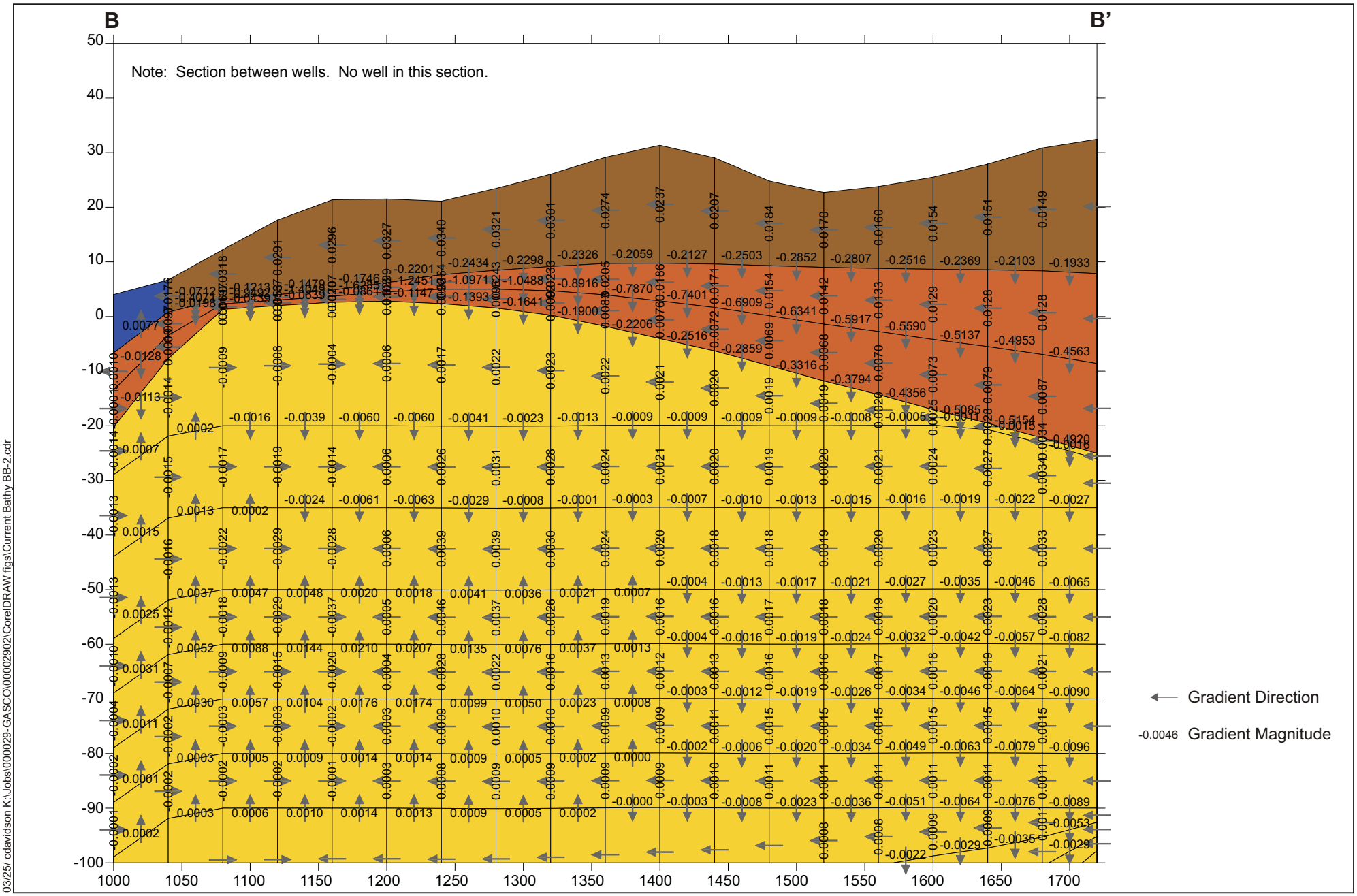


Figure A-21

Gradient Profile B-B', Current Bathymetry, No Vertical Barrier, Intermediate Wells
NW Natural "Gasco" Site

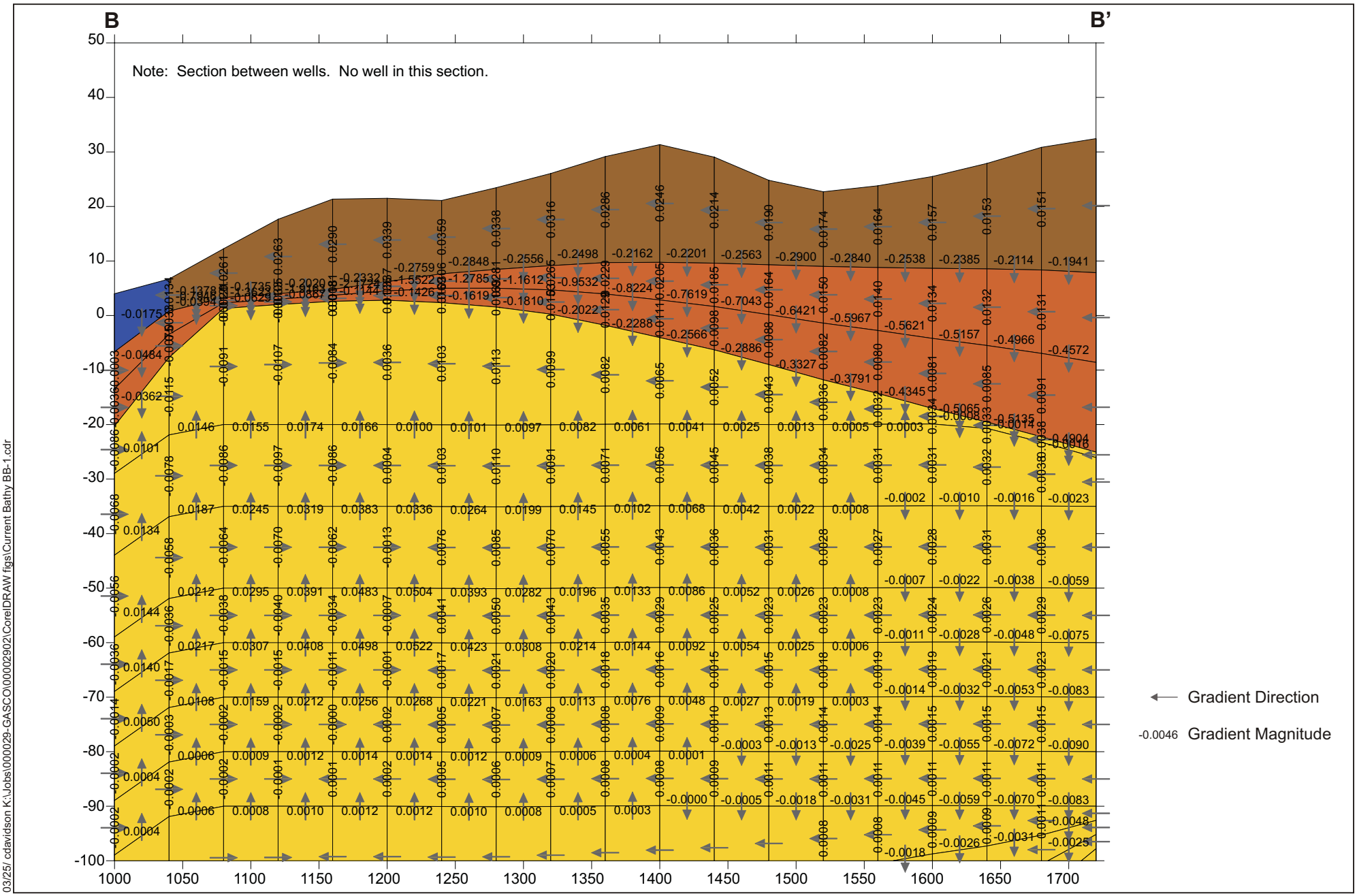


Figure A-22

Gradient Profile B-B', Current Bathymetry, No Vertical Barrier, Shallow Wells
NW Natural "Gasco" Site

S.S. PAPADOPULOS & ASSOCIATES, INC.
ENVIRONMENTAL & WATER-RESOURCE CONSULTANTS

Memorandum

Date: December 28, 2009

From: Michael J. Riley

To: John Edwards, AnchorQEA

Subject: Supporting information on Groundwater Modeling related to the Groundwater Source Control Interim Design Report, NW Natural Gasco Site, Portland, OR

During a meeting and conference call on December 15, 2009, between Oregon Department of Environmental Quality (DEQ) and NW Natural, several questions were raised by DEQ related to the groundwater modeling analyses conducted in support of the Groundwater Source Control Interim Design Report. Most of the questions were related to the effect of incorporating the deep aquitard into the model. In a follow-up conference call between SSPA and DEQ, Dana Bayuk and Henning Larson requested the following supporting information to explain the ability of the proposed extraction system to contain groundwater down to bedrock:

1) A plan view figure from groundwater particle path modeling with particles starting at the bottom of the alluvium below the aquitard. The path lines would be shown in different colors with one color showing the path lines below the deep aquitard and another showing the continuation of the path lines above the aquitard.
2) A cross sectional figure showing a path line from below the deep aquitard. The figure would show the path line relative to the location of the aquitard. DEQ asked that the particle path be located in the vicinity of PW-6 and PW-7
3) Particle travel time from the deep aquifer to an extraction well.

The two figures are provided below. The plan view figure shows the particle path lines in both blue and red segments. This model predicts the path of a particle of groundwater. The model is not designed to predict the transport of dissolved contaminants in groundwater and potential retardation of dissolved contaminants is addressed later in this memorandum. The blue segment shows the path lines from where the particle starts near bedrock until it is above the aquitard. The red segment shows the segment of the particle path that is above the aquitard. The path lines show that groundwater is predicted to flow around the edge of the aquitard, which is truncated at the shoreline. Once past the edge of the aquitard, the particles flow back to and are captured by the extraction wells. Complete capture of the groundwater below the aquitard is attained with all the groundwater below the aquitard captured by extraction wells PW-3, PW-4, PW-5 and PW-6. The preferential capture by these wells rather than by other wells is due to the limited lateral extent of the aquifer below the aquitard to the northwest and the fact that in a line of wells

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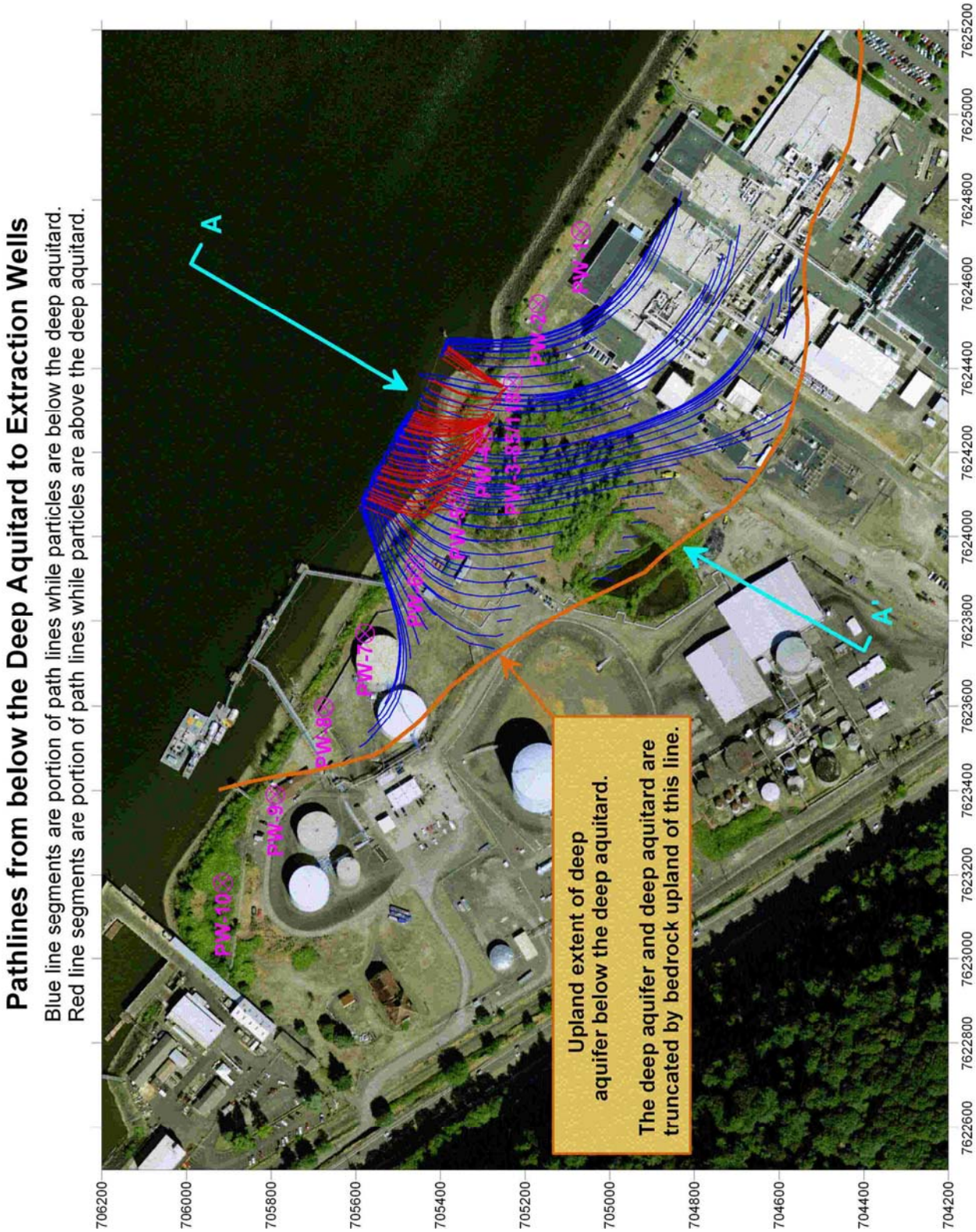
pumping at the same pump rate, as presented here, the greatest drawdown and therefore the strongest capture will occur toward the center of the line of wells rather than at the ends.

The cross section figure shows a path line starting from near bedrock and traveling to PW-4. This particle was selected because the location of well PW-4 is aligned with the model grid, which means the path line is more accurately shown since the cross section is drawn along the model grid. A particle that moves diagonally through the grid, such as the single particle captured by PW-6, would essentially be passing through a model cross section and therefore would not accurately align with the model layers and geologic units. The cross section figure illustrates that the particle travels laterally from near bedrock around the edge of the deep aquitard and then back to the extraction well above the aquitard.

The travel time for groundwater migrating from below the deep aquitard to the extraction wells is on the order of decades. Groundwater starting farther from the extraction wells, such as on the Siltronic property, has travel times of greater than 50 years. As shown in the plan-view figure, these groundwater particles have a long travel path, particularly since they travel to wells PW-3, PW-4, PW-5, and PW-6 near the center of the line of wells. The reason for this is the greater drawdown near the center of the line of wells as discussed above. Particles located closer to the extraction wells have travel times on the order of 10 to 20 years. For instance, the particle shown on the cross section has a travel time of 17 years. These estimated travel times are for groundwater only and it is likely that the travel time of many of the groundwater contaminants, such as BTEX components, or PAHs, would be longer, due to retardation.

The travel time is the time it takes for groundwater to reach the extraction well. It is not the time it takes to for the capture zone to develop and control upland groundwater. The time for the capture zone to fully form is given by the time for the hydraulic effect of pumping to propagate through the aquifer. The hydraulic effect of pumping propagates very rapidly as it is largely a pressure response since the aquifer is semi-confined by the silt interbeds in the alluvium. Previous pump tests at PW-3-85 and PW-3-118 (then known as PW-4) indicate that the aquifer responds very quickly to pumping stresses with even deep wells reaching an approximately steady-state drawdown within hours of initiation of pumping. Based on this information, it is expected that development of the capture zone will occur in a matter of hours after the extraction system is started.


Pathlines from below the Deep Aquitard to Extraction Wells
Blue line segments are portion of path lines while particles are below the deep aquitard.
Red line segments are portion of path lines while particles are above the deep aquitard.
A
A'
PW-10
PW-9
PW-8
PW-7
PW-3
PW-2
PW-1
Upland extent of deep aquifer below the deep aquitard.
The deep aquifer and deep aquitard are truncated by bedrock upland of this line.
706200
706000
705800
705600
705400
705200
705000
704800
704600
704400
704200
7622600
7622800
7623000
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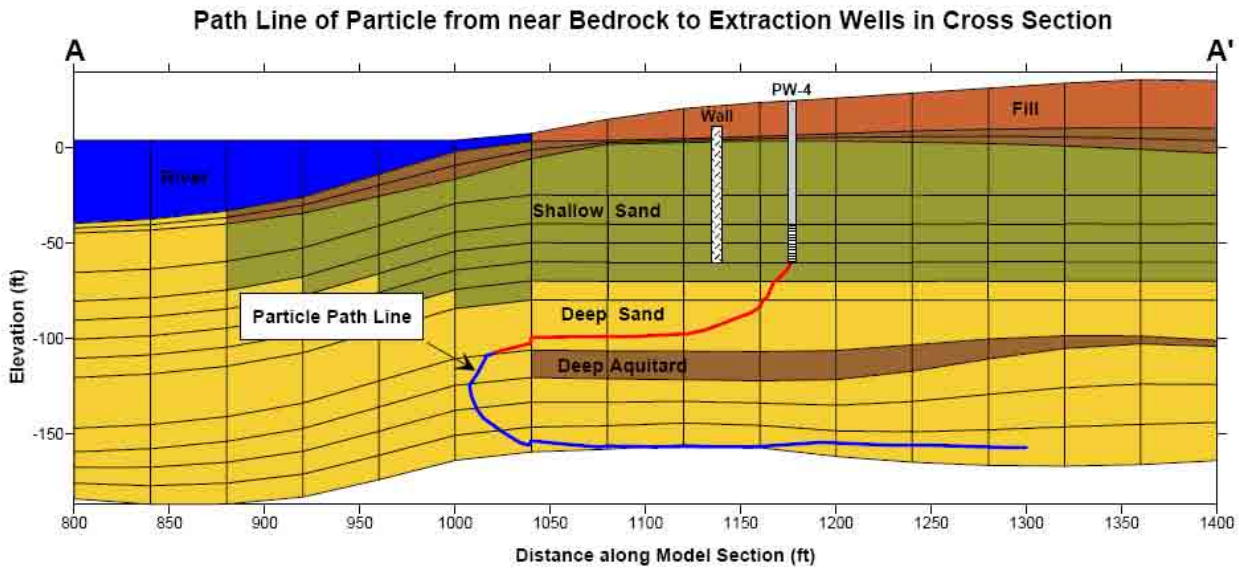
7625000
7625200


Path Line of Particle from near Bedrock to Extraction Wells in Cross Section
A
A'
PW-4
Wall
Fill
River
Shallow Sand
Deep Sand
Deep Aquitard
Particle Path Line
Elevation (ft)
0
-50
-100
-150
800
850
900
950
1000
1050
1100
1150
1200
1250
1300
1350
1400
Distance along Model Section (ft)

APPENDIX G
BORING LOGS

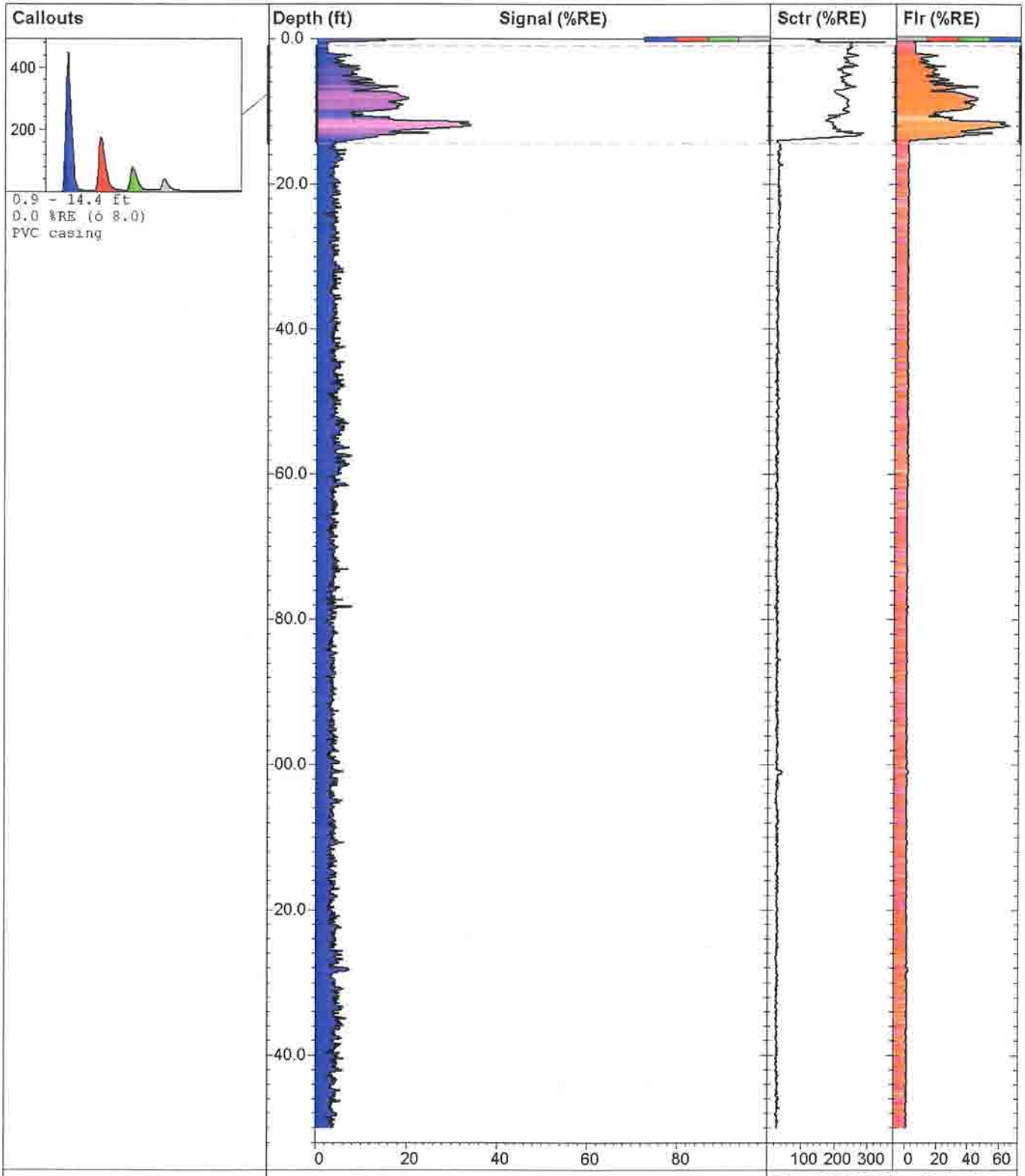
TABLE 1 - TarGOST Boring Summary

BORING	PROPERTY	DATE	COORDINATES[1] NORTHING	EASTING	GS ELEVATION (feet MSL)[2]	Fill Penetration Method[3]	Pre-Drill Hole or PVC Casing Depth (feet)[3]	Estimated Fill Thickness (feet)[4]	DEPTH (feet)
TG-1	Gasco	27-Aug-07	705521.3	7623806	19.6	PVC Casing	15	13	150.1
TG-2	Gasco	24-Aug-07	705401.7	7623941.3	32.5	PVC Casing	27	25	150.3
TG-3	Gasco	23-Aug-07	705336.2	7624102	32.5	PVC Casing	28	27	150.3
TG-4	Gasco	26-Aug-07	705276.1	7624230.2	28.6	PVC Casing	30	20	150
TG-5	Gasco	26-Aug-07	705198.1	7624321.9	25.3	PVC Casing	20	16	99.1
TG-5A	Gasco	9-Sep-07	705187.5	7624332.5	25.3	PVC Casing	20	16	150.3
TG-6	Gasco	28-Aug-07	705594.2	7623523.2	21.5	PVC Casing	5	10	125.5
TG-7	Gasco	24-Aug-07	705316.3	7623879.7	33.7	PVC Casing	30	25	150.4
TG-8	Gasco	25-Aug-07	705110.4	7624222.5	36.7	PVC Casing	25	25	150.2
TG-9	Gasco	28-Mar-08	705454.6	7623852.7	31.4	Pre-Drill Hole	26.0	27	148.2
TG-10	Gasco	29-Mar-08	705258.1	7624361.7	25.0	PVC Casing	19.0	16	150.9
TG-11	Gasco	29-Mar-08	705189.6	7624150.2	36.9	TarGOST	-	25	150.2
TG-12	Gasco	28-Mar-08	705032.5	7624318.8	27.0	TarGOST	-	25	149.5
TG-13	Gasco	30-Mar-08	704889.6	7624102.7	36.1	Pre-Drill Hole	24.0	26.5	101.7
TG-14	Gasco	28-Mar-08	704736.1	7624073.5	34.1	TarGOST	-	23	100.5
TG-15	Gasco	29-Mar-08	705332.3	7623961.9	33.6	TarGOST	-	22.5	149.4
TG-16	Gasco	30-Mar-08	705157.6	7623823.8	35.6	TarGOST	-	26.5	149.1
TG-1S	Siltronic	5-Sep-07	705123.1	7624613.2	35.2	PVC Casing	30.0	31	151.3
TG-2S	Siltronic	7-Sep-07	704953.2	7624856.6	35.7	PVC Casing	38.0	32-37	151
TG-3S	Siltronic	8-Sep-07	704877.7	7624265.5	35.0	PVC Casing	34.0	38	150.2
TG-4S	Siltronic	7-Sep-07	705112.8	7624436.7	33.6	PVC Casing	36.0	30	150.3
TG-5S	Siltronic	6-Sep-07	704719.1	7624443.6	34.5	PVC Casing	30.0	<30	150.6
TG-6S	Siltronic	8-Sep-07	704598.5	7624577.8	34.6	PVC Casing	36.0	30	149.8
TG-7S	Siltronic	26-Mar-08	705069.4	7624690.9	35.3	Pre-Drill Hole	26.0	28.5	150
TG-8S	Siltronic	31-Aug-07	704895.4	7624770.2	35.2	Pre-Drill Hole	23.0	23	146.8
TG-9S	Siltronic	26-Mar-08	704601.9	7624289.8	34.8	PVC Casing	31.0	30	101.3
TG-10S	Siltronic	26-Mar-08	704397.8	7624017.4	37.1	PVC Casing	18.0	20.2	90.5
TG-11S	Siltronic	26-Mar-08	704290.4	7624227.4	34.9	PVC Casing	22.5	25	78.5
TG-12S	Siltronic	27-Mar-08	705195.5	7624494.2	34.0	TarGOST	-	31	156

Notes: 1 = State Plane Coordinates, NAD83
2 = City of Portland Datum
3 = TarGOST data collected across depth interval of PVC casing or a pre-drilled open hole are not usable.
4 = Fill thickness estimate is based on co-located / nearby boring, or in certain cases depth to silt was verified as part of TarGOST pre-drill or casing emplacement.

TARGOST BORING LOGS

TG-1 THROUGH TG-16
NW NATURAL – GASCO PROPERTY



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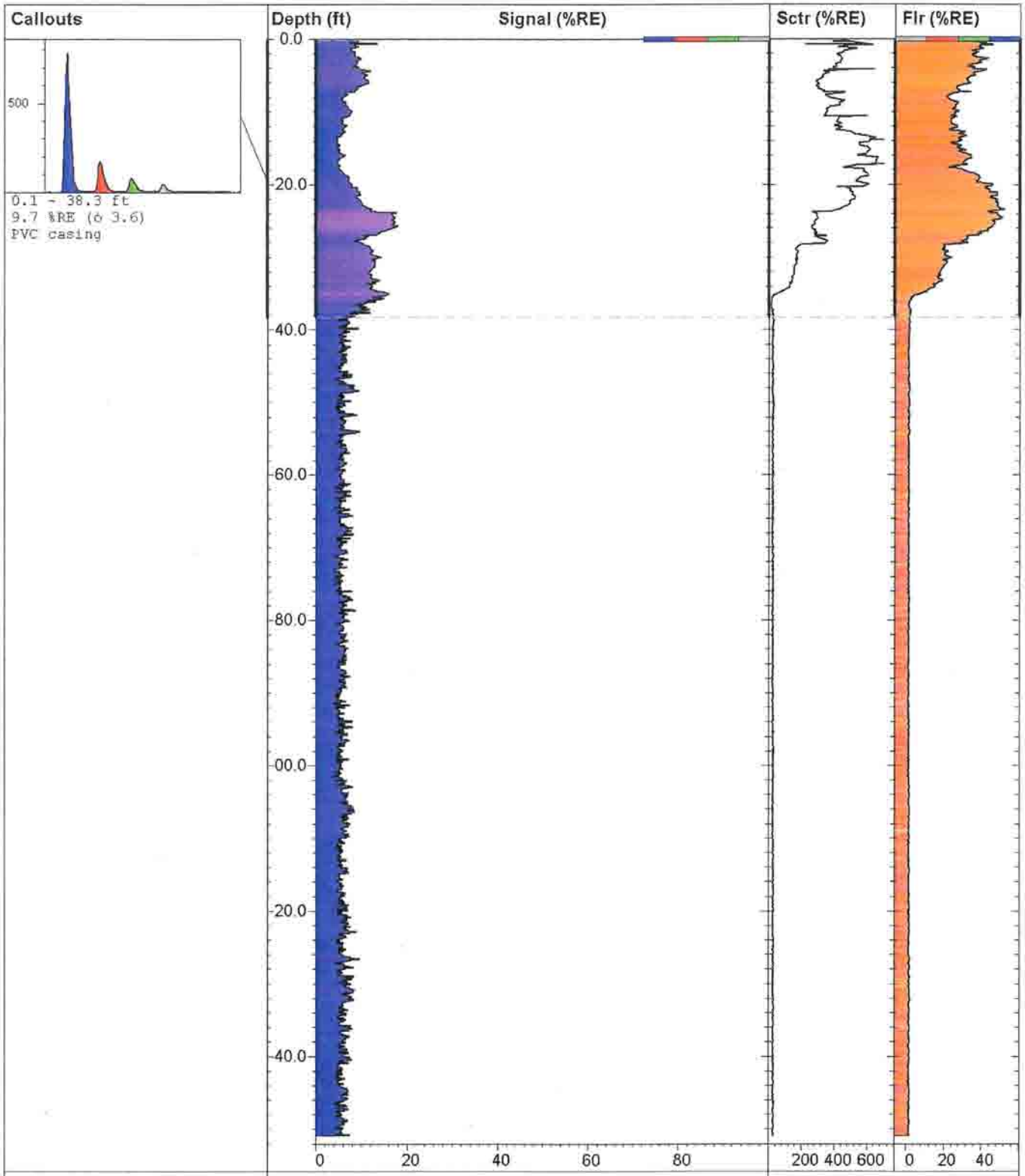
TG001		**TarGOST By Dakota** www.DakotaTechnologies.com
Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **150.10 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **34.1 % @ 11.43 ft**
Job: **2708**	*Operator/Unit:* **Steve Adamek/DTI01**	*Date & Time:* **8/27/2007 8:48:44 AM**



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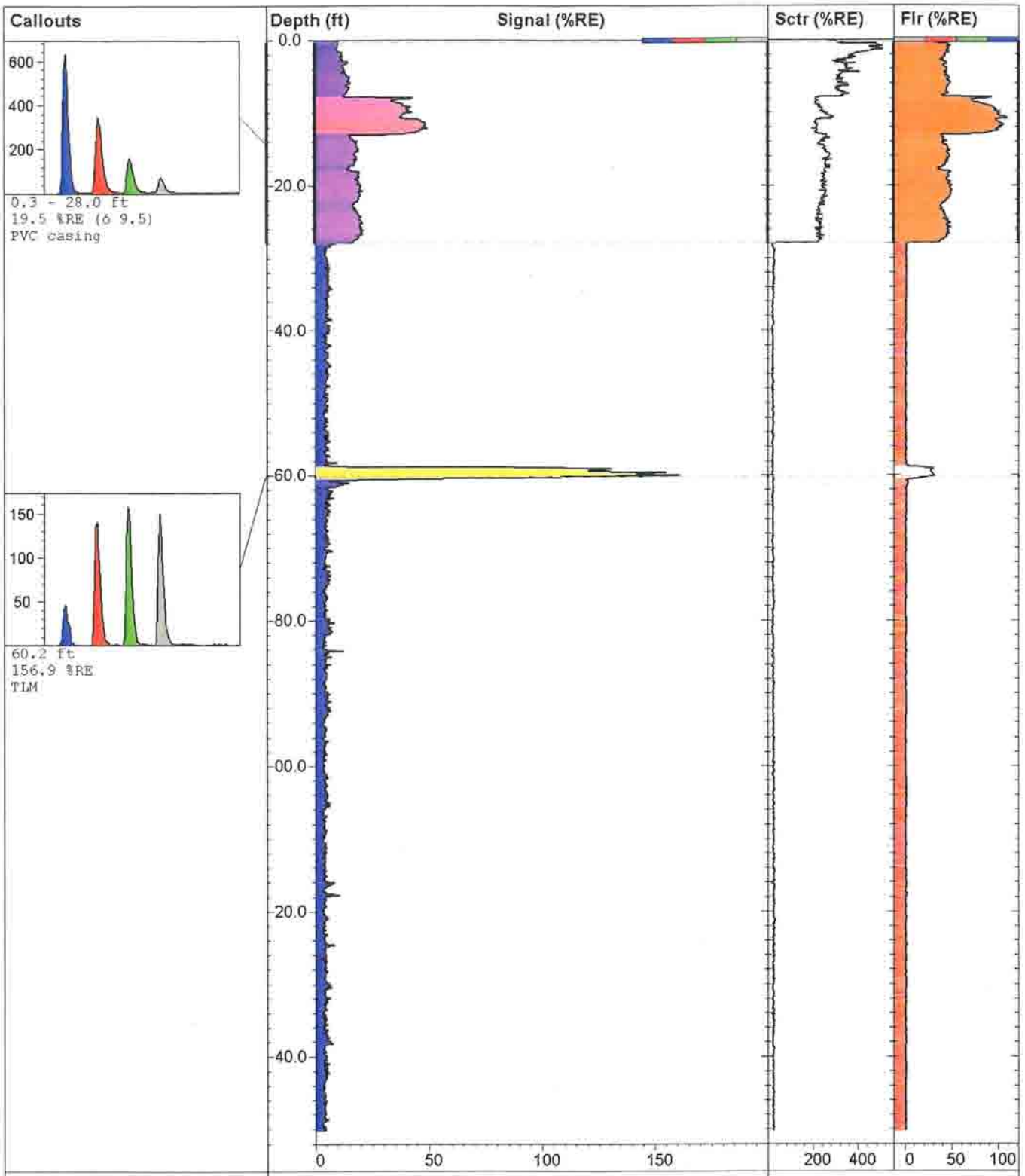
TG02Sc

TarGOST By Dakota
www.DakotaTechnologies.com

Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **151.04 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **19.4 % @ 35.72 ft**
Job: **2708**	*Operator/Unit:* **Steve Adamek/DTI01**	*Date & Time:* **9/7/2007 10:14:17 AM**



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TG003

TarGOST By Dakota
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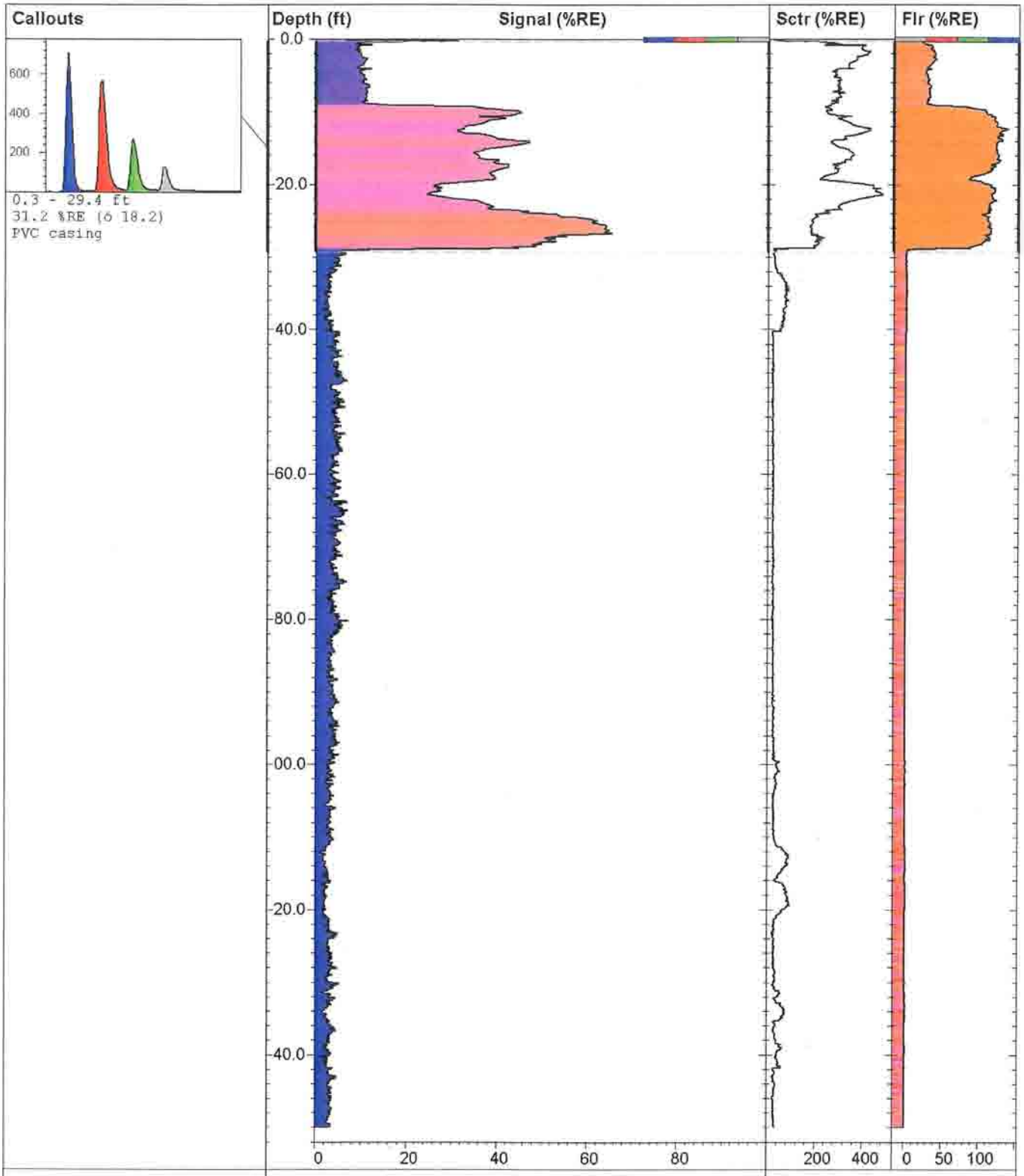
Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **150.32 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **165.2 % @ 59.93 ft**
Job: **2708**	*Operator/Unit:* **Steve Adamek/DTI01**	*Date & Time:* **8/23/2007 10:06:34 AM**



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TG004

TarGOST By Dakota
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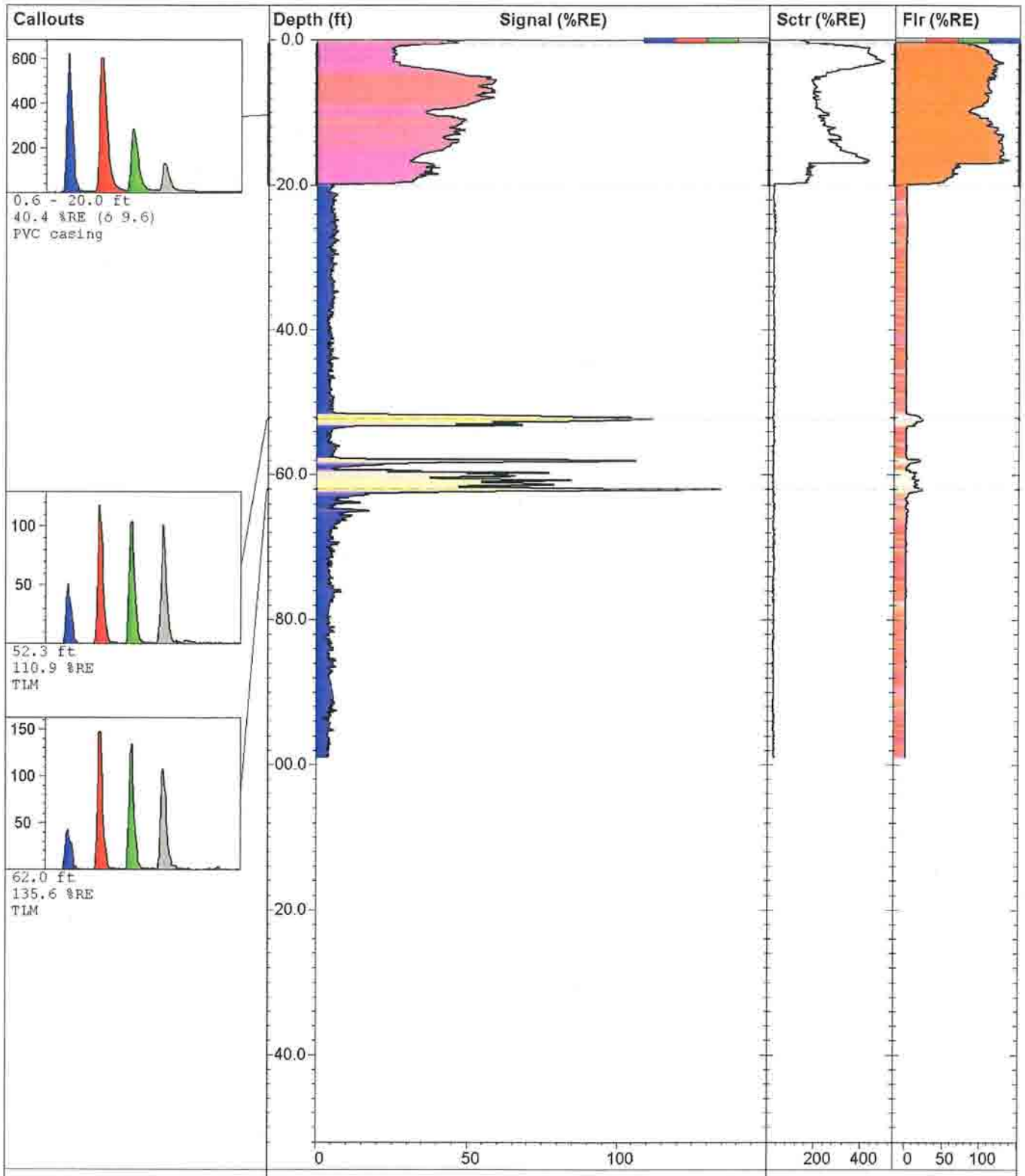
Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **150.01 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **66.1 % @ 26.64 ft**
Job: **2708**	*Operator/Unit:* **Steve Adamek/DTI01**	*Date & Time:* **8/26/2007 12:05:47 PM**



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TG005

TarGOST By Dakota
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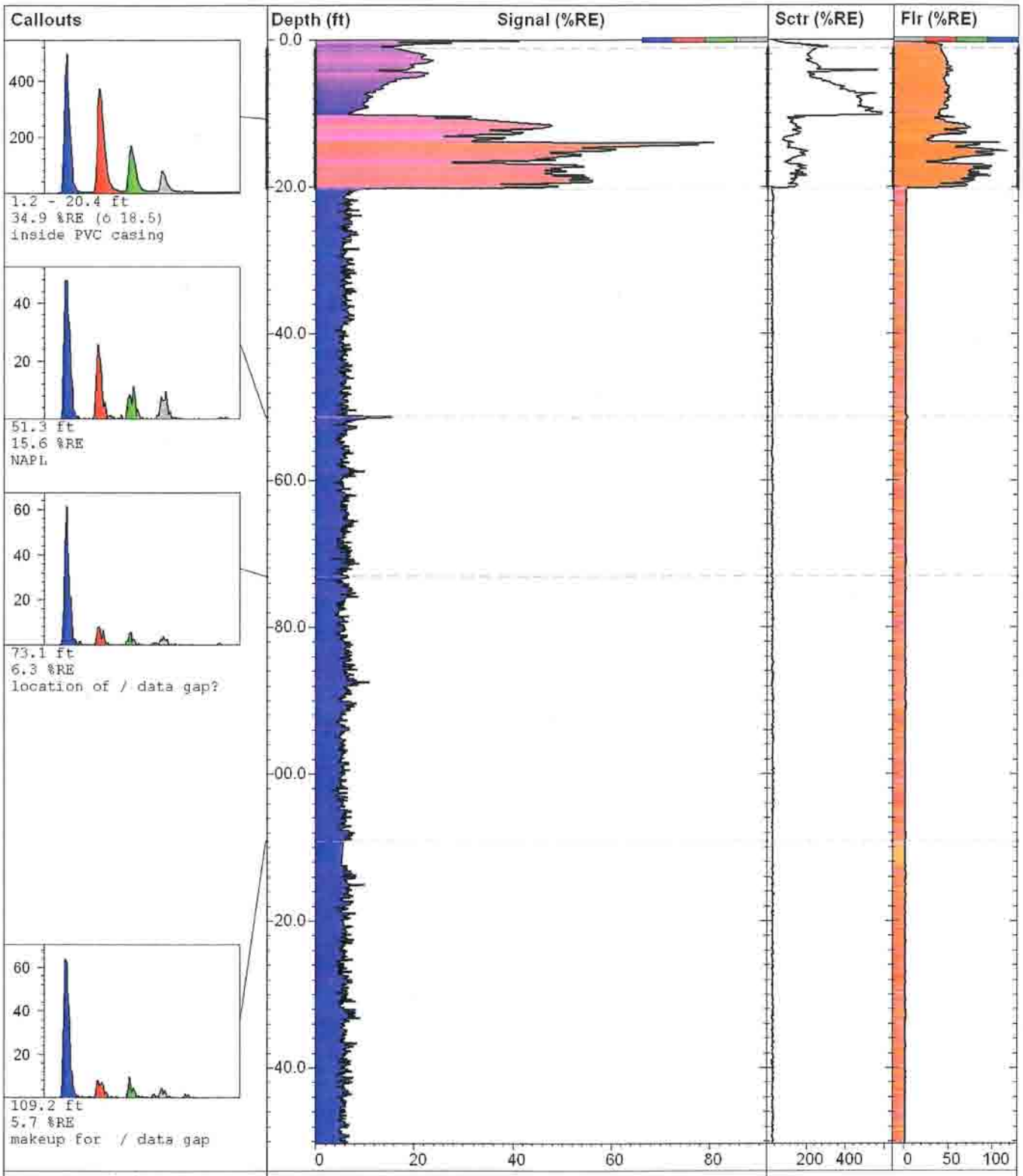
Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **99.06 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **135.6 % @ 61.97 ft**
Job: **2708**	*Operator/Unit:* **Steve Adamek/DTI01**	*Date & Time:* **8/26/2007 8:10:34 AM**



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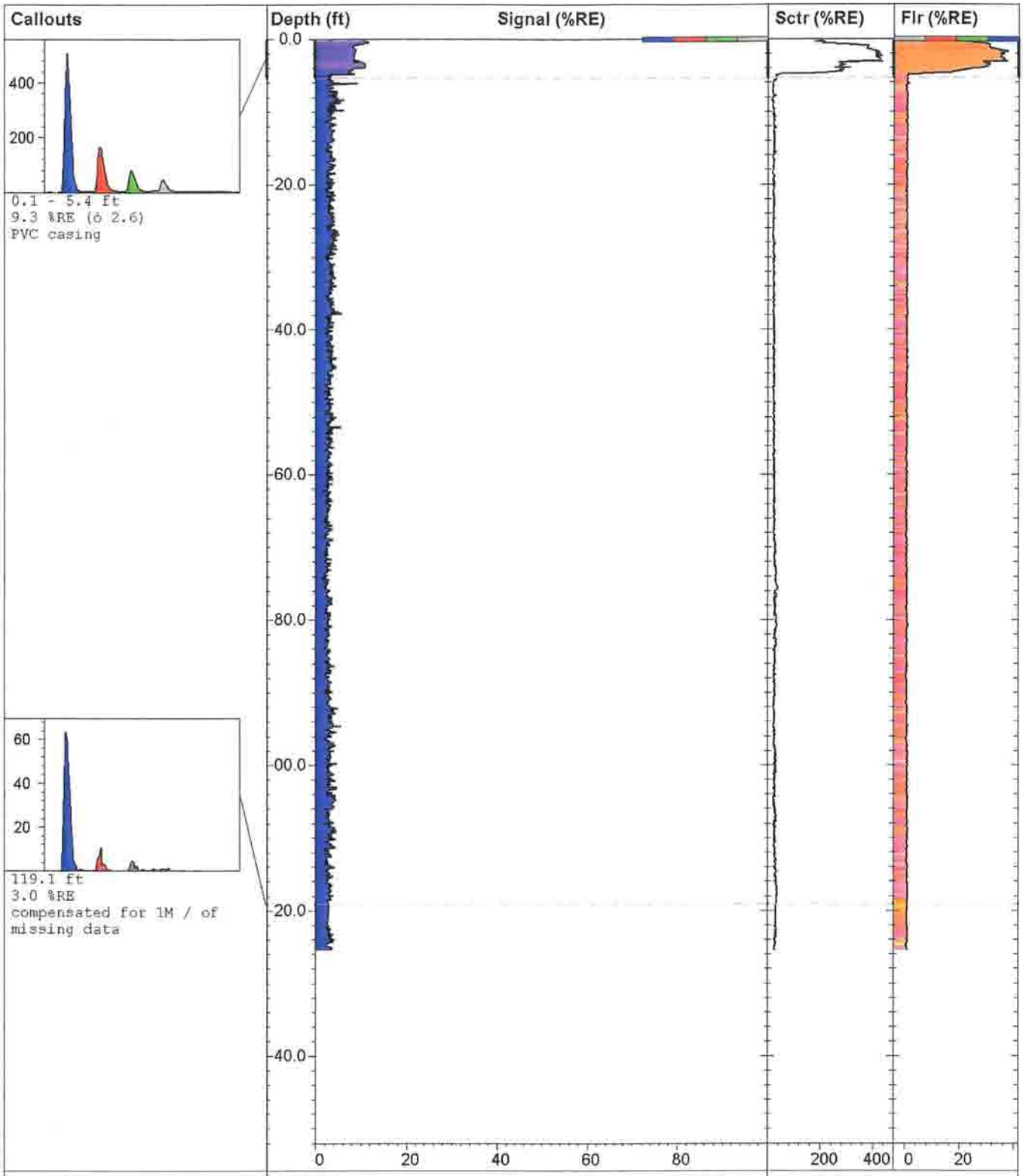
TG005A		TarGOST
Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **150.27 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **83.3 % @ 13.99 ft**
Job: **2708**	*Operator/Unit:* **Steve Adamek/DTI01**	*Date & Time:* **9/9/2007 8:16:33 AM**



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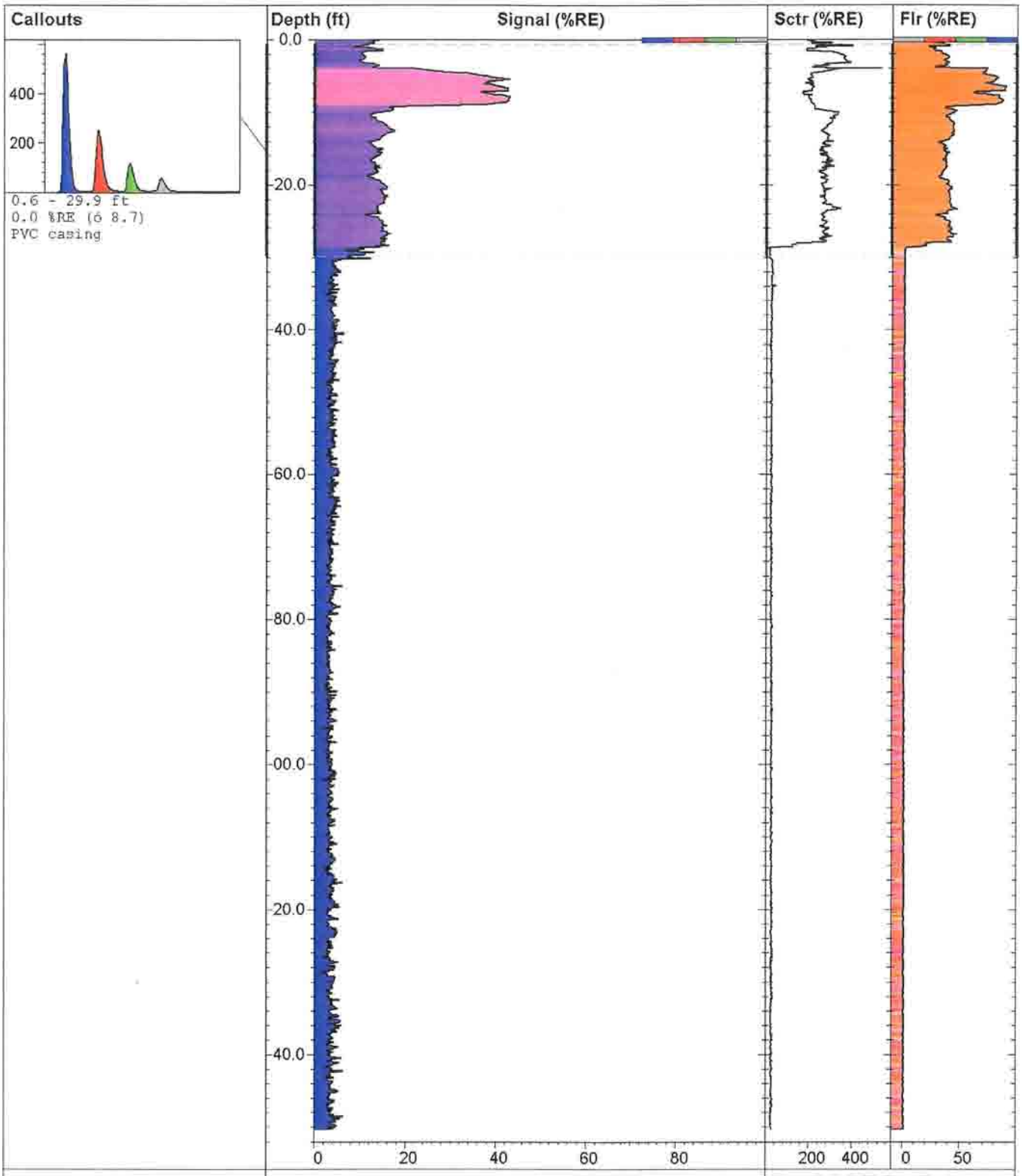
TG006

TarGOST By Dakota
www.DakotaTechnologies.com

Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **125.50 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **12.8 % @ 0.39 ft**
Job: **2708**	*Operator/Unit:* **Steve Adamek/DTI01**	*Date & Time:* **8/28/2007 1:01:59 AM**



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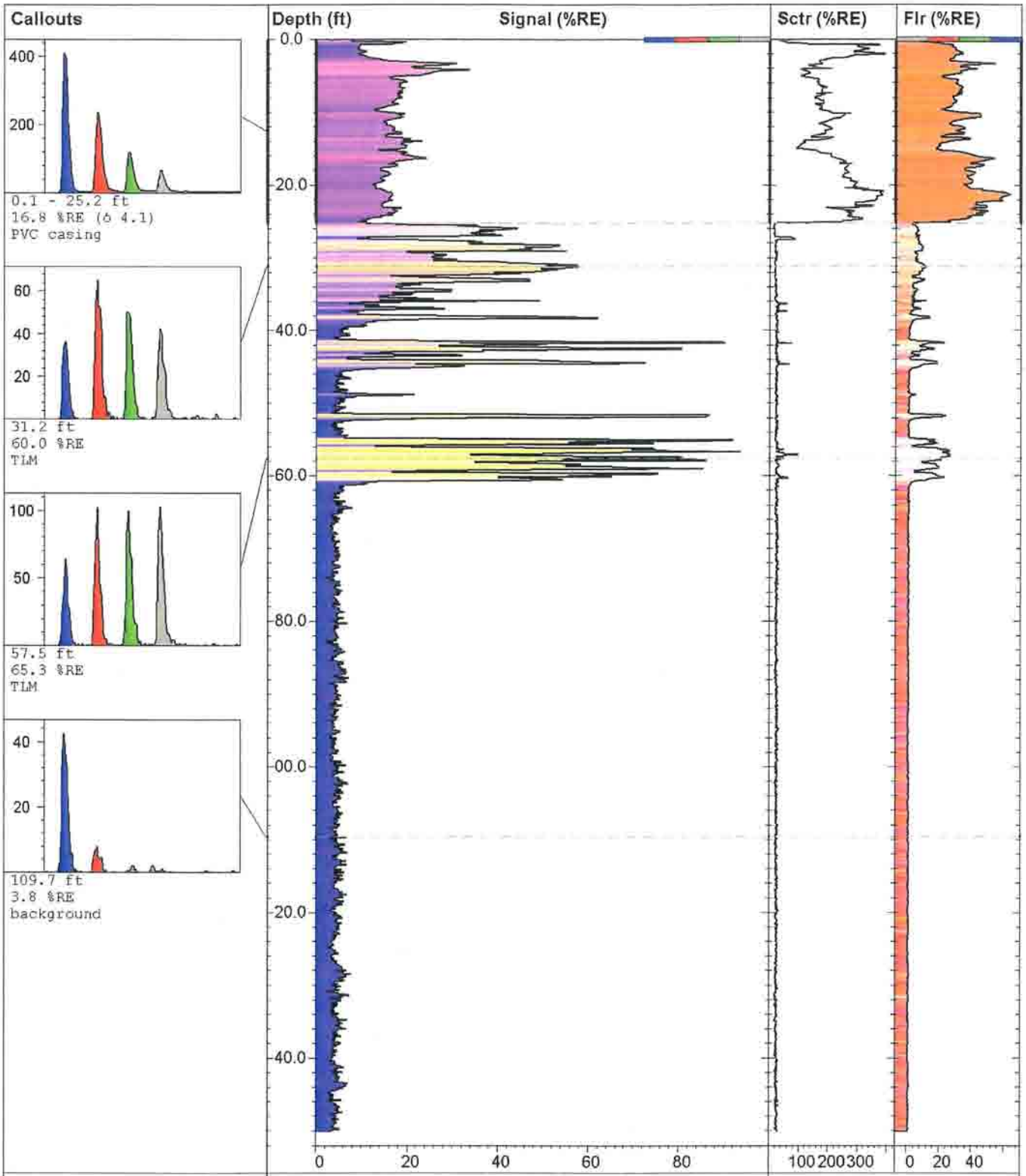
TG007

TarGOST By Dakota
www.DakotaTechnologies.com

Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **150.37 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **43.1 % @ 7.77 ft**
Job: **2708**	*Operator/Unit:* **Steve Adamek/DTI01**	*Date & Time:* **8/24/2007 1:53:18 PM**



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TG008

TarGOST By Dakota
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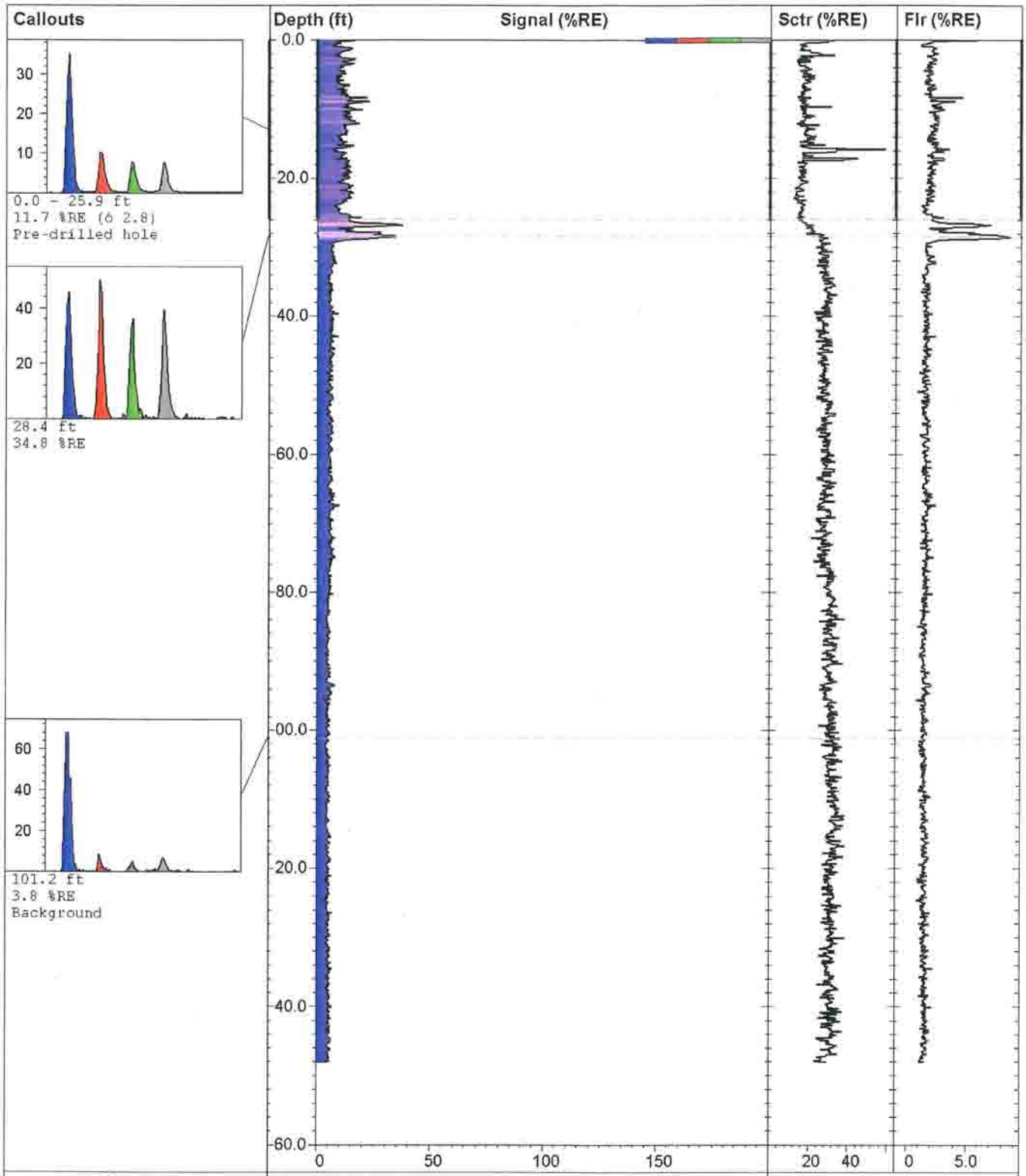
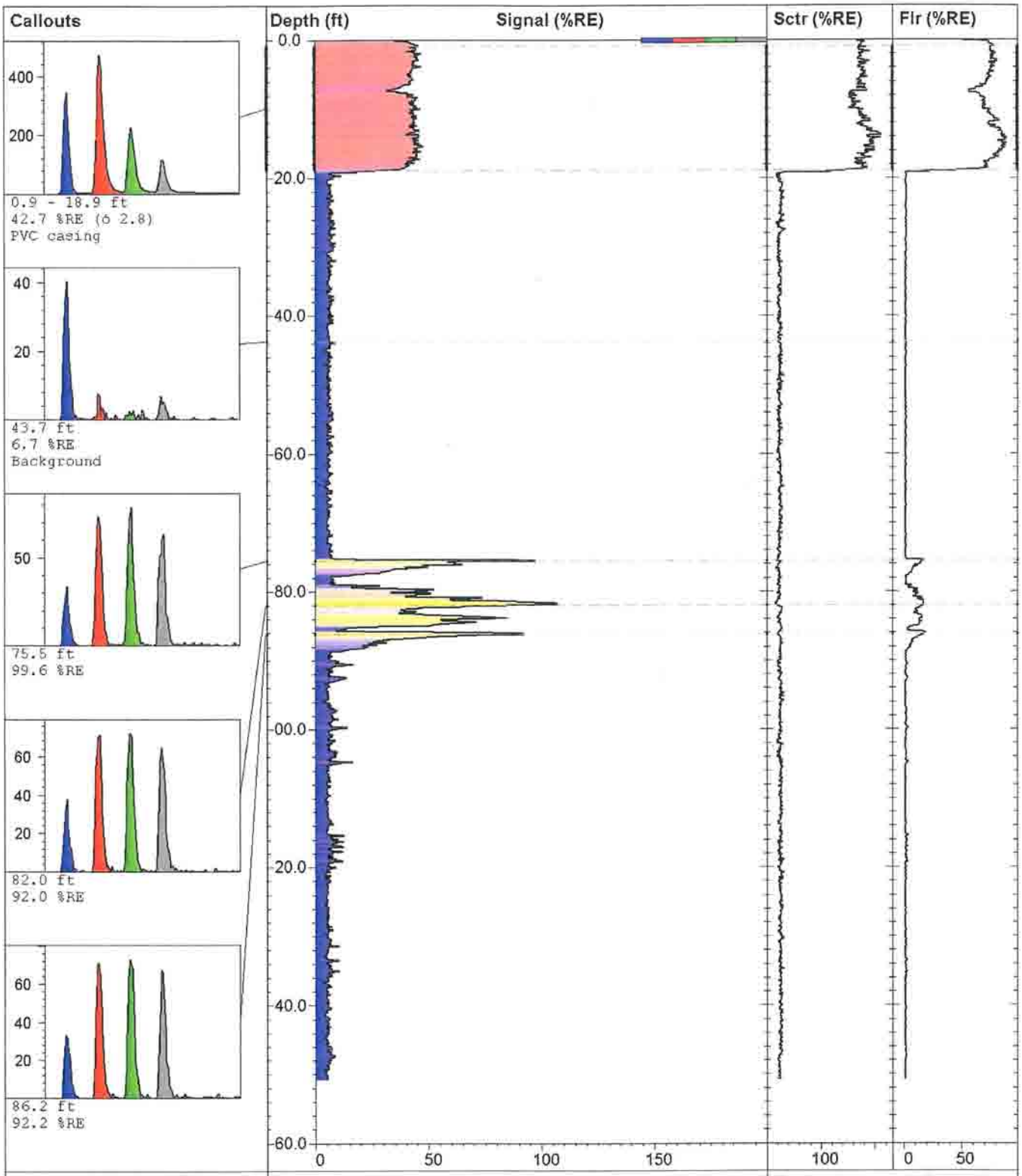
Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **150.16 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **102.3 % @ 41.66 ft**
Job: **2708**	*Operator/Unit:* **Steve Adamek/DTI01**	*Date & Time:* **8/25/2007 8:26:38 AM**



TG-9		**TarGOST By Dakota** www.DakotaTechnologies.com
Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **148.18 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **38.9 % @ 26.75 ft**
Job:	*Operator/Unit:* **T.Rudolph/DTI01**	*Date & Time:* **3/28/2008 2:18:09 PM**



TG-10

TarGOST By Dakota
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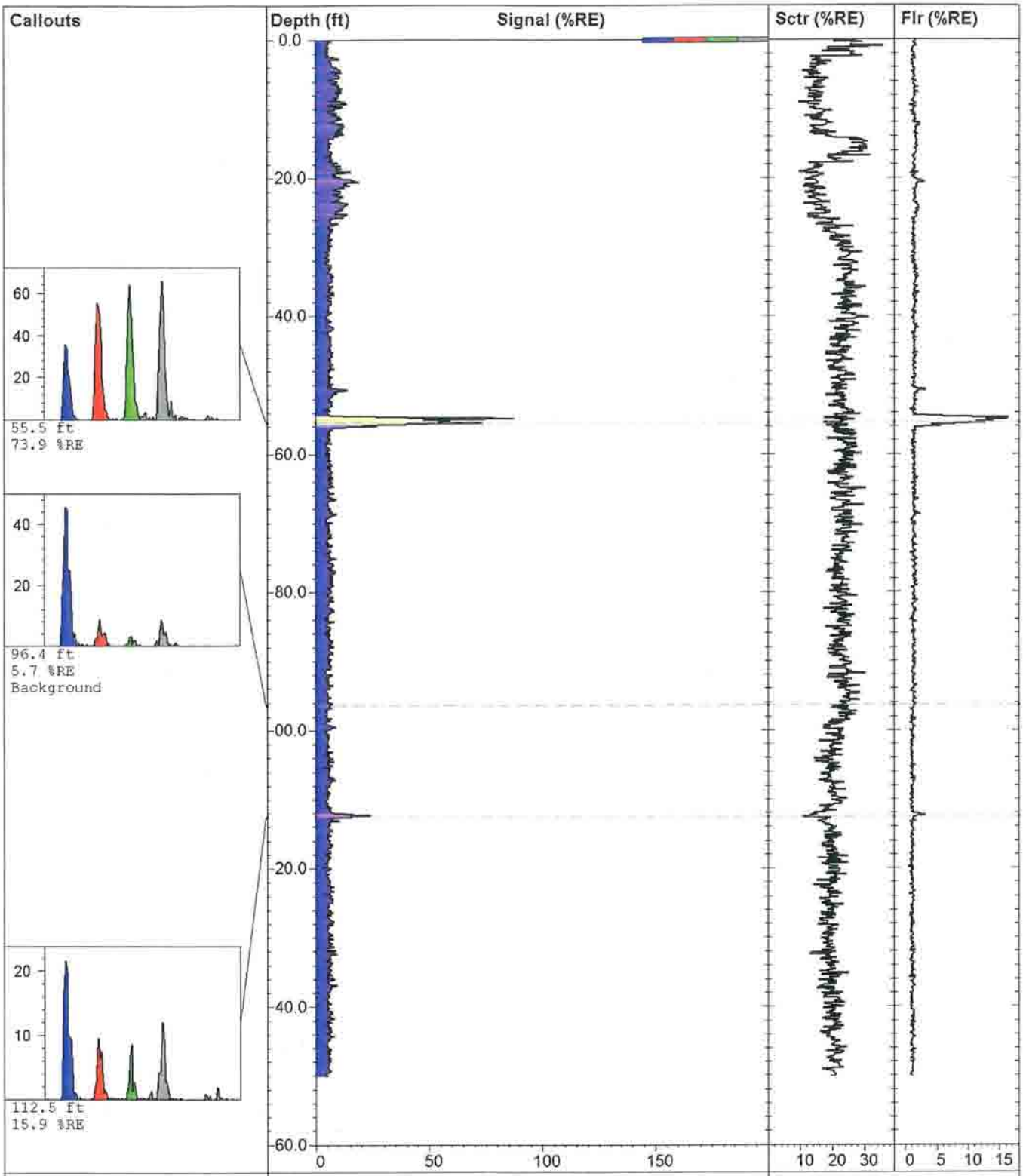
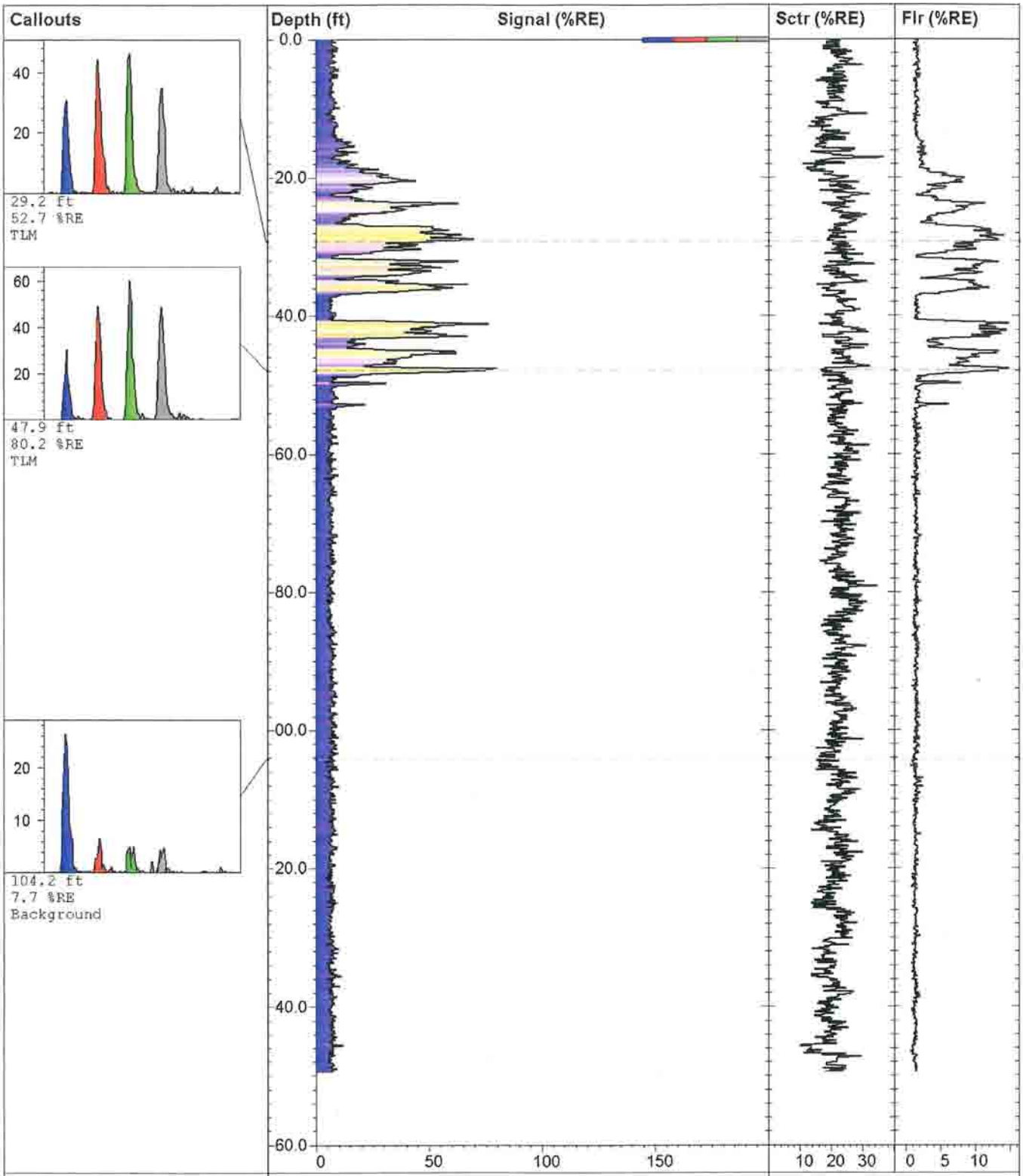
Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **150.85 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **107.3 % @ 81.81 ft**
Job:	*Operator/Unit:* **T.Rudolph/DTI01**	*Date & Time:* **3/29/2008 3:24:36 PM**



TG-11

TarGOST By Dakota
www.DakotaTechnologies.com

Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **150.18 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **94.0 % @ 54.78 ft**
Job:	*Operator/Unit:* **T.Rudolph/DTI01**	*Date & Time:* **3/29/2008 9:26:04 AM**



TG-12

TarGOST By Dakota
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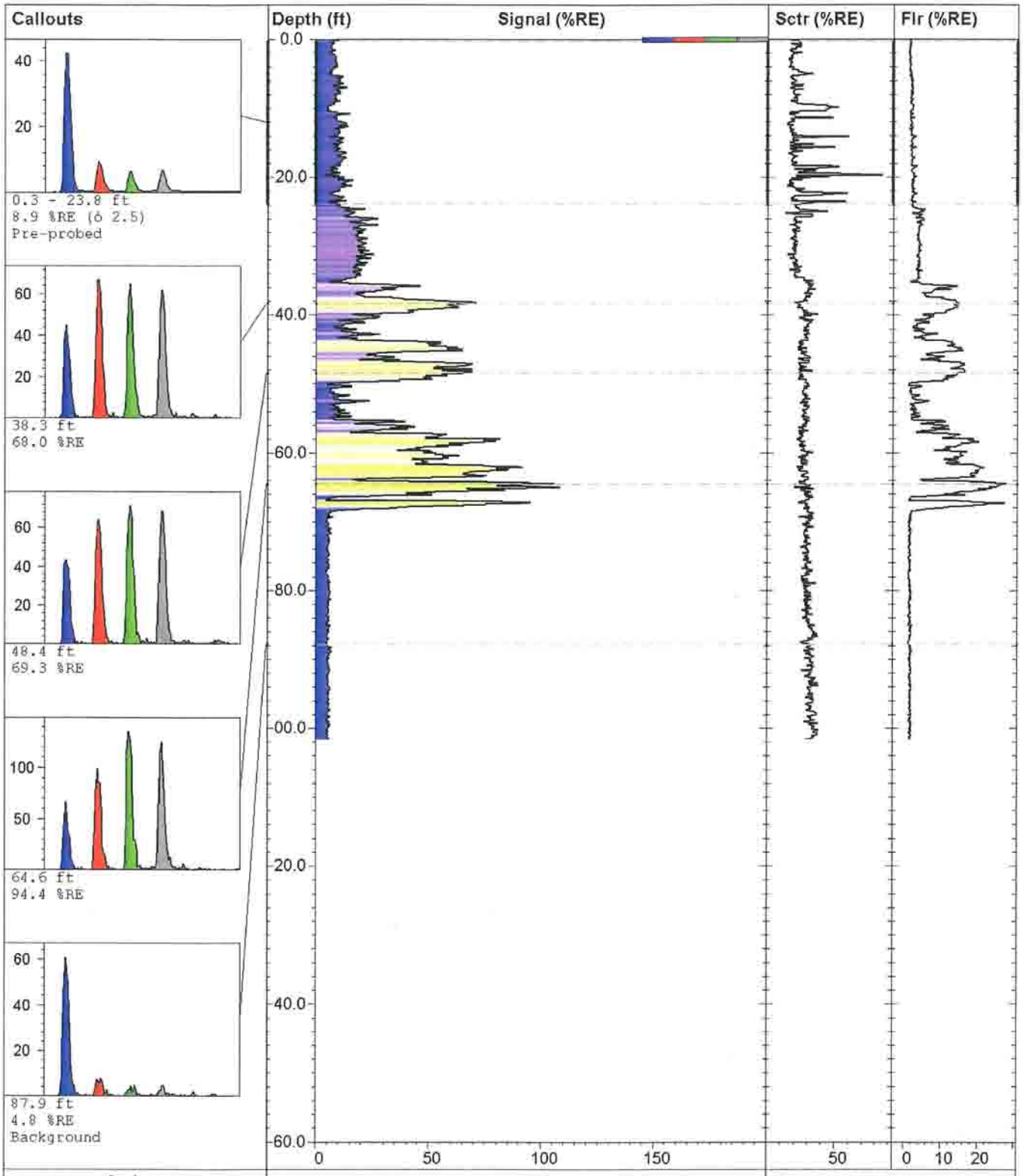
Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **149.52 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **82.7 % @ 47.61 ft**
Job:	*Operator/Unit:* **T.Rudolph/DTI01**	*Date & Time:* **3/28/2008 9:51:28 AM**



TG-13

TarGOST By Dakota
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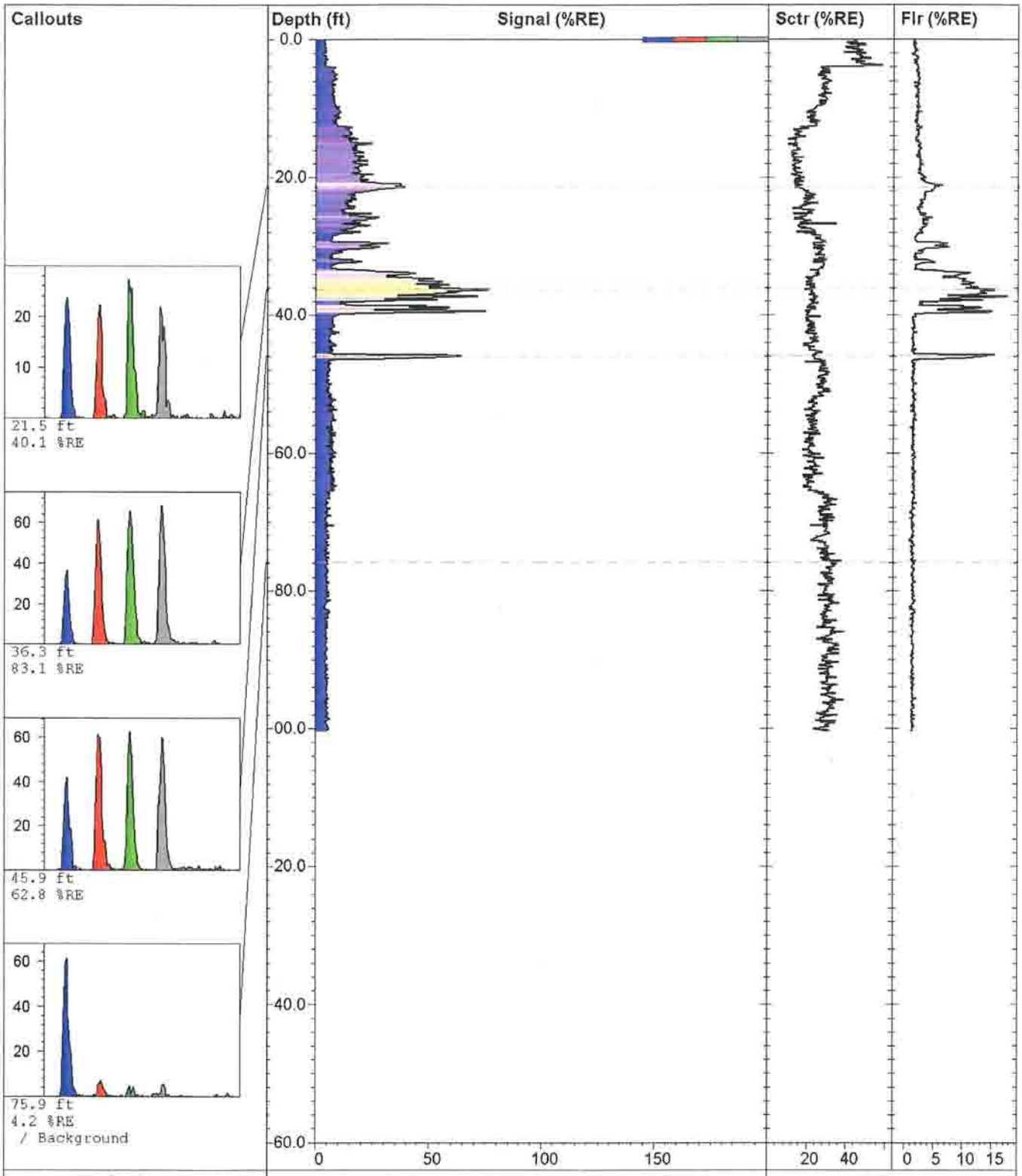
Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **101.70 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **113.6 % @ 64.97 ft**
Job:	*Operator/Unit:* **T.Rudolph/DTI01**	*Date & Time:* **3/30/2008 1:52:57 PM**



TG-14

TarGOST By Dakota
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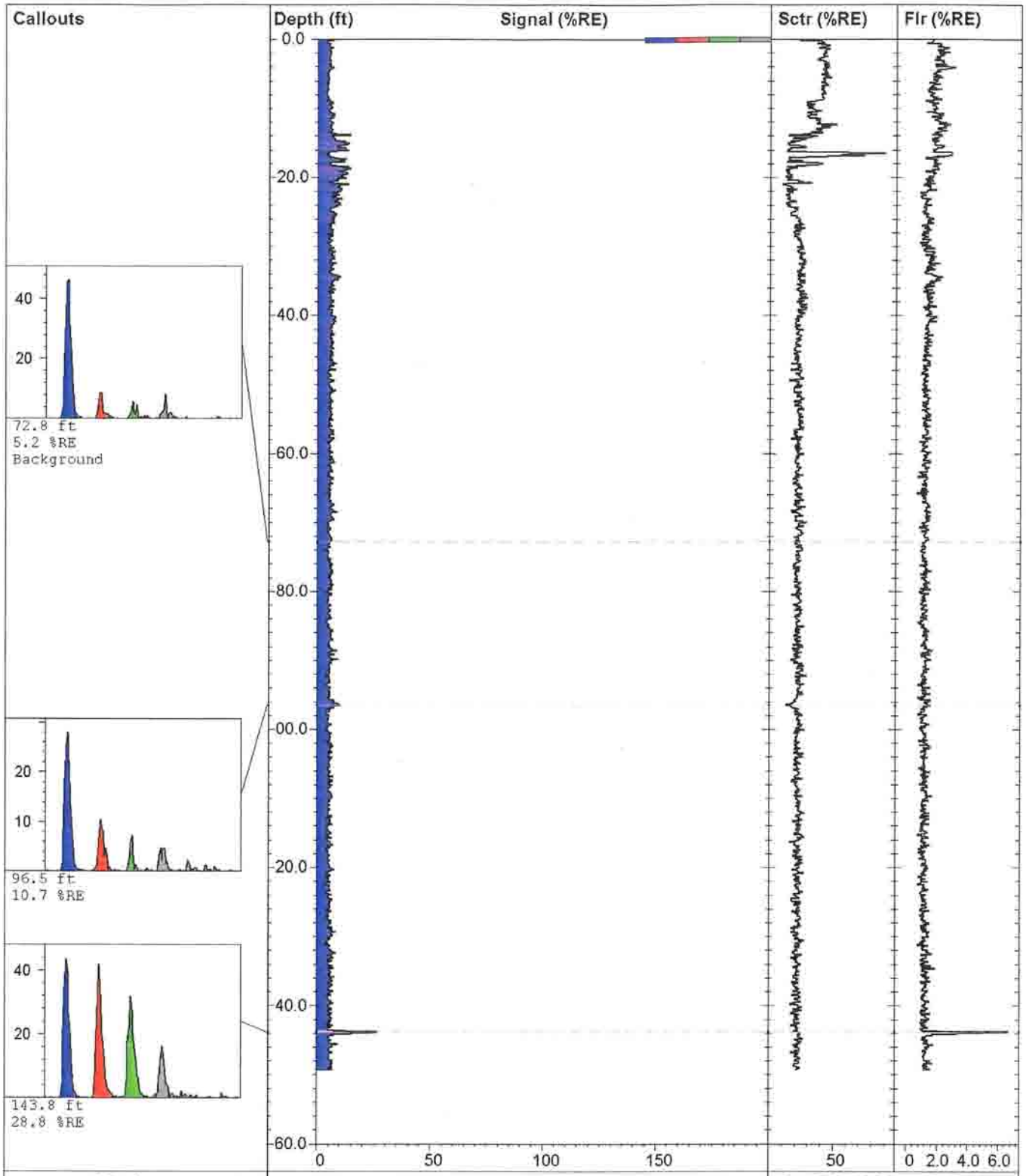
Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **100.48 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **83.1 % @ 36.28 ft**
Job:	*Operator/Unit:* **T.Rudolph/DTI01**	*Date & Time:* **3/28/2008 12:23:14 PM**



TG-15

TarGOST By Dakota
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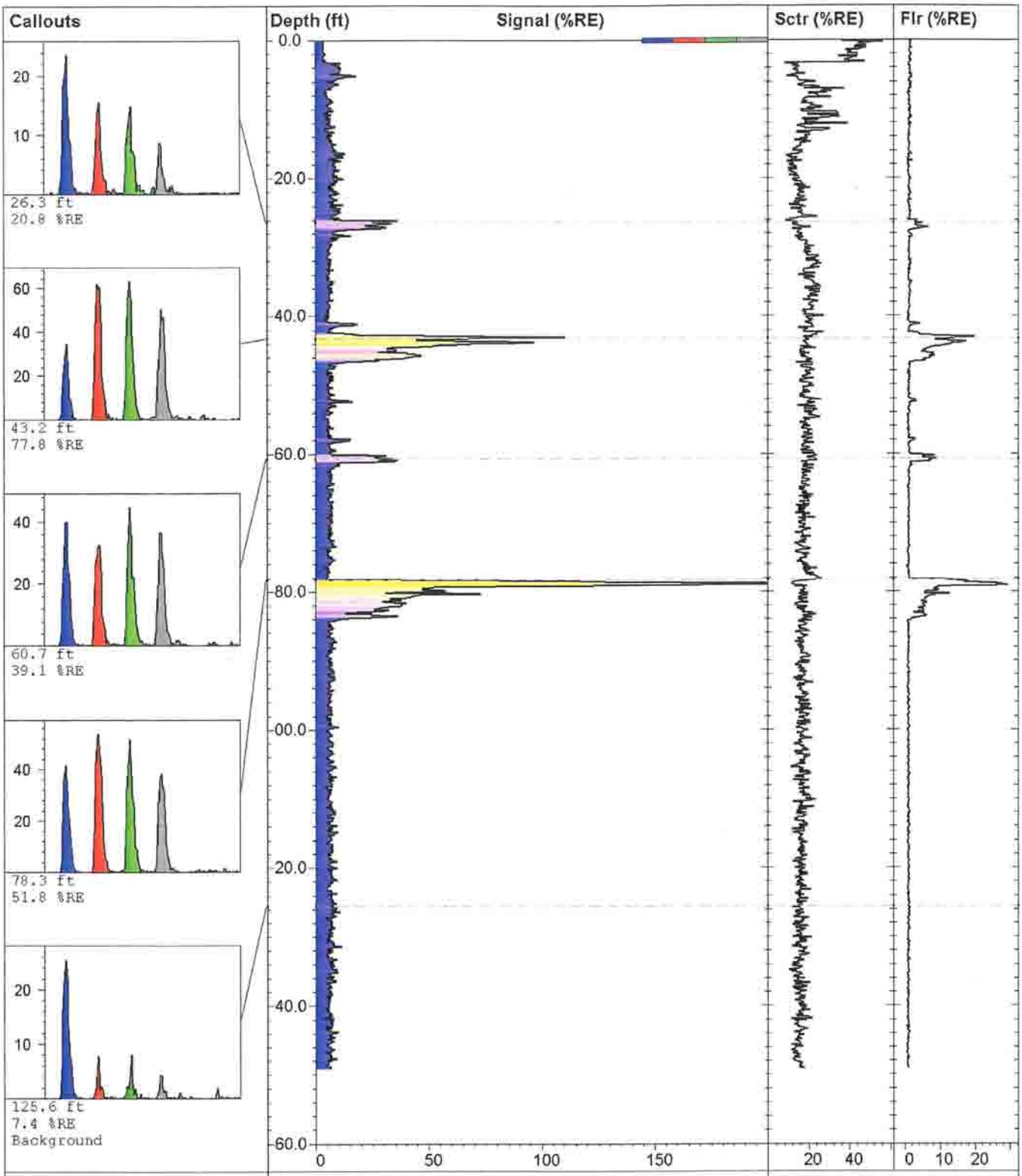
Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **149.42 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **28.8 % @ 143.81 ft**
Job:	*Operator/Unit:* **T.Rudolph/DTI01**	*Date & Time:* **3/29/2008 1:16:56 PM**



TG-16b

TarGOST By Dakota
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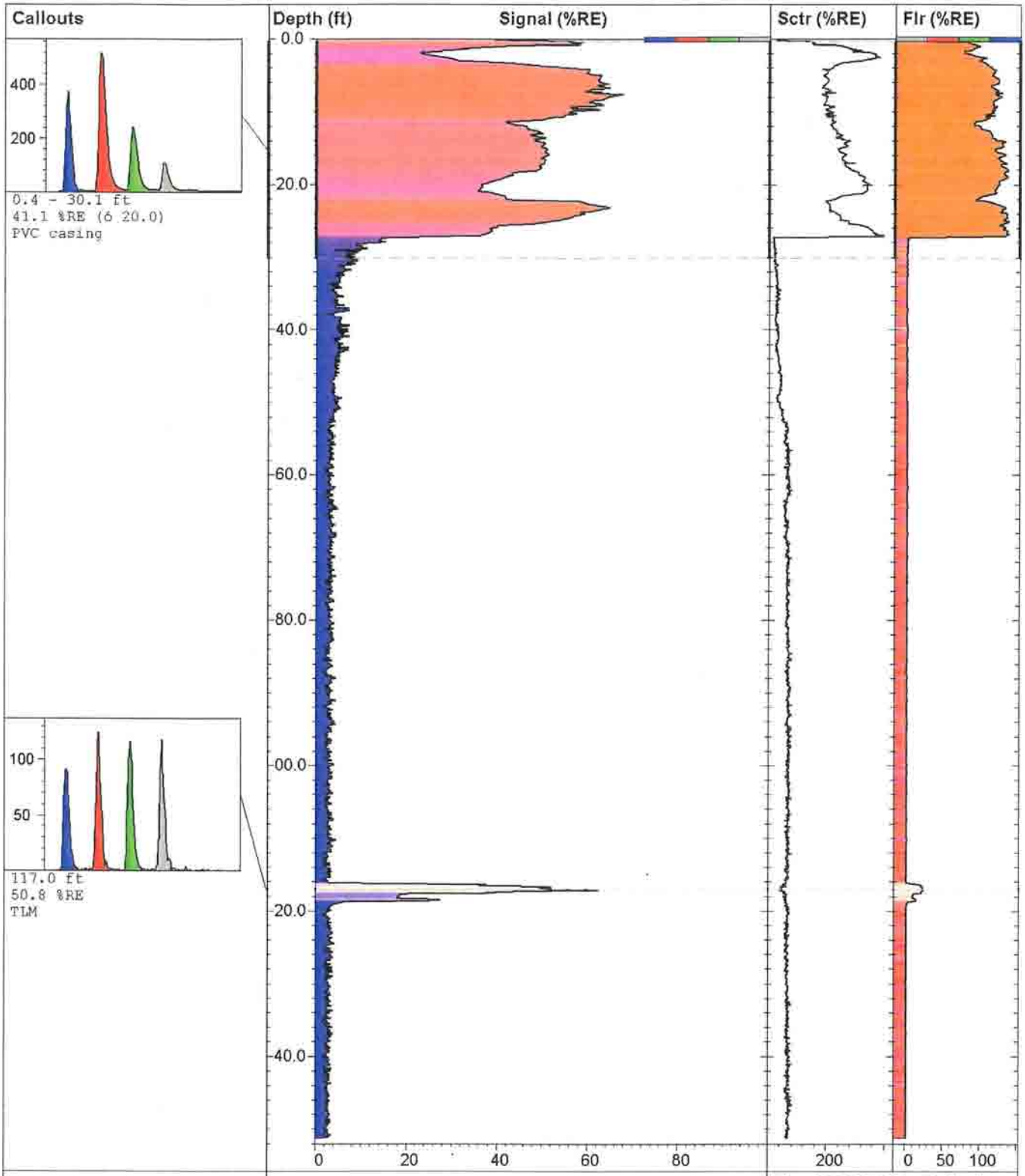
Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **149.14 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **232.1 % @ 78.99 ft**
Job:	*Operator/Unit:* **T.Rudolph/DTI01**	*Date & Time:* **3/30/2008 11:02:55 AM**

TARGOST BORING LOGS

TG-1S THROUGH TG-12S
SILTRONIC CORPORATION PROPERTY



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TG01S

TarGOST By Dakota
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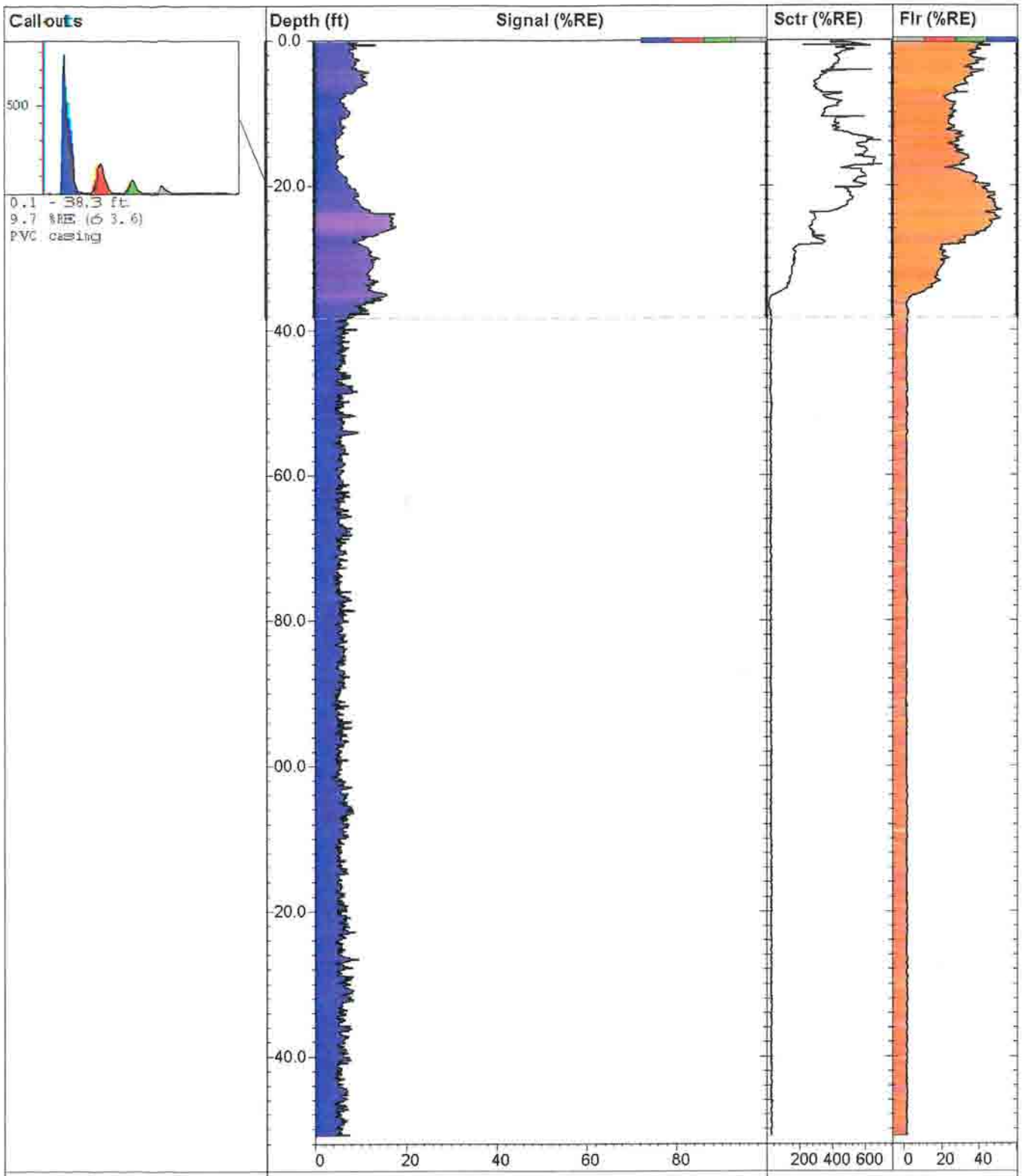
Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **151.27 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **67.7 % @ 7.64 ft**
Job: **2708**	*Operator/Unit:* **Steve Adamek/DTI01**	*Date & Time:* **9/5/2007 2:43:17 PM**



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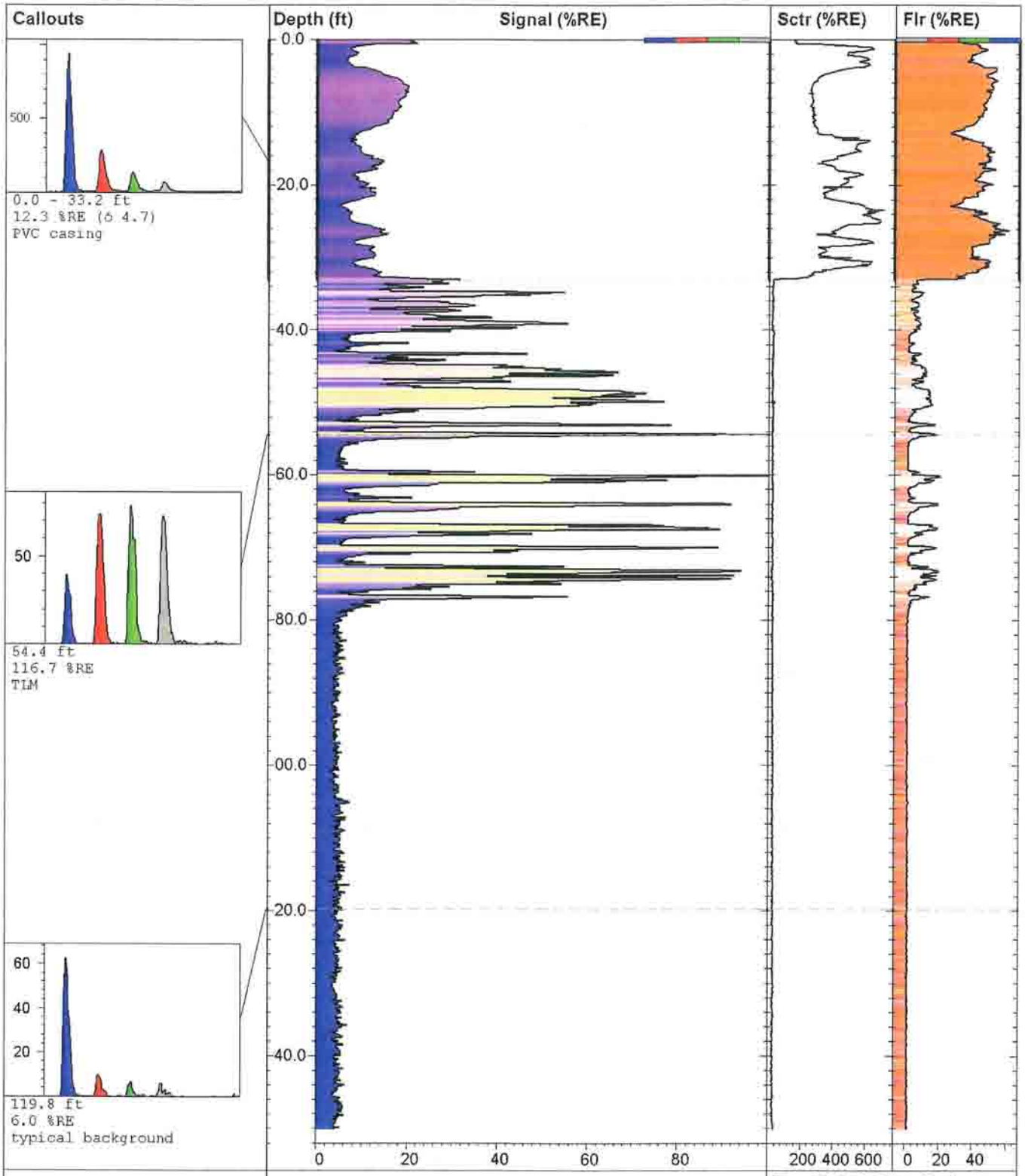
TG02Sc

TarGOST By Dakota
www.DakotaTechnologies.com

Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **151.04 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **19.4 % @ 35.72 ft**
Job: **2708**	*Operator/Unit:* **Steve Adamek/DTI01**	*Date & Time:* **9/7/2007 10:14:17 AM**



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TG03S

TarGOST By Dakota
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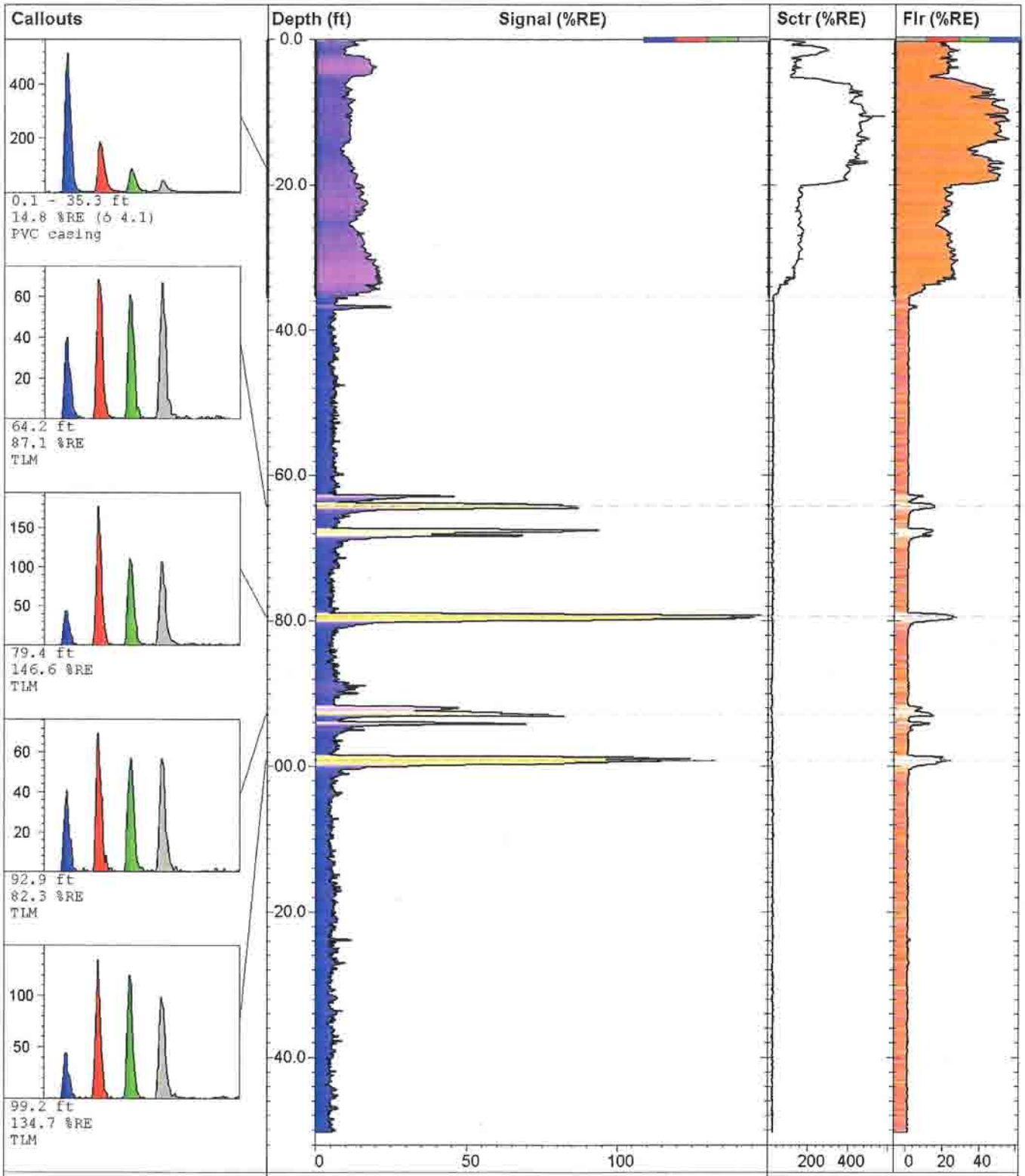
Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **150.19 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **116.7 % @ 54.40 ft**
Job: **2708**	*Operator/Unit:* **Steve Adamek/DTI01**	*Date & Time:* **9/8/2007 1:29:13 PM**



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TG04S

TarGOST By Dakota
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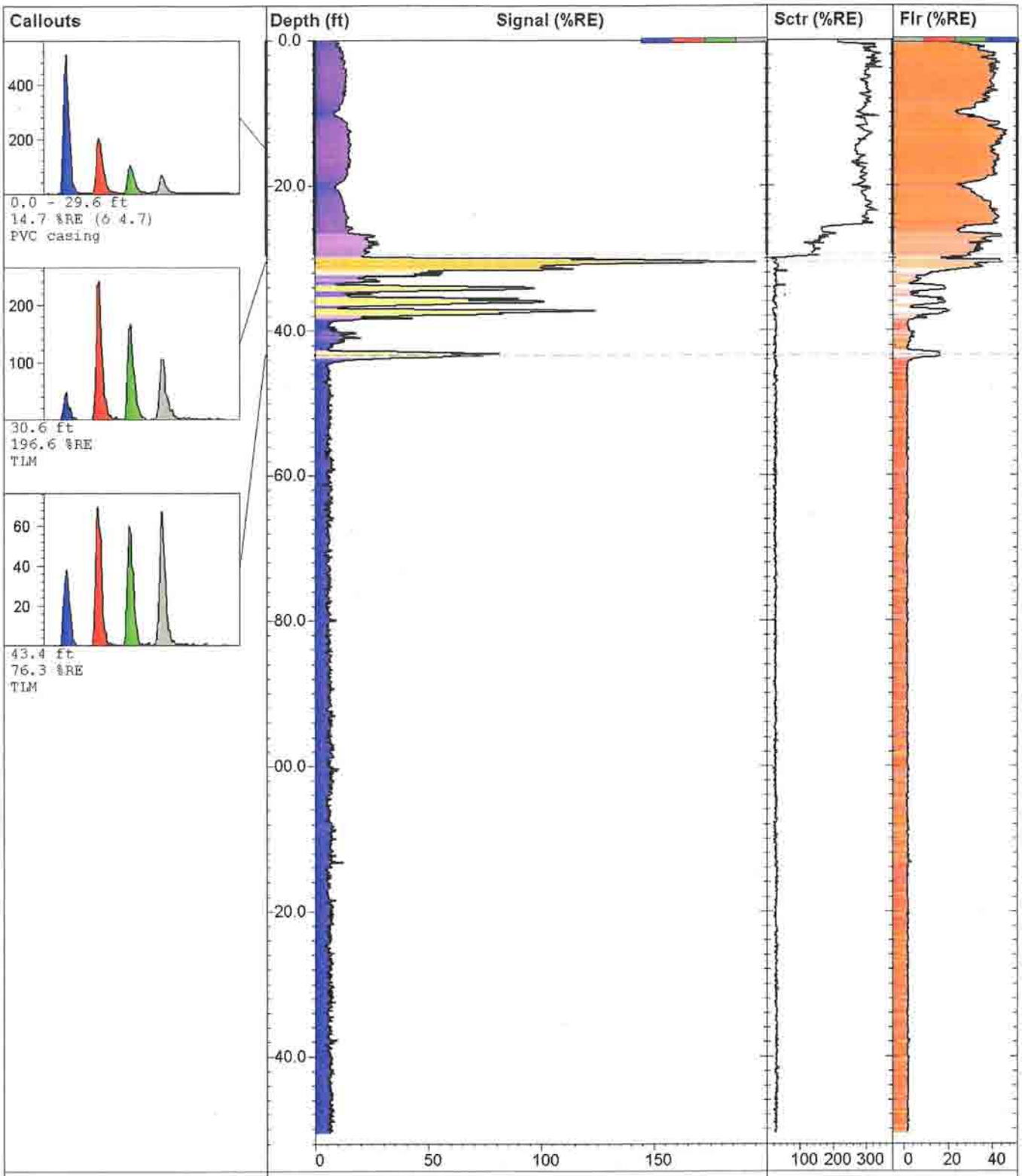
Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **150.33 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **150.2 % @ 79.23 ft**
Job: **2708**	*Operator/Unit:* **Steve Adamek/DTI01**	*Date & Time:* **9/7/2007 2:37:45 PM**



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TG05S

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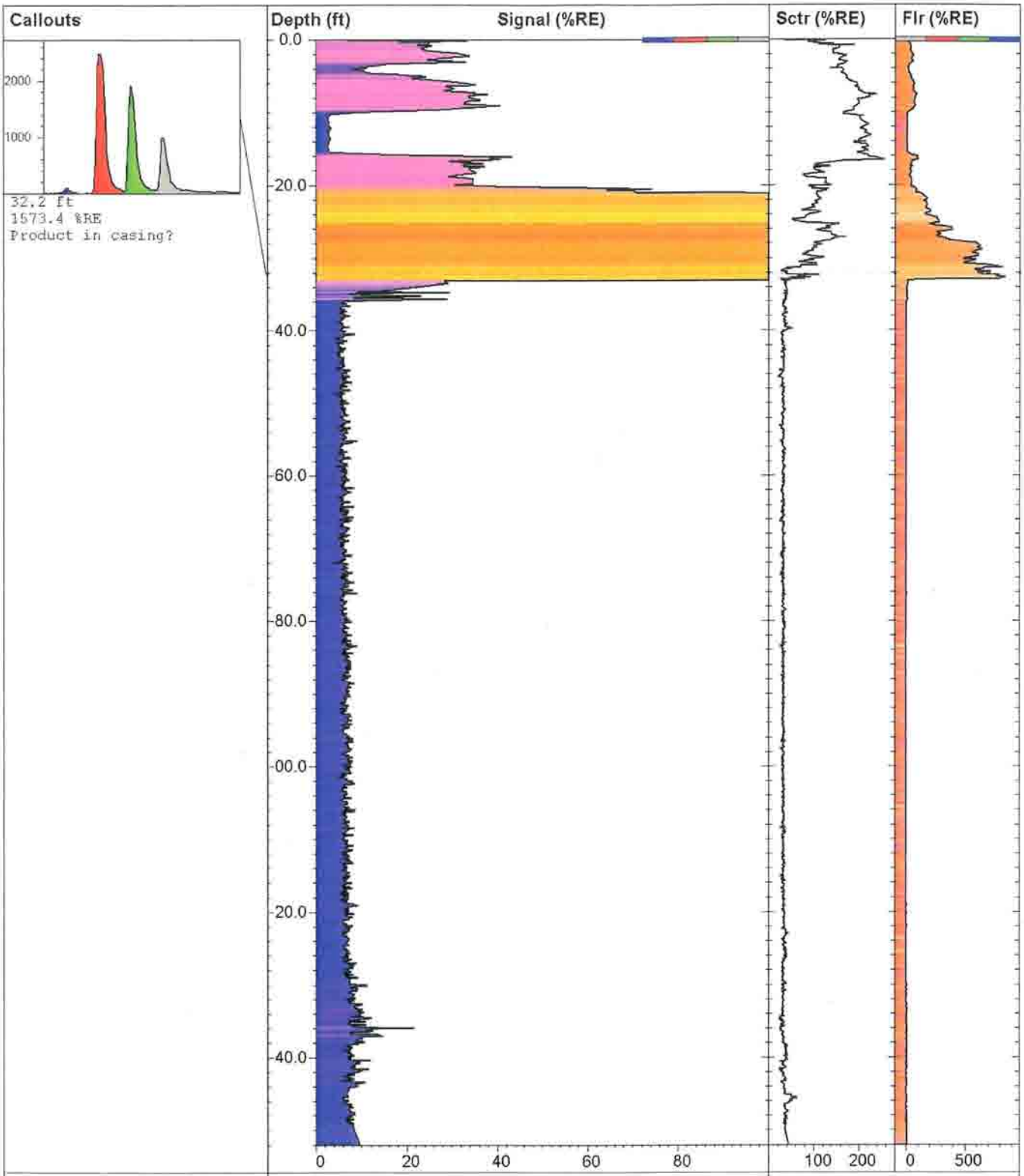
Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **150.57 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **210.4 % @ 30.24 ft**
Job: **2708**	*Operator/Unit:* **Steve Adamek/DTI01**	*Date & Time:* **9/6/2007 1:41:05 PM**



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TG06S

TarGOST By Dakota
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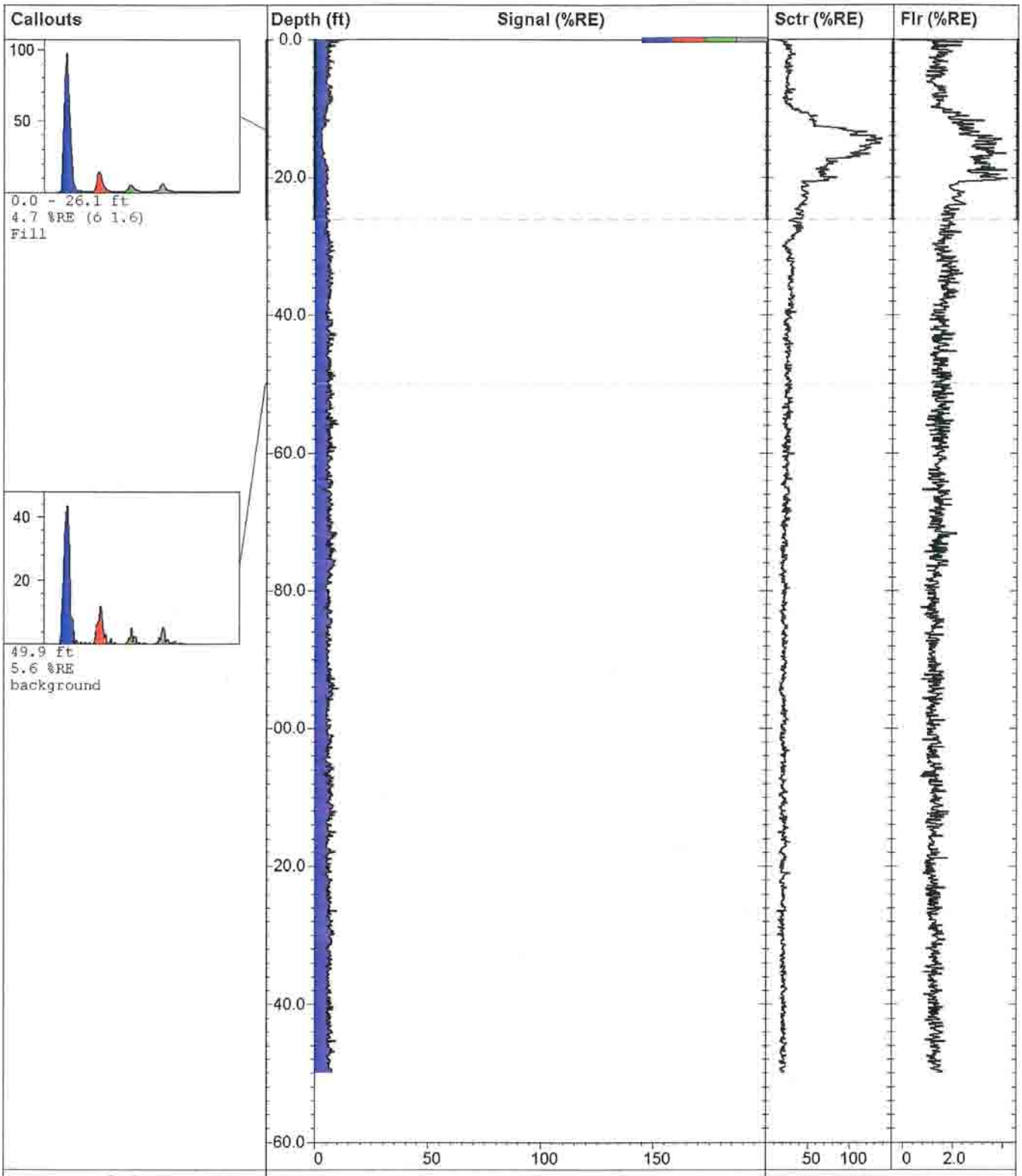
Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **152.00 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **2233.8 % @ 31.81 ft**
Job: **2708**	*Operator/Unit:* **Steve Adamek/DTI01**	*Date & Time:* **9/8/2007 8:54:59 AM**



TG-7Sb

TarGOST By Dakota
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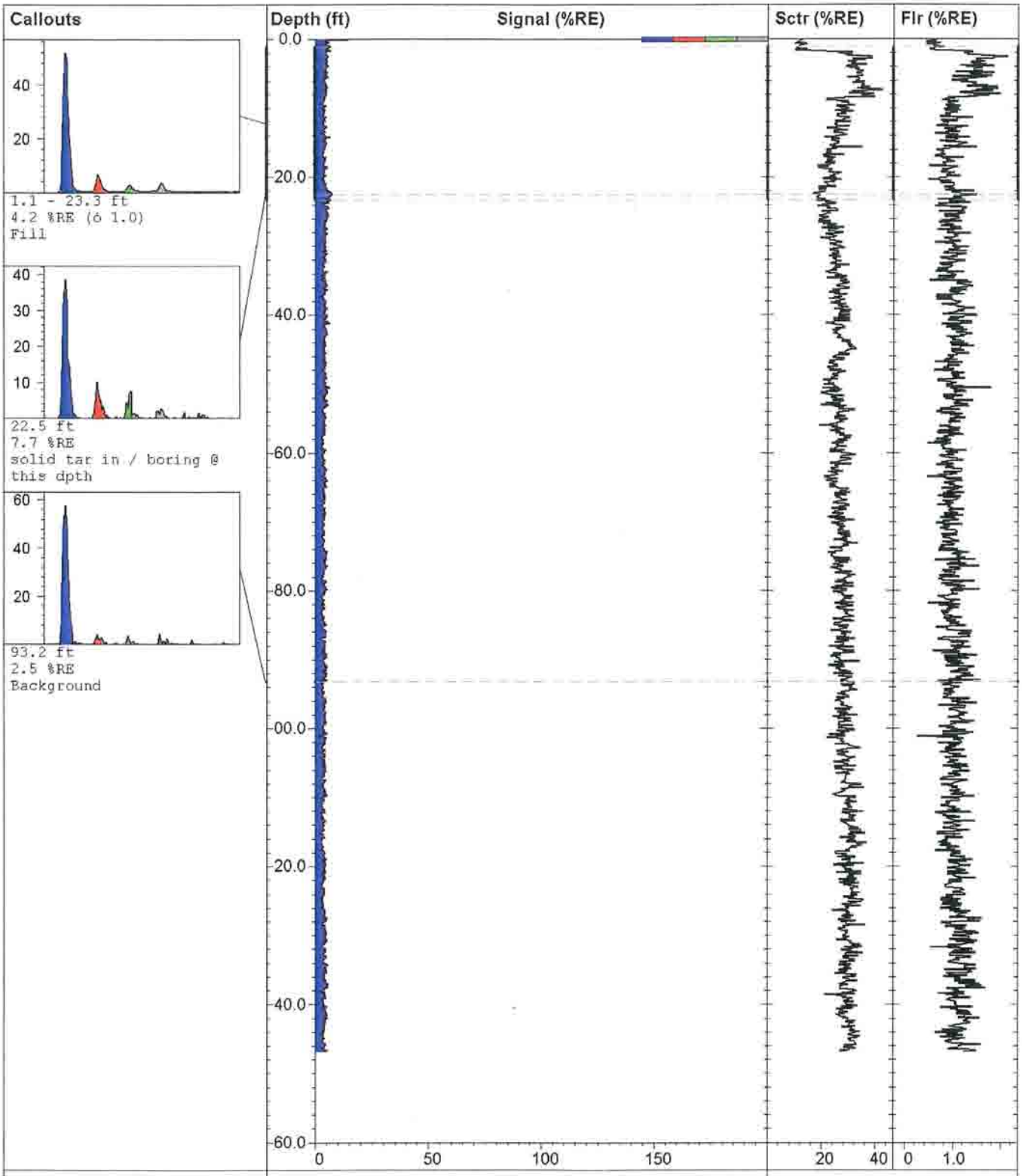
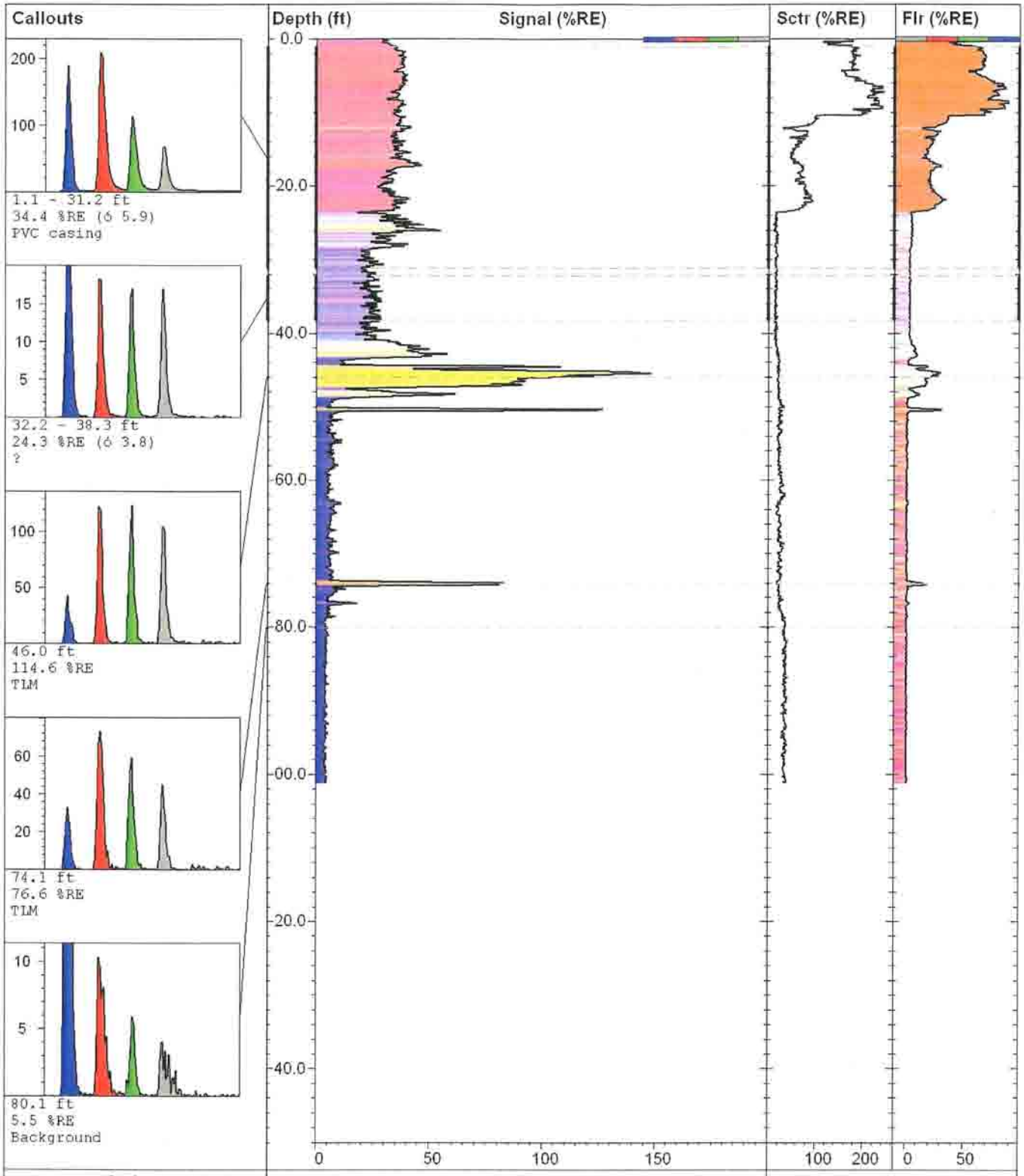
Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **149.98 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **12.1 % @ 0.00 ft**
Job:	*Operator/Unit:* **T.Rudolph/DTI01**	*Date & Time:* **3/26/2008 9:36:29 AM**



TG-8S

TarGOST By Dakota
www.DakotaTechnologies.com

Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **146.83 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **14.8 % @ 0.00 ft**
Job:	*Operator/Unit:* **T.Rudolph/DTI01**	*Date & Time:* **8/31/2007 4:38:07 AM**



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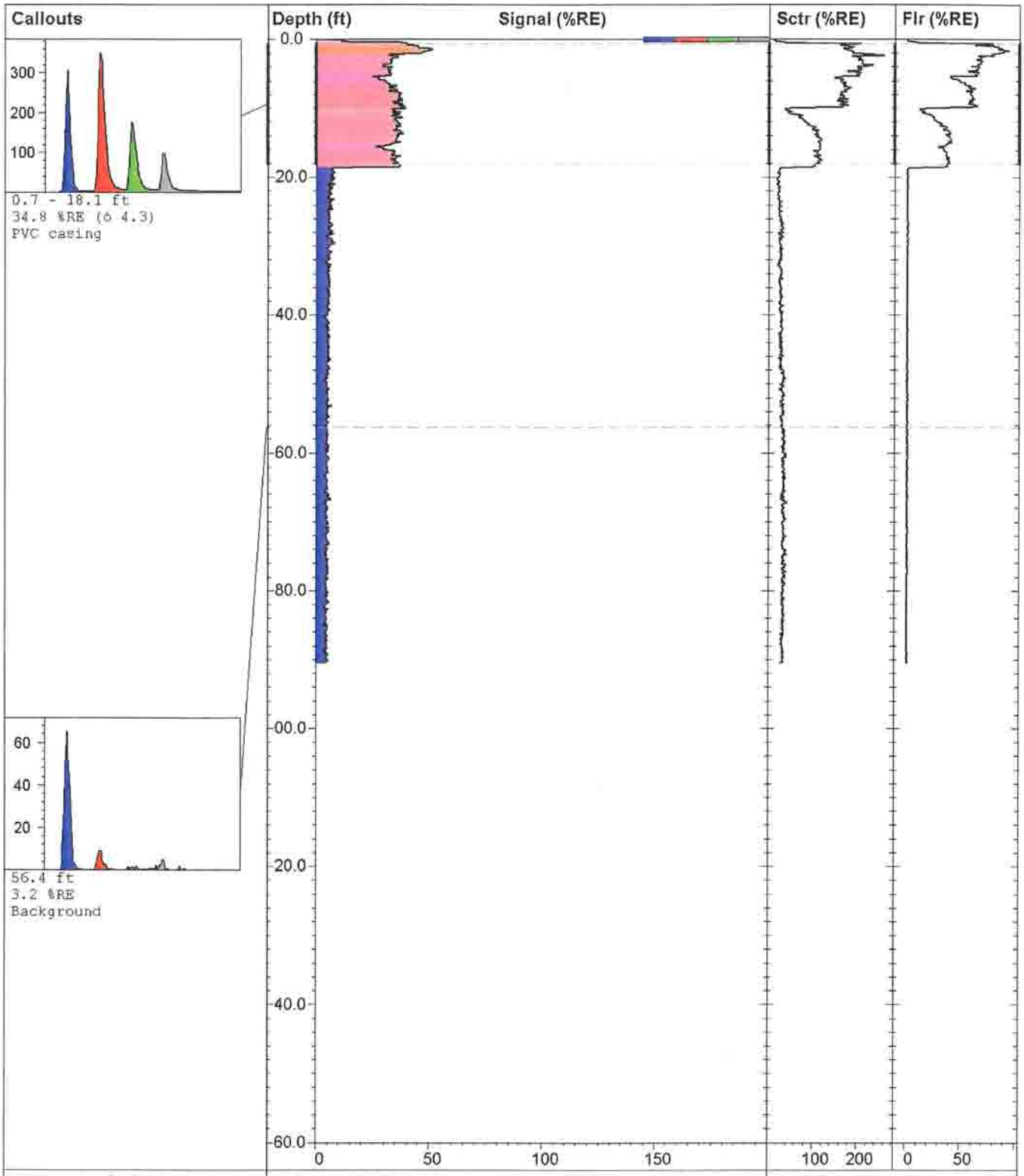
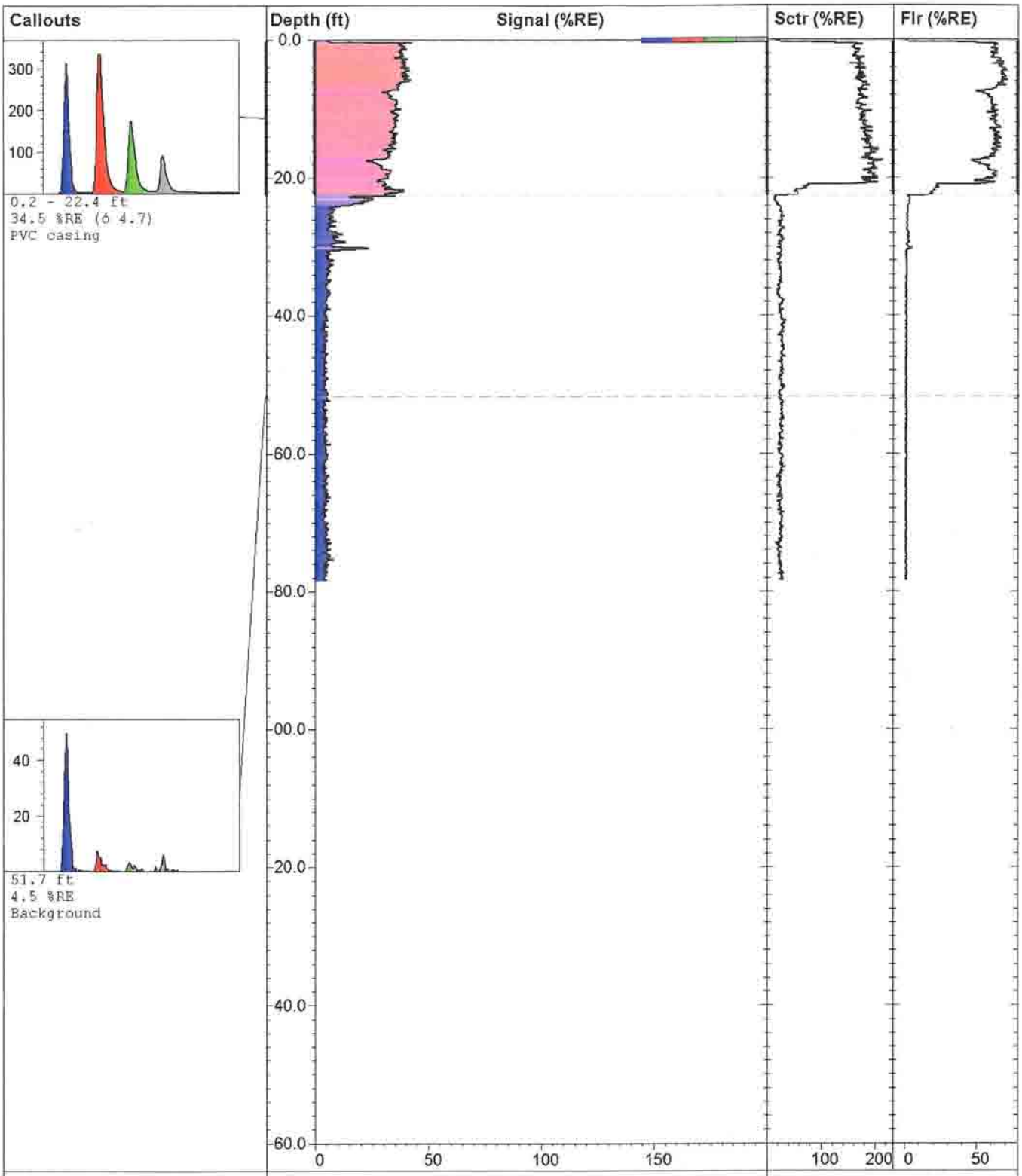
TG-9S		TarGOST
Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **101.32 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **148.4 % @ 45.48 ft**
Job:	*Operator/Unit:* **T.Rudolph/DTI01**	*Date & Time:* **3/26/2008 11:59:35 AM**



TG-10S

TarGOST By Dakota
www.DakotaTechnologies.com

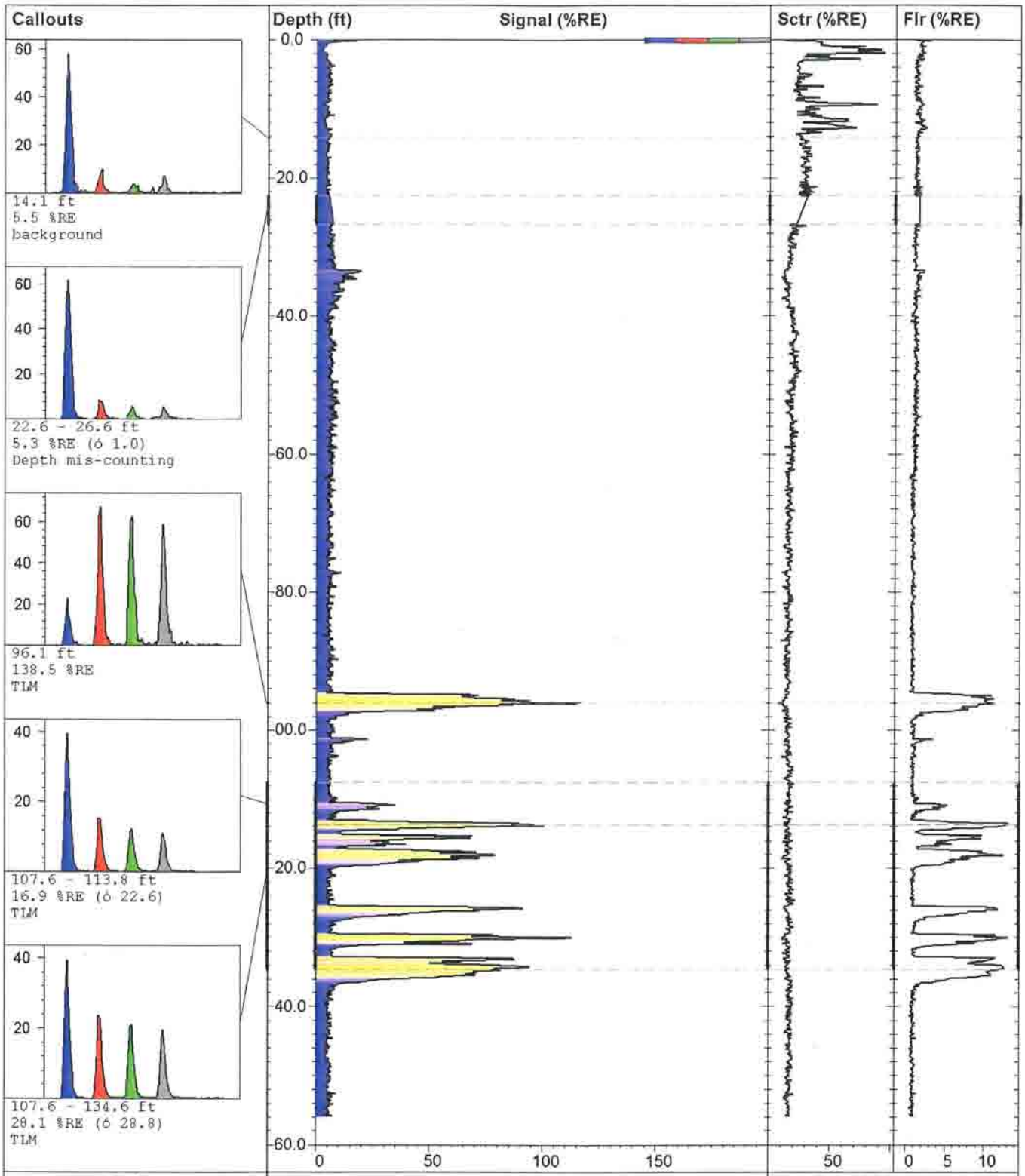
Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **90.54 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **52.2 % @ 1.36 ft**
Job:	*Operator/Unit:* **T.Rudolph/DTI01**	*Date & Time:* **3/26/2008 3:07:54 PM**



TG-11S

TarGOST By Dakota
www.DakotaTechnologies.com

Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **78.53 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **43.2 % @ 0.39 ft**
Job:	*Operator/Unit:* **T.Rudolph/DTI01**	*Date & Time:* **3/26/2008 4:59:47 PM**



TG-12S

TarGOST By Dakota
www.DakotaTechnologies.com

Site: **Portland, OR MGP**	*Latitude / System:* **Unavailable / NAD83**	*Final depth:* **156.02 ft**
Client: **Hahn & Associates, Inc.**	*Longitude:* **Unavailable**	*Max signal:* **138.5 % @ 96.05 ft**
Job:	*Operator/Unit:* **T.Rudolph/DTI01**	*Date & Time:* **3/27/2008 10:38:21 AM**

APPENDIX H
TECHNICAL MEMORANDUM, MARCH 18, 2009 EVALUATION OF DNAPL MOBILIZATION

ANCHOR QEA

6650 SW Redwood Lane, Suite 333
Portland, Oregon 97224
Phone 503.670.1108
Fax 503.670.1128
www.anchorqea.com

MEMORANDUM

To:	Bob Wyatt, NW Natural	**Date:**	March 18, 2009
From:	David Keith, Mike Riley, and John Edwards, Anchor QEA	**Project:**	000029-02
Cc:			
Re:	Evaluation of Potential DNAPL Mobilization in Former Effluent Pond Area by Shoreline Source Control Extraction Wells, Gasco Site, Portland, Oregon		

INTRODUCTION

This memorandum provides an evaluation of the potential for the mobilization of dense non-aqueous phase liquids (DNAPL) in the former effluent pond area as a result of groundwater pumping at the Gasco Site in Portland, Oregon. The evaluation is in response to an Oregon Department of Environmental Quality (DEQ) request that NW Natural assess the potential migration of DNAPL in the former effluent pond area under the pumping influence of shoreline source control wells.

The sources and distribution of DNAPL at the site are described in detail in the Remedial Investigation Report (RI) (HAI 2007). The RI Report describes root macropores in the former effluent pond area that provide a very limited method for migration of DNAPL through the silt in this area. The RI report also concludes that mobile DNAPL is now largely absent in the fill in the former effluent pond area. DNAPL recovery efforts conducted to date at Gasco and the findings from manufactured gas plant (MGP) sites around the United States have shown that mobile DNAPL oil migrates very slowly (Gerhard 2007), while the solid tar does not migrate at all. The results from TarGost borings completed in 2008 showed that the RI did a good job of defining the extent of DNAPL in the former effluent pond area.

Although DEQ has stated in recent documents that they believe DNAPL is currently migrating in lenses toward the shoreline, evidence of current movement has not been found. The extensive offshore investigations completed in 2007 (Anchor 2007) indicated that the only DNAPL present in shoreline sediments is very shallow and is the result of historic direct

discharge of effluent into the river, not the result of subsurface migration of DNAPL from the former effluent pond area into river sediments. This was conclusively demonstrated in near shoreline borings GS-01 through GS-12, where DNAPL was absent in deep sediments, thereby showing that DNAPL detected in upland nearshore alluvium has not migrated into nearshore sediments. Therefore, subsurface DNAPL has not migrated from upland site areas into river sediment after nearly 100 years since the former effluent ponds began operation.

In summary, these extensive investigations have shown that any migration of DNAPL that may exist occurs so slowly as to be insignificant. However, at DEQ's request we have prepared this technical memorandum to further evaluate the potential for DNAPL migration to be influenced during proposed source control activities.

The next section provides a conceptual model for DNAPL flow in the subsurface based on literature descriptions. The subsequent sections focus on development and interpretation of various analytical solutions specific to mobilization of subsurface DNAPL occurrences in saturated porous groundwater systems.

DNAPL CONCEPTUAL SITE MODEL

Subsurface DNAPL is acted upon by three distinct forces in a groundwater environment (Yan et al. 1994) including:

1. Gravity
2. Capillary pressure
3. Hydrodynamic force

After release, DNAPLs will generally migrate vertically downward because they are denser than groundwater and gravitational forces are dominant compared to hydraulic forces in most groundwater systems. The rate of flow of a DNAPL through a geologic medium depends on: 1) the density and viscosity of the DNAPL; 2) the pressure driving the DNAPL migration; 3) the intrinsic permeability of the geologic medium; and 4) the degree of DNAPL saturation of the pore space in the medium. More permeable media and higher DNAPL saturations will permit higher rates of DNAPL flow. Higher-density and lower-viscosity fluids, such as chlorinated solvents, are subject to higher flow rates than lower-density and higher-viscosity fluids such as MGP wastes like those at Gasco (Pankow and Cherry 1996).

Nearly all movement of subsurface DNAPL occurs within zones of continuous (i.e., connected) DNAPL. In such zones, the DNAPL in different pore openings forms an immiscible-phase continuum through the intervening pore throats. Once the release of DNAPL into the subsurface ceases, the forces driving DNAPL movement eventually dissipate and the DNAPL in the pore openings become disconnected to form zones of residual DNAPL. DNAPLs distribute themselves in the subsurface in the form of disconnected blobs and ganglia of organic liquid referred to as residual occurrences, and in higher saturation configurations along bedding discontinuities referred to as pools (Gerhard et al. 2007). Very high hydraulic gradients are required in groundwater to induce movement of residual DNAPL occurrences (Pankow and Cherry 1996), which is one of the reasons remediation/recovery of DNAPL is so difficult. Wilson and Conrad estimated that a gradient of 0.1 foot/foot is necessary to start some blobs or ganglia of DNAPL moving in a fine gravel (approximately 10 cm/sec permeability). This is a steep, but not unreasonable, gradient. However, typical hydraulic gradients at Gasco are two orders of magnitude lower than 0.1 foot/foot, and there are no gravel zones associated with DNAPL at the Site. In a medium sand (approximately 10^{-3} cm/sec permeability), the gradient necessary for residual DNAPL movement is on the order of 10 feet/foot.

For most DNAPLs, which are non-wetting on the mineral grains of an aquifer with respect to water, water will coat the soil grains and occupy the smaller pores and pore throats; therefore, the DNAPL is restricted to the larger pore openings. When the DNAPL is non-wetting, like the DNAPL at Gasco, capillary forces oppose the entry of the DNAPL into wet geologic media. The forces driving subsurface DNAPL movement are a function of the DNAPL density and the pressures resulting from its release into the subsurface. For DNAPL movement to occur in wet media, these driving forces must overcome the capillary resistance. The DNAPL in the larger pore openings must deform to pass through smaller pore throats to reach other pore openings. The pressure required for this deformational movement is the entry pressure. The value of the entry pressure is proportional to the interfacial tension between the DNAPL and the water, and inversely proportional to the size of the pore throats. Therefore, the entry of a DNAPL into a fine-grained porous medium or into a fractured medium having small apertures requires high driving forces to overcome high entry pressures.

Consequently, low permeability strata (permeabilities of 10^{-5} cm/sec or less) can be barriers to DNAPL migration (Pankow and Cherry 1996). Vertical permeability tests were run on six

shelby tube samples obtained during geotechnical soil borings completed along the proposed vertical barrier alignment in 2007. This work was done at the request of DEQ. The samples were obtained at depths ranging from 61 to 96 feet below top of the shoreline bank. Following are the measured vertical permeabilities in cm/sec:

Silt	4.42E-07
Clayey silt	9.60E-08
Clayey silt	1.67E-07
Clayey silt w/fine sand	3.19E-07
Clayey silt w/fine sand	2.68E-07
Fine sand	6.14E-05

Subsurface investigations have shown that the upper alluvium contains a higher percentage of fine-grained layers than the lower alluvium. This explains why DNAPL is not found below the upper alluvium in most of the former effluent pond area.

The Gasco Site is underlain by a heterogeneous granular aquifer. In these environments, small horizontal zones of residual or free-phase DNAPL are not solely caused by particularly low permeability zones such as silt or clay. A minor contrast in grain size distribution and permeability, as from a coarse sand layer to a finer sand, causes variation in DNAPL entry pressure. A DNAPL moving downwards through a coarse-grained material will encounter a higher entry pressure when a finer-grained layer is contacted. This will cause lateral spreading of the DNAPL. The DNAPL will accumulate on the finer-grained layer while spreading laterally until it reaches the edge of the layer, or until the height of free product accumulation on the layer exceeds the entry pressure for the layer. In the latter case, the DNAPL will pass through the layer and continue its downward movement towards the bottom of the aquifer (Pankow and Cherry 1996). Pools of DNAPL generally form at stratigraphic discontinuities, where finer-grained and lower permeability materials prevent vertical DNAPL migration because intergranular surface tension and capillary forces prevent further penetration. It should be noted that DNAPL pools that form on stratigraphic discontinuities will generally flow in the direction of stratigraphic dip because of gravitational forces, and this direction may be different than the dominant direction of groundwater flow defined by the hydraulic gradient.

DNAPL MOBILIZATION AT GASCO

Based on the conceptual models for the distribution of DNAPL in groundwater environments described above, and site observations of the occurrence of DNAPL at Gasco, there are two cases for potential mobilization of DNAPL as a result of pumping, including:

- Mobilization of a DNAPL pool
- Mobilization of residual ganglia or blobs of DNAPL

Case 1. Mobilization of a DNAPL Pool

McWhorter (1992) provided an equation that describes the movement of a DNAPL pool along a stratigraphic discontinuity at a slope (a) to horizontal as follows:

$$q_{nwi} = \frac{-kk_{rnw}}{\mu_{nw}} p_w g \frac{d}{dx_i}\left[h + \frac{Pc}{p_w g} + \frac{\Delta p}{p_w} z\right] \tag{1}$$

Where:

q_{nwi}	=	DNAPL mass flux
k	=	the intrinsic permeability
k_{rnw}	=	the relative permeability to DNAPL
μ_{nw}	=	the viscosity of the DNAPL
p_w	=	the water density
g	=	the gravitational acceleration
h	=	the hydraulic head in the aqueous phase
Pc	=	the capillary pressure
Δp	=	the density difference between the DNAPL and water
z	=	the vertical coordinate
x_i	=	the coordinate direction (defined as the direction of slope)

At equilibrium, the flux of DNAPL is 0 and Equation 1 becomes:

$$\frac{d}{dx_i}\left[h + \frac{Pc}{p_w g} + \frac{\Delta p}{p_w} z\right] = 0 \tag{2}$$

Integrating Equation 2 from 0 to L (the length of a DNAPL pool) yields the following equation:

$$p_w \frac{dh}{dx_i} L\cos\alpha + \frac{Pc}{g} + \Delta p L \sin\alpha = 0 \qquad (3)$$

Where

α = the slope angle as defined in Figure 1

Physically, the first term in Equation 3 represents the hydraulic force acting on a unit area of DNAPL, the sign of which can be positive or negative, depending on whether water flow is upslope or downslope compared to the dip of the host stratigraphy. The second term represents the capillary force that is resisting the flow of DNAPL. This force is always opposite to that of the resultant of the hydraulic flow and gravity forces. The third term is the gravity or buoyancy force of DNAPL at equilibrium in the direction of the stratigraphic dip (Yan et al. 1994).

Geologic three point problems were solved on the top of two continuous apparent bedding layers from cross sections at Gasco to determine the slope of bedding at the Site. Figure 2 is a map showing the locations of the TarGost borings used to assess the slope of bedding at the Site. The base of fill/top of silt and the top of the lower sand layer were used for the calculations. The calculated angles for those bedding layers were less than 0.5 degrees and indicate that the bedding that DNAPL would tend to pool on at Gasco is essentially horizontal. Table 1 shows the slope of the bedding layers. This information was developed from the TarGost borings provided on the left side of the table.

Table 1
Summary of Bedding Strike and Dip Calculations for the Base of Fill/Silt and Top of Medium Sand Contacts

Borings			Base of Fill/ Silt contact			Top of Medium Grained Sand		
			Gradient (ft/ft)	Direction (degrees)	ATAN of Gradient (Alpha - degrees)	Gradient (ft/ft)	Direction (degrees)	ATAN of Gradient (Alpha - degrees)
TG-3	TG-5	TG-11	0.037	21	0.037	0.10	39	0.10
TG-3	TG-5	TG-8	0.065	26	0.065	0.11	39	0.11
TG-1	TG-7	TG-3	0.019	335	0.019	0.15	229	0.15
TG-1	TG-1S	TG-13	0.033	28	0.033	0.32	48	0.31

Because Sinα ≈ 0 and Cos α ≈ 1 under these conditions, Equation 3 reduces to:

$$pw\frac{dh}{dx_i}L + \frac{Pc}{g} = 0 \qquad (4)$$

Groundwater model output for the Site previously presented to the Oregon DEQ (Anchor and SSPA 2008) included predicted groundwater gradients under ambient and pumping conditions, and these results were used to evaluate potential DNAPL movement due to hydraulic stress (Anchor and SSPA 2008). These results were combined to look at the change in groundwater gradient between ambient and pumping conditions. A review of the model output shows the shallow well configuration imposes the largest increase in groundwater gradients and the intermediate well configuration has the least effect. The subsurface profiles on Figures 3a, 3b, and 3c show the predicted gradients using shallow, intermediate depth, and paired extraction wells. Figure 3d shows the map location of the subsurface profiles. Groundwater gradients in the former effluent pond area under the shallow extraction well configuration increase by 0.01 to 0.02 while groundwater gradients increased by only 0.001 to 0.002 with intermediate depth extraction wells.

The maximum effect of these changes in gradient can be computed from Equation 1 by making the following assumptions:

- Capillary forces = 0
- Stratigraphic slope (α) = 0, which has been shown to be negligible at the Site
- Relative permeability = 1, which is the maximum value
- Intrinsic permeability computed for the Site = 6e-8 cm2
- Porosity = 0.3

These assumptions provide the maximum DNAPL velocity that can be expected due to pumping, and travel distance derived for different time periods can be computed. The results are shown in the Table 2 for changes in gradient in the former effluent pond area due to shallow and intermediate depth extraction wells.

Table 2
Predicted Horizontal DNAPL Travel Distance due to Increased Gradient from Nearshore Groundwater Pumping

Extraction Well Configuration	Groundwater Gradient Increase in Former Effluent Pond Area	Velocity (ft/day)	Distance traveled (ft) over the following time periods			
			0.5 years	1 year	2 years	3 years
Shallow Depth Extraction Wells	0.01	0.0047	0.9	1.7	3.5	5.2
	0.02	0.0095	1.7	3.5	6.9	10.4
Intermediate Depth Extraction Wells	0.001	0.00047	0.1	0.2	0.3	0.5
	0.002	0.00095	0.2	0.3	0.7	1.0

From this analysis, enhanced groundwater movement in the former effluent pond area due to shoreline extraction wells is minimal and would not substantially change DNAPL distribution over time, especially if the capillary term were factored into the calculation. The analysis also shows that pumping from the intermediate wells produces significantly smaller potential distances of travel. Therefore, it is unlikely that that shallow extraction wells will be selected for design of the shoreline extraction system.

Case 2. Mobilization of Residual Ganglia or Blobs of DNAPL

Residual DNAPL in the form of ganglia or blobs can also be mobilized by increasing hydraulic gradients, such as what may occur during pumping. In this case, the capillary number, (σ), the ratio of capillary to viscous forces, provides a measure of the propensity of DNAPL trapping and mobilization (Cohen and Mercer 1993). It is defined as:

$$Nc = \frac{kpwgJ}{\sigma} \tag{5}$$

Where:

σ = the interfacial tension between the DNAPL and water

J = the hydraulic gradient

Other terms are defined in Equation 1

The critical value (N_c) of the capillary number is defined as the value at which motion of some of the DNAPL blob is initiated. Based on experimental data, Wilson and Conrad (1984)

noted a strong correlation between displacement of residual DNAPL and the capillary number. Conrad and Wilson found that initial movement occurred when the gradient produced N_c values greater than 2e-5. The hydraulic gradient necessary to initiate ganglia mobilization for various permeabilities and interfacial tensions is shown in Figure 4.

Figure 4 shows that in very permeable media (e.g., gravel and coarse sand) it is theoretically possible to obtain sufficient hydraulic gradients to mobilize DNAPL blobs. In soils with medium permeability (e.g., fine to medium sands), some of the residual DNAPL can be hydraulically mobilized. In less permeable materials, mobilization is not possible unless surfactants are used to drastically reduce interfacial tensions (Cohen and Mercer 1993). This is another example of why DNAPLs are difficult to recover from groundwater environments.

At Gasco, measured interfacial tensions between DNAPL and water were 14.2 and 15.8 dynes/cm and most of the soil where DNAPL occurs would be classified as silty sands or finer (HAI 2007). The intrinsic permeability was calculated from the hydraulic conductivity of the shallow alluvium used in the Site MODFLOW model of 15 feet/day, which gives an intrinsic permeability of 6e-8 cm^2. Based on Figure 4, the hydraulic gradient that would be required to mobilize residual DNAPL under these conditions would be near 1 foot/foot or greater, which is much higher than any gradient that could be induced in the former effluent pond area under non-pumping or pumping conditions at the Site.

SUMMARY DISCUSSION AND CONCLUSIONS

The lack of stratigraphic gradient and the presence of silt interbeds in the upper alluvium at the Gasco Site indicates that the most likely mechanism for potential lateral DNAPL movement is by pooling on silt lenses and flowing along stratigraphic interfaces to the edge of the silt lens. Upon reaching coarser and more permeable media at the edges of silt lenses, DNAPL would tend to flow downward under the influence of gravity until reaching another lower permeability stratigraphic discontinuity.

The maximum effect of changes in hydraulic gradient was computed from Equation 1 by making the following assumptions:

- Capillary forces = 0
- Stratigraphic slope (α) = 0, which has been shown to be negligible at the Site
- Relative permeability = 1, which is the maximum value

- Intrinsic permeability computed for the Site = 6e-8 cm^2
- Porosity = 0.3

These assumptions, which neglect the capillary forces that would resist DNAPL flow, provide the maximum DNAPL velocity that can be expected due to pumping, and travel distance derived for different time periods can be computed. The results, summarized in Table 2 above, show that changes in gradient in the former effluent pond area due to shallow and intermediate depth extraction well pumping would cause maximum distances traveled over a 3 year period to range between approximately 5.2 to 10.4 feet using shallow extraction wells, and 0.5 to 1.0 feet for intermediate depth extraction wells.

From this analysis, enhanced groundwater movement in the former effluent pond area due to shoreline extraction wells is minimal and would not substantially change DNAPL distribution over time. These calculations are conservative approximations of the potential distances that DNAPL could travel and the true estimate would be less if the capillary term were factored into the calculation. The analysis also shows that pumping from the intermediate wells produces significantly smaller potential distances of travel. Therefore it is unlikely that that shallow extraction wells will be selected for design of the shoreline extraction system.

Finally, as shown in Case 2, mobilization of residual DNAPL (as opposed to pools) is not expected to occur at Gasco in the former effluent pond area because groundwater gradients that result from pumping, and the material properties of the aquifer matrix and of the DNAPL produce a capillary number that is well below the critical value (Figure 4).

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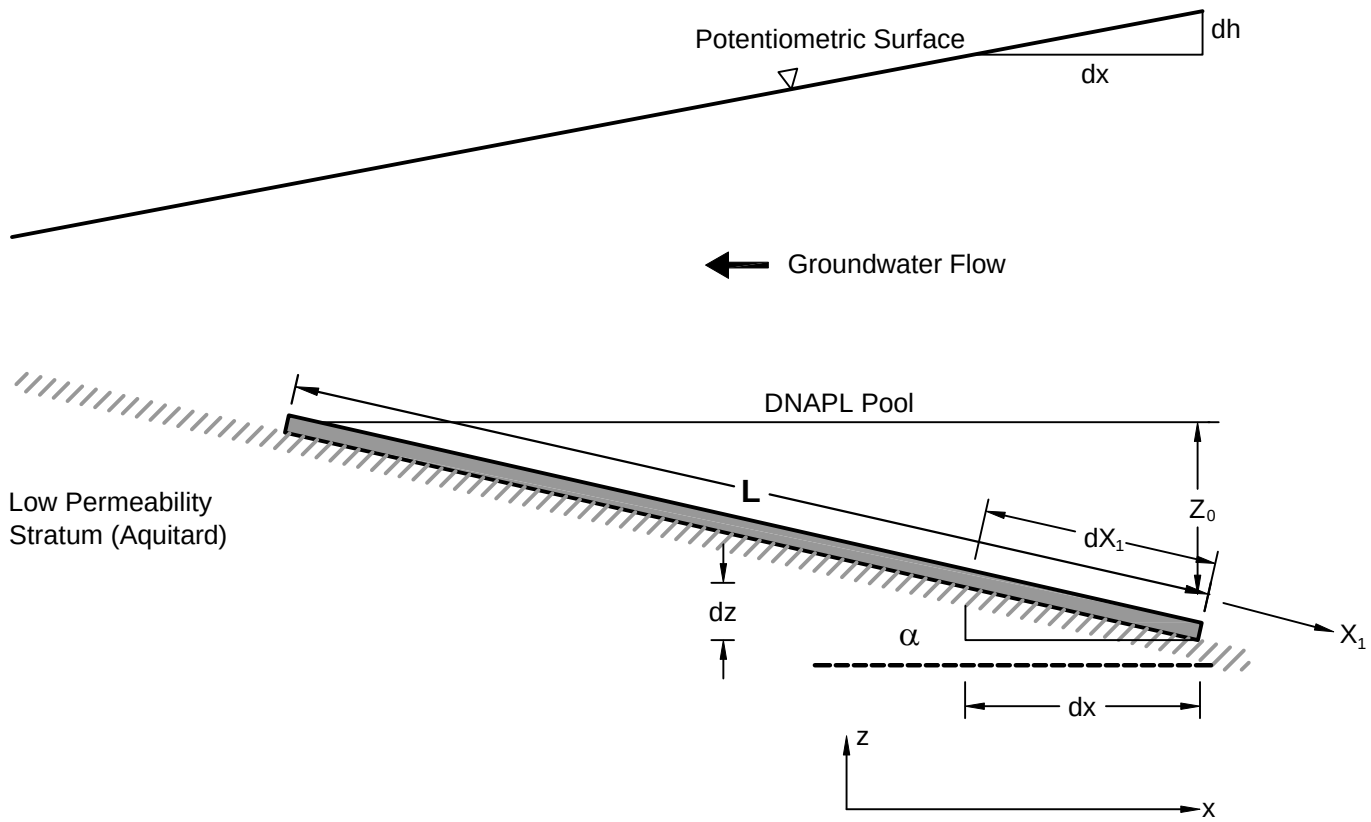


Source: Yan, S., G.R. Landry and T. Tate, 1994.

Feb 03, 2009 10:59am cdavidson K:\Jobs\000029-GASCO\00002902\00002902-RP-018.dwg FIG 1

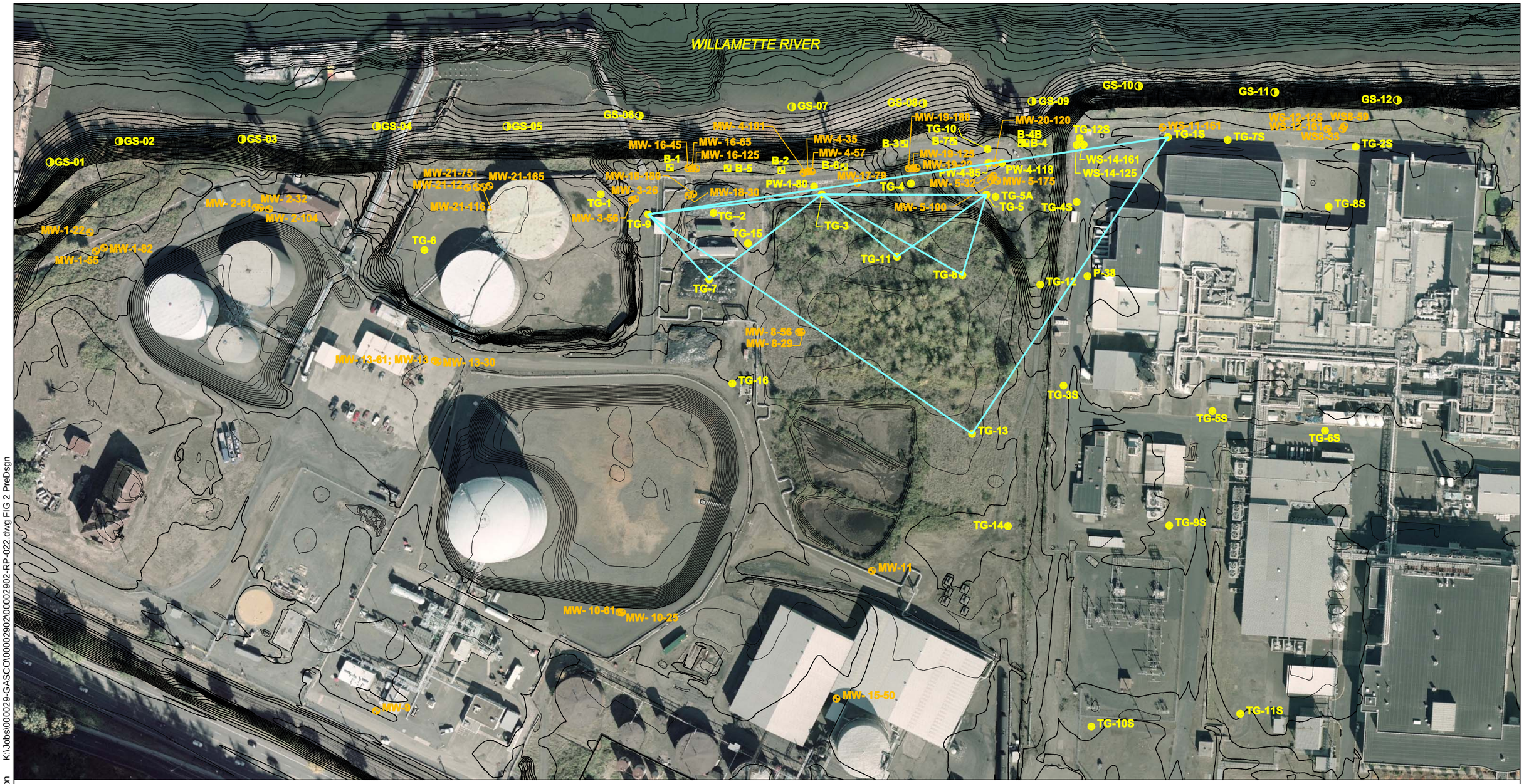
ANCHOR QEA

Figure 1

Diagram of DNAPL Pool held in Aquifer on a Low Permeability Sloping Bed

Gasco/Siltronic

Portland, Oregon



Legend

TG-9	Boring Location and Number
MW-2-12	Existing Monitoring Well Location and Number
GS-01	Gasco Phase 1 Offshore Boring Location and Number
B-1	Geotechnical Boring Location and Number

Area used to Calculate Bedding Slope

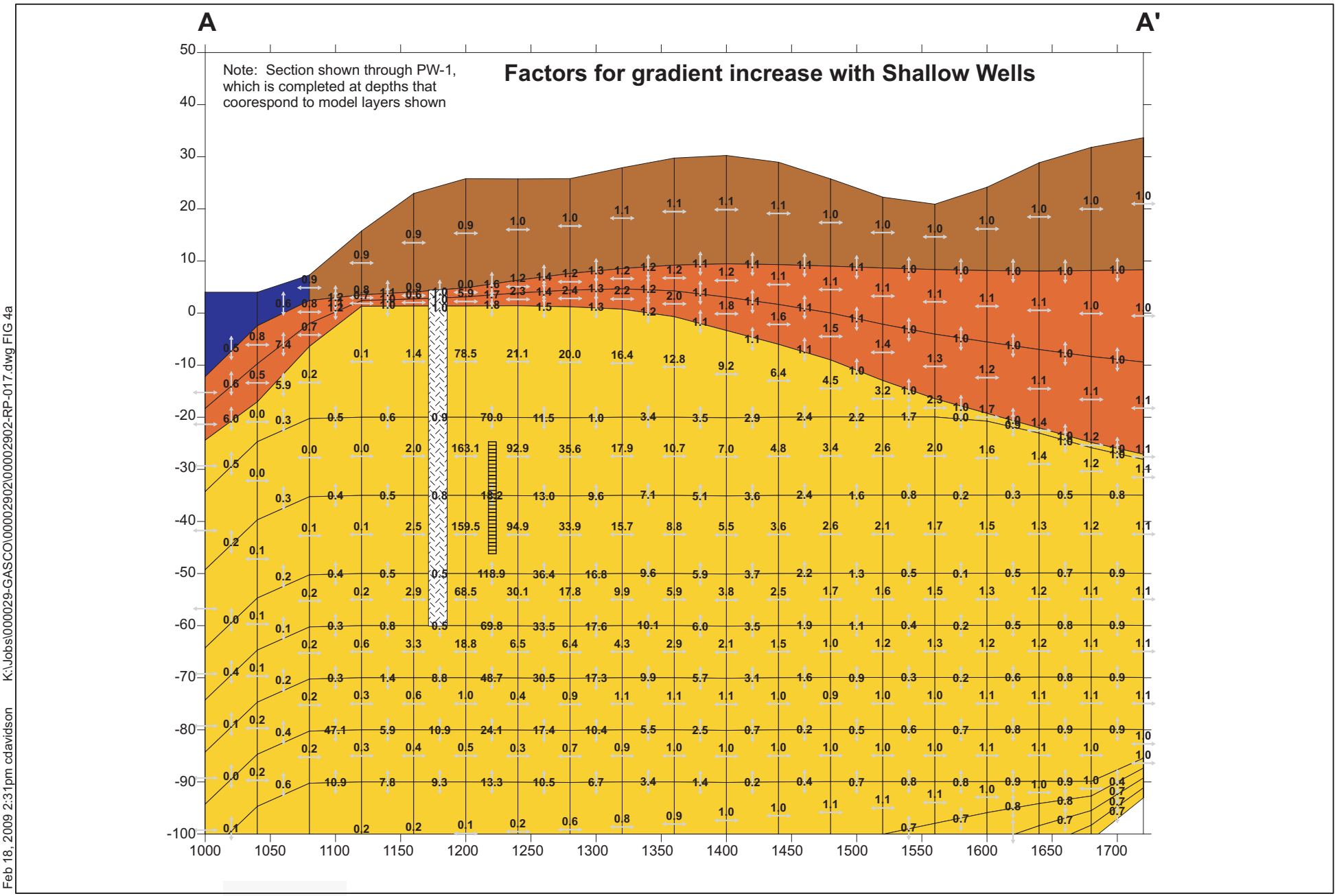
0 150
Scale in Feet

K:\Jobs\000029-GASCO\00002902\00002902-RP-022.dwg FIG 2 PreDsgn

Feb 17, 2009 2:22pm cdavidson

ANCHOR ENVIRONMENTAL, L.L.C.

Figure 2
Location of Bedding Slope Calculations
Gasco, Portland, Oregon



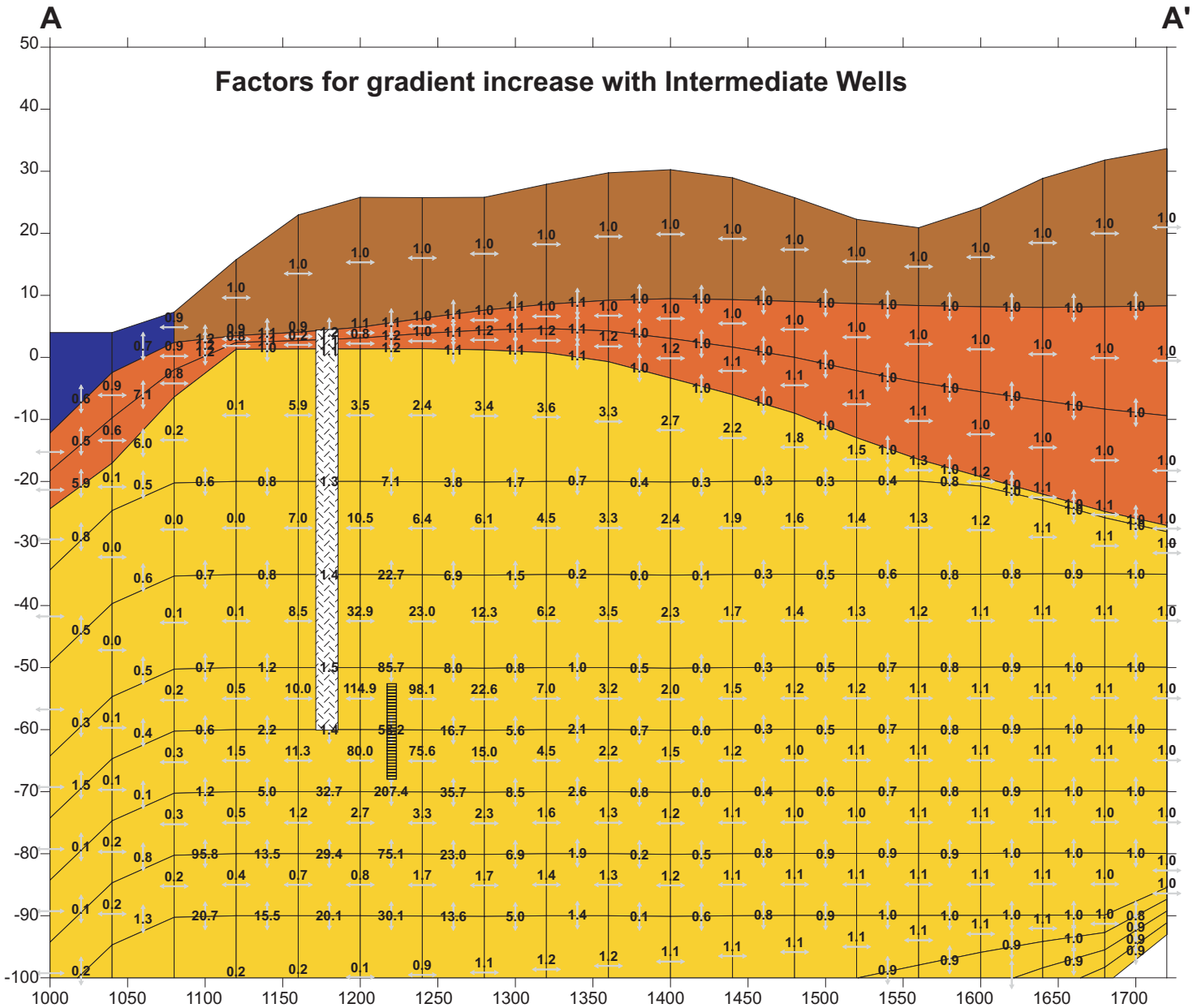
Feb 18, 2009 2:31pm cdavidson K:\Jobs\000029-GASCO\00002902\00002902-RP-017.dwg FIG 4a

ANCHOR QEA

$\Sigma^2\Pi$

Figure 3a

Predicted Factors for Hydraulic Gradient Increases Under Pumping Conditions for Shallow Wells
Gasco/Siltronic
Portland, Oregon



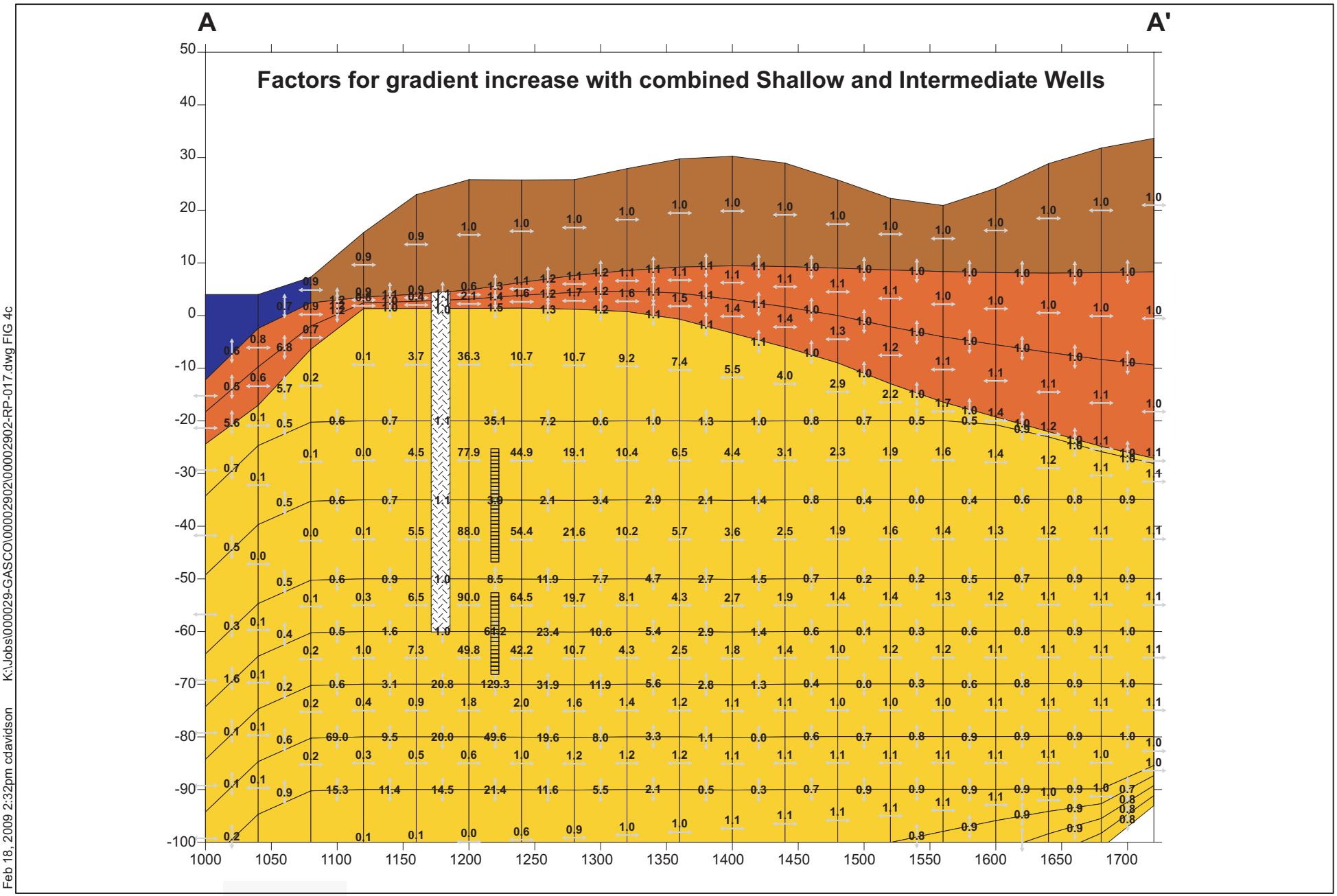
Feb 18, 2009 2:32pm cdavidson K:\Jobs\000029-GASCO\00002902\00002902-RP-017.dwg FIG 4b

ANCHOR QEA

$\Sigma^2\Pi$

Figure 3b

Predicted Factors for Hydraulic Gradient Increases Under Pumping Conditions for Intermediate Wells
Gasco/Siltronic
Portland, Oregon



Feb 18, 2009 2:32pm cdavidson K:\Jobs\000029-GASCO\00002902\00002902-RP-017.dwg FIG 4c

ANCHOR QEA

$\Sigma^2\Pi$

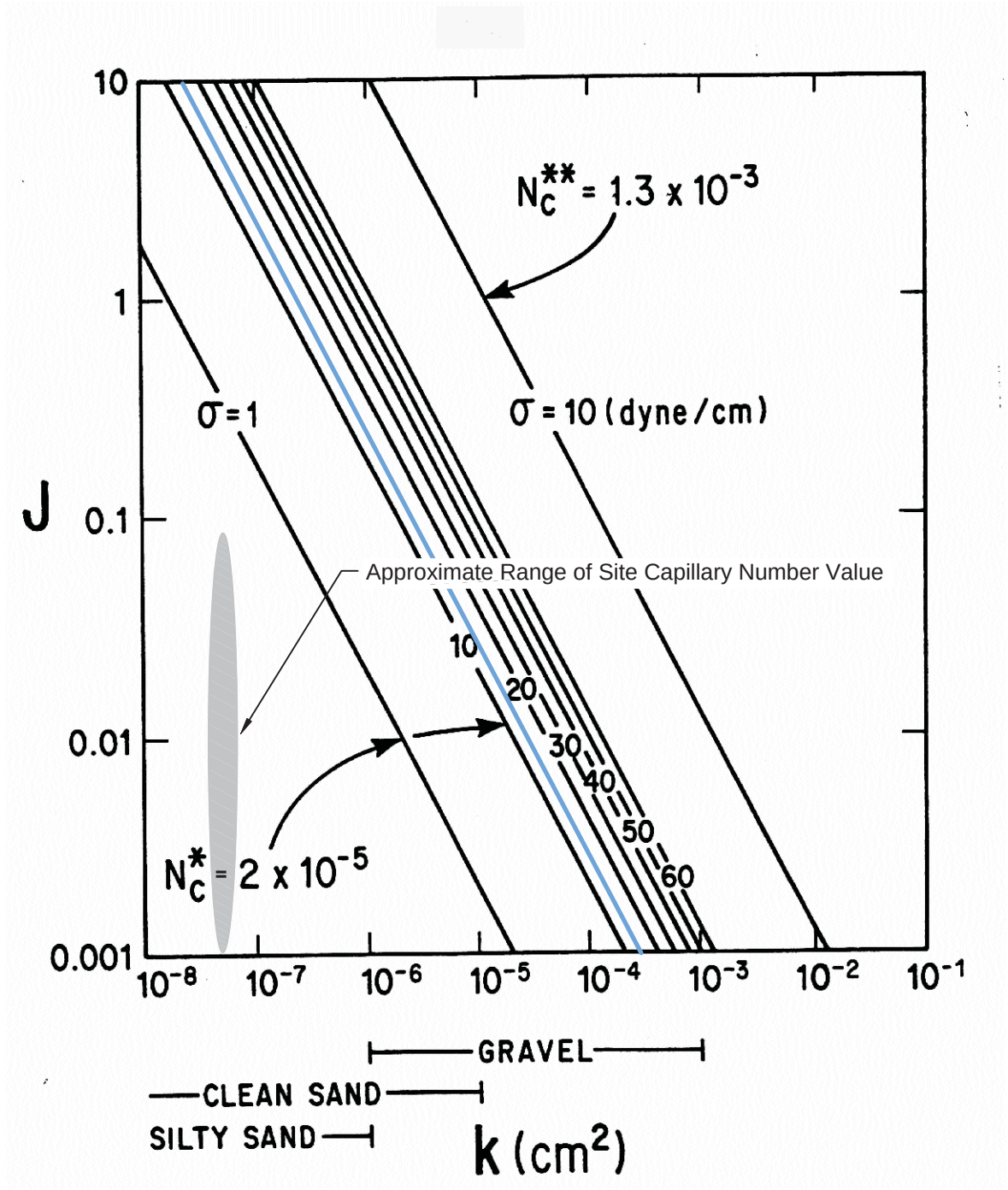
Figure 3c

Predicted Factors for Hydraulic Gradient Increases
Under Pumping Conditions for combined Shallow and Intermediate Wells
Gasco/Siltronic
Portland, Oregon

ANCHOR ENVIRONMENTAL, L.L.C.

0 150
Scale in Feet
1 inch = 150 feet

Figure 3d
Approximate Location of Cross Sections Showing Predicted Changes in Hydraulic Gradients Under Pumping Conditions at the Gasco Site
Gasco/Siltronic
Portland, Oregon



Line of Critical Capillary Values for σ of 15 dynes/cm

Source: Mercer and Cohen, 1993.

Feb 19, 2009 10:28am cdavidson K:\Jobs\000029-GASCO\00002902\00002902-RP-017.dwg FIG 5

ANCHOR QEA

Figure 4
Hydraulic Gradient Necessary to Initiate DNAPL Blob Mobilization in Soils of Various Permeabilities
Gasco/Siltronic
Portland, Oregon

APPENDIX I
SEGMENT 2 CAPTURE ZONE TEST REPORT

SEGMENT 2 CAPTURE ZONE FIELD TEST REPORT
GASCO SEDIMENTS SITE, PORTLAND, OREGON

Prepared for

NW Natural

Prepared by

Anchor QEA, LLC

March 2011

SEGMENT 2 CAPTURE ZONE FIELD TEST REPORT

GASCO SEDIMENTS SITE, PORTLAND, OREGON

Prepared for

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March 2011

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LIST OF ACRONYMS AND ABBREVIATIONS

City	City of Portland
DEQ	Oregon Department of Environmental Quality
DNAPL	dense non-aqueous phase liquid
EPA	U.S. Environmental Protection Agency
Field Test Report	Segment 2 Capture Zone Field Test Report
GAC	Granular activated carbon
gpm	gallons per minute
HASP	health and safety plan
Order	Administrative Settlement Agreement and Order on Consent
POTW	Publicly Owned Treatment Works
Siltronic	Siltronic Corporation
Test Plan	Capture Zone Field Test Plan (Anchor QEA 2009c)
WBZ	Water bearing zone

1 INTRODUCTION

NW Natural and Siltronic Corporation (Siltronic) are working with the U.S. Environmental Protection Agency (EPA) under an Administrative Settlement Agreement and Order on Consent (Order) for sediments cleanup at the Gasco Sediments Site within Portland Harbor. The Segment 2 Capture Zone Field Test was conducted to provide information on offshore groundwater seepage control for the design of the in-water sediment cleanup.

Anchor QEA, LLC, is also designing a groundwater and dense non-aqueous phase liquid (DNAPL) source control system for the NW Natural Gasco Upland Site working with Oregon Department of Environmental Quality (DEQ) under a Voluntary Cleanup Program agreement. Anchor QEA is currently preparing the Draft Groundwater Source Control Design Report. The findings presented in the Segment 2 Capture Zone Field Test Report (Field Test Report) will also be used by Anchor QEA to support that design.

Studies conducted to date for upland groundwater source control design conclude that the shoreline extraction wells will control groundwater discharge from the Gasco Sediments Site into the river. Shoreline groundwater containment will also reduce groundwater discharge from the sediment mudline into the river channel within an area of the riverbed near the Gasco Sediments Site. Because regional groundwater discharge would continue at some distance from the Gasco Sediments Site, the effect of the Gasco groundwater controls on groundwater flux are expected to diminish with distance from the site.

In order to best evaluate design alternatives for the sediment cleanup, Anchor QEA will conduct modeling studies to predict the offshore area of groundwater seepage control that would result from operation of the upland shoreline extraction wells. To better inform these modeling efforts and assist in the overall design of the in-water sediment cleanup, it is important to measure the offshore area of seepage control that will be induced by the shoreline source control extraction wells. The information presented in this report will be used to support that modeling effort.

Segment 2 is one of three shoreline segments designated by NW Natural and approved by DEQ for identifying potential shoreline areas for upland source control. As shown on Figure 1, Segment 1 extends across portions of NW Natural and Siltronic property. Segment 2 is located on the north shoreline of NW Natural property. DEQ has designated Segments 1 and 2 as having high priority for source control. Segment 3 is located on the south shoreline of Siltronic

property. The *Source Control Evaluation Report "Segment 3" Siltronic Property Related to NW Natural "Gasco" Site* (Anchor QEA 2009b) was submitted to DEQ in February 2009, and comments have not yet been received from DEQ.

The findings from this Segment 2 field test are intended to adjust and calibrate the groundwater model to better predict the area of offshore seepage control along the entire shoreline where sediment cleanup is expected to occur.

The *Capture Zone Field Test Plan* (Anchor QEA 2009c; Test Plan) describes the process of constructing and testing shoreline extraction wells, upland monitoring wells, and offshore piezometers to accomplish the following goals:

1. Determine the offshore area of seepage control that results from pumping the shoreline wells at the pumping rate identified in Goal No. 2.
2. Confirm the model-predicted pumping rates anticipated to achieve groundwater capture at the shoreline adjacent to the Gasco Sediments Site.
3. Determine if adjustments to the extraction well pumping rates are needed to change the area of offshore seepage control to better complement cost-effective offshore sediment cleanup.

The information collected during achievement of these goals will be used for the future design of the in-water cleanup action.

The following sections of this Field Test Report describe the field Investigation and findings resulting from the offshore capture zone investigation.

2 FIELD INVESTIGATION

2.1 Capture Zone Field Test Plan

The Test Plan was submitted to EPA and DEQ in September, 2009. At NW Natural's request EPA and DEQ completed an expedited review of the piezometer and well construction portion of the plan to facilitate implementation of the offshore work during the in-water construction window. EPA and DEQ reviewed the Test Plan and provided comments and conditional approval in an October 8, 2009 email. In an October 23, 2009 letter, Anchor QEA responded to EPA and DEQ comments on the Test Plan. On October 27, Anchor QEA sent EPA's consultant, CDM, proposed piezometer construction details, a memorandum providing request for proposal discussions with drillers to install offshore piezometers at the site, and copies of typical field forms. EPA sent NW Natural an October 28, 2009 letter containing further comments and instructing NW Natural to proceed with the work, conditioned upon EPA approval of the health and safety plan (HASP) and NW Natural responses to comments. On November 8, 2009, Anchor QEA submitted to EPA a document titled "Revised Additional Responses to Agency's Capture Zone Field Test Plan Comments and Reponses" to EPA's HASP comments. On November 11, 2009, EPA sent an email to Anchor QEA and NW Natural approving NW Natural's response to the Test Plan comments, pending EPA approval of the project HASP. A November 15 e-mail from EPA to Anchor QEA stated the agency has no further comments on the HASP and that work may proceed. EPA's conditional approval of the Test Plan was e-mailed to NW Natural and Anchor QEA on January 7, 2010.

2.2 Well Installation and Instrumentation

Table 1 shows the construction details of all site monitoring wells, piezometers, and pilot extraction wells. Per the Test Plan, a number of new monitoring wells, offshore piezometers, and pilot extraction wells were installed for the offshore capture zone assessment. The geologic logs and construction details for the new wells are included in Appendix A.

Between November 19 and December 4, 2009, the following offshore piezometers were installed using a barge mounted rotosonic drill rig:

- PZ1-50
- PZ2-43
- PZ2-77
- PZ3-33

- PZ4-12
- PZ4-41
- PZ5-5
- PZ5-20
- PZ5-55
- PZ5-85

Between January 28 and March 8, 2010, the following upland monitoring wells, observation wells, and Pilot Extraction Wells were installed with a truck mounted rotosonic drill rig.

- MW22-80
- MW23-27
- MW23-75
- MW23-123
- MW24-70
- MW24-130
- OW7-17
- OW8-15
- OW9-25
- PW7-93
- PW8-68
- PW9-92

Observation well OW8-28 and pilot extraction well PW8-39 were both installed on August 13, 2010 using a truck mounted rotosonic drill rig.

All wells were installed and completed with locking protective surface casings, as described in the Test Plan, and the screens were developed using the methods described in the Test Plan. Copies of the well development records are in Appendix B. Investigation derived waste generated from the well installation and development was handled as described in the Test Plan. The wastewater was treated in the onsite GAC treatment system prior to discharge under permit to the City of Portland (City) Publicly Owned Treatment Works (POTW). The soil was drummed, characterized, and disposed offsite at Waste Management's Subtitle D landfill in Hillsboro, Oregon.

Prior to beginning the field tests, *InSitu LevelTroll 500* pressure transducers were installed in the new monitoring wells, piezometers, pilot extraction wells, 16 pre-existing wells, and the Willamette River.

2.3 Field Tests

2.3.1 Lower Alluvium Extraction Wells

Prior to beginning the field tests, a temporary pipeline to the onsite GAC treatment system was constructed. The pipeline was connected to all of the extraction wells. During the subsequent pump tests the groundwater was treated and discharged under permit to the City POTW.

Table 2 shows a summary of the pump tests that were conducted during this investigation, including pumping period, pumping rate in gpm, and the wells that were pumped during each period.

From April 19 to 21, 2010, each of the three lower alluvium pilot wells (PW7-93, PW8-68, and PW9-68) were pumped for approximate two-hour periods at varying pumping rates to test the specific capacity of each well. The purpose was to make sure that each well is capable of pumping the desired flow without excessive drawdown. The tests concluded that each well was capable of pumping the required discharge.

Table 3 shows the groundwater elevation data for each of the wells during all of the 72 hour pump tests. As shown on Table 3, the three lower alluvium wells were subjected to two 72-hour tests in April and May 2010. For the test conducted from April 27 to 30, each of the three wells was pumped at a constant rate of 25 gallons per minute (gpm). The 25 gpm rate was selected because that pumping rate was predicted by modeling to be appropriate for achieving upland groundwater containment. Transducer data from each of the tests shown in Table 3 are included in a data CD in Appendix C. The data CD also contains water elevation hydrographs and water temperature graphs plotted from the transducer data.

Following the 25 gpm test, Anchor QEA conducted another period of ambient monitoring. The second 72-hour pump test was conducted from May 4 to 7, with each of the three wells pumping at a constant rate of 35 gpm. The 35 gpm test was conducted to determine if the offshore groundwater gradients would be substantially different at a higher pumping rate.

As described in the Section 2.3.2, an upper alluvium pilot extraction well (PW8-39) was installed and tested following the previously described 35-gpm 72-hour test.

Following installation and testing of PW8-39, a final 72-hour test of all four pilot extraction wells was conducted. Before the test, s a period of ambient monitoring occurred from November 5 to November 8, 2010. This was followed by the 72-hour test that extended from November 8 to November 11, 2010. During that test, the three lower alluvium wells were pumped at a constant rate of 25 gpm and well PW8-39 was pumped at a rate of 2 gpm.

2.3.2 Upper Alluvium Extraction Well

The groundwater elevation data derived from the April and May 2010 72-hour tests (described in Section 2.3.1) indicated that the low hydraulic conductivity and interbedded silt layers of the upper alluvium near well PW8-68 were reducing the seepage control effect of the lower alluvium extraction wells. That analysis will be further explained in Section 3.

Following the April and May 2010 tests, a pilot extraction well was proposed for the upper alluvium near well PW8-68. A June 24, 2010 technical memorandum was sent to EPA with the plan to install an upper alluvium pilot extraction well (Anchor QEA 2010a). That memorandum provided a summary of the results of testing the lower alluvium extraction wells and how those results indicated that an upper alluvium extraction well should be installed and tested.

EPA approved the June 24 technical memorandum, and well PW8-37 was installed on July 1. Following installation, Anchor QEA prepared the July 15 *Capture Zone Field Test Plan Addendum* to provide further details on plans to continue capture zone testing (Anchor QEA 2010b. On July 21, comments from DEQ on the *Capture Zone Field Test Plan Addendum* directed NW Natural to prepare plans to abandon well PW8-37. On July 28, Anchor QEA sent EPA and DEQ a letter with a plan for abandonment and a request for further discussion to better understand and potentially resolve DEQ's concerns about the well. Although Anchor QEA did not agree that the construction of the well violated Oregon Well Construction regulations, DEQ continued to require abandonment of the well. Nonetheless, at DEQ's direction, the Oregon Water Resources Department required the drilling contractor, Cascade Drilling Corporation, to decommission the well. Despite multiple requests, the Water Resources Department has not provided a written explanation for its determination that the well was in violation of Oregon regulations.

In the August 3 *Capture Zone Test Plan Addendum 2* (Anchor QEA 2010c), Anchor QEA provided a plan to abandon PW8-37 and construct a new extraction well in the same borehole. Further details on the proposed field procedures were provided to EPA and DEQ in the August 6 *Capture Zone Test Plan Addendum 3* (Anchor QEA 2010d). At DEQ's request, the third addendum included a plan to install a new observation well near the planned replacement for PW7-37.

Following these agreements, Anchor QEA installed pilot extraction well PW8-39 and observation well OW8-28 on August 13, 2010. Those wells were constructed and the screens developed using the same protocols as the previously installed wells. Following installation of the two wells, Anchor QEA installed pressure transducers and short term pump tests were conducted to determine the specific capacity of well PW8-39. The tests determined that the well has a very low specific capacity and that the maximum sustained yield of the well is about 2 gpm.

Following installation and pretesting of new pilot well PW8-39, Anchor QEA conducted a 72-hour pump test of that well. From September 9 through September 12, 2010, Anchor QEA pumped well PW8-39 at a constant rate of 2 gpm. The lower alluvium extraction wells were not pumped during this period. As described in the previous section, a final 72-hour pump test was then conducted in November 2010 with all four pilot extraction wells.

3 CAPTURE ZONE ANALYSIS

Figure 2 shows the locations of wells in the capture zone test study area, and the locations for two cross sections prepared as part of this Field Test Report. On the cross sections, the upper alluvium is designated with a solid green color and the lower alluvium is designated with a green cross hatch pattern. The upper alluvium is silty fine sand with silt interbeds. The lower alluvium is medium sand with fewer silt interbeds. Based on historic aquifer tests conducted in wells located further south along the shoreline, the hydraulic conductivity of the lower alluvium is about 200 feet per day and the upper alluvium about 10 feet per day. However, as further explained in the next subsection, subsequent field tests have shown that the hydraulic conductivity of the upper alluvium in the vicinity of the Segment 2 Capture Zone test area is about 1 foot per day, much lower than further south along the shoreline.

Figure 3 (F-F′ cross section) and Figure 4 (G-G′ cross section) show the difference (ΔH) between the average water elevation at the wells and piezometers compared to the river water elevation for pre-test ambient flow conditions. Figure 5 (F-F′ cross section) and Figure 6 (G-G′ cross section) show the difference during the 25 gpm pump test.

Where ΔH is positive, the groundwater elevation is higher than the river elevation; where ΔH is negative, the groundwater elevation is lower than the river elevation. Negative ΔH indicates reversal of gradient (that is, no groundwater seepage into the river at that location). The river elevation data are from the permanent electric water level transducer attached to the dock. The groundwater elevations were calculated from the pump test data using the method of Serfes (1991) that was described in the Test Plan. The data and calculated elevations are shown on Table 3.

On Table 3, the negative or downward gradients are shown in red. The Serfes method filters tidal data over a 72-hour period to obtain mean groundwater and river elevations. These mean elevations are used to determine groundwater gradients and flow direction. The Serfes method is specifically designed for use at sites where groundwater levels are strongly influenced by tidal fluctuations, as with the Gasco Sediments Site.

At all well locations on Figures 3 and 4, for the pre-pumping ambient data, the ΔH is positive, indicating groundwater gradient toward the river. However, the difference is very small in the lower alluvium, so there is very little groundwater gradient. The cross sections on Figures 3 and 4 also display the tidal efficiencies for the pre-test ambient condition calculated at each

well/piezometer. As expected, the figures show higher tidal efficiencies at the wells screened in the more permeable lower alluvium.

The gradient calculations completed from the April 2010, 25 gpm pump test data are shown on the cross sections of Figures 5 and 6. For pumping conditions, the tidal efficiency is not relevant, so it is not shown on these figures. As with Figures 3 and 4, the ΔH on Figures 5 and 6 were calculated using the 72-hour averaging method of Serfes (1991).

A simple interpretation of the data shows that negative differences mean the groundwater levels are below the river and therefore contained by the pumping wells. In both sections, the lower alluvium is captured by the pumping wells. By comparing the ΔH in the upper alluvium between the pretest data and the 25 gpm data, it is seen that significant gradient reductions in the upper alluvium are also achieved; however, in the fill and shallow alluvium, only PZ4-12 on Figure 6 is contained.

3.1 Groundwater Chemistry Testing

In comments to the Test Plan, DEQ requested that groundwater chemistry data be collected as part of the capture zone testing (DEQ 2009). Accordingly, Anchor QEA conducted groundwater sampling during the final 72 hour pump test. Copies of the field sampling data sheets are in Appendix B. Groundwater and river water samples were obtained at start of the test on November 8, during the test on November 10, and at the end of the test on November 11. The samples were obtained from spigots that had been installed at each well head. The sampling methods and analytes tested were consistent with the DEQ's request. Copies of the laboratory data reports are in Appendix D. Laboratory data was subjected to a standard data validation review. The data were judged to be acceptable for their intended use as qualified. Please refer to the data validation review in Appendix E. The validated data are shown on Table 4.

4 FINDINGS

4.1 Capture Zone Analysis

In 2011, slug tests have been conducted in a number of upper alluvium and Fill WBZ monitoring wells and pilot extraction wells. The findings from those slug tests were provided to DEQ and EPA in a February 17, 2011 data report (Anchor QEA 2011).

The slug test findings and the information from the testing of the Segment 2 pilot extraction well PW8-39 show that the hydraulic conductivity of the upper alluvium declines from the southern shoreline area to the north. Based on historic testing of well PW3-85, the hydraulic conductivity of the upper alluvium in the area near the Gasco/Siltronic property line is about 10 feet per day. Testing of well PW1-80 during the Gasco Remedial Investigation showed the hydraulic conductivity of the upper alluvium in that area is about 5 feet per day. Subsequent 2011 slug testing of monitoring wells and the 2010 pump test of Segment 2 pilot well PW8-39 indicate that the hydraulic conductivity of the upper alluvium in the vicinity of PW8-39 is about 1 foot per day, about an order of magnitude lower than the vicinity of well PW3-85.

The area for the Segment 2 capture zone tests was selected because there is no DNAPL in the Segment 2 area of the shoreline. Based on the previously stated findings, the Segment 2 capture zone tests were inadvertently conducted in an area where the hydraulic conductivity of the upper alluvium is the lowest of any known area along the Gasco/Siltronic shoreline source control area. Therefore, the pump test results for the upper alluvium in the area of PW8-39 are not representative of the upper alluvium in the rest of the planned shoreline source control area.

However, because the Segment 2 tests did achieve a high degree of gradient reduction in the upper alluvium, Anchor QEA believes that complete containment can be achieved by varying the extraction well pumping rate to counterbalance the effect of river tidal fluctuations on groundwater gradients. The Final Source Control design is intended to use a Programmable Logic Control system to monitor the ΔH between groundwater and river elevation at selected control wells. The system will use variable frequency drive extraction well pumps whose discharge can be varied with the tidal fluctuations. By doing this, it is anticipated that the upper alluvium gradient reduction will be improved for seepage control.

Hydraulic conductivity data obtained from the Segment 2 capture zone tests, plus the individual well slug tests, are being used as input to the site MODFLOW model. The updated

groundwater model will be used for future design of the sediment cleanup action and is being used for final design of the upland source control system.

4.2 Groundwater Chemistry Data

The groundwater chemistry data obtained during the Segment 2 tests are shown on Table 4. Figure 7 shows the data for the four pilot extraction wells and the river water plotted on a Piper diagram. The data show that the river water chemistry and groundwater chemistry are similar and plot in the same general quadrants of the diagrams.

There were detections of total and WAD cyanide in the three Willamette River samples, but these detections were caused by contamination from either the sampling equipment, cross contamination during storage, or another unknown source. This accidental contamination of the samples is evidenced by the detection of total cyanide and WAD cyanide in the field blank sample obtained on November 10. The field blank is composed of deionized water that is put through the same sampling, storage, and chain of custody procedures as the actual samples. Since new polyethylene tubing was used to obtain the samples, it is very unlikely the contamination was sourced from the sampling equipment. There were no cyanide detections in the laboratory blank, so the Willamette River data were not qualified as a result of data validation.

5 REFERENCES

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NW Natural Gasco, Pump Test Analysis and MODFLOW Model Summary, 2008. SS. Papadopulos & Associates, Inc. April 25, 2008.

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TABLES

Table 1
Well and Piezometer Construction Details
Gasco Siltronic, Portland, Oregon

Well Number	Installed Transducer	Water-Bearing Zone	Date Installed	Date De-commissioned	Installation Method	Monument Type	Screen Type	Slot Size (inches)	Sand Pack (Colorado)	Well Diam. (inches)	Ground Surface (feet COP)	Top of Casing (feet COP)	Top of Casing (feet bgs)	Well Depth[1] (feet bgs)	Well Depth[1] (feet COP)	Top Screen (feet bgs)	Top Screen (feet COP)	Base Screen (feet bgs)	Base Screen (feet COP)
Existing Monitoring Well																			
MW-1-22		Surficial Fill	23-Oct-91	-	Hollow-Stem Auger	Above-grade	Slotted PVC	0.020	10-20	2	32.00	34.75	(2.8)	22.0	10.0	11.0	21.0	21.0	11.0
MW-1-55		Alluvial	9-Jul-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	33.10	35.75	(2.7)	57.0	-23.9	45.0	-11.9	55.0	-21.9
MW-1-82		Alluvial	8-Jul-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	33.50	36.08	(2.6)	85.4	-51.9	72.0	-38.5	82.0	-48.5
MW-2-32	X	Surficial Fill	5-Nov-91	-	Hollow-Stem Auger	Flush	Slotted PVC	0.020	10-20	2	34.83	34.50	0.3	32.5	2.3	21.5	13.3	31.5	3.3
MW-2-61	X	Alluvial	7-Oct-94	-	Hollow-Stem Auger	Flush	Slotted PVC	0.020	10-20	2	34.61	34.42	0.2	61.5	-26.9	50.0	-15.4	60.0	-25.4
MW-2-104	X	Alluvial	24-Jun-03	-	Sonic	Flush	Continuous wrap stainless steel	0.020	10-20	2	34.86	34.88	(0.0)	116.5	-81.6	94.0	-59.1	104.0	-69.1
MW-3-26	X	Surficial Fill	31-Oct-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.30	34.13	(2.8)	26.0	5.3	15.0	16.3	25.0	6.3
MW-3-56	X	Alluvial	31-Oct-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.51	34.10	(2.6)	56.0	-24.5	45.0	-13.5	55.0	-23.5
MW-4-35		Surficial Fill	30-Oct-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.70	34.54	(2.8)	35.0	-3.3	24.0	7.7	34.0	-2.3
MW-4-57		Alluvial	29-Oct-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.70	34.53	(2.8)	57.0	-25.3	46.0	-14.3	56.0	-24.3
MW-4-101		Alluvial	15-Oct-94	-	Dual Wall Reverse Air	Above-grade	Slotted PVC (pre-pack)	0.010	20-40	2	31.80	34.36	(2.6)	120.0	-88.2	89.5	-57.7	99.5	-67.7
MW-5-32		Surficial Fill/Alluvial	26-Oct-91	-	Hollow-Stem Auger	Above-grade	Slotted PVC	0.020	10-20	2	25.10	27.83	(2.7)	32.0	-6.9	21.0	4.1	31.0	-5.9
MW-5-100		Alluvial	22-Oct-94	-	Dual Wall Reverse Air	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	25.40	27.31	(1.9)	100.0	-74.6	88.0	-62.6	98.0	-72.6
MW-5-175		Alluvial	21-Oct-94	-	Dual Wall Reverse Air	Above-grade	Slotted PVC (pre-pack)	0.010	20-40	2	25.20	27.19	(2.0)	175.0	-149.8	163.0	-137.8	173.0	-147.8
MW-6-32		Surficial Fill	8-Nov-91	-	Hollow-Stem Auger	Flush	Continuous wrap stainless steel	0.020	10-20	2	35.80	35.51	0.3	32.0	3.8	21.0	14.8	31.0	4.8
MW-6-61		Alluvial	6-Nov-91	21-Dec-93	Hollow-Stem Auger	Flush	Continuous wrap stainless steel	0.020	10-20	2	35.80	34.50	1.3	61.0	-25.2	50.0	-14.2	60.0	-24.2
MW-8-29		Surficial Fill	25-Oct-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	36.50	39.09	(2.6)	29.0	7.5	18.0	18.5	28.0	8.5
MW-8-56		Alluvial	24-Oct-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	36.50	39.13	(2.6)	56.0	-19.5	45.0	-8.5	55.0	-18.5
MW-9-29		Surficial Fill/Alluvial	22-Oct-91	-	Hollow-Stem Auger	Flush	Slotted PVC	0.020	10-20	2	37.90	37.65	0.3	29.0	8.9	18.0	19.9	28.0	9.9
MW-10-25		Surficial Fill	8-Nov-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	36.50	39.22	(2.7)	25.0	11.5	14.0	22.5	24.0	12.5
MW-10-61		Alluvial	7-Nov-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	36.50	39.33	(2.8)	61.0	-24.5	50.0	-13.5	60.0	-23.5
MW-11-32		Surficial Fill	2-Nov-91	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	35.40	38.39	(3.0)	32.0	3.4	21.0	14.4	31.0	4.4
MW-12-36		Surficial Fill/Alluvial	22-Oct-91	-	Hollow-Stem Auger	Above-grade	Slotted PVC	0.020	10-20	2	35.90	38.69	(2.8)	36.0	-0.1	25.0	10.9	35.0	0.9
MW-13-30		Surficial Fill	18-Dec-93	-	Hollow-Stem Auger	Flush	Continuous wrap stainless steel	0.020	10-20	2	35.23	34.86	0.4	30.0	5.2	19.0	16.2	29.0	6.2

Table 1
Well and Piezometer Construction Details
Gasco Siltronic, Portland, Oregon

Well Number	Installed Transducer	Water-Bearing Zone	Date Installed	Date De-commissioned	Installation Method	Monument Type	Screen Type	Slot Size (inches)	Sand Pack (Colorado)	Well Diam. (inches)	Ground Surface (feet COP)	Top of Casing (feet COP)	Top of Casing (feet bgs)	Well Depth[1] (feet bgs)	Well Depth[1] (feet COP)	Top Screen (feet bgs)	Top Screen (feet COP)	Base Screen (feet bgs)	Base Screen (feet COP)
MW-13-61		Alluvial	17-Dec-93	-	Hollow-Stem Auger	Flush	Continuous wrap stainless steel	0.020	10-20	2	35.23	34.78	0.4	61.0	-25.8	50.0	-14.8	60.0	-24.8
MW-13-61R		Alluvial	31-May-03	-	Sonic	Flush	Continuous wrap stainless steel	0.020	20-40	2	35.31	35.38	(0.1)	63.0	-27.7	51.0	-15.7	61.0	-25.7
MW-14-110		Alluvial	18-Oct-94	-	Dual Wall Reverse Air	Above-grade	Slotted stainless steel (pre-pack)	0.010	20-40	2	35.30	37.41	(2.1)	110.0	-74.7	98.0	-62.7	108.0	-72.7
MW-15-50		Alluvial	30-Jun-95	-	Air Rotary	Flush	Slotted stainless steel (pre-pack)	0.010	10-20	2	36.27	35.97	0.3	50.0	-13.7	40.0	-3.7	50.0	-13.7
MW-15-66		Alluvial	29-Jun-95	-	Air Rotary	Flush	Slotted stainless steel	0.010	10-20	2	36.27	36.06	0.2	66.0	-29.7	60.5	-24.2	65.5	-29.2
MW-16-45		Alluvial	19-Jul-00	-	Sonic	Above-grade	Slotted stainless steel	0.010	10-20	2	30.81	33.12	(2.3)	49.0	-18.2	30.0	0.8	45.0	-14.2
MW-16-65	X	Alluvial	18-Jul-00	-	Sonic	Above-grade	Slotted stainless steel	0.010	10-20	2	30.75	33.21	(2.5)	68.0	-37.3	55.0	-24.3	65.0	-34.3
MW-16-125		Alluvial	14-Jul-00	26-Apr-10	Sonic	Above-grade	Slotted stainless steel	0.010	10-20	2	30.90	33.18	(2.3)	130.0	-99.1	115.0	-84.1	125.0	-94.1
MW-17-79		Alluvial	25-Jul-01	-	Sonic	Above-grade	Continuous wrap stainless steel	0.010	10-20	2	32.56	34.83	(2.3)	82.0	-49.4	38.5	-5.9	78.5	-45.9
MW-18-30		Surficial Fill	26-Feb-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.61	34.27	(2.7)	30.0	1.6	19.0	12.6	29.0	2.6
MW-18-125		Alluvial	22-Apr-10	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.93	34.65	(2.7)	126.0	-94.1	115.0	-83.1	125.0	-93.1
MW-18-180	X	Alluvial	25-Feb-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	31.70	33.90	(2.2)	230.0	-198.3	170.0	-138.3	180.0	-148.3
MW-19-22		Surficial Fill	5-Mar-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	27.40	29.82	(2.4)	23.0	4.4	12.0	15.4	22.0	5.4
MW-19-125		Alluvial	11-Mar-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	27.20	29.42	(2.2)	126.0	-98.8	115.0	-87.8	125.0	-97.8
MW-19-180		Alluvial	1-Mar-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	27.28	29.81	(2.5)	227.0	-199.7	170.0	-142.7	180.0	-152.7
MW-20-120		Alluvial	7-Mar-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	25.63	27.84	(2.2)	213.0	-187.4	110.0	-84.4	120.0	-94.4
MW-21-12	X	Surficial Fill	5-Jul-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	20.34	23.25	(2.9)	14.0	6.3	7.0	13.3	12.0	8.3
MW-21-75	X	Alluvial	4-Jul-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	20.22	23.11	(2.9)	77.0	-56.8	65.0	-44.8	75.0	-54.8
MW-21-115	X	Alluvial	1-Jul-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	20.32	23.43	(3.1)	118.0	-97.7	105.0	-84.7	115.0	-94.7
MW-21-166	X	Alluvial	27-Jun-03	-	Sonic	Above-grade	Continuous wrap stainless steel	0.020	10-20	2	20.35	23.15	(2.8)	193.0	-172.7	156.0	-135.7	166.0	-145.7
MW-22-80	X	Alluvial	28-Jan-10	-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	33.59	36.01	(2.5)	80.9	-47.3	69.9	-36.3	79.9	-46.3
MW-23-27	X	Surficial Fill	16-Feb-10	-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	32.77	34.72	(2.3)	28.0	4.8	17.7	15.1	27.7	5.1
MW-23-75	X	Alluvial	16-Feb-10	-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	32.91	34.87	(2.5)	75.7	-42.8	64.7	-31.8	74.7	-41.8
MW-23-123	X	Alluvial	5-Feb-10	-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	32.88	35.05	(2.5)	124.3	-91.4	113.3	-80.4	123.3	-90.4
MW-24-70	X	Alluvial	3-Feb-10	-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	31.42	33.83	(2.4)	71.1	-39.7	60.1	-28.7	70.1	-38.7
MW-24-130	X	Alluvial	2-Feb-10	-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	31.34	33.76	(2.5)	131.1	-99.8	120.1	-88.8	130.1	-98.8
PW-01-80		Alluvial	8-Aug-01	-	Sonic	Flush	Continuous wrap stainless steel	0.020	10-20	6	32.00	31.80	0.2	82.0	-50.0	39.5	-7.5	79.5	-47.5

Table 1
Well and Piezometer Construction Details
Gasco Siltronic, Portland, Oregon

Well Number	Installed Transducer	Water-Bearing Zone	Date Installed	Date De-commissioned	Installation Method	Monument Type	Screen Type	Slot Size (inches)	Sand Pack (Colorado)	Well Diam. (inches)	Ground Surface (feet COP)	Top of Casing (feet COP)	Top of Casing (feet bgs)	Well Depth[1] (feet bgs)	Well Depth[1] (feet COP)	Top Screen (feet bgs)	Top Screen (feet COP)	Base Screen (feet bgs)	Base Screen (feet COP)
Existing Observation Well																			
OW-7-17	X	Surficial Fill	23-Feb-10	-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	24.20	26.51	(2.3)	17.7	6.5	12.5	11.7	17.5	6.7
OW-8-15	X	Surficial Fill	12-Feb-10	-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	24.56	26.42	(1.9)	15.3	9.3	10.1	14.5	15.1	9.5
OW-8-28	X	Alluvial	13-Aug-10	-	Hollow-Stem Auger	Above-grade	Slotted PVC	0.020	10-20	2	23.79	26.38	(2.6)	29.0	-5.2	23.1	0.7	28.1	-4.3
OW-9-25	X	Surficial Fill	8-Mar-10	-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	33.11	35.38	(2.3)	25.3	7.8	20.0	13.1	25.0	8.1
Existing Extraction Well																			
PW-7-93	X	Alluvial	22-Feb-10	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	8	24.19	26.74	(2.6)	95.5	-71.3	73.5	-49.3	93.5	-69.3
PW-8-39	X	Alluvial	13-Aug-10	-	Hollow-Stem Auger	Above-grade	Continuous wrap stainless steel	0.035	10-20	15	23.22	25.69	(2.5)	50.0	-26.8	24.2	-1.0	39.2	-16.0
PW-8-68	X	Alluvial	11-Feb-10	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	8	24.64	27.13	(2.5)	70.0	-45.4	48.0	-23.4	68.0	-43.4
PW-9-92	X	Alluvial	1-Mar-10	-	Sonic	Above-grade	Continuous wrap stainless steel	0.035	10-20	8	33.02	35.78	(2.8)	94.6	-61.6	72.6	-39.6	92.6	-59.6
Existing Piezometer																			
PZ1-5	X	Surficial Fill	18-Mar-09	-	Manual	Above-grade	Solinst push point		NA	1	9.96	36.07	(26.1)	5.6	4.3	4.5	5.5	5.4	4.6
PZ1-20	X	Alluvial	18-Mar-09	-	Manual	Above-grade	Solinst push point		NA	1	10.15	36.43	(26.3)	20.5	-10.3	19.3	-9.2	20.2	-10.1
PZ1-50	X	Alluvial	23-Nov-09	-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.17	37.67	(27.5)	50.4	-40.2	45.2	-35.0	50.2	-40.0
PZ2-5	X	Alluvial	18-Mar-09	-	Manual	Above-grade	Solinst push point		NA	1	2.89	37.90	(35.0)	6.7	-3.8	5.5	-2.6	6.4	-3.5
PZ2-20	X	Alluvial	18-Mar-09	-	Manual	Above-grade	Solinst push point		NA	1	3.38	37.89	(34.5)	21.7	-18.4	20.6	-17.2	21.5	-18.1
PZ2-43	X	Alluvial	3-Dec-09	-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	3.76	37.96	(34.2)	43.6	-39.8	38.4	-34.6	43.4	-39.6
PZ2-77	X	Alluvial	2-Dec-09	-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	3.05	38.65	(35.6)	77.2	-74.2	72.0	-69.0	77.0	-74.0
PZ4-12	X	Alluvial	4-Dec-09	-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	-8.63	34.67	(43.3)	12.0	-20.6	6.8	-15.4	11.8	-20.4
PZ4-41	X	Alluvial	24-Nov-09	-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	-8.33	33.07	(41.4)	41.4	-49.7	36.2	-44.5	41.2	-49.5
PZ5-5	X	Surficial Fill	20-Nov-09	-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.70	16.51	(5.5)	5.0	5.7	3.8	6.9	4.8	5.9
PZ5-20	X	Alluvial	20-Nov-09	-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.72	16.24	(5.5)	20.3	-9.6	15.1	-4.4	20.1	-9.4
PZ5-55	X	Alluvial	20-Nov-09	-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.79	16.31	(5.5)	55.3	-44.5	50.1	-39.3	55.1	-44.3
PZ5-85	X	Alluvial	19-Nov-09	-	Sonic	Above-grade	Slotted PVC	0.020	10-20	2	10.79	16.44	(5.4)	85.2	-74.4	80.0	-69.2	85.0	-74.2

Notes:
Highlighted cells = Previous survey value updated with 3/15/2009 survey results
bgs = below ground surface
btc = below top of casing
COP = City of Portland Datum
PVC = polyvinyl chloride
[1] actual completion depths may differ depending on actual lithology encountered during drilling

Table 2
Pump Test Summary
Gasco Segment 2 Capture Zone Test

Test Duration and Rate	Start Pump Test	End Pump Test	Pumping Wells			
			PW-7-93	PW-8-39	PW-8-68	PW-9-92
2 hour Pump Test - 15 GPM	4/19/2010 8:45	4/19/2010 10:45	X		X	X
2 hour Pump Test - 25 GPM	4/20/2010 9:30	4/20/2010 11:30	X		X	X
2 hour Pump Test - 35 GPM	4/21/2010 10:42	4/21/2010 12:42	X		X	X
72 hour Pump Test - 25 GPM	4/26/2010 16:57	4/30/2010 8:38	X		X	X
72 hour Pump Test - 35 GPM	5/4/2010 8:37	5/7/2010 16:29	X		X	X
72 hour Pump Test - 2 GPM	9/9/2010 10:28	9/12/2010 10:28		X		
72 hour Pump Test - 25 GPM	11/8/2010 12:00	11/11/2010 12:45	X	X*	X	X

Note:
GPM = gallons per miute
* Well pumped at 2 GPM

Table 3
Pump Test Results – Groundwater Elevations

	Ambient Pre-Test		Ambient Pre-test		72 hour Pump Test - 25 GPM		72 hour Pump Test - 35 GPM		Pre Test Ambient		72 hour Pump Test - 25 GPM		Post Test Ambient	
	4/21 18:00 - 4/24 18:00		4/23 0:00 - 4/26 0:00		4/27 0:00 - 4/30 0:00 25 GPM		5/4 12:00 - 5/7 12:00		11/5 12:00 - 11/8 11:00		11/8 12:47 - 11/11 12:47		11/12 8:40 - 11/15 8:40	
	72 hour Moving Average	Δ H from River	72 hour Moving Average	Δ H from River	72 hour Moving Average	Δ H from River	72 hour Moving Average	Δ H from River	72 hour Moving Average	Δ H from River	72 hour Moving Average	Δ H from River	72 hour Moving Average	Δ H from River
MW-2-32	13.13	5.60	13.11	4.97	13.27	3.92	13.08	5.21	10.14	2.61	10.22	2.76	9.79	4.08
MW-2-61	7.63	0.11	8.24	0.10	9.12	(0.23)	7.57	(0.30)	7.65	0.12	7.27	(0.19)	5.91	0.19
MW-2-104	7.64	0.11	8.25	0.11	9.11	(0.24)	7.54	(0.33)	7.69	0.16	7.30	(0.16)	5.96	0.24
MW-3-26	13.78	6.26	13.65	5.51	14.31	4.96	13.82	5.94	13.97	6.44	14.44	6.98	14.37	8.66
MW-3-56	7.76	0.24	8.33	0.19	9.34	(0.01)	7.96	0.09	7.77	0.25	7.54	0.08	6.14	0.43
MW-16-65	7.76	0.24	8.33	0.19	9.37	0.02	8.00	0.13	9.22	1.69	9.02	1.56	7.58	1.87
MW-18-125									6.22	(1.31)	5.98	(1.48)	4.48	(1.24)
MW-18-180	7.74	0.22	8.35	0.21	9.51	0.16	8.06	0.19	7.78	0.25	7.68	0.22	6.03	0.32
MW-21-12	12.73	5.20	12.72	4.58	13.16	3.81	12.85	4.98	12.23	4.70	12.48	5.02	12.34	6.62
MW-21-75	7.67	0.15	8.28	0.14	9.12	(0.23)	7.56	(0.32)	7.73	0.20	7.32	(0.14)	6.01	0.29
MW-21-115	7.73	0.20	8.33	0.19	9.23	(0.12)	7.65	(0.22)	7.78	0.25	7.40	(0.06)	6.02	0.31
MW-21-166	7.84	0.32	8.45	0.31	9.60	0.25	8.14	0.26	7.88	0.35	7.76	0.30	6.12	0.41
MW-22-80	7.53	0.00	8.14	(0.00)	9.09	(0.26)	7.63	(0.25)	7.64	0.11	7.32	(0.14)	5.88	0.17
MW-23-27	9.51	1.99	9.59	1.45	10.10	0.75	9.89	2.01	9.01	1.48	9.16	1.70	8.86	3.15
MW-23-75	7.58	0.06	8.20	0.06	9.05	(0.30)	7.51	(0.37)	7.65	0.12	7.27	(0.19)	5.89	0.18
MW-23-123	7.59	0.07	8.20	0.06	9.19	(0.16)	7.69	(0.18)	7.69	0.16	7.37	(0.09)	5.93	0.22
MW-24-70	7.73	0.21	8.30	0.16	9.32	(0.03)	7.93	0.05	7.78	0.25	7.55	0.09	6.14	0.42
MW-24-130	7.66	0.14	8.27	0.13	9.28	(0.07)	7.78	(0.09)	7.70	0.17	7.44	(0.02)	5.95	0.24
OW-7-17	11.72	4.19	11.71	3.57	12.28	2.93	11.78	3.91	11.91	4.38	12.18	4.72	11.88	6.17
OW-8-15	12.02	4.50	12.04	3.90	12.49	3.14	12.15	4.28	11.42	3.89	11.54	4.08	11.34	5.62
OW-8-28									9.24	1.71	8.21	0.75	8.38	2.66
OW-9-25	9.83	2.31	9.88	1.74	10.29	0.94	9.93	2.05	9.31	1.78	9.40	1.93	9.17	3.45
PW-7-93	7.87	0.35	8.48	0.34	3.59	(5.76)	-1.14	(9.02)	7.83	0.30	1.73	(5.73)	6.09	0.37
PW-8-39									8.24	0.71	-7.88	(15.34)	6.72	1.00
PW-8-68	7.81	0.29	8.42	0.28	6.38	(2.97)	3.60	(4.27)	7.84	0.31	4.51	(2.95)	6.09	0.37
PW-9-92	7.78	0.25	8.39	0.25	-2.83	(12.18)	-10.60	(18.47)	7.69	0.16	-4.41	(11.87)	5.94	0.22
PZ1-5	7.87	0.34	8.35	0.21	9.63	0.28	8.38	0.51	8.33	0.80	8.29	0.83	7.08	1.37
PZ1-20	7.86	0.34	8.41	0.27	9.47	0.12	8.14	0.27	7.67	0.14	7.50	0.04	5.97	0.25
PZ1-50	7.63	0.10	8.24	0.10	9.17	(0.18)	7.64	(0.23)	7.66	0.13	7.32	(0.14)	5.91	0.20
PZ2-5	7.68	0.15	8.29	0.15	9.31	(0.04)	7.80	(0.08)	7.63	0.10	7.57	0.11	5.83	0.12
PZ2-20	7.70	0.18	8.30	0.16	9.39	0.04	7.97	0.10	7.67	0.14	7.50	0.04	5.97	0.25
PZ2-43	7.60	0.08	8.21	0.07	9.30	(0.05)	7.83	(0.05)	7.65	0.12	7.46	(0.00)	5.90	0.19
PZ2-77	7.68	0.15	8.29	0.15	9.31	(0.04)	7.80	(0.08)	7.70	0.17	7.45	(0.02)	5.94	0.23
PZ4-12	7.55	0.03	8.13	(0.01)	9.28	(0.07)	7.90	0.02	7.60	0.07	7.49	0.03	5.91	0.19
PZ4-41	7.59	0.06	8.19	0.05	9.34	(0.01)	7.89	0.01	7.63	0.10	7.50	0.04	5.87	0.16
PZ5-5	9.52	2.00	9.69	1.55	10.35	1.00	9.69	1.81	9.61	2.08	9.60	2.14	9.12	3.41
PZ5-20	8.58	1.05	8.98	0.84	9.92	0.57	8.88	1.00	8.61	1.08	8.51	1.05	7.55	1.83
PZ5-55	7.69	0.17	8.30	0.16	9.21	(0.14)	7.67	(0.21)	7.71	0.18	7.35	(0.11)	5.96	0.25
PZ5-85	7.70	0.18	8.31	0.17	9.24	(0.11)	7.70	(0.17)	7.71	0.18	7.35	(0.11)	5.96	0.24
Willamette River	7.52	0.00	8.14	0.00	9.35	0.00	7.87	0.00	7.53	0.00	7.46	0.00	5.71	0.00

Notes:
Values represent average water level elevation in feet, City of Portland datum. Average values calculated using a 72 hour moving average method (Serfes, 1991).
Values in red with parentheses represent negative values (average water level in River higher than average water level in well).

Table 4
Groundwater Chemistry Data

Sample ID	GS-110810-1	GS-111010-6	GS-111110-15	GS-110810-3	GS-111010-8	GS-111010-9	GS-111110-14	GS-110810-2	GS-111010-7	GS-111110-13
Well ID	PW-7-93	PW-7-93	PW-7-93	PW-8-39	PW-8-39	PW-8-39	PW-8-39	PW-8-68	PW-8-68	PW-8-68
Sample Date	11/8/2010	11/10/2010	11/11/2010	11/8/2010	11/10/2010	11/10/2010	11/11/2010	11/8/2010	11/10/2010	11/11/2010
Sample Type	N	N	N	N	N	Dup	N	N	N	N
Conventional Parameters (mg/l)										
Alkalinity, Bicarbonate as CaCO3	**374**	**347**	**352**	**353**	**327**	**318**	**319**	**359**	**320**	**317**
Alkalinity, Carbonate as CaCO3	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
Alkalinity, total as CaCO3	**374**	**347**	**352**	**353**	**327**	**318**	**319**	**359**	**320**	**317**
Chloride (total)	**7.08**	**7.3**	**7.33**	**79.9**	**54.2**	**53.7**	**51.7**	**17.1**	**8.01**	**8.05**
Cyanide, total	**0.1**	**0.0742**	**0.0781**	**0.0788**	**0.0709**	**0.0659**	**0.0839**	**0.122**	**0.0877**	**0.12**
Cyanide, free	0.005 UJ	0.005 U	0.005 U	0.005 UJ	0.005 U	0.005 U	0.005 U	0.005 UJ	0.005 U	0.005 U
Cyanide, Weak acid dissociable (WAD)	**0.0282**	**0.0141**	**0.0388**	**0.0198**	**0.0278**	**0.0334**	**0.0364**	**0.0209**	**0.0249**	**0.0309**
Nitrate as nitrogen	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
Sulfate	1 U	**24.2**	**33.2**	**28.5**	**13**	**13**	**9.84**	1 U	1 U	1 U
Dissolved Metals (µg/l)										
Calcium	**77200**	**79300**	**81200**	**62700**	**59000**	**58300**	**56800**	**57700**	**64600**	**65800**
Iron	**42200**	**43500**	**44400**	**31900**	**21400**	**21200**	**21500**	**42500**	**42000**	**41200**
Magnesium	**27900**	**29000**	**29600**	**30800**	**34700**	**33900**	**34600**	**39900**	**23600**	**23800**
Manganese	**3150**	**3320**	**3450**	**2750**	**2000**	**1980**	**1910**	**2050**	**4360**	**4280**
Potassium	**6450**	**6830**	**6470**	**2800**	**2970**	**2940**	**2780**	**3890**	**5000**	**4610**
Sodium	**18200**	**18300**	**18600**	**81200**	**56600**	**55500**	**46200**	**20100**	**15500**	**15700**
Total Metals (µg/l)										
Calcium	**71600**	**76500**	**59700**	**58500**	**55700**	**56100**	**59700**	**54100**	**64100**	**66500**
Iron	**40500**	**42400**	**42500**	**31100**	**20900**	**20500**	**20900**	**43000**	**41100**	**40700**
Magnesium	**26300**	**28500**	**28600**	**29200**	**33300**	**33200**	**35100**	**39000**	**23900**	**23400**
Manganese	**3010**	**3240**	**3210**	**2600**	**1960**	**1940**	**1870**	**1960**	**4250**	**4130**
Potassium	**6230**	**6690**	**6700**	**2710**	**3030**	**3030**	**2800**	**3900**	**5170**	**4770**
Sodium	**17200**	**18200**	**15300**	**76800**	**54800**	**54800**	**48600**	**19700**	**15900**	**15500**

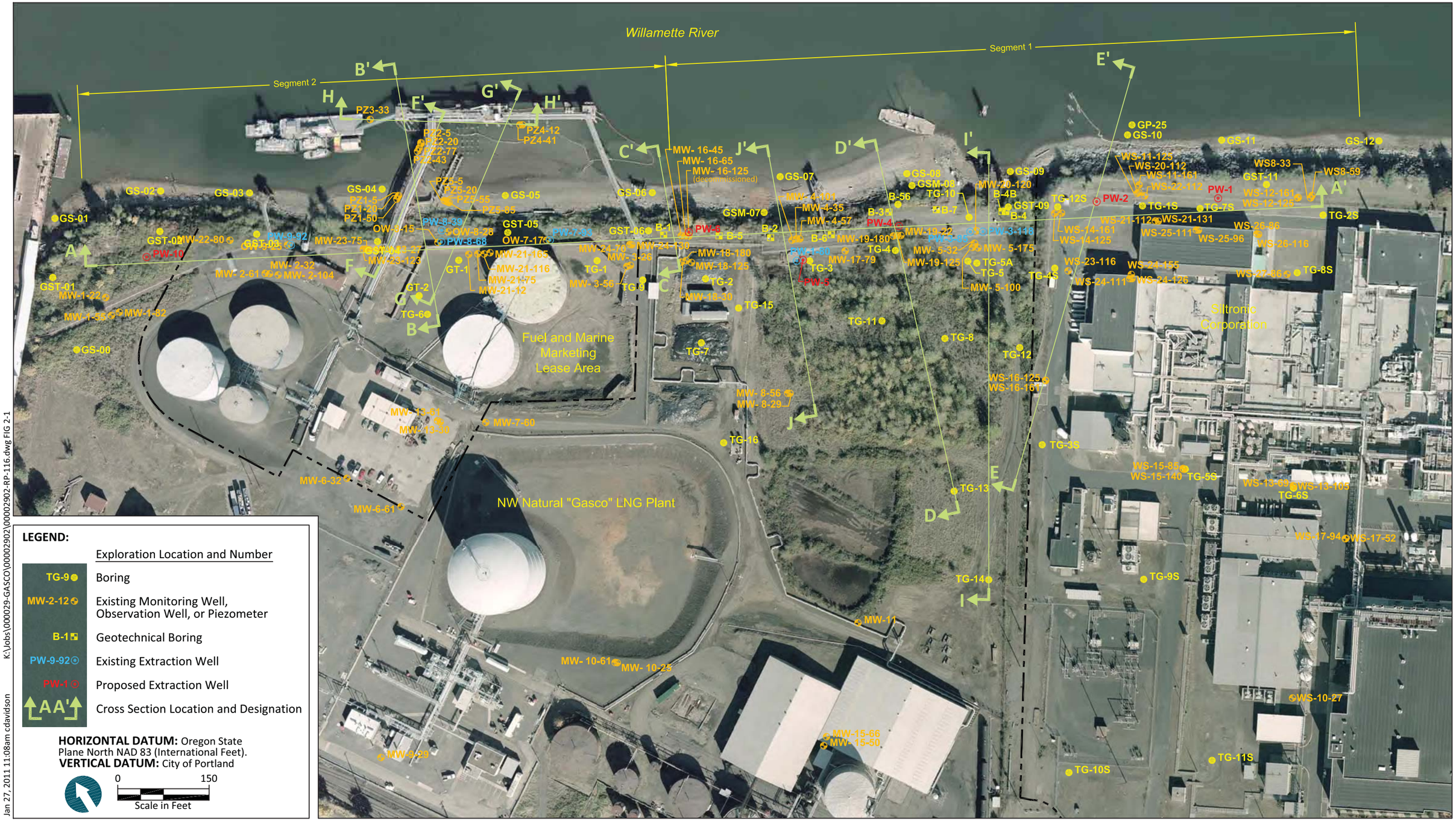
Notes:
Bold = Detected result
J = Estimated value
U = Compound analyzed, but not detected above detection limit
UJ = Compound analyzed, but not detected above estimated detection limit

Table 4
Groundwater Chemistry Data

Sample ID	GS-110810-4	GS-111010-10	GS-111110-17	GS-110810-5	GS-111010-12	GS-111110-16	GS-111010-11
Well ID	PW-9-92	PW-9-92	PW-9-92	Willamette River	Willamette River	Willamette River	Field Blank
Sample Date	11/8/2010	11/10/2010	11/11/2010	11/8/2010	11/10/2010	11/11/2010	11/10/2010
Sample Type	N	N	N	N	N	N	N
Conventional Parameters (mg/l)							
Alkalinity, Bicarbonate as CaCO3	**299**	**306**	**312**	**27.6**	**27.6**	**24.2**	20 U
Alkalinity, Carbonate as CaCO3	20	U 20	U 20	U 20	U 20	U 20 U	20 U
Alkalinity, total as CaCO3	**299**	**306**	**312**	**27.6**	**27.6**	**24.2**	20 U
Chloride (total)	**25.4**	**17.6**	**17**	**4.65**	**4.29**	**3.76**	1 U
Cyanide, total	**0.15**	**0.165**	**0.185**	**0.0251**	**0.0076**	**0.0246**	**0.0082**
Cyanide, free	0.005	UJ 0.005	U 0.005	U 0.005	U 0.005	U 0.005 U	0.005 U
Cyanide, Weak acid dissociable (WAD)	**0.0309**	**0.0416**	**0.0387**	**0.0297**	**0.0351**	**0.0128**	**0.0273**
Nitrate as nitrogen	0.25	U 0.25	U 0.25	U **0.536**	**0.572**	**0.715**	0.25 U
Sulfate	1	U 1	U 1	U **3.53**	**3.44**	**3.69**	1 U
Dissolved Metals (µg/l)							
Calcium	**58800**	**58800**	**58000**	**6680**	**6550**	**6690**	**30.6 J**
Iron	**43400**	**42700**	**41300**	**156**	**132**	**218**	**16.2 J**
Magnesium	**30000**	**29200**	**28300**	**2150**	**2070**	**2110**	50 U
Manganese	**3340**	**3280**	**3210**	**11.1**	**11.6**	**12.4**	**0.467 J**
Potassium	**3320**	**3530**	**3210**	**1040**	**1040**	**1150**	100 U
Sodium	**15600**	**15600**	**15200**	**5220**	**4880**	**4580**	100 U
Total Metals (µg/l)							
Calcium	**56200**	**56200**	**83300**	**6130**	**6640**	**6810**	100 U
Iron	**43500**	**41100**	**44600**	**383**	**431**	**646**	50 U
Magnesium	**29100**	**28200**	**29500**	**2080**	**2200**	**2160**	50 U
Manganese	**3290**	**3160**	**3370**	**18.1**	**21.4**	**21.8**	1 U
Potassium	**3290**	**3460**	**3290**	**938**	**1060**	**1170**	**13.9 J**
Sodium	**15300**	**15300**	**18300**	**4920**	**5010**	**4620**	**46.1 J**

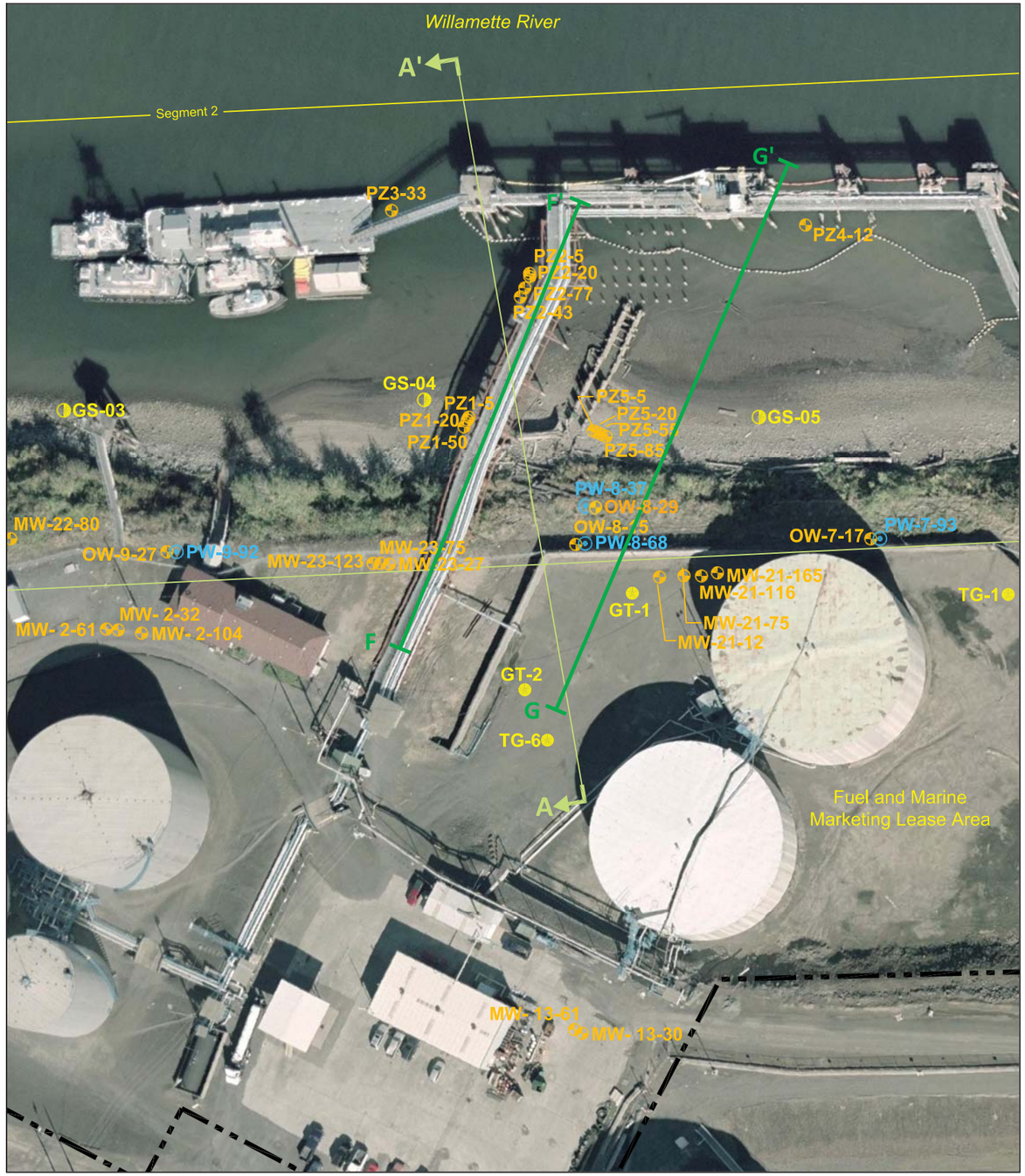
Notes:
Bold = Detected result
J = Estimated value
U = Compound analyzed, but not detected above detection limit
UJ = Compound analyzed, but not detected above estimated detec

FIGURES



ANCHOR QEA

Figure 1
Well Location Map
Segment 2 Capture Zone Field Test
Gasco, Portland, Oregon



LEGEND:

	Exploration Location and Number
TG-9	Boring
12	Existing Monitoring Well, Observation Well, or Piezometer
GS-01	Gasco Phase 1 Offshore Boring
B-1	Geotechnical Boring
PW-9-92	Existing Extraction Well
PW-1	Proposed Extraction Well
AA'	Cross Section Location and Designation

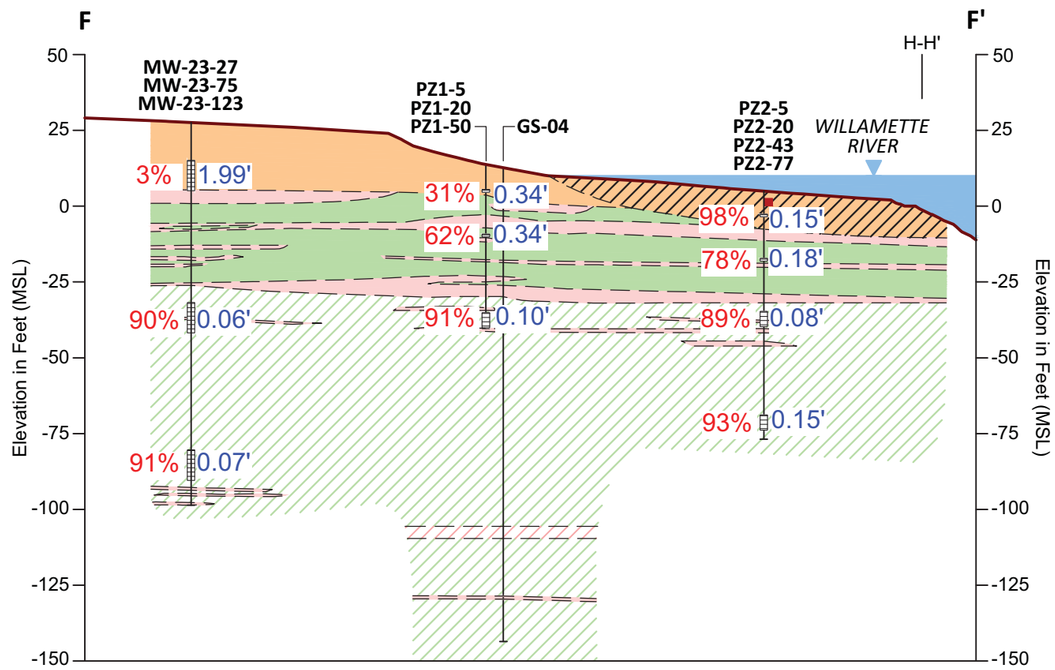
0 150
Scale in Feet

HORIZONTAL DATUM: Oregon State Plane North NAD 83 (International Feet).
VERTICAL DATUM: City of Portland

obs\000029-GASCO\00002902\00002902-RP-098.dwg FIG 1
Jul 13, 2010 11:09am cdavidson

ANCHOR QEA

Figure 2
Study Area Well Location Map
Segment 2 Capture Zone Field Test Report
Gasco, Portland, Oregon



Tidal Efficiencies / ΔH from River

LEGEND:

- Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily fine to medium grained SAND and SILTY-SAND interbedded with thin silt and sandy-silt layers
- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- SAND and SILT mixed with wood chips and anthropogenic material (wood, metal, cardboard)
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Existing Ground Surface

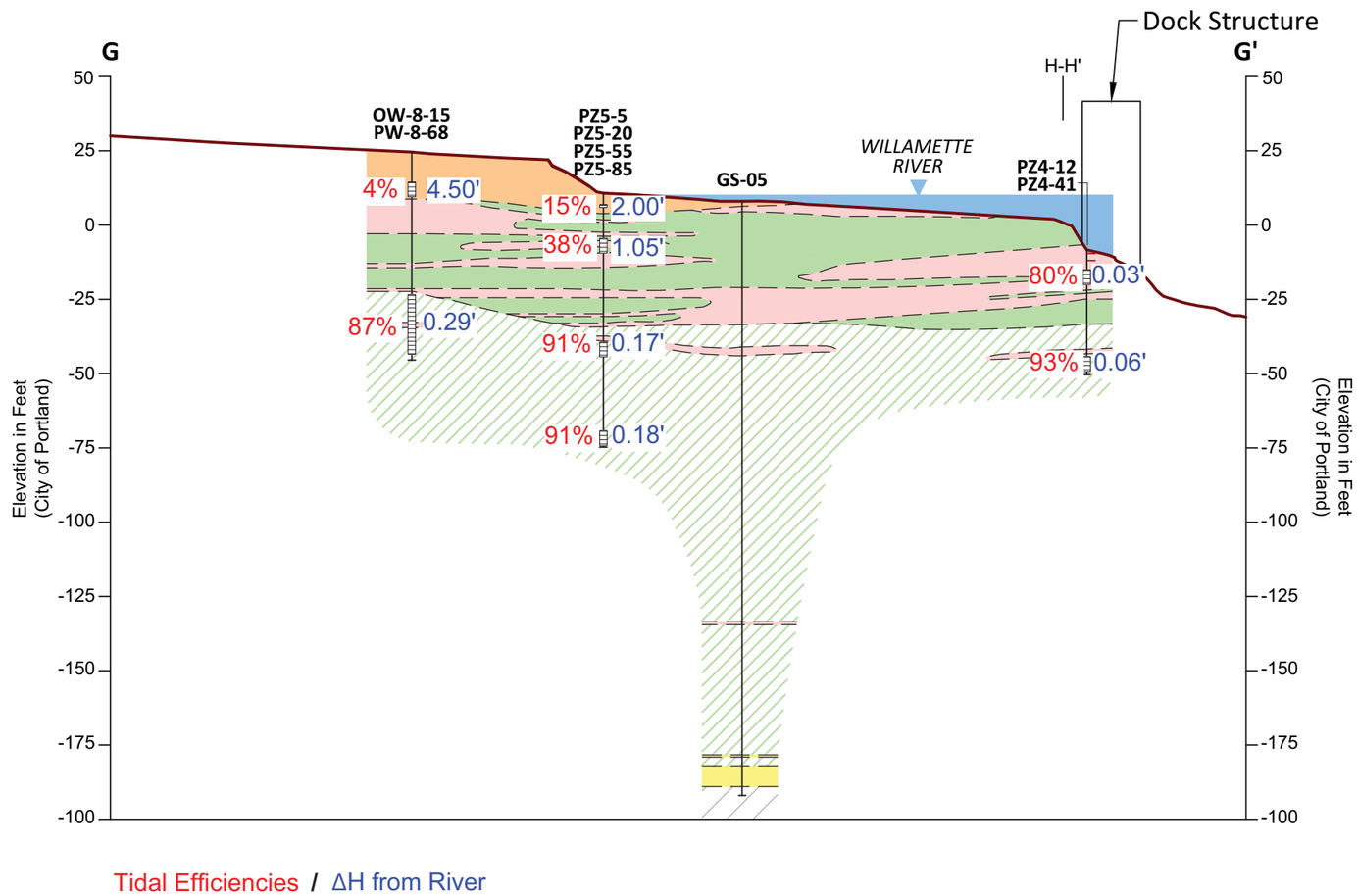
MW-23-123 — Boring ID
NAPL and/or Tar Interval
xx — Boring ID
Existing Well or Piezometer
— Well Screen

050
Scale in Feet

obs\000029-GASCO\00002902\00002902-RP-086.dwg F-F'
Jan 27, 2011 11:01am cdavidson

ANCHOR QEA

Figure 3
Pre-test Data
Cross Section F-F'
Segment 2 Capture Zone Test Report
Gasco, Portland, Oregon



LEGEND:

- Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily fine to medium grained SAND and SILTY-SAND interbedded with thin silt and sandy-silt layers
- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Existing Ground Surface

PW8-68 — Boring ID

xx — Boring ID

Existing Well or Piezometer

NAPL and/or Tar Interval

Well Screen

0 50

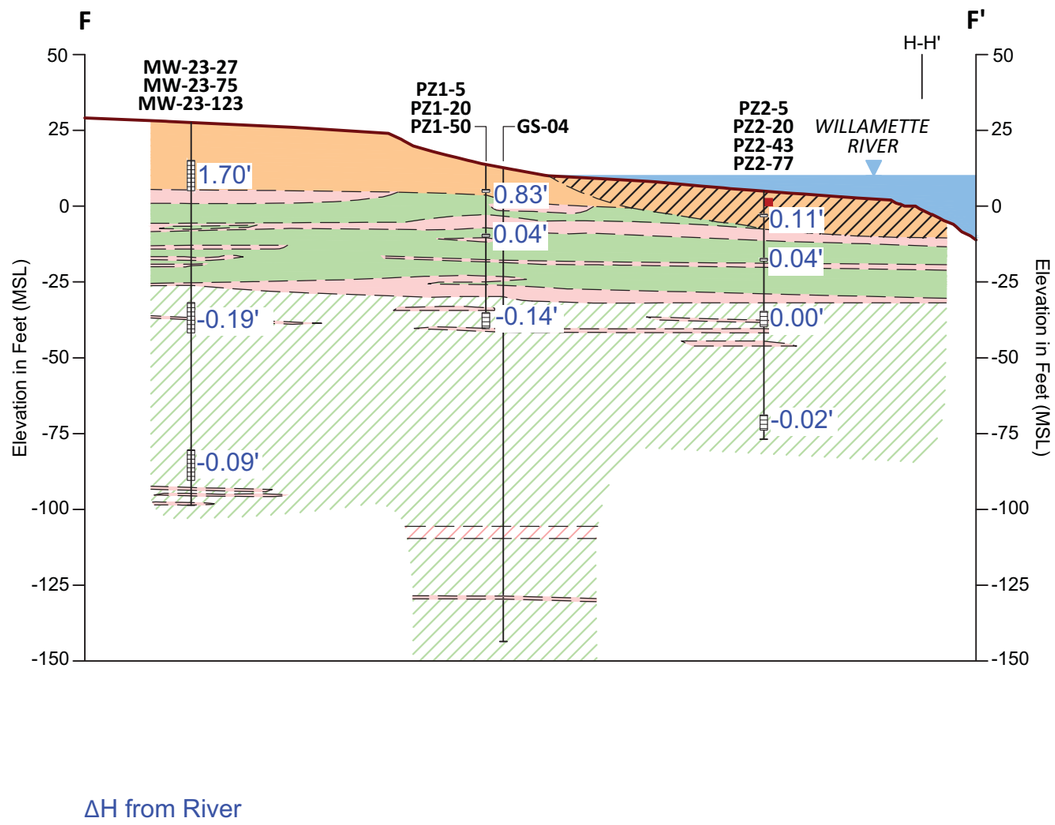
Scale in Feet

K:\Jobs\000029-GASCO\00002902\00002902-RP-086.dwg G-G'

Jan 27, 2011 11:02am cdavidson

ANCHOR QEA

Figure 4
Pre-test Data
Cross Section G-G'
Segment 2 Capture Zone Test Report
Gasco, Portland, Oregon



LEGEND:

- Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily fine to medium grained SAND and SILTY-SAND interbedded with thin silt and sandy-silt layers
- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- SAND and SILT mixed with wood chips and anthropogenic material (wood, metal, cardboard)
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Existing Ground Surface

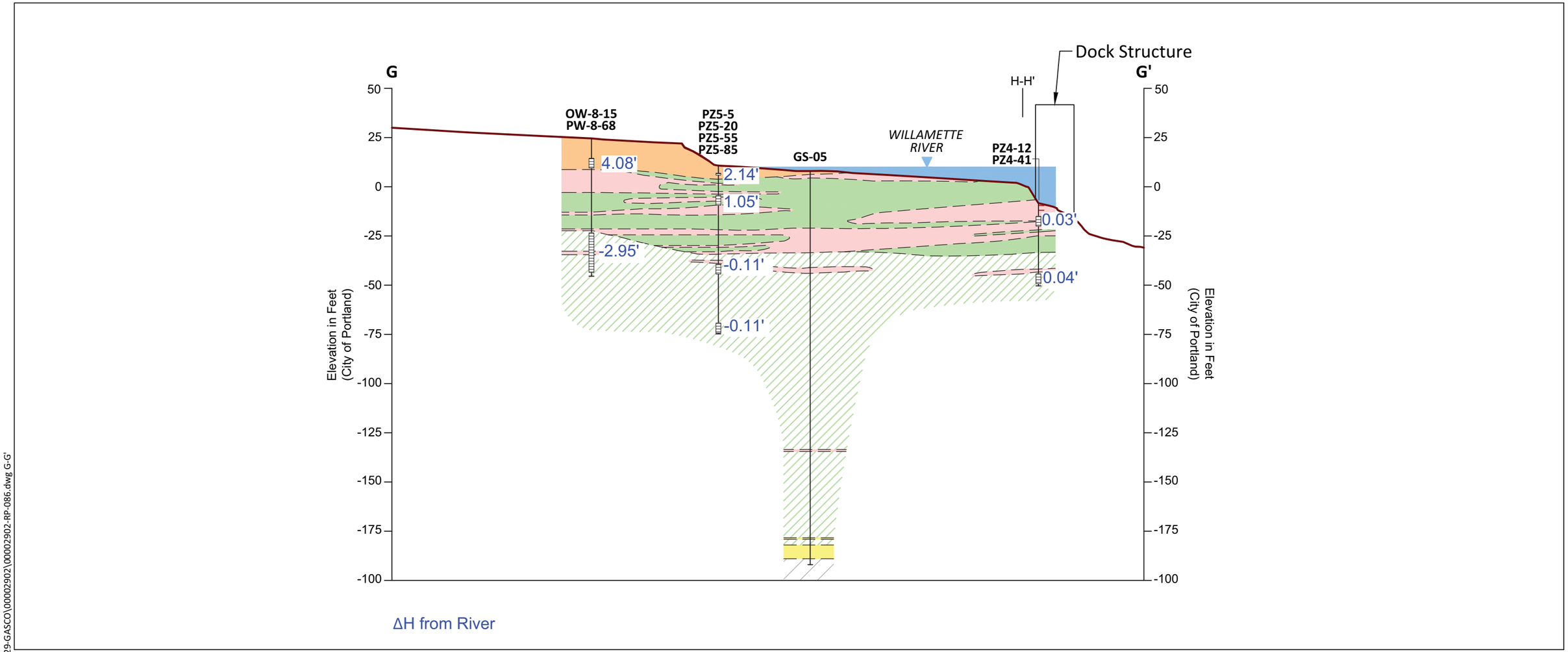
MW-23-123 — Boring ID
NAPL and/or Tar Interval
xx — Boring ID
Existing Well or Piezometer
— Well Screen

050
Scale in Feet

obs\000029-GASCO\00002902\00002902-RP-086.dwg F-F'
Jan 27, 2011 11:01am cdavidson

ANCHOR QEA

Figure 5
3 Day 25 GPM Data
Cross Section F-F'
Segment 2 Capture Zone Test Report
Gasco, Portland, Oregon



LEGEND:

- Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Aquitard; Primarily SILT and SANDY-SILT interbedded with thin sand and silty-sand layers
- Primarily fine to medium grained SAND and SILTY-SAND interbedded with thin silt and sandy-silt layers
- Fill composed of gravel, silt, sand, metal, brick, and concrete debris
- Alluvial GRAVEL, sandy gravel, gravelly sand, and gravelly silt
- Primarily medium grained SAND with generally less than 15% fines.
- Basalt BEDROCK
- Existing Ground Surface

PW8-68 — Boring ID

xx — Boring ID

Existing Well or Piezometer

NAPL and/or Tar Interval

Well Screen

0 50

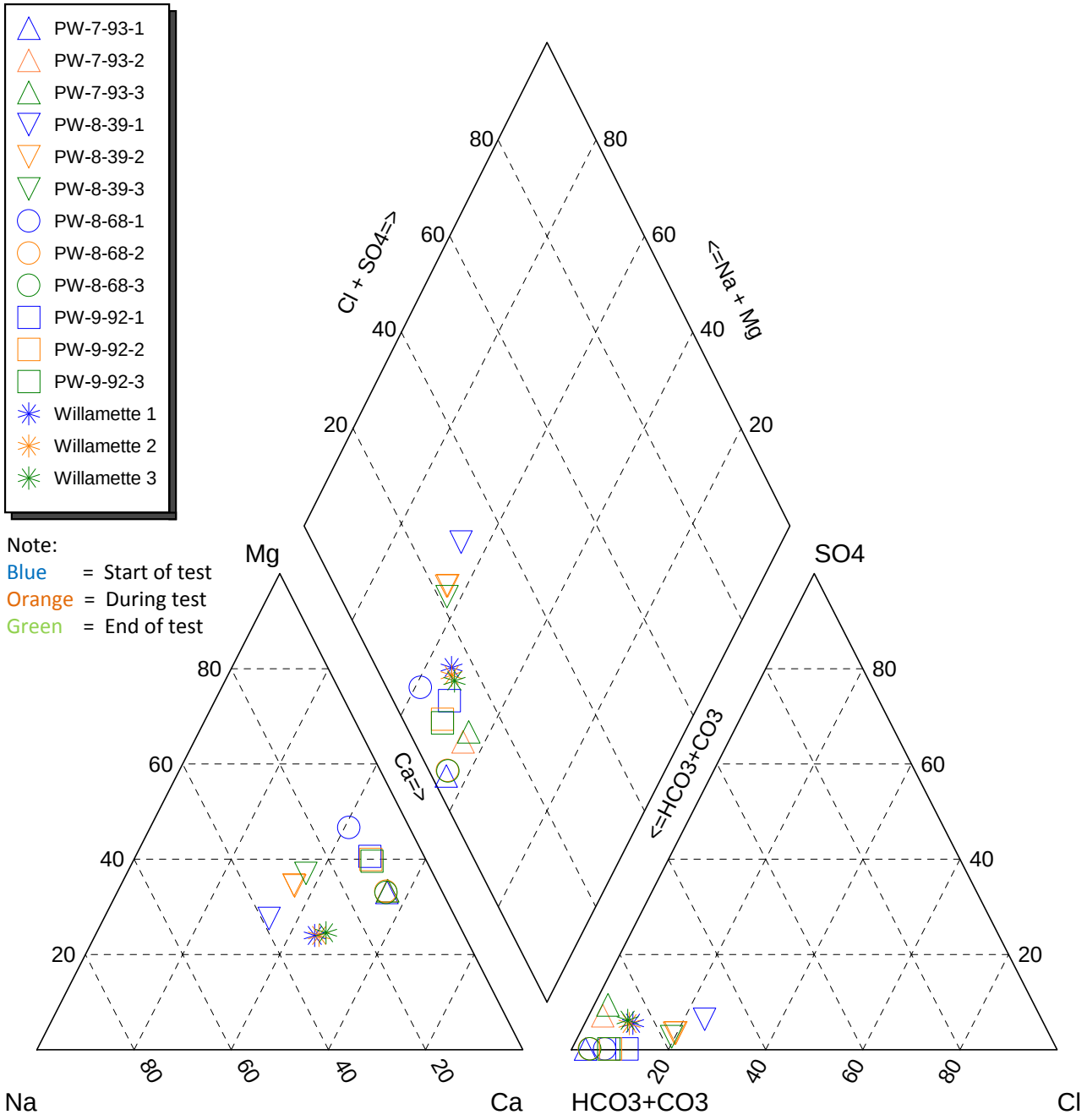
Scale in Feet

K:\Jobs\000029-GASCO\00002902\00002902-RP-086.dwg G-G'

Jan 27, 2011 11:02am cdavidson

ANCHOR QEA

Figure 6
3 Day 25 GPM Data
Cross Section G-G'
Segment 2 Capture Zone Test Report
Gasco, Portland, Oregon



DESCRIPTION: 72 hour Pump Test Data

ANCHOR QEA

PROJECT: Gasco

CLIENT: NW Natural

Figure 7
Piper Diagram
Segment 2 Capture Zone Test Report
Gasco, Portland, Oregon

APPENDIX A
BORING LOGS

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-22-80**
LOCATION	**Portland, Oregon**	PAGE	**1 of 5**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**33.6 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**80.9 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**1/28/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009301**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102834**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
Hand Dug	0.8	0	None	NA				**0 to 1.0 foot: GRAVEL (GW)**, dark gray, angular. (FILL)	100	0	0
CB	0.7	0	None	2/8.5				**1.0 to 10.0 feet: GRAVELLY SILT (ML)**, dark brown, firm, moist, abundant rootlets, non plastic. @ 1.5 feet: abundant lampblack, gravel-sized pieces, small brick pieces, fibrous material, broken glass, electrical wires. (FILL)	20	0	80
	NA	NA	NA		5						
CB	2.4	2	None	3/5	10			**10.0 to 15.0 feet: GRAVEL WITH SAND AND SILT (GW-GM)**, black, moist, large chunks of brick and gravel, electrical wires, metal fragments, slight hydrocarbon-like odor, lampblack, concrete chunks, well graded. (FILL)	80	10	10
	NA	NA	NA								
CB	0.9	1	None	4.5/5	15			**15.0 to 22.0 feet: SILTY SANDY GRAVEL (GW-GM)**, black, dry, loose, abundant lampblack, brick, electrical wire, concrete chunks, well graded. (FILL)	50	30	20
	1.7	1	None		20			@ 18.5 feet: wet.			

REMARKS

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-22-80**
LOCATION	**Portland, Oregon**	PAGE	**2 of 5**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**33.6 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**80.9 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**1/28/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009301**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102834**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0	0	None	2/2				**15.0 to 22.0 feet: SILTY SANDY GRAVEL (GW-GM)**, continued.	50	30	20
CB	0.3	0	None	10/10				**22.0 to 23.0 feet: SAND (SP)**, dark reddish brown, loose, moist, poorly graded, medium grained, homogenous. (FILL)	0	100	0
	0.2	0	None		25			**23.0 to 26.6 feet: SILTY SAND (SM)**, gray, wet, with intermittent, thin silt layers. @ 24.5 to 26.6 feet: red and gray mottling. (FILL)	0	60	40
	0.5	0	None					**26.6 to 40.0 feet: SILT WITH SAND (MH)**, gray, wet, firm, highly plastic with thin sand layers (~1-2 mm). (ALLUVIUM)	0	10	90
	0.5	0	None		30						
	0.3	0	None					@ 30.5 to 31.5 feet: SILTY SAND layer (SM), dark gray, fine to medium sand. @ 31.5 to 40.0 feet: no recovery.	0	80	20
CB	NA	NA	NA	0/8	35						
					40						

REMARKS

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-22-80**
LOCATION	**Portland, Oregon**	PAGE	**3 of 5**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**33.6 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**80.9 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**1/28/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009301**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102834**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0.1	0	None	3.8/5				**40.0 to 45.0 feet: SANDY SILT (MH)**, dark brownish gray, very soft, wet, medium plasticity, fine sand. (ALLUVIUM)	0	20-30	70-80
								@ 41.8 to 42.5 feet: silty sand layer, fine sand. (ALLUVIUM)	0	90	10
	0.0	0	None								
CB	0.3	0	None	5/5	45			**45.0 to 45.9 feet: SAND (SP)**, dark gray, loose, wet, fine sand, <5 percent fines, poorly graded, homogenous. (ALLUVIUM)	0	95-100	0-5
								45.9 to 49.3 feet: SANDY SILT (MH), dark brownish gray, soft, moist, medium plasticity, intermittent thin (~1-2 mm) sand layers. (ALLUVIUM) @ 46.4 to 46.6 feet: sand layer. @ 47.1 to 47.2 feet: sand layer. @ 48.0 to 48.2 feet: sand layer.	0	20-30	70-80
	1.0	0	None								
CB	0.4	0	None	10/10	50			**49.3 to 52.4 feet: SAND (SP)**, dark gray, loose, wet, fine to medium grained, poorly graded sand, occasional silt blebs (<5 percent fines). (ALLUVIUM)	0	95-100	0-5
	0.4	0	None					**52.4 to 56.6 feet: SANDY SILT (MH)**, dark brownish gray, soft, wet, medium plasticity, intermittent thin (~1-2 mm) sand layers. (ALLUVIUM) @ 53.8 to 54.0 feet: sand layer.	0	20-30	70-80
	0.8	0	None		55			@ 55.4 to 55.6 feet: sand layer.			
	0.4	0	None					**56.6 to 59.0 feet: SAND (SP)**, dark gray, loose, wet, fine to medium grained, poorly graded sand, occasional silt blebs. (ALLUVIUM) @ 57.4 to 58.0 feet: silt layer.	0	95-100	0-5
					60			**59.0 to 60.0 feet: SILTY SAND (SM)**, dark gray, loose, wet, fine to medium grained,	0	70-80	20-30

REMARKS

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-22-80**
LOCATION	**Portland, Oregon**	PAGE	**4 of 5**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**33.6 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**80.9 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**1/28/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009301**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102834**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB				7.4/10				poorly graded sand, occasional silt blebs. (ALLUVIUM)	0	100	0
	0.7	0	None					**60.0 to 60.6 feet: SAND (SP)**, variegated sand grain color, dark gray, loose, wet, medium grained,poorly graded. (ALLUVIUM)	0	15	85
	0.7	0	None					**60.6 to 69.5 feet: SILT (MH)**, dark brownish gray, soft, moist, medium plasticity silt intermixed with medium grained sand. (ALLUVIUM)			
					65			@ 61.0 to 61.2 feet: medium grained sand layer.			
	0.4	0	None					@ 66.1 to 66.4 feet: SAND (SP), medium grained.			
	0.3	0	None								
CB				5/5	70			**69.5 to 80.0 feet: SAND (SP)**, dark gray, wet, loose, medium grained, poorly graded, variegated grain colors (mostly black with gray, white, red, tan). (ALLUVIUM)	0	100	0
	1.1	0	None								
	1.0	0	None								
CB				3.5/5	75						
	0.8	3	None								
	1.3	1	None								
					80						

REMARKS

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-22-80**
LOCATION	**Portland, Oregon**	PAGE	**5 of 5**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**33.6 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**80.9 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**1/28/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009301**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102834**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
					85			Total depth = 80.9 feet. **WELL COMPLETION DETAILS** 0 to 69.9 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC blank riser pipe. 69.9 to 79.9 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC well screen with 0.020-inch machined slots. 79.9 to 80.9 feet: 2-inch-diameter threaded end cap. 0 to 5.0 feet: Concrete. 5.0 to 64.8 feet: Bentonite grout. 64.8 to 67.8 feet: 20-40 Colorado silica sand. 67.8 to 80.9 feet: 10-20 Colorado silica sand.			
					90						
					95						
					100						

REMARKS

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-23-123**
LOCATION	**Portland, Oregon**	PAGE	**1 of 7**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**32.9 ft msl**
DRILL METHOD	**Rotosonic - AMS I7-C Compact Sonic**	TOTAL DEPTH	**131.5 ft.**
LOGGED BY	**Matt Wilson/John Renda**	DATE COMPLETED	**2/5/10**
SAMPLING METHOD	**4-in. by 5-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009310**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102839**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	1.1	0	None	3/3				**0 to 2.2 feet: GRAVELLY SILT (MH)**, brown moist, soft, sticky, fine to cobble sized, angular gravel, highly plastic silt. (FILL)	40	0	60
CB	0.6	0	None	2/4	5			**2.2 to 9.0 feet: GRAVELLY SILT (ML)**, black and dark olive gray mixed, dry, hard, concrete pieces at 3.8 to 4.0 feet, gravel is well rounded, fine to cobble sized, low plasticity silt. (FILL)	40-50	0	50-60
	0.6	0	None								
CB	1.8	0	None	0.8/2							
	0.9	0	None								
CB	NA	NA	None	2.5/5	10			**9.0 to 14.5 feet: SILTY GRAVEL (GW)**, gray and black mixed, dry, very hard, large cobble from 9.0 to 10.0 feet, gravel is angular, fine to cobble sized, well graded, nonplastic silt, very soft silt. (FILL) @ 10.0 feet: wet, black, sticky, concrete and lampblack (fine grained soot-like material present).	60-70	0	30-40
	1.1	0	None								
CB	10.2	0	None	4/4	15			@ 14.4 feet: chunk of concrete. **14.5 to 21.0 feet: GRAVELLY SILT (ML)**, black, dry, hard, brittle, friable, nonplastic, strong hydrocarbon-like naphthalene-like odor. (FILL)	30	0	70
	25.9	0	None					@ 17.9 feet: hard, dry, gray concrete.			
	9.0	0	None	2.5/3	20			@ 18.6 feet: hard, dry, gray concrete.			

REMARKS

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LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-23-123**
LOCATION	**Portland, Oregon**	PAGE	**2 of 7**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**32.9 ft msl**
DRILL METHOD	**Rotosonic - AMS I7-C Compact Sonic**	TOTAL DEPTH	**131.5 ft.**
LOGGED BY	**Matt Wilson/John Renda**	DATE COMPLETED	**2/5/10**
SAMPLING METHOD	**4-in. by 5-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009310**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102839**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
								14.5 to 21.0 feet: GRAVELLY SILT (ML), continued.	30	0	70
CB	5.4	0	None	2/2				**21.0 to 22.5 feet: SANDY SILT (ML)**, dark gray to black, medium to high plasticity fines, fine to coarse sand, angular, fine gravel, naphthalene odor, moist to wet. (FILL)	5	25-30	70-75
CB	4.7	0	None	2.5/3	25			**22.5 to 24.0 feet: GRAVELLY SILT (MH)**, greenish gray, medium to high plasticity fines, fine to coarse gravel, angular to subrounded, moist. (FILL)	40	5	60
									0	0	100
									0	0	100
								24.0 to 24.5 feet: SAND (SP), light brown, fine to medium, dry. (FILL)	0	100	0
CB	3.9	2	None	1/1				**24.5 to 25.0 feet: SANDY SILT (MH)**, dark gray to black, dense, brittle. (FILL)	Trace	40	60
								25.0 to 26.0 feet: SAND (SP), light brown, fine to medium, dry. (FILL)			
CB	0.9	0	None	3/3				**26.0 to 27.5 feet: SILTY SAND (SM)**, mottled dark gray to brown, fine to medium sand, medium to high plasticity fines, trace angular gravel, wood pieces at 27.5 feet (anthropogenic). (FILL)	0	0-20	80-100
CB	0.9	0	None	3/3	30			**27.5 to 32.0 feet: SANDY SILT (MH)**, light gray, medium to high plasticity fines, fine sand. (ALLUVIUM) @ 31.0 to 31.5 feet: fine sand lens.			
CB	1.1	0	None	3/3	35			**32.0 to 59.0 feet: SAND (SP)**, light gray, fine sand, trace root hairs and fine wood chips. (ALLUVIUM) @ 34.0 feet: 0.2-foot silt lens. @ 35.0 feet: 0.2-foot silt lens.	0	80-100	0-30
CB	0.9	0	None	2/2				@ 36.0 feet: 0.3-foot silt lens. @ 37.5 feet: 0.2-foot silt lens.			
CB	0.6	0	None	3/3	40			@ 38.5 to 39.5 feet: silt lens.			

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-23-123**
LOCATION	**Portland, Oregon**	PAGE	**3 of 7**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**32.9 ft msl**
DRILL METHOD	**Rotosonic - AMS I7-C Compact Sonic**	TOTAL DEPTH	**131.5 ft.**
LOGGED BY	**Matt Wilson/John Renda**	DATE COMPLETED	**2/5/10**
SAMPLING METHOD	**4-in. by 5-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009310**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102839**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
								32.0 to 59.0 feet: SAND (SP), (ALLUVIUM), continued.			
CB	1.2	0	None	2/2				@ 40.5 to 41.0 feet: silt lens. @ 42.0 feet: 0.2-foot silt lens.			
CB	1.2	0	None	3/3	45						
CB	1.6	0	None	1/1				@ 46.5 to 47.0 feet: silt lens.			
CB	1.3	0	None	4/4	50			@ 49.5 feet: 0.3-foot silt lens. @ 50.3 to 50.8 feet: silt lens.			
CB	1.0	0	None	3/3				@ 51.0 feet: 0.3-foot silt lens. @ 52.0 feet: 0.5-foot silt lens.			
CB	1.3	0	None	3/3	55			@ 53.0 to 54.0 feet: silt with organic laminations.			
CB	0.9	0	None	2/2							
CB	1.0	0	None	3/3				@ 58.5 to 59.0 feet: silt lens, trace organics.			
					60			**59.0 to 91.0 feet: SAND (SP)** , as on following page.	0	95-100	0-5

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-23-123**
LOCATION	**Portland, Oregon**	PAGE	**4 of 7**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**32.9 ft msl**
DRILL METHOD	**Rotosonic - AMS I7-C Compact Sonic**	TOTAL DEPTH	**131.5 ft.**
LOGGED BY	**Matt Wilson/John Renda**	DATE COMPLETED	**2/5/10**
SAMPLING METHOD	**4-in. by 5-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009310**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102839**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
								59.0 to 91.0 feet: SAND (SP), gray, medium grained, poorly graded, less than 5 percent fines, individual grains gray, red, white, clear. (ALLUVIUM)	0	95-100	0-5
CB	1.5	0	None	5/5							
CB	1.8	0	None		65						
CB	0.3	0	None	5/5				@ 68.0 feet: 0.1-foot silt lens, brown.			
	0.1	0	None		70			@ 69.0 feet: 0.1-foot silt lens. @ 70.0 to 70.5 feet: silt lens, trace organics, medium plasticity.			
CB	0.2	1	None	5/5				@ 72.0 feet: 0.1-foot silt lens.			
	0.2	0	None		75			@ 74.7 feet: 0.2-foot silt lens.			
	NA	NA	None	0/0				@ 76.0 to 81.0 feet: no recovery/drillers pushed past without sampling.			
	NA	NA	None		80						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-23-123**
LOCATION	**Portland, Oregon**	PAGE	**5 of 7**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**32.9 ft msl**
DRILL METHOD	**Rotosonic - AMS I7-C Compact Sonic**	TOTAL DEPTH	**131.5 ft.**
LOGGED BY	**Matt Wilson/John Renda**	DATE COMPLETED	**2/5/10**
SAMPLING METHOD	**4-in. by 5-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009310**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102839**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
	NA	NA	None					**59.0 to 91.0 feet: SAND (SP)**, as on previous page, medium grained, poorly graded. (ALLUVIUM)			
CB	0.5	3	None	5/5							
	0.0	0	None		85						
CB	0.4	3	None	4/5				@ 88.0 feet: 10 to 15 percent fines (increase in fines), soupy, loose, wet.	0	85-90	10-15
	0.5	9	None		90						
CB	0.4	8	None	5/5				**91.0 to 97.0 feet: SILTY SAND (SM)**, gray, fine to medium sand, low to medium plasticity fines, firm, dense, single piece of gravel at 92.0 feet, flat 1-inch diameter. (ALLUVIUM)	0	80-85	15-20
	0.8	12	None		95						
NA	NA	NA	None	0/0				@ 96.0 to 97.0 feet: no recovery, driller over drilled casing.			
CB	0.6	1	None	4/4	100			**97.0 to 131.5 feet: SAND (SP)**, dark gray, loose, wet, poorly graded, medium grained, <5 percent fines, homogenous, variegated grain colors (mostly black with gray, white, red, tan, clear). (ALLUVIUM)	0	95-100	0-5

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-23-123**
LOCATION	**Portland, Oregon**	**PAGE**	**6 of 7**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**32.9 ft msl**
DRILL METHOD	**Rotosonic - AMS I7-C Compact Sonic**	TOTAL DEPTH	**131.5 ft.**
LOGGED BY	**Matt Wilson/John Renda**	DATE COMPLETED	**2/5/10**
SAMPLING METHOD	**4-in. by 5-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009310**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102839**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
								97.0 to 131.5 feet: SAND (SP), as on previous page, medium grained, poorly graded. (ALLUVIUM)	0 0	95-100 95-100	0-5 0-5
CB	1.0	0	None	3.6/5							
	1.4	0	None		105						
CB	1.4	0	None	10/10							
	1.1	0	None		110						
	1.4	2	None								
	1.5	7	None		115			@ 114.9 to 115.3 feet: SANDY SILT (ML), dark grayish brown, dry, stiff, low plasticity, friable, medium grained sand.	0	20	80
CB	1.8	8	None	15/15							
	0.9	1	None		120						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-23-123**
LOCATION	**Portland, Oregon**	PAGE	**7 of 7**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**32.9 ft msl**
DRILL METHOD	**Rotosonic - AMS I7-C Compact Sonic**	TOTAL DEPTH	**131.5 ft.**
LOGGED BY	**Matt Wilson/John Renda**	DATE COMPLETED	**2/5/10**
SAMPLING METHOD	**4-in. by 5-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009310**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102839**

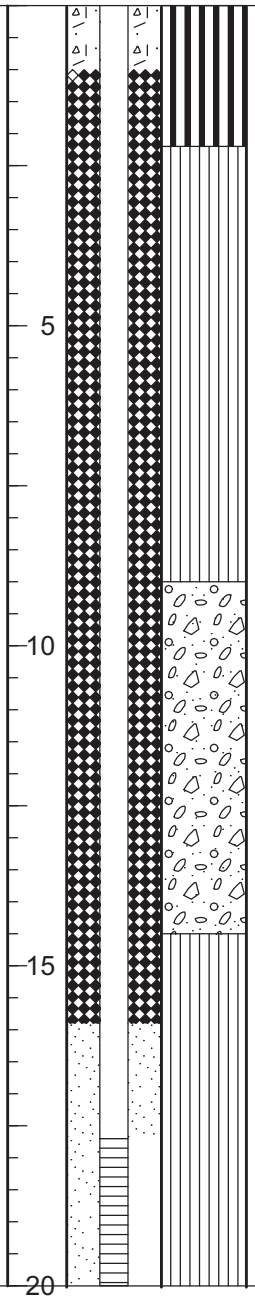
SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
								97.0 to 131.5 feet: SAND (SP) , as on previous page, medium grained, poorly graded. (ALLUVIUM)	0	95-100	0-5
	2.8	8	None					@ 123.0 feet: grain size change to fine grained.			
	1.4	2	None		125			@ 123.5 to 124.0 feet: silt layer (MH). @ 124.2 to 124.5 feet: silt layer (MH). @ 125.4 to 125.5 feet: silt layer (MH).			
	2.0	2	None					@ 125.7 to 126.6 feet: silt layer (MH). @ 126.7 to 126.9 feet: silt layer.			
	1.4	4	None		130			@ 128.1 to 128.5 feet: silt layer. @ 129.3 feet: color change to mixed dark gray and brown, dark gray is fine grained sand, brown is medium grained sand. @ 130.7 to 131.0 feet: sandy silt layer.			
					135			Total depth = 131.5 feet. **WELL COMPLETION DETAILS** 0 to 113.3 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC blank riser pipe. 113.3 to 123.3 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC well screen with 0.020-inch machined slots. 123.3 to 124.3 feet: 2-inch-diameter threaded end cap. 0 to 5.0 feet: Concrete. 5.0 to 108.7.0 feet: Bentonite grout. 108.7 to 111.4 feet: 20-40 Colorado silica sand. 111.4 to 124.2 feet: 10-20 Colorado silica sand. 124.2 to 131.5 feet: Bentonite chips.			
					140						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-23-27**
LOCATION	**Portland, Oregon**	PAGE	**1 of 2**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**32.8 ft msl**
DRILL METHOD	**Rotosonic - AMS I7-C Compact Sonic**	TOTAL DEPTH	**30.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/16/10**
SAMPLING METHOD	**4-in. by 5-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009312**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102841**

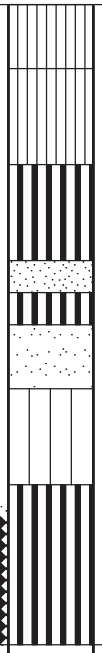
SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
								See boring log for well MW-23-123 for geologic description.			

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-23-27**
LOCATION	**Portland, Oregon**	PAGE	**2 of 2**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**32.8 ft msl**
DRILL METHOD	**Rotosonic - AMS I7-C Compact Sonic**	TOTAL DEPTH	**30.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/16/10**
SAMPLING METHOD	**4-in. by 5-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009312**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102841**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
					25			See boring log for well MW-23-123 for geologic description.			
					30			Total depth = 30.0 feet. **WELL COMPLETION DETAILS** 0 to 17.7 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC blank riser pipe. 17.7 to 27.7 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC well screen with 0.020-inch machined slots. 27.7 to 28.0 feet: 2-inch-diameter threaded end cap. 0 to 1.0 foot: Concrete. 1.0 to 15.9 feet: 3/8-inch bentonite chips. 15.9 to 28.0 feet: 10-20 Colorado silica sand. 28.0 to 30.0 feet: 3/8-inch bentonite chips.			
					35						
					40						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-23-75**
LOCATION	**Portland, Oregon**	PAGE	**1 of 4**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**32.9 ft msl**
DRILL METHOD	**Rotosonic - AMS I7-C Compact Sonic**	TOTAL DEPTH	**75.7 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/16/10**
SAMPLING METHOD	**4-in. by 5-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009311**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102840**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
					5			See boring log for well MW-23-123 for geologic description.			
					10						
					15						
					20						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-23-75**
LOCATION	**Portland, Oregon**	PAGE	**2 of 4**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**32.9 ft msl**
DRILL METHOD	**Rotosonic - AMS I7-C Compact Sonic**	TOTAL DEPTH	**75.7 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/16/10**
SAMPLING METHOD	**4-in. by 5-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009311**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102840**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
					25			See boring log for well MW-23-123 for geologic description.			
					30						
					35						
					40						

REMARKS

ANCHOR QEA

GASCO4.gds:3.5/26/10...GASCO4

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-23-75**
LOCATION	**Portland, Oregon**	PAGE	**3 of 4**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**32.9 ft msl**
DRILL METHOD	**Rotosonic - AMS I7-C Compact Sonic**	TOTAL DEPTH	**75.7 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/16/10**
SAMPLING METHOD	**4-in. by 5-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009311**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102840**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
					45						
					50						
					55						
					60						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-23-75**
LOCATION	**Portland, Oregon**	PAGE	**4 of 4**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**32.9 ft msl**
DRILL METHOD	**Rotosonic - AMS I7-C Compact Sonic**	TOTAL DEPTH	**75.7 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/16/10**
SAMPLING METHOD	**4-in. by 5-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009311**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102840**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
								See boring log for well MW-23-123 for geologic description.			
					65						
					70			**WELL COMPLETION DETAILS** 0 to 64.7 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC blank riser pipe. 64.7 to 74.7 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC well screen with 0.020-inch machined slots. 74.7 to 75.7 feet: 2-inch-diameter threaded end cap.			
					75			0 to 2.0 feet: Concrete. 2.0 to 59.7 feet: Bentonite grout. 59.7 to 62.7 feet: 20-40 Colorado silica sand. 62.7 to 75.7 feet: 10-20 Colorado silica sand. Total depth = 75.7 feet.			
					80						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-24-130**
LOCATION	**Portland, Oregon**	PAGE	**1 of 7**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**31.3 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**131.1 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/2/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009302**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102832**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0.7	0	None	6/6				**0 to 6.0 feet: SILTY GRAVEL (GM)**, dark brown, wet, fine to coarse gravel, nonplastic silt. (FILL)	70	0	30
	0.4	0	None					@ 1.6 feet: color change to light reddish brown, hard, dry.			
	0.5	0	None		5			@ 4.5 feet: mixed black and light reddish brown color.			
CB	0.1	0	None	4/4				**6.0 to 14.1 feet: SILTY GRAVEL (GM)**, dark brown, moist, soft, fine to cobble size angular gravel, highly plastic sticky silt. (FILL)	60	0	40
	1.0	0	None								
CB	0.6	3	None	4/5	10						
	0.6	1	None								
	1.1	0	None					**14.1 to 25.0 feet: SILTY SANDY GRAVEL (GW-GM)**, mixed dark gray and black, loose, dry, fine to cobble, well rounded angular gravel, nonplastic silt, well graded. (FILL)	60	20	20
CB				2.5/5	15						
	0.6	1	None								
	14.1	0	Yes [1]					@ 18.2 feet: color change to black, wet, oily, strong hydrocarbon-like odor, spotty sheen at 19.0 to 20.0 feet.			
					20						

REMARKS

[1] Dull orange swirls and specks of fluorescence, green fluorescent smearing on plastic sample bag. [2] Trace orange fluorescence.

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-24-130**
LOCATION	**Portland, Oregon**	PAGE	**2 of 7**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**31.3 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**131.1 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/2/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009302**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102832**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB				5/5				**14.1 to 25.0 feet: SILTY SANDY GRAVEL (GW-GM)**, as on previous page.	60	20	20
	10.9	0	Yes [1]					@ 21.0 to 24.6 feet: heavy sheen, oily, strong hydrocarbon-like odor.			
								@ 22.2 to 22.4 feet: tar.			
	16.1	0	Yes [1]					@ 23.0 feet: lampblack and charcoal-like material.			
								@ 24.0 feet: wood chips.	30	70	0
								@ 24.2 to 24.6 feet: gravelly sand layer, heavily saturated with oil.	10	0	90
CB				5/5	25			@ 24.6 to 25.0 feet: SILT WITH GRAVEL, dark olive gray with black banding, highly plastic, sticky, heavy sheen. (FILL)	0	20	80
	29.6	0	Yes [1]					**25.0 to 29.4 feet: SANDY SILT (MH)**, dark gray with red mottling, soft, moist, highly plastic, fine sand, spotty sheen, rootlets, hydrocarbon-like odor. (ALLUVIUM)	0	40	60
	4.2	0	Yes [1]					@ 25.8 feet: increased sand content.			
								@ 29.4 feet: heavy sheen, trace oil.			
CB				8.9/10	30			**29.4 to 65.5 feet: SAND (SP)**, gray, wet, loose, poorly graded, fine to medium grained, occasional silt blebs, slight hydrocarbon-like odor. (ALLUVIUM)	0	100	0
	4.8	0	Yes [1]					@ 29.4 to 30.0 feet: heavy sheen, trace oil.			
								@ 30.0 to 34.0 feet: slough from upper units.			
	2.2	0	Yes [1]					@ 34.0 feet: no sheen.			
					35						
	1.0	0	Yes [2]					@ 35.6 feet: color change to brown.			
								@ 35.6 to 36.2 feet: rust colored banding.			
	1.4	2	None								
					40						

REMARKS

[1] Dull orange swirls and specks of fluorescence, green fluorescent smearing on plastic sample bag. [2] Trace orange fluorescence.

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-24-130**
LOCATION	**Portland, Oregon**	PAGE	**3 of 7**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**31.3 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**131.1 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/2/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009302**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102832**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB				9.3/10				**29.4 to 65.5 feet: SAND (SP)**, (ALLUVIUM), same as previous page.	0	100	0
	0.9	0	None					@ 40.0 feet: color change to dark gray.			
								@ 40.0 to 50.0 feet: slight hydrocarbon-like odor.			
								@ 42.2 to 42.5 feet: silt layer, highly plastic.			
	1.4	0	None								
					45						
CB	1.8	0	None					@ 45.8 to 46.2 feet: highly plastic silt layer.	5	85	10
								@ 47.0 to 47.3 feet: silt layer.			
	1.9	0	None					@ 48.6 to 49.2 feet: silt layer.			
					50						
CB				5/10							
	0.2	0	None								
					55						
	0.7	0	None								
								@ 57.6 feet: grain size change to fine to medium sand.			
					60						

REMARKS

[1] Dull orange swirls and specks of fluorescence, green fluorescent smearing on plastic sample bag. [2] Trace orange fluorescence.

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-24-130**
LOCATION	**Portland, Oregon**	PAGE	**4 of 7**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**31.3 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**131.1 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/2/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009302**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102832**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0.0	1	None	7.3/10				**29.4 to 65.5 feet: SAND (SP)**, (ALLUVIUM), as on previous page.	0	95-100	0-5
	0.3	1	None								
					65						
	0.1	1	None					**65.5 to 68.6 feet: SILT (MH)**, dark brownish gray, firm, moist, highly plastic. (ALLUVIUM) @ 66.7 to 67.1 feet: poorly graded sand layer, fine grained.	0	0	100
	0.3	1	None					**68.6 to 70.0 feet: SILTY SAND (SM)**, dark gray, wet, slightly cohesive, fine grained sand, high plasticity silt, "dirty gym sock" odor. (ALLUVIUM)	0	60	40
					70						
CB	0.0	1	None	6/10				**70.0 to 80.0 feet: SILT (MH)**, dark brownish gray, firm, moist, medium plasticity. (ALLUVIUM) @ 71.5 to 72.3 feet: silty sand layer.	0	0	100
	0.0	0	None								
					75						
	0.0	1	None					@ 77.0 to 78.6 feet: sand layer.			
	0.0	1	None								
					80						

REMARKS

[1] Dull orange swirls and specks of fluorescence, green fluorescent smearing on plastic sample bag. [2] Trace orange fluorescence.

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-24-130**
LOCATION	**Portland, Oregon**	PAGE	**5 of 7**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**31.3 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**131.1 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/2/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009302**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102832**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0.7	0	None	3.2/10				**80.0 to 130.0 feet: SAND (SP)** , dark gray, loose, wet, poorly graded, medium grained, homogenous, strong "dirty gym sock" odor, variegated grain colors (mostly black, with gray, white, red and tan). (ALLUVIUM) @ 80.3 to 80.8 feet: highly plastic, dark grayish brown silt layer.			
	0.3	1	None		85						
CB	0.7	2	None	10/10	90			@ 90.0 to 92.7 feet: occasional silt blebs.			
	0.6	1	None					@ 92.7 to 94.2 feet: highly plastic, dark grayish brown, firm silt layer.	0	0	100
	1.0	1	None		95						
	1.2	2	None		100						

REMARKS

[1] Dull orange swirls and specks of fluorescence, green fluorescent smearing on plastic sample bag. [2] Trace orange fluorescence.

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-24-130**
LOCATION	**Portland, Oregon**	PAGE	**6 of 7**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**31.3 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**131.1 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/2/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009302**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102832**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB				10/10				**80.0 to 130.0 feet: SAND (SP)**, as on previous page, medium grained. (ALLUVIUM)	0	100	0
	13.1	0	None								
	6.3	0	None								
					105						
	10.4	0	None								
	1.4	1	None								
					110						
CB				10/10							
	3.1	5	None								
	3.1	8	None								
					115			@ 114.8 to 117.0 feet: trace silt (~5 percent).	0	95	5
	2.6	7	None								
								@ 117.0 feet: wood fragments and silt laminations.	0	95	5
	1.2	1	None					@ 117.3 to 120.0 feet: occasional silt blebs, hard, light brown.			
					120						

REMARKS

[1] Dull orange swirls and specks of fluorescence, green fluorescent smearing on plastic sample bag. [2] Trace orange fluorescence.

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-24-130**
LOCATION	**Portland, Oregon**	PAGE	**7 of 7**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**31.3 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**131.1 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/2/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009302**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102832**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0.9	4	None	10/10				**80.0 to 130.0 feet: SAND (SP)**, as on previous page, medium grained. (ALLUVIUM)	0	100	0
	1.0	3	None					@ 123.1 to 124.0 feet: very wet, very soft, soupy, sandy silt layer, low plasticity.	0	30	70
	0.7	2	None		125						
	0.6	1	None					@ 128.1 to 129.4 feet: trace silt, medium dense.	0	95	5
					130			Total depth = 130.0 feet. Sampling stopped at 130.0 feet. Well materials to 131.1 feet during well installation. **WELL COMPLETION DETAILS** 0 to 120.1 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC blank riser pipe. 120.1 to 130.1 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC well screen with 0.020-inch machined slots. 130.1 to 131.1 feet: 2-inch-diameter threaded end cap. 0 to 5.0 feet: Concrete. 5.0 to 115.0 feet: Bentonite grout with 10 percent organoclay by volume. 115.0 to 117.5 feet: 20-40 Colorado silica sand. 117.5 to 131.1 feet: 10-20 Colorado silica sand.			
					135						
					140						

REMARKS

[1] Dull orange swirls and specks of fluorescence, green fluorescent smearing on plastic sample bag. [2] Trace orange fluorescence.

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-24-70**
LOCATION	**Portland, Oregon**	PAGE	**1 of 4**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**31.4 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**71.1 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/3/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009303**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102833**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
					5			See boring log for well MW-24-130 for geologic description.			
					10						
					15						
					20						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-24-70**
LOCATION	**Portland, Oregon**	PAGE	**2 of 4**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**31.4 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**71.1 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/3/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009303**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102833**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
					25			See boring log for well MW-24-130 for geologic description.			
					30						
					35						
					40						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-24-70**
LOCATION	**Portland, Oregon**	PAGE	**3 of 4**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**31.4 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**71.1 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/3/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009303**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102833**

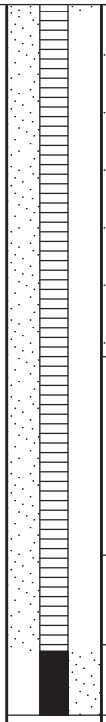
SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
					45			See boring log for well MW-24-130 for geologic description.			
					50						
					55						
					60						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**MW-24-70**
LOCATION	**Portland, Oregon**	PAGE	**4 of 4**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**31.4 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**71.1 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/3/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009303**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102833**

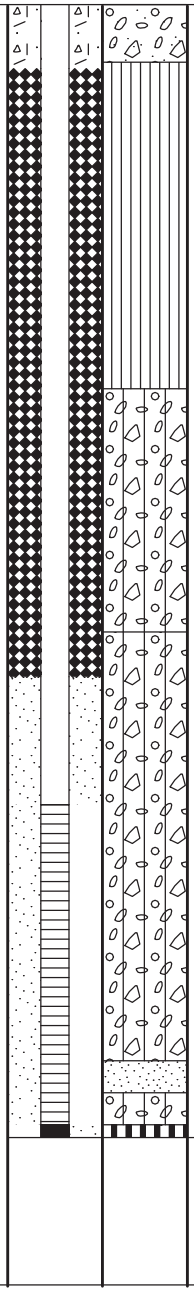
SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
					65 70			See boring log for well MW-24-130 for geologic description.			
					75 80			Total depth = 71.1 feet. **WELL COMPLETION DETAILS** 0 to 60.1 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC blank riser pipe. 60.1 to 70.1 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC well screen with 0.020-inch machined slots. 70.1 to 71.1 feet: 2-inch-diameter threaded end cap. 0 to 5.0 feet: Concrete. 5.0 to 54.8 feet: Bentonite grout with 10 percent organoclay by volume. 54.8 to 57.7 feet: 20-40 Colorado silica sand. 57.7 to 71.1 feet: 10-20 Colorado silica sand.			

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**OW-7-17**
LOCATION	**Portland, Oregon**	PAGE	**1 of 1**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**24.2 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**17.7 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/23/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009307**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102838**

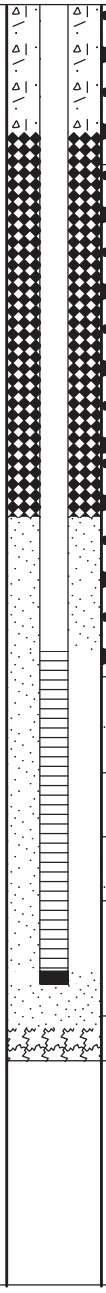
SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
								See boring log for well PW-7-93 for geologic description.			
					5						
					10						
								WELL COMPLETION DETAILS 0 to 12.5 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC blank riser pipe. 12.5 to 17.5 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC well screen with 0.020-inch machined slots. 17.5 to 17.7 feet: 2-inch-diameter threaded end cap. 0 to 1.0 foot: Concrete. 1.0 to 10.5 feet: Granular bentonite. 10.5 to 17.7 feet: 10-20 Colorado silica sand.			
					15						
								Total depth = 17.7 feet.			
					20						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**OW-8-15**
LOCATION	**Portland, Oregon**	PAGE	**1 of 1**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**24.6 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**16.5 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/12/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009304**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102835**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
								See boring log for well PW-8-68 for geologic description.			
					5						
					10			**WELL COMPLETION DETAILS** 0 to 10.1 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC blank riser pipe. 10.1 to 15.1 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC well screen with 0.020-inch machined slots. 15.1 to 15.3 feet: 2-inch-diameter threaded end cap.			
					15			0 to 2.0 feet: Concrete. 2.0 to 8.0 feet: 3/8-inch bentonite chips. 8.0 to 16.0 feet: 10-20 Colorado silica sand. 16.0 to 16.5 feet: Native.			
								Total depth = 16.5 feet.			
					20						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**OW-8-28**
LOCATION	**Portland, Oregon**	PAGE	**1 of 2**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**23.79[2] feet**
DRILL METHOD	**Hollow-stem Augers**	TOTAL DEPTH	**29.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**8/13/10**
SAMPLING METHOD	**2-foot split-spoon (SS)**	PERMIT/STARTCARD NO.	**1010937**
BOREHOLE DIAMETER	**8-inches**	WATER RESOURCES WELL ID	**L103383**

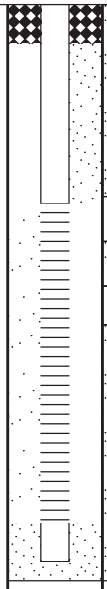
SAMPLING METHOD	HYDROGEN CYANIDE HEADSPACE (ppm)	VOC HEAD-SPACE (ppm)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
SS	1	0.3	No	1.3/2.0				**0 to 10.9 feet: GRAVELLY SILT (ML)**, dark brown to black, dry, hard, friable, nonplastic silt, angular, fine to coarse gravel. (FILL)	30	0	70
SS	1	0.0	No	1.0/2.0							
SS	NA	NA	NA	0.0/2.0	5			@ 4.0 to 6.0 feet: no recovery (gravel blocked sampler).			
SS	0	0.0	No	1.0/2.0				@ 6.0 feet: moist, trace yellow brown patches, low plasticity.			
SS	0	0.0	No	1.2/2.0				@ 8.4 to 9.0 feet: lampblack. @ 9.0 feet: color change to black.			
SS	0	0.0	No	1.4/2.0	10						
SS	1	0.0	No	0.8/2.0				**10.9 to 17.2 feet: SAND (SP)**, dark reddish brown, dry, loose, fine grained, poorly graded. (FILL) @ 12.0 to 14.0 feet: trace gravel.	0	100	0
SS	0	0.1	No	1.0/2.0	15			@ 14.0 feet: wet.			
SS	1	0.3	[1]	1.5/2.0				@ 16.5 to 17.2 feet: sheen visible on sample.			
SS	0	0.1	[1]	1.5/2.0				**17.2 to 19.5 feet: SILT (MH)**, dark grayish brown, medium plasticity, firm, wet, trace fine sand, trace rootlets. (ALLUVIUM) @ 19.5 feet: silty sand.	0	5	95
					20			**19.5 to 25.0 feet: SILTY SAND AND SILT**			

REMARKS

[1] Faint dull yellow fluorescence in soil. [2] City of Portland Datum.

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**OW-8-28**
LOCATION	**Portland, Oregon**	PAGE	**2 of 2**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**23.79[2] feet**
DRILL METHOD	**Hollow-stem Augers**	TOTAL DEPTH	**29.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**8/13/10**
SAMPLING METHOD	**2-foot split-spoon (SS)**	PERMIT/STARTCARD NO.	**1010937**
BOREHOLE DIAMETER	**8-inches**	WATER RESOURCES WELL ID	**L103383**

SAMPLING METHOD	HYDROGEN CYANIDE HEADSPACE (ppm)	VOC HEAD-SPACE (ppm)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
SS	1	1.6	No	1.7/2.0				**19.5 to 25.0 feet: SILTY SAND AND SILT (SM-MH)** intermixed, dark brownish gray, soft, wet, slight hydrocarbon-like odor.	0	50-55	45-50
SS	0	0.4	No	1.0/2.0				@ 23.0 to 23.7 feet: silt layer.	0	0	100
								@ 23.7 to 24.4 feet: silty fine sand.	0	80	20
SS	0	0.9	No	1.0/2.0				@ 24.4 to 25.0 feet: silt.	0	0	100
					25			**25.0 to 29.0 feet: SILTY SAND (SM)**, dark brownish gray, wet, medium dense, fine-grained sand.	0	80	20
SS	0	0.4	No	0.4/2.0							
SS	0	0.3	No	0.8/1.0							
					30			Total depth = 29.0 feet.			
								WELL COMPLETION DETAILS 0 to 23.1 feet: 2-inch-diameter Schedule 40 PVC blank riser pipe. 23.1 to 28.1 feet: 2-inch-diameter slotted PVC screen with 0.020-inch slots. 28.1 to 28.7 feet: 2-inch-diameter Schedule 40 PVC end cap. 0 to 2.0 feet: Concrete. 2.0 to 20.6 feet: Bentonite chips. 20.6 to 29.0 feet: 10-20 Colorado Silica Sand.			
					35						
					40						

REMARKS

[1] Faint dull yellow fluorescence in soil. [2] City of Portland Datum.

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**OW-9-25**
LOCATION	**Portland, Oregon**	PAGE	**1 of 2**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**33.1 ft msl**
DRILL METHOD	**Rotosonic - AMS 17-C Compact Sonic**	TOTAL DEPTH	**25.3 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**3/8/10**
SAMPLING METHOD	**4-in. by 5-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009309**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102843**

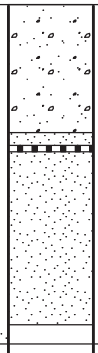
SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
					5			See boring log for well PW-9-92 for geologic description.			
					10						
					15						
					20						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**OW-9-25**
LOCATION	**Portland, Oregon**	PAGE	**2 of 2**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**33.1 ft msl**
DRILL METHOD	**Rotosonic - AMS 17-C Compact Sonic**	TOTAL DEPTH	**25.3 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**3/8/10**
SAMPLING METHOD	**4-in. by 5-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009309**
BOREHOLE DIAMETER	**6-inches**	WATER RESOURCES WELL ID	**L102843**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
								See boring log for well PW-9-92 for geologic description.			
					25			Total depth = 25.3 feet. **WELL COMPLETION DETAILS** 0 to 20.0 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC blank riser pipe. 20.0 to 25.0 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC well screen with 0.020-inch machined slots. 25.0 to 25.3 feet: 2-inch-diameter threaded end cap. 0 to 2.0 feet: Concrete. 2.0 to 17.7 feet: Granular bentonite. 17.7 to 25.3 feet: 10-20 Colorado silica sand.			
					30						
					35						
					40						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**PW-7-93**
LOCATION	**Portland, Oregon**	PAGE	**1 of 6**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**24.2 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**96.5 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/22/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009306**
BOREHOLE DIAMETER	**12-inches**	WATER RESOURCES WELL ID	**L102837**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB				2.8/5				**0 to 0.9 foot: GRAVEL WITH SILT (GW)**, dark gray, loose, wet, angular, well graded. (FILL)	90	0	10
	0.4	0	None					**0.9 to 6.0 feet: GRAVELLY SILT (ML)**, black with reddish brown patches, stiff, moist, low plasticity, grass fibers at 1.0 foot, gravel is coarse to cobble size, angular, trace red brick pieces. (FILL)	30	0	70
	0.0	0	None								
CB				2.7/5	5						
	0.1	0	None					**6.0 to 9.8 feet: SILTY GRAVEL (GM)**, light gray, dry, loose, dusty, concrete pieces, gravel is well graded, fine to cobble size, angular. (FILL)	80	0	20
	0.2	0	None								
CB				2.6/5	10			**9.8 to 17.5 feet: SILTY GRAVEL WITH SAND (GM)**, dark reddish brown, soft, moist, well graded, fine to cobble sized, angular gravel, low plasticity silt, fine to medium sand. (FILL) @ 11.2 feet: wet. @ 11.6 to 15.0 feet: very wet, light sheen on water, brown oil spots observed on plastic sampling bag.	50	20	30
	0.2	0	None								
	0.1	0	None								
CB				4/5	15						
	0.3	0	None					@ 16.5 to 17.0 feet: sand layer, dark gray, loose, wet, poorly graded, fine to medium, no sheen.	0	100	0
	0.0	0	None		20			**17.5 to 23.2 feet: SILT (MH)**, dark olive gray, wet, very soft, medium to high plasticity, trace fine sand, no sheen, slight hydrocarbon-like odor. (ALLUVIUM)	0	0-5	95-100

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**PW-7-93**
LOCATION	**Portland, Oregon**	PAGE	**2 of 6**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**24.2 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**96.5 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/22/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009306**
BOREHOLE DIAMETER	**12-inches**	WATER RESOURCES WELL ID	**L102837**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0.2	0	None	4/10				**17.5 to 23.2 feet: SILT (MH)**, (ALLUVIUM), same as on previous page.	0	0-5	95-100
	0.4	0	None					**23.2 to 43.6 feet: SAND (SP)**, dark olive gray, loose, wet, poorly graded, fine to medium grained, <5 percent fines, slight hydrocarbon-like odor. (ALLUVIUM)	0	95-100	0-5
	0.5	0	None		25						
	0.5	0	None					@ 28.0 to 28.2 feet: silt layer. @ 28.2 feet: grain size change to fine.			
CB	0.3	0	None	7.2/10	30						
	0.7	0	None					@ 33.2 to 33.3 feet: sheen observed, moderate hydrocarbon-like odor.			
	1.0	0	None		35			@ 36.0 to 36.3 feet: silt layer.			
	0.9	0	None					@ 37.9 to 38.2 feet: silt layer. @ 38.6 to 39.4 feet: silt layer.			
					40						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**PW-7-93**
LOCATION	**Portland, Oregon**	PAGE	**3 of 6**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**24.2 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**96.5 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/22/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009306**
BOREHOLE DIAMETER	**12-inches**	WATER RESOURCES WELL ID	**L102837**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0.6	0	None	8.1/10				**23.2 to 43.6 feet: SAND (SP)**, as on previous page, fine to medium grained. (ALLUVIUM)	0	95-100	0-5
	0.6	0	None					**43.6 to 47.2 feet: SILT (MH)**, dark grayish brown, moist, soft, highly plastic, <5 percent fine sand. (ALLUVIUM)	0	0-5	95-100
	0.9	0	None		45			@ 44.2 to 44.6 feet: sand layer.			
	0.5	0	None					**47.2 to 55.4 feet: SAND (SP)**, dark gray, loose, wet, poorly graded, fine to medium grained, occasional silt blebs (up to cobble size). (ALLUVIUM)	0	95-100	0-5
								@ 49.5 to 50.0 feet: silt content increases, sand with silt, fine grained sand.	0	85-90	10-15
CB	1.5	0	None	6.7/10	50			@ 50.0 to 53.1 feet: medium grained, poorly graded sand, slight "dirty gym sock"/"onion" odor.	0	100	0
	0.4	0	None					@ 53.1 to 53.7 feet: silt with sand banding in 1-inch-thick bands, fine grained sand.	0	10	90
								@ 53.7 to 55.4 feet: fine grained sand with silt.	0	90	10
	0.4	0	None		55			**55.4 to 59.4 feet: SILT (MH)**, dark grayish brown, moist, soft, highly plastic, trace very thin sand partings (<1 mm). (ALLUVIUM)	0	0-5	95-100
	0.5	0	None					**59.4 to 64.9 feet: SAND (SP)**, next page.	0	95-100	0-5
					60						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**PW-7-93**
LOCATION	**Portland, Oregon**	PAGE	**4 of 6**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**24.2 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**96.5 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/22/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009306**
BOREHOLE DIAMETER	**12-inches**	WATER RESOURCES WELL ID	**L102837**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0.3	0	None	4.1/10				**59.4 to 64.9 feet: SAND (SP)**, dark gray, loose, wet, fine grained, poorly graded, trace fines. (ALLUVIUM) @ 60.0 to 63.4 feet: very loose, very wet, fine grained.	0	95-100	0-5
	0.9	4	None					@ 63.4 to 64.9 feet: SAND WITH SILT layer (SP-SM), fine grained, slightly cohesive, wet, ~5 to 10 percent fines, occasional silt blebs.	0	90-95	5-10
	0.7	0	None		65			**64.9 to 69.0 feet: SILT (MH)**, dark gray-brown, moist, soft, highly plastic, trace organic debris and shell fragments. (ALLUVIUM) @ 67.6 to 68.1 feet: sand layer.	0	0	100
	1.1	0	None					**69.0 to 69.5 feet: SAND (SP)**, dark gray, slightly cohesive and compact, medium dense, wet, fine to medium grained, poorly graded. (ALLUVIUM)	0	95-100	0-5
CB	1.8	1	None	8.7/10	70			**69.5 to 72.4 feet: SAND (SP)**, dark gray, loose, wet, poorly graded, fine to medium grained, trace fines. (ALLUVIUM)	0	95-100	0-5
	1.7	0	None					**72.4 to 86.6 feet: SAND (SP)**, dark gray, loose, wet, poorly graded, medium grained, little to no fines, slight "dirty gym sock/onion" odor, variegated grain colors (black, gray, white, tan, red). (ALLUVIUM)	0	100	0
	1.7	0	None		75						
	1.9	0	None		80			@ 77.7 to 78.6 feet: abundant silt blebs.			

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**PW-7-93**
LOCATION	**Portland, Oregon**	PAGE	**5 of 6**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**24.2 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**96.5 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/22/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009306**
BOREHOLE DIAMETER	**12-inches**	WATER RESOURCES WELL ID	**L102837**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0.5	1	None	8.9/10				**72.4 to 80.6 feet: SAND (SP)**, as on previous page, medium grained. (ALLUVIUM)	0	100	0
	0.8	3	None								
	1.4	12	None		85						
	1.3	6	None					**86.6 to 90.0 feet: SAND WITH SILT (SW-SM)**, gray, dense, wet, well graded, fine to coarse, trace gravel, slight "gym sock/onion" odor. (ALLUVIUM)	5	85	10
CB	1.4	2	None	3/5	90			**90.0 to 95.0 feet: SAND (SP)**, dark gray, loose, wet, well graded, medium grained, little to no fines, variegated grain colors (black, gray, white, tan, red, clear), slight "gym sock/onion" odor. (ALLUVIUM)	0	100	0
	1.9	6	None								
					95			Sampling terminated at 95.0 feet bgs. Borehole advanced to 96.5 feet because of washout from circulating water.			
								WELL COMPLETION DETAILS 0 to 73.5 feet: 8-inch-diameter, flush-threaded, Schedule 40 carbon steel blank riser pipe. 73.5 to 93.5 feet: 8-inch-diameter, flush-threaded, stainless steel continuous wire-wrapped screen with 0.035-inch slots.			
					100						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**PW-7-93**
LOCATION	**Portland, Oregon**	PAGE	**6 of 6**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**24.2 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**96.5 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/22/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009306**
BOREHOLE DIAMETER	**12-inches**	WATER RESOURCES WELL ID	**L102837**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
								93.5 to 95.5 feet: 8-inch-diameter stainless steel sump. 0 to 1.5 feet: Concrete. 1.5 to 69.5 feet: Bentonite grout with 10 percent organoclay by volume. 69.5 to 72.0 feet: 20-40 Colorado silica sand. 72.0 to 96.5 feet: 10-20 Colorado silica sand.			
					105						
					110						
					115						
					120						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PW-8-39**
LOCATION	**Portland, Oregon**	PAGE	**1 of 3**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**23.22[3] feet**
DRILL METHOD	**Rotosonic and Hollow-stem Augers[2]**	TOTAL DEPTH	**50.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**8/13/10**
SAMPLING METHOD	**10-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1010439**
BOREHOLE DIAMETER	**15-inches**	WATER RESOURCES WELL ID	**L103390**

SAMPLING METHOD	HCN (ppm)	FID/PID (ppm)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	1	0.1	None	2.8/5				**0 to 10.0 feet: SILT (ML)**; dark reddish brown with black patches, dry, gravelly silt, hard, no plasticity, trace concrete pieces, well-rounded gravel, fine to cobble size. (FILL)	25	0	75
	1	0.2	None								
CB	1	0.3	None	5/5	5			@ 5.0 feet: color change to black with patches of reddish brown, slightly moist, low plasticity, trace red brick and pink concrete.			
	0	0.2	None								
CB	1	0.4	None	4.8/5	10			**10.0 to 14.4 feet: SAND (SP)**; dark brownish red, wet, fine to medium, poorly graded, loose, homogeneous.	0	100	0
	1	0.5	None								
								14.4 to 16.1 feet: SAND (SP); gray to brown, wet, loose, fine to medium grained, poorly graded, sheen from 15.7 to 16.1 feet, slight petroleum hydrocarbon-like odor.	0	100	0
CB	1 2	1.2 1.4	Yes[1]	5/5	15			**16.1 to 19.7 feet: SILT (MH)**; dark gray, moist, high plasticity, soft, trace fine sand, trace spotty sheen from 16.1 to 17.5 feet, trace petroleum hydrocarbon-like odor, trace rootlets and black organic material residue and small plant debris.	0	5	95
	1	0.8	Yes[1]					@ 19.7 feet: increased sand content, sandy silt.			
					20						

REMARKS

[1] Yellow and dull orange fluorescence. [2] Boring was originally drilled and sampled with Rotosonic methods to 50.0 feet. Boring was then overdrilled with hollow-stem augers to 42.0 feet and well was installed. [3] City of Portland datum.

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PW-8-39**
LOCATION	**Portland, Oregon**	PAGE	**2 of 3**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**23.22[3] feet**
DRILL METHOD	**Rotosonic and Hollow-stem Augers[2]**	TOTAL DEPTH	**50.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**8/13/10**
SAMPLING METHOD	**10-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1010439**
BOREHOLE DIAMETER	**15-inches**	WATER RESOURCES WELL ID	**L103390**

SAMPLING METHOD	HCN (ppm)	FID/PID (ppm)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	1	0.4	None	7.5/10				**19.7 to 31.4 feet: SILTY SAND AND SILT (SM-MH)**; dark gray, wet, fine sand, moderately plastic silt, soft, trace hydrocarbon-like odor, trace gravel, sand and silt are intermixed, some thin sand layers can be discerned but there appears to be no stratification.	0	50-60	40-50
	1	0.4	None								
	1	0.4	None		25						
	1	0.2	None					@ 28.8 to 30.0 feet: silt layer.			
CB	1	0.5	None	8/10	30			**31.4 to 37.5 feet: SILTY SAND (SM)**; dark brownish gray, wet, very soft, fine sand and high plasticity silt, abundant silt blebs.	0	60	40
	1	0.4	None								
	1	0.6	None		35						
	1	0.6	None		40			**37.5 to 43.0 feet: SAND (SP)**; dark gray, loose, wet, poorly graded, abundant high plasticity silt blebs, fine to medium sand, sand grains variegated in color (mostly black with gray, red, clear, tan, white).	0	70	30

REMARKS

[1] Yellow and dull orange fluorescence. [2] Boring was originally drilled and sampled with Rotosonic methods to 50.0 feet. Boring was then overdrilled with hollow-stem augers to 42.0 feet and well was installed. [3] City of Portland datum.

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PW-8-39**
LOCATION	**Portland, Oregon**	PAGE	**3 of 3**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**23.22[3] feet**
DRILL METHOD	**Rotosonic and Hollow-stem Augers[2]**	TOTAL DEPTH	**50.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**8/13/10**
SAMPLING METHOD	**10-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1010439**
BOREHOLE DIAMETER	**15-inches**	WATER RESOURCES WELL ID	**L103390**

SAMPLING METHOD	HCN (ppm)	FID/PID (ppm)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB				7.5/10				**37.5 to 43.0 feet: SAND (SP)**, as on previous page.	0	70	30
	1	0.4	None								
	1	0.0	None					**43.0 to 50.0 feet: SAND (SP)**; dark gray with variegated sand grains color (mostly black with red, gray, white, clear, tan), loose, poorly graded, medium grained, wet.	0	100	0
					45						
	1	0.2	None								
	1	0.2	None								
								@ 49.0 to 50.0 feet: large silt bleb, sand with silt.	0	90	10
					50			Total depth = 50.0 feet.			
								WELL COMPLETION DETAILS 0 to 24.2 feet: 6-inch-diameter, flush-threaded, Schedule 40 low-carbon steel blank riser pipe. 24.2 to 39.2 feet: 6-inch-diameter, stainless steel, continuous wire-wrapped well screen with 0.035-inch slots. 39.2 to 42.2 feet: 6-inch-diameter stainless steel sump.			
					55			0 to 2.0 feet: Concrete. 2.0 to 23.0 feet: Bentonite chips. 23.0 to 42.2 feet: 10-20 Colorado Silica Sand. 42.2 to 50.0 feet: Bentonite.			
					60						

REMARKS

[1] Yellow and dull orange fluorescence. [2] Boring was originally drilled and sampled with Rotosonic methods to 50.0 feet. Boring was then overdrilled with hollow-stem augers to 42.0 feet and well was installed. [3] City of Portland datum.

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**PW-8-68**
LOCATION	**Portland, Oregon**	PAGE	**1 of 4**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**24.6 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**70.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/11/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009305**
BOREHOLE DIAMETER	**12-inches**	WATER RESOURCES WELL ID	**L102836**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0.2	0	None	2.9/5	**0 to 2.5 feet: GRAVEL WITH SILT (GW-GM)**, dark grayish brown, loose, moist, fine to cobble, angular gravel. (FILL)	90	0	10
	0.2	0	None		**2.5 to 7.0 feet: GRAVEL WITH SILT (GW-GM)**, light gray, loose, dry, dusty, fine to cobble-sized angular gravel. (FILL)	90	0	10
CB	0.2	0	None	2/2	@ 5.0 feet: dark gray, brick and concrete rubble.			
CB	0.3	0	None	0.7/3	**7.0 to 10.5 feet: GRAVEL WITH SILT (GW-GM)**, mottled dark reddish brown and black, sticky, moist, well graded, fine to cobble-sized gravel, high plasticity silt, trace brick pieces. (FILL)	80	0	20
CB	0.4	1	None	5/5	**10.5 to 12.0 feet: SILTY SAND (SM)**, brown, loose, moist to wet, fine to medium sand, trace brick pieces. (FILL)	0	80	20
					12.0 to 13.0 feet: SANDY SILT (ML), mottled reddish brown and gray, wet, firm (1.0 kg/cm^2), low plasticity, fine sand. (FILL)	0	40-50	50-60
	2.0	1	None		**13.0 to 14.0 feet: SAND WITH SILT (SP-SM)**, reddish brown, very loose, wet, medium grained, poorly graded. (FILL)	0	90	10
CB	5.9	1	None	1.2/5	**14.0 to 15.8 feet: SAND (SP)**, dark gray, very loose, wet, poorly graded, fine to medium grained, slight hydrocarbon-like odor, variegated grain colors (black, gray, white, clear, red). (FILL) @ 15.0 feet: moderate hydrocarbon-like odor, trace oil, sheen present, crude oil odor.	0	100	0
					15.8 to 20.0 feet: SILT (MH), dark grayish brown, high plasticity, very soft, wet. (ALLUVIUM)	0	0	100

DEPTH IN FEET: 5, 10, 15, 20

WELL DETAILS

LITHO-LOGIC COLUMN

REMARKS

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**PW-8-68**
LOCATION	**Portland, Oregon**	PAGE	**2 of 4**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**24.6 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**70.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/11/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009305**
BOREHOLE DIAMETER	**12-inches**	WATER RESOURCES WELL ID	**L102836**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0.4	1	None	10/10				**20.0 to 27.5 feet: SANDY SILT (ML)**; dark grayish brown, low plasticity, fine sand, no sheen, very soft, wet. (ALLUVIUM)	0	30	70
	0.4	1	None								
	0.6	1	None		25			@ 26.0 to 27.5 feet: increasing sand content with depth.			
	0.3	0	None					**27.5 to 30.0 feet: SAND WITH SILT (SP-SM)**, dark gray, loose, wet, fine to medium grained, poorly graded, no sheen. (ALLUVIUM)	0	90	10
CB	0.8	1	None	8/10	30			**30.0 to 35.1 feet: SAND (SP)**, dark gray, very loose, very wet, fine to medium grained, poorly graded, no sheen. (ALLUVIUM)	0	100	0
	0.4	0	None								
	0.6	1	None		35			**35.1 to 38.9 feet: SILT (MH)**, dark grayish brown, highly plastic, wet. (ALLUVIUM) @ 35.1 to 35.6 feet: sheen, moderate hydrocarbon-like odor. @ 35.6 to 35.8 feet: sand layer. @ 37.1 to 37.5 feet: sand layer. @ 37.9 to 38.0 feet: sand layer.	0	0	100
	0.4	0	None		40			**38.9 to 46.0 feet: SAND (SP)**, as on following page.	0	95-100	0-5

REMARKS

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**PW-8-68**
LOCATION	**Portland, Oregon**	PAGE	**3 of 4**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**24.6 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**70.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/11/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009305**
BOREHOLE DIAMETER	**12-inches**	WATER RESOURCES WELL ID	**L102836**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0.6	0	None	8/10				**38.9 to 46.0 feet: SAND (SP)**, dark gray, very loose, very wet, fine to medium grained, poorly graded, no sheen, moderate hydrocarbon-like odor. (ALLUVIUM)	0	95-100	0-5
	0.4	0	None								
	0.3	0	None		45			**46.0 to 46.9 feet: SILT (MH)**, dark grayish brown, highly plastic, wet with organic debris laminations. (ALLUVIUM)	0	0	100
	0.2	0	None					**46.9 to 70.0 feet: SAND (SP)**, dark gray, very loose, wet, poorly graded, medium grained, <5 percent fines, variegated grain color (black with gray, white, red, clear). (ALLUVIUM) @ 49.0 to 49.3 feet: highly plastic silt layer.	0	100	0
CB	0.2	1	None	9/10	50						
	0.4	1	None								
	0.2	0	None		55			@ 55.2 feet: no silt.			
	0.3	0	None					@ 57.3 to 57.8 feet: highly plastic silt layer. @ 58.7 to 59.1 feet: highly plastic silt layer. @ 59.5 to 60.0 feet: abundant silt blebs with organic debris.			
					60						

REMARKS

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**PW-8-68**
LOCATION	**Portland, Oregon**	PAGE	**4 of 4**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**24.6 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**70.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**2/11/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009305**
BOREHOLE DIAMETER	**12-inches**	WATER RESOURCES WELL ID	**L102836**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB				7.5/10				**46.9 to 70.0 feet: SAND (SP)**, (ALLUVIUM), continued.	0	100	0
	0.9	2	None								
	0.7	3	None								
					65						
	1.0	1	None								
	0.6	1	None								
					70			Total depth = 70.0 feet.			
								WELL COMPLETION DETAILS 0 to 48.0 feet: 8-inch-diameter, flush-threaded, Schedule 40 carbon steel riser pipe. 48.0 to 68.0 feet: 8-inch-diameter, flush-threaded, Schedule 40 stainless steel continuous wire-wrapped screen with 0.035-inch slots. 68.0 to 70.0 feet: 8-inch-diameter stainless steel sump. 0 to 4.0 feet: Concrete. 4.0 to 43.0 feet: Bentonite grout with 10 percent organoclay by volume. 43.0 to 45.7 feet: 20-40 Colorado silica sand. 45.7 to 70.0 feet: 10-20 Colorado silica sand.			
					75						
					80						

REMARKS

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**PW-9-92**
LOCATION	**Portland, Oregon**	PAGE	**1 of 6**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**33.0 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**95.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**3/1/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009308**
BOREHOLE DIAMETER	**12-inches**	WATER RESOURCES WELL ID	**L102842**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
Hand Dug	NA	NA	None	NA				**0 to 2.0 feet: SILTY GRAVEL (GW-GM)**, dark brown, moist to wet, well graded, angular gravel, low plasticity silt. (FILL)	80	0	20
CB	0.2	0	None	3/3				**2.0 to 15.8 feet: GRAVELLY SILT (ML)**, dark gray to black, moist, sticky, low plasticity, well graded angular gravel, slight hydrocarbon-like odor, trace red brick pieces, fine to cobble size gravel. (FILL)	45-50	0	50-55
CB	0.3	0	None	2.9/5	5						
	0.4	0	None					@ 7.4 feet: color change to brown.			
CB	0.3	0	None	3.5/5	10						
	0.3	0	None								
CB	0.9	0	None	1.8/5	15			**15.8 to 22.0 feet: GRAVELLY SAND WITH SILT (SW)**, black, moist, abundant cobble size pieces of concrete, sooty (lampblack), well graded, fine to coarse sand, no sheen, moderate hydrocarbon-like odor (naphthalene) (core blockage, poor recovery). (FILL)	40	50	10
	0.7	0	None		20			@ 18.0 feet: wet; large chunks of lampblack, brick, and concrete.			

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**PW-9-92**
LOCATION	**Portland, Oregon**	PAGE	**2 of 6**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**33.0 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**95.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**3/1/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009308**
BOREHOLE DIAMETER	**12-inches**	WATER RESOURCES WELL ID	**L102842**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	1.1	0	None	4/5				**15.8 to 22.0 feet: GRAVELLY SAND WITH SILT (SP)**, (ALLUVIUM), continued.	40 0	50 100	10 0
	0.5	0	None					**22.0 to 25.0 feet: SAND (SP)**, brownish red, wet, loose, poorly graded, fine to medium sand. (ALLUVIUM) @ 22.2 to 22.3 feet: silt layer.	0	100	0
CB	0.5	0	None	5/5	25						
	0.5	0	None					**26.3 to 27.6 feet: SANDY SILT (MH)**, dark olive gray, soft, wet, fine sand, highly plastic silt with intermittent sand layers. (ALLUVIUM)	0	45-50	50-55
								27.6 to 29.1 feet: SILT (MH), dark olive gray, soft, wet, highly plastic silt, trace fine sand, trace brown organic debris. (ALLUVIUM) @ 28.7 to 29.1 feet: sand layer.	0	0-5	95-100
CB	0.5	0	None	6.6/10	30			**29.1 to 37.7 feet: SILTY SAND (SM)**, dark olive gray, soft, wet, interbedded thin fine sand and high plasticity silt layers (0.1 to 0.2-feet thick), slightly cohesive. (ALLUVIUM)	0	50-55	45-50
	0.9	0	None								
	0.7	0	None		35						
	0.5	0	None					**37.7 to 40.0 feet: SILTY SAND (SM)**, dark olive gray, loose, very wet, fine sand, poorly graded. (ALLUVIUM)	0	70-80	20-30
					40						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**PW-9-92**
LOCATION	**Portland, Oregon**	PAGE	**3 of 6**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**33.0 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**95.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**3/1/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009308**
BOREHOLE DIAMETER	**12-inches**	WATER RESOURCES WELL ID	**L102842**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0.7	0	None	4.6/10				**40.0 to 46.3 feet: SILT WITH SAND (ML)**, dark grayish brown, very soft, very wet, low plasticity, fine sand, interspersed interbedded thin sand layers. (ALLUVIUM)	0	10	90
	0.7	0	None								
	0.3	0	None		45						
	0.4	0	None					**46.3 to 50.0 feet: SILTY SAND (SM)**, dark brownish gray, medium dense, wet, cohesive, fine sand, low plasticity silt. (ALLUVIUM)	0	60	40
CB	1.3	0	None	9/10	50			**50.0 to 57.7 feet: SAND (SP)**, dark brownish gray, very loose, very wet, poorly graded fine to medium grained sand, <5 percent fines, slight "dirty gym sock/onion" odor. (ALLUVIUM)	0	95-100	0-5
	0.9	0	None								
	1.1	0	None		55						
	0.6	0	None					**57.7 to 64.0 feet: SILTY SAND (SM)**, dark grayish brown, medium dense, wet, fine sand. (ALLUVIUM)	0	80	20
					60						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**PW-9-92**
LOCATION	**Portland, Oregon**	PAGE	**4 of 6**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**33.0 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**95.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**3/1/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009308**
BOREHOLE DIAMETER	**12-inches**	WATER RESOURCES WELL ID	**L102842**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	NA	NA	None	2.3/10				**57.7 to 64.0 feet: SILTY SAND (SM)**, (ALLUVIUM), continued. (@ 60.0 to 67.7 feet: no recovery.)	0	80	20
	NA	NA	None								
	NA	NA	None		65			**64.0 to 70.0 feet: SAND (SW)**, dark brownish gray, loose, wet, well graded, fine to coarse, coarse sand occurs in thin intermittent layers, majority of sand is fine grained, occasional silt blebs. (ALLUVIUM)	0	95-100	0-5
	1.2	5	None								
CB	1.3	3	None	5.5/10	70			**70.0 to 95.0 feet: SAND (SP)**, dark gray, loose, wet, poorly graded, medium grained, homogenous, variegated grain colors (black, gray, white, clear, red, brown). (ALLUVIUM) @ 70.0 to 71.5 feet: trace fines.	0 0	95-100 100	0-5 0
	0.2	2	None								
	0.2	1	None		75						
	0.2	0	None								
					80						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**PW-9-92**
LOCATION	**Portland, Oregon**	PAGE	**5 of 6**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**33.0 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**95.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**3/1/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009308**
BOREHOLE DIAMETER	**12-inches**	WATER RESOURCES WELL ID	**L102842**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB				3.8/10				**0 to 95.0 feet: SAND (SP)**, (ALLUVIUM), continued.	0	95-100	0-5
	NA	NA	None					(@ 80.0 to 86.2 feet: no recovery.)			
	NA	NA	None								
					85						
	0.3	3	None								
	0.7	42	None								
					90			@ 89.5 to 90.0 feet: medium dense, grayish brown compacted silty sand layer.			
CB				5/5							
	0.3	13	None								
	0.3	5	None								
					95			Total depth of boring at 95.0 feet.			
								WELL COMPLETION DETAILS 0 to 72.6 feet: 8-inch-diameter, flush-threaded, Schedule 40 carbon steel blank riser pipe. 72.6 to 92.6 feet: 8-inch-diameter, flush-threaded, Schedule 40 stainless steel continuous wire-wrapped screen with 0.035-inchs slots. 92.6 to 94.6 feet: 8-inch-diameter stainless			
					100						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**NW Natural Gasco Site**	BORING NO.	**PW-9-92**
LOCATION	**Portland, Oregon**	PAGE	**6 of 6**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**33.0 ft msl**
DRILL METHOD	**Rotosonic - Speedstar 15K**	TOTAL DEPTH	**95.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**3/1/10**
SAMPLING METHOD	**4-in. by 10-ft. core barrel (CB)**	PERMIT/STARTCARD NO.	**1009308**
BOREHOLE DIAMETER	**12-inches**	WATER RESOURCES WELL ID	**L102842**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
								steel sump.			
								0 to 1.0 foot: Concrete. 1.0 to 68.3 feet: Bentonite grout with 10 percent organclay by volume. 68.3 to 70.8 feet: 20-40 Colorado silica sand. 70.8 to 94.6 feet: 10-20 Colorado silica sand. 94.6 to 95.0 feet: Native.			
					105						
					110						
					115						
					120						

REMARKS

ANCHOR QEA

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ1-50**
LOCATION	**Portland, Oregon**	PAGE	**1 of 3**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**10.2 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**50.5 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**11/23/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008694**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99079**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0.2	0	No	5/5				**0 to 1.0 foot: SANDY GRAVEL (GW)**, dark reddish-brown, very loose, moist, fine to cobble sized, medium graded, angular to rounded gravel, medium sand. (FILL)	60	40	0
	0.2	0	No					**1.0 to 2.8 feet: SAND (SP)**, dark reddish brown, loose, moist at 1.0 to 2.0 feet, wet at 2.0 feet, medium grained, poorly graded, no sheen. (FILL)	0	100	0
								2.8 to 6.5 feet: SAND (SP), dark brownish red, loose, wet, poorly graded, fine to medium grained, no sheen. (FILL)	0	95-100	0-5
CB	0.2	1	Yes[1]	1.5/1.5	5			@ 3.1 to 3.2 feet: 0.1 foot silt layer. @ 4.5 feet: 0.1 foot silt layer, no sheen.			
CB	0.5	0	Yes[1]	2.7/3.5				**6.5 to 12.9 feet: SILTY SAND (SM)**, dark gray, soft, wet, slight hydrocarbon-like odor, no sheen. (ALLUVIUM)	0	50-55	45-50
CB	0.2	0	No	5/5	10			@ 10.6 feet: increased sand content.	0	70	30
	0.6	0	No					@ 12.3 feet: 0.1 foot sandy silt layer.			
								12.9 to 13.4 feet: SANDY SILT (MH), medium plasticity, grayish-brown, soft, moist. (ALLUVIUM)	0	20	80
								13.4 to 17.3 feet: SANDY SILT (ML/SM), dark gray, soft, wet, low plasticity, no sheen, numerous intermittent interbedded thin silty sand layers. (ALLUVIUM)	0	30	70
	0.5	0	No	5/5	15						
	0.6	0	No		20			**17.3 to 20.6 feet: SILTY SAND (SM/ML)**, dark gray, soft, wet, with sandy silt interbeds, no sheen. (ALLUVIUM)	0	60-70	30-40

REMARKS

[1] Mildly fluorescent in silt nodules.

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ1-50**
LOCATION	**Portland, Oregon**	PAGE	**2 of 3**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**10.2 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**50.5 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**11/23/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008694**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99079**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0.4	0	No	5/5				**17.3 to 20.6 feet: SILTY SAND (SM/ML)**, continued.			
								20.6 to 22.0 feet: SANDY SILT (ML), with silty sand interbeds, dark gray, firm, wet, no sheen. (ALLUVIUM)	0	20	80
	0.5	0	No					@ 21.5 to 21.7 feet: sandy silt layer.	0	70	30
								22.0 to 25.8 feet: SILTY SAND (SM) , dark gray, firm, wet, no sheen. (ALLUVIUM)			
								@ 23.7 to 23.9 feet: silt layer, fine to medium sand.			
								@ 24.6 to 24.8 feet: silt layer.			
CB	0.5	0	No	5/5	25						
								25.8 to 30.0 feet: SAND WITH SILT (SP-SM), dark gray, loose, wet, fine to medium sand, no sheen, poorly graded. (ALLUVIUM)	0	80-90	10-20
	0.3	0	No					@ 27.8 to 28.6 feet: silt layer, high plasticity.			
	0.0	0	No					@ 29.2 to 29.5 feet: sandy silt layer, high plasticity.			
CB				3.3/5	30			**30.0 to 33.3 feet: SAND (SP)**, dark gray, very loose, wet, soupy, poorly graded, no sheen, <5 percent fines. (ALLUVIUM)	0	95-100	0-5
	0.2	0	No								
								33.3 to 40.0 feet: SILT WITH SAND (MH), dark grayish-brown, highly plastic, no sheen, firm. (ALLUVIUM)	0	10	90
CB	0.5	0	No	4.3/5	35			@ 35.2 to 35.9 feet: sand layer, poorly graded, fine to medium grained, dark gray.			
	0.1	0	No								
								@ 37.9 to 38.1 feet: sand layer.			
								@ 38.8 to 39.0 feet: sand layer.			
					40						

REMARKS

[1] Mildly fluorescent in silt nodules.

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ1-50**
LOCATION	**Portland, Oregon**	PAGE	**3 of 3**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**10.2 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**50.5 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**11/23/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008694**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99079**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0.3 0.5	0 0	No No	4.6/5				**40.0 to 43.7 feet: SAND (SP)**, dark gray, loose, wet, poorly graded, fine to medium sand, no sheen, <5 percent fines. (ALLUVIUM) @ 41.5 to 41.9 feet: highly plastic silt layer.	0	95-100	0-5
CB	0.5 0.7	0 2	No No	4.1/5	45 50			**43.7 to 50.5 feet: SAND (SP)**, dark gray, loose, wet, poorly graded, medium grained sand with red, white, brown grains, <5 percent fines. (ALLUVIUM) @ 44.0 to 44.6 feet: highly plastic silt layer. @ 48.1 to 48.2 feet: silt layer. @ 48.4 to 48.5 feet: silt layer. @ 49.7 to 49.8 feet: silt layer.	0	95-100	0-5
					55 60			Total depth = 50.5 feet below mudline. **WELL COMPLETION DETAILS** +27.5 to 45.3 feet: 2-inch-diameter, flush-threaded, Schedule 40 steel blank riser pipe. 45.3 to 50.1 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC well screen with 0.020-inch machined slots. 50.1 to 50.4 feet: 2-inch-diameter threaded end cap. 0 to 40.4 feet: Bentonite grout. 40.4 to 43.3 feet: 20-40 Colorado Silica Sand. 43.3 to 50.4 feet: 10-20 Colorado Silica Sand. 50.4 to 50.5 feet: Native.			

REMARKS

[1] Mildly fluorescent in silt nodules.

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ2-43**
LOCATION	**Portland, Oregon**	PAGE	**1 of 3**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**3.8 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**43.8 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**12/3/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008697**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99082**

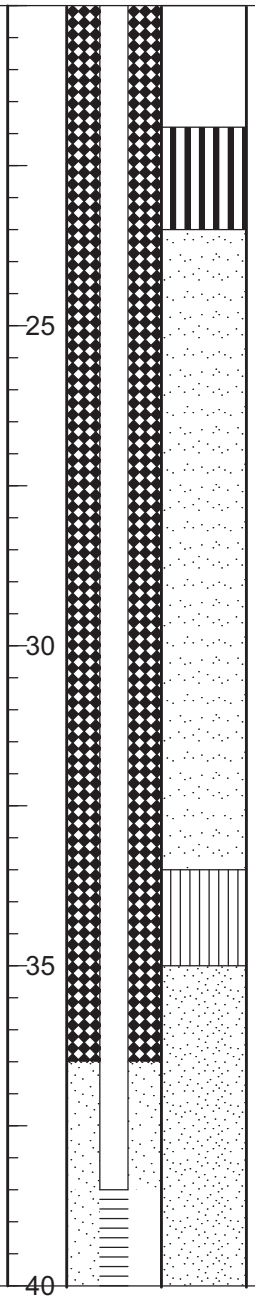
SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
					5 10 15 20			See boring log PZ2-77 for lithologic description.			

REMARKS

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ2-43**
LOCATION	**Portland, Oregon**	PAGE	**2 of 3**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**3.8 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**43.8 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**12/3/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008697**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99082**

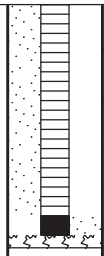
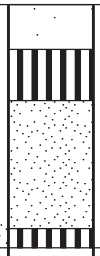
SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %



REMARKS

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ2-43**
LOCATION	**Portland, Oregon**	PAGE	**3 of 3**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**3.8 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**43.8 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**12/3/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008697**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99082**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
											
					45			Total depth = 43.8 feet below mudline. **WELL COMPLETION DETAILS** +34.2 to 38.5 feet: 2-inch-diameter, flush-threaded, Schedule 40 steel blank riser pipe. 38.5 to 43.3 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC well screen with 0.020-inch machined slots. 43.3 to 43.6 feet: 2-inch-diameter threaded end cap. 0 to 33.5 feet: Bentonite grout with 10% organoclay. 33.5 to 36.5 feet: 20-40 Colorado Silica Sand. 36.5 to 43.6 feet: 10-20 Colorado Silica Sand. 43.6 to 43.8 feet: Native.			
					50						
					55						
					60						

REMARKS

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ2-77**
LOCATION	**Portland, Oregon**	PAGE	**1 of 5**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**3.1 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**80.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**12/2/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008698**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99083**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	1.2	1	No	2/3				**0 to 9.1 feet: SILTY SAND WITH WOOD CHIPS (SM)**, black, loose, wet, poorly graded, fine to medium grained with abundant small wood chips and wood fragments (approximately 75 percent of sample), strong hydrocarbon-like odor, spotty sheen with rainbow iridescence, oily from 0.7 to 3.0 feet, strong hydrocarbon-like odor.	0	80	20
	1.4	0	No								
CB	13.6	0	Yes[2]	2/2							
CB	16.5	7	Yes[2]	2/5[1]	5			@ 5.0 feet: light spotty sheen.			
CB	4.1	1	No	3/3							
								9.1 to 11.3 feet: SILT WITH WOOD CHIPS (ML), black, very soft, wet, low plasticity, with abundant small to large wood chips and fragments (approximately 35 to 50 percent of sample), heavy sheen, strong hydrocarbon-like odor, strong hydrogen sulfide-like odor.	0	0	100
CB	6.1	1	Yes[2]	5/5	10						
								11.3 to 14.5 feet: SILT (MH), gray-brown, soft, moist, highly plastic, occasional wood fragments and twig pieces, moderate hydrocarbon-like odor, moderate hydrogen sulfide-like odor, trace sand, no noticeable sheen. (ALLUVIUM)	0	0-5	95-100
	1.1	1	Yes[2]								
CB	0.8	0	No	5/5	15			**14.5 to 21.9 feet: SAND (SP)**, dark gray, loose, wet, poorly graded, fine to medium sand, moderate hydrocarbon-like odor, moderate hydrogen sulfide-like odor. (ALLUVIUM)	0	100	0
	0.5	1	No		20			@ 17.5 to 17.6 feet: silt layer.			

REMARKS

[1] Wood chips plugged catcher in shoe. [2] Yellow fluorescence consistent with wood chips.

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ2-77**
LOCATION	**Portland, Oregon**	PAGE	**2 of 5**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**3.1 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**80.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**12/2/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008698**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99083**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB				5/5				**14.5 to 21.9 feet: SAND (SP)**, continued.	0	100	0
	0.4	0	No								
	0.5	0	No					**21.9 to 23.5 feet: SILT (MH)**, dark gray-brown, soft, moist, high plasticity, trace organic debris, no sheen. (ALLUVIUM)	0	0	100
								23.5 to 33.5 feet: SAND (SP), dark gray, loose, wet, poorly graded, fine to medium grained, slight hydrocarbon-like odor, no sheen. (ALLUVIUM)	0	100	0
CB				5/5	25						
	1.0	0	No								
	0.9	0	No								
CB				5/5	30						
	1.0	2	No								
	0.4	0	No					**33.5 to 35.0 feet: SANDY SILT (ML)**, dark gray-brown, wet, fine to medium sand, low plasticity, no sheen. (ALLUVIUM)	0	20	80
CB				5/5	35			**35.0 to 40.7 feet: SAND (SP)**, dark gray, loose, wet, poorly graded, medium grained, variegated grain colors (red, brown, gray, black, white, tan), <5 percent fines, no sheen. (ALLUVIUM)	0	95-100	0-5
	0.9	5	No								
	0.6	3	No					@ 39.8 feet: silt blebs.			
					40						

REMARKS

[1] Wood chips plugged catcher in shoe. [2] Yellow fluorescence consistent with wood chips.

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ2-77**
LOCATION	**Portland, Oregon**	PAGE	**3 of 5**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**3.1 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**80.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**12/2/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008698**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99083**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB				5/5				**35.0 to 40.7 feet: SAND (SP)**, continued.			
	0.5	3	No					**40.7 to 41.5 feet: SILT (MH)**, gray-brown, soft, wet, highly plastic, no sheen. (ALLUVIUM)	0	0	100
								41.5 to 43.5 feet: SAND (SP), dark gray, loose, wet, medium grained, poorly graded, no sheen. (ALLUVIUM)	0	100	0
	0.6	1	No					**43.5 to 44.9 feet: SILT (MH)**, gray-brown, soft, moist, high plasticity, no sheen. (ALLUVIUM)	0	0	100
CB				5/5	45			**44.9 to 80.0 feet: SAND (SP)**, dark gray, loose, wet, poorly graded, medium grained, variegated grain colors, <5 percent fines, no sheen. (ALLUVIUM)	0	95-100	0-5
	0.6	1	No								
	0.2	0	No					@ 47.9 to 48.8 feet: SILT (MH), high plasticity silt layer.	0	0	100
CB				5/5	50						
	0.3	1	No								
	0.7	2	No								
CB				5/5	55			@ 55.0 to 80.0 feet: slight "dirty gym sock" odor.			
	0.5	1	No								
	0.5	0	No		60						

REMARKS

[1] Wood chips plugged catcher in shoe. [2] Yellow fluorescence consistent with wood chips.

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ2-77**
LOCATION	**Portland, Oregon**	PAGE	**4 of 5**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**3.1 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**80.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**12/2/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008698**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99083**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB				5/5				**44.9 to 80.0 feet: SAND (SP)**, continued.	0	95-100	0-5
	0.4	2	No								
	0.6	9	No								
CB				5/5	65						
	0.5	6	No								
	0.5	8	No					@ 68.0 feet: trace silt blebs.			
CB				5/5	70						
	0.5	5	No								
	0.5	4	No								
CB				5/5	75			@ 74.5 to 75.0 feet: dark gray-brown silty sand layer.			
	0.5	7	No								
	0.5	5	No		80						

REMARKS

[1] Wood chips plugged catcher in shoe. [2] Yellow fluorescence consistent with wood chips.

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ2-77**
LOCATION	**Portland, Oregon**	PAGE	**5 of 5**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**3.1 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**80.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**12/2/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008698**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99083**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
					85			Total depth = 80.0 feet below mudline. **WELL COMPLETION DETAILS** +35.6 to 72.1 feet: 2-inch-diameter, flush-threaded, Schedule 40 steel blank riser pipe. 72.1 to 76.9 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC well screen with 0.020-inch machined slots. 76.9 to 77.2 feet: 2-inch-diameter threaded end cap. 0 to 66.8 feet: Bentonite grout (with 10% organoclay from 0 to 30.0 feet). 66.8 to 69.8 feet: 20-40 Colorado Silica Sand. 69.8 to 77.2 feet: 10-20 Colorado Silica Sand. 77.2 to 80.0 feet: Native.			
					90						
					95						
					100						

REMARKS

[1] Wood chips plugged catcher in shoe. [2] Yellow fluorescence consistent with wood chips.

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ3-33**
LOCATION	**Portland, Oregon**	PAGE	**1 of 3**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**-15.5 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**36.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**11/25/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008696**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99081**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	7.7	0	Yes[1]	2.7/3				**0 to 8.9 feet: SILT (ML)**, dark grayish-brown with black staining, very soft, wet, low plasticity, abundant rootlets, strong hydrocarbon-like odor (naphthalene), strong sheen with rainbow iridescence. (ALLUVIUM) @ 1.0 to 1.5 feet: black sticky oil like substance. Much anthropogenic material: wood fragments, a magnet, cardboard. @ 4.0 to 4.1 feet: heavy sheen and oil. @ 4.1 to 8.9 feet: no sheen. @ 7.0 to 7.1 feet: coarse sand layer. @ 7.5 feet: cardboard fragments, twigs.	0	0-5	95-100
CB	5.3	0	Yes[1]	5/5	5						
	4.9	0	Yes[1]								
CB	2.0	0	Yes[2]	5/5	10			**8.9 to 15.5 feet: SAND (SP)**, very dark gray, loose, wet, poorly graded, fine to medium grained, occasional silt blebs, trace spotty sheen. (ALLUVIUM) @ 12.8 to 13.0 feet: SILT layer, medium plasticity.	0	95-100	0-5
	1.5	0	No								
CB	1.4	0	Yes[2]	5/5	15						
	0.6	0	No					**15.5 to 18.0 feet: SAND (SP)**, very dark gray, loose, wet, poorly graded, medium grained, occasional silt blebs, no sheen. (ALLUVIUM)	0	95-100	0-5
CB	0.7	1	No	4/5	20			**18.0 to 23.8 feet: SAND WITH SILT (SP-SM)**, dark grayish-brown, very loose, wet, soupy, occasional silt blebs, poorly graded fine sand, no sheen. (ALLUVIUM)	0	85-90	10-15

REMARKS

[1] Specks of green, orange, and yellow fluorescence. [2] Trace fluorescence.

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ3-33**
LOCATION	**Portland, Oregon**	PAGE	**2 of 3**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**-15.5 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**36.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**11/25/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008696**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99081**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB				4/5				**18.0 to 23.8 feet: SAND WITH SILT (SP-SM)**, continued.	0	85-90	10-15
	0.6	0	No								
CB				5/5				@ 23.5 to 23.7 feet: sandy silt layer.			
	0.5	0	No					**23.8 to 24.8 feet: SANDY SILT (MH)**, grayish brown, soft, wet, medium plasticity silt, fine sand, no sheen. (ALLUVIUM)	0	20	80
					25			**24.8 to 32.4 feet: SAND (SP)**, very dark gray, loose, wet, poorly graded, medium grained, variegated grain colors from gray, white, black, red, and tan, no sheen. (ALLUVIUM)	0	100	0
	0.6	1	No								
CB				5/5							
	0.8	3	Yes[2]		30						
	0.6	1	No					**32.4 to 33.4 feet: SANDY SILT (MH)**, dark grayish-brown, soft, wet, highly plastic, no sheen, medium sand. (ALLUVIUM)	0	20	80
CB				3/3				**33.4 to 36.0 feet: SAND (SP)**, dark grayish brown, loose, wet, poorly graded, fine to medium sand, no sheen. (ALLUVIUM)	0	95-100	0-5
	0.6	2	No		35			@ 34.1 to 34.3 feet: silt layer.			
								@ 34.6 to 35.0 feet: silt layer.			
								Total depth = 36.0 feet below mudline.			
					40			See Page 3 for Well Completion Details.			

REMARKS

[1] Specks of green, orange, and yellow fluorescence. [2] Trace fluorescence.

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ3-33**
LOCATION	**Portland, Oregon**	PAGE	**3 of 3**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**-15.5 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**36.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**11/25/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008696**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99081**

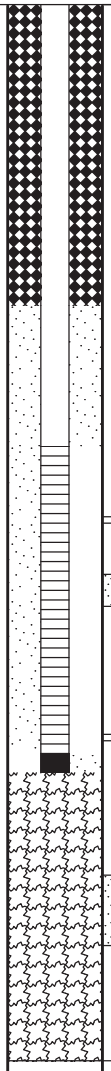
SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
					45			**WELL COMPLETION DETAILS** +42.5 to 27.7 feet: 2-inch-diameter, flush-threaded, Schedule 40 steel blank riser pipe. 27.7 to 32.5 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC well screen with 0.020-inch machined slots. 32.5 to 32.8 feet: 2-inch-diameter threaded end cap. 0 to 23.5 feet: Bentonite grout. 23.5 to 25.5 feet: 20-40 Colorado Silica Sand. 25.5 to 32.8 feet: 10-20 Colorado Silica Sand. 32.8 to 36.0 feet: Native.			
					50						
					55						
					60						

REMARKS

[1] Specks of green, orange, and yellow fluorescence. [2] Trace fluorescence.

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ4-12**
LOCATION	**Portland, Oregon**	PAGE	**1 of 2**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**-8.6 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**16.5 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**12/4/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008699**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99084**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
								See boring log PZ4-41 for lithologic description.			
								Total depth = 16.5 feet below mudline.			
								See page 2 for Well Completion Details.			

REMARKS

GASCO3.gds:4.1/21/10.GASCO3

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ4-12**
LOCATION	**Portland, Oregon**	PAGE	**2 of 2**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**-8.6 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**16.5 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**12/4/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008699**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99084**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
					25			**WELL COMPLETION DETAILS** +43.3 to 6.9 feet: 2-inch-diameter, flush-threaded, Schedule 40 steel blank riser pipe. 6.9 to 11.7 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC well screen with 0.020-inch machined slots. 11.7 to 12.0 feet: 2-inch-diameter threaded end cap. 0 to 4.7 feet: Bentonite chips. 4.7 to 13.0 feet: 10-20 Colorado Silica Sand. 13.0 to 16.5 feet: Bentonite chips.			
					30						
					35						
					40						

REMARKS

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ4-41**
LOCATION	**Portland, Oregon**	PAGE	**1 of 3**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**-8.3 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**42.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**11/24/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008695**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99080**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	1.1	0	Yes[1]	4/5	**0 to 13.6 feet: SILT (ML)**, grayish brown to dark gray, very soft, wet, low plasticity, trace sand and gravel (<5 percent), spotty sheen, slight hydrocarbon-like odor. (ALLUVIUM)	0-5	0-5	95-100
	1.0	0			@ 1.1 to 1.3 feet: black, tarry-like interval.			
	1.3	0	Yes[2]		@ 3.5 to 3.6 feet: slightly tarry, trace rootlets.			
CB	0.5	0	Yes[2]	5/5	@ 5.6 to 5.8 feet: black laminations.			
	0.2	0	Yes[2]		@ 6.6 to 6.8 feet: sand layer with spotty sheen.			
					@ 8.0 to 8.1 feet: sand layer, spotty sheen.			
	0.4	0	Yes[2]		@ 8.9 to 9.4 feet: sand layer, spotty sheen (in PZ4-12 1.3 feet layer of sand).			
CB				5/5				
	0.4	0	Yes[3]		@ 11.4 to 11.5 feet: sand layer.			
	0.6	0	Yes[3]		**13.6 to 14.7 feet: SAND (SP)**, dark gray, loose, wet, poorly graded, fine to medium grained, no sheen, gray, brown, white and red sand grains. (ALLUVIUM)	0	100	0
CB				4.5/5	**14.7 to 16.6 feet: SILT (ML)**, grayish-brown, soft, moist, low plasticity. (ALLUVIUM)	0	0	100
					@ 15.8 feet: thin sand parting (<1 cm).			
	0.4	0	No		**16.6 to 25.0 feet: SAND (SP)**, dark gray, loose, wet, poorly graded, fine to medium grained with silt blebs. (ALLUVIUM)	0	95-100	0-5
					@ 17.2 to 17.3 feet: silt layer.			

DEPTH IN FEET: 5, 10, 15, 20

WELL DETAILS

LITHO-LOGIC COLUMN

REMARKS

[1] Green, yellow, and orange fluorescent specks and droplets. [2] Heavy green, yellow, and orange fluorescent droplets. [3] Trace fluorescent droplets. [2] Trace fluorescent sheen.

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ4-41**
LOCATION	**Portland, Oregon**	PAGE	**2 of 3**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**-8.3 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**42.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**11/24/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008695**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99080**

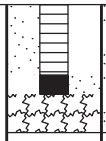
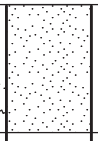
SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0.3 0.5	0 0	No No	4.5/5				**16.6 to 25.0 feet: SAND (SP)**, continued. @ 20.8 feet: brown, hard, silt blebs. @ 21.3 feet: brown, hard, silt blebs. @ 22.2 to 22.5 feet: silt layer. @ 23.0 feet: increased silt content, sand with silt.	0	95-100	0-5
CB	0.6 0.4	0 0	No No	4.9/5	25			**25.0 to 33.5 feet: SAND (SP)**, very dark gray, loose, wet, poorly graded, medium grained, gray, black, white, brown and red grains, occasional silt blebs, no sheen. (ALLUVIUM)	0	95-100	0-5
CB	0.4 0.5	0 2	No No	5/5	30						
								33.5 to 35.0 feet: INTERBEDDED SANDY SILT AND SILTY SAND (SM/ML), dark grayish-brown and dark gray, soft, wet, interbeds are approximately 1- to 2-inches thick, medium plasticity silt, fine to medium grained sand, no sheen. (ALLUVIUM)	0	60	40
CB	0.8 0.4	1 1	No No	5/5	35			**35.0 to 42.0 feet: SAND (SP)**, very dark gray, loose, wet, poorly graded, medium grained, gray, black, white, brown sand grains, no sheen, occasional silt blebs. (ALLUVIUM)	0	95-100	0-5
					40						

REMARKS

[1] Green, yellow, and orange fluorescent specks and droplets. [2] Heavy green, yellow, and orange fluorescent droplets. [3] Trace fluorescent droplets. [2] Trace fluorescent sheen.

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ4-41**
LOCATION	**Portland, Oregon**	PAGE	**3 of 3**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**-8.3 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**42.0 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**11/24/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008695**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99080**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0.2	0	Yes[4]	2/2				**35.0 to 42.0 feet: SAND (SP)**, continued.	0	95-100	0-5
					45			Total depth = 42.0 feet below mudline. **WELL COMPLETION DETAILS** +41.4 to 36.3 feet: 2-inch-diameter, flush-threaded, Schedule 40 steel blank riser pipe. 36.3 to 41.1 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC well screen with 0.020-inch machined slots. 41.1 to 41.4 feet: 2-inch-diameter threaded end cap. 0 to 32.3 feet: Bentonite grout. 32.3 to 34.3 feet: 20-40 Colorado Silica Sand. 34.3 to 41.4 feet: 10-20 Colorado Silica Sand. 41.4 to 42.0 feet: Native.			
					50						
					55						
					60						

REMARKS

[1] Green, yellow, and orange fluorescent specks and droplets. [2] Heavy green, yellow, and orange fluorescent droplets. [3] Trace fluorescent droplets. [2] Trace fluorescent sheen.

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ5-20**
LOCATION	**Portland, Oregon**	PAGE	**1 of 2**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**10.8 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**20.3 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**11/20/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008692**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99034**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
					5 10 15 20			See boring log PZ5-85 for lithologic description.			

REMARKS

LOG OF EXPLORATORY BORING

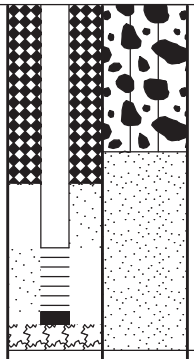
PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ5-20**
LOCATION	**Portland, Oregon**	PAGE	**2 of 2**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**10.8 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**20.3 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**11/20/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008692**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99034**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
								Total depth = 20.3 feet.			
								WELL COMPLETION DETAILS +5.5 to 15.2 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC blank riser pipe. 15.2 to 20.0 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC well screen with 0.020-inch machined slots. 20.0 to 20.3 feet: 2-inch-diameter threaded end cap. +0.3 to 1.0 foot: Cement. 1.0 to 12.9 feet: Bentonite chips. 12.9 to 20.3 feet: 10-20 Colorado Silica Sand.			
					25						
					30						
					35						
					40						

REMARKS

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ5-5**
LOCATION	**Portland, Oregon**	PAGE	**1 of 1**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**10.7 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**5.4 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**11/20/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008693**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99035**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
					5			See boring log PZ5-85 for lithologic description.			
					10			Total depth = 5.4 feet. **WELL COMPLETION DETAILS** +5.5 to 3.8 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC blank riser pipe. 3.8 to 4.8 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC well screen with 0.020-inch machined slots. 4.8 to 5.0 feet: 2-inch-diameter threaded end cap. +0.5 to 0 feet: Concrete. 0 to 2.8 feet: Bentonite chips. 2.8 to 5.0 feet: 10-20 Colorado Silica Sand. 5.0 to 5.4 feet: Native.			
					15						
					20						

REMARKS

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ5-55**
LOCATION	**Portland, Oregon**	PAGE	**1 of 4**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**10.8 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**55.3 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**11/20/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008691**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99033**

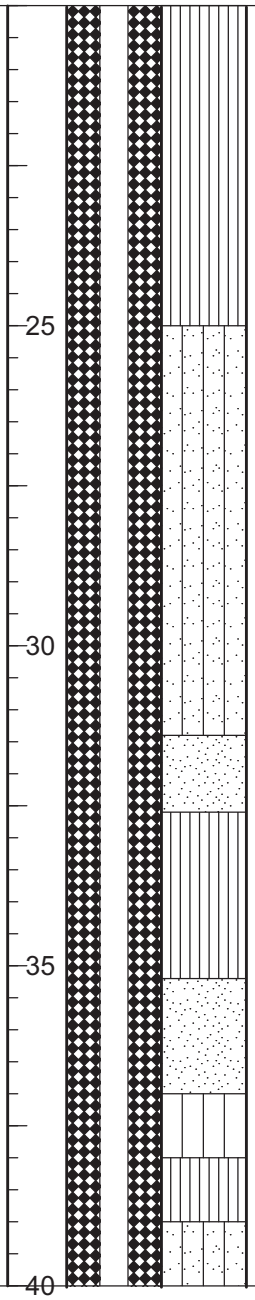
SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
					5 10 15 20			See boring log PZ5-85 for lithologic description.			

REMARKS

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ5-55**
LOCATION	**Portland, Oregon**	PAGE	**2 of 4**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**10.8 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**55.3 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**11/20/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008691**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99033**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %



REMARKS

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ5-55**
LOCATION	**Portland, Oregon**	PAGE	**3 of 4**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**10.8 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**55.3 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**11/20/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008691**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99033**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
					45						
					50						
					55			Total depth = 55.3 feet.			
					60			See Page 4 for Well Completion Details.			

REMARKS

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ5-55**
LOCATION	**Portland, Oregon**	PAGE	**4 of 4**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**10.8 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**55.3 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**11/20/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008691**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99033**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
					65			**WELL COMPLETION DETAILS** +5.5 to 50.2 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC blank riser pipe. 50.2 to 55.0 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC well screen with 0.020-inch machined slots. 55.0 to 55.3 feet: 2-inch-diameter threaded end cap. +0.3 to 1.0 foot: Concrete. 1.0 to 6.0 feet: Bentonite chips. 6.0 to 45.2 feet: Bentonite grout. 45.2 to 48.0 feet: 100 Colorado Silica Sand. 48.0 to 55.3 feet: 10-20 Colorado Silica Sand.			
					70						
					75						
					80						

REMARKS

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ5-85**
LOCATION	**Portland, Oregon**	PAGE	**1 of 5**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**10.8 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**85.5 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**11/18/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008690**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99032**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0.0	NA	No	1/1	**0 to 2.3 feet: SANDY GRAVEL WITH SILT (GW-GM)**, dark brown and dark gray, moist, loose, fine to coarse angular gravel, fine to medium sand, well graded. (FILL)	60	30	10
CB	0.1	NA	No	1/4	@ 2.0 feet: wet, no sheen.			
	0.6	NA	No		**2.3 to 6.8 feet: SAND (SP)**, dark gray, loose, wet, poorly graded, light hydrocarbon-like odor. (FILL)	0	100	0
					@ 4.0 feet: large chunks of wood and wood debris.	0	100	0
CB				1/1				
CB	0.5	NA	No	4/4	@ 6.2 feet: light sheen observed.			
	0.3	NA	No		**6.8 to 20.0 feet: INTERBEDDED SILTY SAND AND SANDY SILT (SM/ML)**, dark gray, loose, wet, fine sand, poorly graded, sand mixed with two separate fractions (interbedded). (ALLUVIUM)	0	50-60	40-50
	0.1	NA	No		@ 7.5 feet: light sheen (spotty), light hydrocarbon-like odor.			
CB				5/5				
	0.2	NA	No		@ 11.0 to 11.7 feet: poorly graded, fine to medium sand layer.			
					@ 13.2 to 13.6 feet: sandy silt layer.	0	20	80
					@ 14.5 to 15.0 feet: sandy silt, trace rootlets and organic debris.	0	20	80
CB	0.0	NA	No	5/5				
					@ 16.0 to 16.4 feet: sandy silt layer.	0	20	80
	0.6	NA	No		@ 16.9 to 18.0 feet: sandy silt layer.			
					@ 18.0 feet: increased sand content.	0	80	20

DEPTH IN FEET: 5, 10, 15, 20

WELL DETAILS / LITHO-LOGIC COLUMN

REMARKS

NA = Not Analyzed.

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ5-85**
LOCATION	**Portland, Oregon**	PAGE	**2 of 5**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**10.8 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**85.5 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**11/18/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008690**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99032**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	NA	NA	NA	3.8/5				**20.0 to 25.0 feet: SANDY SILT (ML)**, dark gray, wet, very soft, low plasticity silt, fine sand, trace wood pieces, trace gravel (<5 percent), no sheen. (ALLUVIUM)	0-5	20	80
	0.1	NA	No								
	0.1	NA	No								
CB				5/5	25			**25.0 to 31.4 feet: SILTY SAND (SM)**, dark gray, very loose, wet, soupy, fine sand, low plasticity silt. (ALLUVIUM) @ 25.0 to 31.4 feet: no sheen.	0	55	45
	0.1	NA	No								
CB	0.0	NA	No	5/5	30			@ 30.0 to 31.4 feet: alternating layers of medium plasticity silt and medium grained sand.			
								31.4 to 32.6 feet: SAND (SP), dark gray, poorly graded, wet, loose, medium grained, >5 percent fines, no sheen. (ALLUVIUM)	0	95-100	0-5
	0.1	NA	No					**32.6 to 35.2 feet: SANDY SILT (ML)**, dark gray, very soft, wet, low plasticity, no sheen. (ALLUVIUM)	0	20	80
	0.2	NA	No								
CB				5/5	35			**35.2 to 37.0 feet: SAND (SP)**, dark gray, loose, wet, poorly graded, fine to medium grained, no sheen. (ALLUVIUM)	0	95	5
	0.0	NA	No					**37.0 to 40.8 feet: SILTY SAND (SM)**, dark gray, very soft, wet, fine to medium grained sand, no sheen. (ALLUVIUM) @ 38.2 to 38.7 feet: medium plasticity sandy silt layer, no sheen.	0	60	40
					40						

REMARKS

NA = Not Analyzed.

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ5-85**
LOCATION	**Portland, Oregon**	PAGE	**3 of 5**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**10.8 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**85.5 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**11/18/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008690**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99032**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0.1	NA	No	5/5				**37.0 to 40.8 feet: SILTY SAND (SM)**, continued.	0	60	40
								40.8 to 41.5 feet: SILT (MH), dark gray, highly plastic, soft, wet, no sheen. (ALLUVIUM)	0	0	100
	0.3	NA	No					**41.5 to 43.8 feet: SILTY SAND (SM)**, dark gray, loose, wet, intermittent thin silt layers, fine to medium grained sand, no sheen. (ALLUVIUM)	0	70	30
								43.8 to 45.0 feet: SANDY SILT (MH), dark gray, moist, very stiff, medium plasticity, medium grained sand, no sheen. (ALLUVIUM)	0	30	70
CB	0.2	NA	No	5/5	45			**45.0 to 48.1 feet: SAND (SP)**, dark gray, loose, wet, poorly graded, <5 percent fines, medium grained, no sheen. (ALLUVIUM)	0	95-100	0-5
	0.1	NA	No								
								48.1 to 49.0 feet: SAND AND SILT (MH/SP), dark gray, alternating lenses. (ALLUVIUM)	0	50	50
								49.0 to 49.8 feet: SILT WITH SAND (MH), dark gray, very soft, wet, highly plastic, no sheen. (ALLUVIUM)	0	10	90
CB	0.1	NA	No	5/5	50			**49.8 to 85.5 feet: SAND (SP)**, dark gray, loose, wet, poorly graded, medium grained, no sheen. (ALLUVIUM)	0	95-100	0-5
	0.1	NA	No					@ 54.0 feet: two coarse-size (2-inches diameter) pieces of gravel.			
CB	0.0	NA	No	5/5	55						
	0.1	NA	No								
					60						

REMARKS

NA = Not Analyzed.

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ5-85**
LOCATION	**Portland, Oregon**	PAGE	**4 of 5**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**10.8 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**85.5 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**11/18/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008690**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99032**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0.0	NA	No	5/5				**49.8 to 85.5 feet: SAND (SP)**, continued.	0	95-100	0-5
	0.0	NA	No								
CB	0.1	NA	No	5/5	65						
	0.0	NA	No								
CB	0.0	NA	No	5/5	70			@ 70.0 to 85.5 feet: moderate "dirty gym sock" odor.			
	0.0	NA	No								
CB	0.0	NA	No	5/5	75						
	0.1	NA	No								
					80						

REMARKS

NA = Not Analyzed.

LOG OF EXPLORATORY BORING

PROJECT NAME	**Gasco Seg 2 Capture Zone Test**	BORING NO.	**PZ5-85**
LOCATION	**Portland, Oregon**	PAGE	**5 of 5**
DRILLED BY	**Cascade Drilling, Inc.**	GROUND SURFACE ELEVATION	**10.8 ft msl**
DRILL METHOD	**Rotosonic - AMS C-17 Rig**	TOTAL DEPTH	**85.5 ft.**
LOGGED BY	**Matt Wilson**	DATE COMPLETED	**11/18/09**
SAMPLING METHOD	**5-foot by 4-inch core barrel (CB)**	PERMIT/STARTCARD NO.	**1008690**
BOREHOLE DIAMETER	**6-inch**	WATER RESOURCES WELL ID	**L99032**

SAMPLING METHOD	VOC HEAD-SPACE (ppm)	HCN (PPM)	ULTRA-VIOLET FLUOR-ESCENCE	RECOVERY (FEET)	DEPTH IN FEET	WELL DETAILS	LITHO-LOGIC COLUMN	LITHOLOGIC DESCRIPTION	GRA %	SAND %	SLT %
CB	0.0	NA	No	2/5				**49.8 to 85.5 feet: SAND (SP)**, continued.	0	95-100	0-5
	0.0	NA	No								
					85						
								Total depth = 85.5 feet. **WELL COMPLETION DETAILS** +6.0 to 80.1 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC blank riser pipe. 80.1 to 84.9 feet: 2-inch-diameter, flush-threaded, Schedule 40 PVC well screen with 0.020-inch machined slots. 84.9 to 85.2 feet: 2-inch-diameter threaded end cap. +0.3 to 1.0 foot: Concrete. 1.0 to 16.5 feet: Bentonite chips. 16.5 to 75.8 feet: Bentonite grout. 75.8 to 80.1 feet: 100 Colorado Silica Sand. 80.1 to 85.2 feet: 10-20 Colorado Silica Sand. 85.2 to 85.5 feet: Native.			
					90						
					95						
					100						

REMARKS
NA = Not Analyzed.

APPENDIX B
WELL DEVELOPMENT RECORDS AND FIELD SAMPLING DATA SHEETS

WELL DEVELOPMENT FORM

ANCHOR QEA

Project No.	000029-02.23	Date: 3/2/10	Well: PW-7
Site Location:	7900 NW St. Helens Rd., Portland	Initial DTB: 96.81 @ 0856	Final DTB: 96.95 1557
Name:	GASCO, Capture Zone Field Test	Initial DTW: 16.25 @ 0853	Final DTW: 18.64 1553
Development Method:	~~Waterra peri-pump~~ Air lift	Casing Volume:	80.56' = 210.10
Total Water Removed:	3450 gal	Casing Diameter:	8" =2.608 gal/ft
Water Contained ?	YES	Meter #:	23069
Estimate of specific capacity or recharge to well:	50.50 gpm	OWRD#:	L102837

Gal/ft = (dia./2)^2 x 0.163	1"=0.041	2"=0.163	3"=0.367	4"=0.653	6"=1.469	8"=2.608	10"=4.080	12"=5.875

Time	Cum. Vol. Removed	Sand/Silt (ml/1000ml)	Temp.	EC	pH	DTW (TOC)	Appearance/Comments
0800	0	—	—	—	—	—	Set up to develop - air lift/surge
0934	0	—	—	—	—	—	Started surging only
0945	0	—	—	—	—	—	Started air lifting/surging
0950	≈ 20	4	A —	—	—	—	chalk brown cloudy - slight sheen
1000	200	900	B 15.59	166	8.10	17.53	chalk brown cloudy stopped *
1025	400	—	—	—	—	21.52	stopped to add 1 length piping —
—	—	—	—	—	—	—	could not reach bottom @ 4' from
—	—	—	—	—	—	—	bottom.
1040	400	250	C 15.06	227	7.56	—	Restarted - chalk brown milky
1051	700	9	A 15.12	371	7.51	22.97	light brown cloudy
1109	1000	2.5	B 15.09	451	7.44	22.20	very light brown - stopped to
—	—	—	—	—	—	—	pump down tank
1147	1000	—	—	—	—	—	Restart surging
1157	1100	—	—	—	—	19.82	
1212	1500	<1	A 14.83	564	7.57	25.90	light brown (tan) cloudy
1223	1700	<1	B 14.94	591	7.57	26.28	very light tan-orange cloudy
1236	1950	<1	A 14.55	606	7.53	26.33	very light tan-orange cloudy
1241	2050	—	—	—	—	—	Stopped to pump down tank & set
—	—	—	—	—	—	—	up to run w/ sub. grundfos pump
1446	2050	—	—	—	—	18.76	DTB = 96.95' STARTED 50 gpm
1447	—	—	—	—	—	—	Stopped - hole in hose.
1449	2050	—	—	—	—	18.75	Restart w/ 50 gpm Grundfos
1459	2800	—	—	—	—	18.75	Restarted again after more repairs
1504	2300	<0.5	A 15.08	654	7.56	42.23	very light tan cloudy
1509	2550	<0.5	B 14.55	709	7.58	43.06	almost clear - 50 gpm via bucket test
1514	2800	<0.5	C 15.09	756	7.50	43.80	clear
1519	3050	<0.5	A 14.78	763	7.56	44.23	clear
1527	3450	<0.5	B 14.92	771	7.52	44.40	clear, stopped pump development
1553						18.64	DTB = 96.95'

* = stopped to remove section of fire hose to allow more flow

WELL DEVELOPMENT FORM

ANCHOR QEA

Project No.	000029-02.23	Date: 3/1/10 Well: PW-8	
Site Location:	7900 NW St. Helens Rd., Portland	Initial DTB: 72.20 (1207)	Final DTB: 72.43'
Name:	GASCO, Capture Zone Field Test	Initial DTW: 19.50 @ 1206	Final DTW: 18.50
Development Method:	~~Waterra peri-pump~~ Air lift	Casing Volume: 52.70' = 137.44	
Total Water Removed:	1500	Casing Diameter: 8" =2.608 gal/ft	
Water Contained ?	YES	Meter #: 23069	
Estimate of specific capacity or recharge to well:	7-10 gal/ft *	OWRD#: L102836	

Gal/ft = (dia./2)^2 x 0.163	1"=0.041	2"=0.163	3"=0.367	4"=0.653	6"=1.469	8"=2.608	10"=4.080	12"=5.875

Time	Cum. Vol. Removed	Sand/Silt (ml/1000ml)	Temp.	EC	pH	DTW (TOC)	Appearance/Comments
1325	0	—	—	—	—	—	Commenced air lift
1335	≈50	70	16.75	850	7.61	—	
1340	≈600	—	—	—	—	—	dark brown/grey
1350	≈600	—	—	—	—	—	~~stopped~~ air lift surging only
1400	≈800	7	A 16.65	704	7.51	24.89	very light cloudy w/ course sand
1410	≈1100	<1	B 16.49	728	7.46	—	almost clear, running ≈20 gpm
1420	≈1300	<1	16.62	726	7.52	24.56	clear, recirculate - 30-40 gpm
1428	≈1500	<1	16.60	725	7.48	—	clear, stopped/finished developement
3/3/10							
0905	1500	—	—	—	—	17.93	DTB=72.43'. Set up to continue
—	—	—	—	—	—	—	develope w/50 gpm Grundfos pump
0915	1500	—	—	—	—	—	Start pumping
0917	1600	<1	15.96	697	7.57	—	very light turbid orange cloudy
0920	1750	<1	16.71	710	7.61	25.69	almost clear
0925	2000	<1	16.69	713	7.62	25.83	clear
0930	2250	<1	16.09	709	7.64	25.95	clear
0935	2500	<1	16.78	715	7.66	26.09	clear / performed bucket test
0940	2750	<1	16.93	715	7.64	26.14	clear
0942	2850	—	—	—	—	—	Completed developement
0944	—	—	—	—	—	18.45	recovery
0945	—	—	—	—	—	18.36	recovery
1027	—	—	—	—	—	18.50	DTB=72.43'

* - 7-10 gal/min/foot

WELL DEVELOPMENT FORM

ANCHOR QEA

Project No.	000029-02.23	Date: 3/3/10	Well: PW-9
Site Location:	7900 NW St. Helens Rd., Portland	Initial DTB: 96.97	Final DTB: 97.47'
Name:	GASCO, Capture Zone Field Test	Initial DTW: 26.48	Final DTW: 28.88
Development Method:	~~Waterra peri-pump~~ Air lift / Grundfos	Casing Volume: 70.49' =	183.84 gal
Total Water Removed:	8310 gal	Casing Diameter:	8" =2.608 gal/ft
Water Contained ?	YES	Meter #:	23069
Estimate of specific capacity or recharge to well:	50 gpm	OWRD#:	L102842

Gal/ft = (dia./2)^2 x 0.163	1"=0.041	2"=0.163	3"=0.367	4"=0.653	6"=1.469	8"=2.608	10"=4.080	12"=5.875

Time	Cum. Vol. Removed	Sand/Silt (ml/1000ml)	Temp.	EC	pH	DTW (TOC)	Appearance/Comments
1404	0	—	—	—	—	26.48	Surging with surge block only
1415	0	"	"	—	—	—	Start air lift along w/ surging
1420	100	16/900 A	15.34	187	8.04	—	dark brown, milky
1428	300	4/500 B	14.98	273	7.42	—	dark brown, milky
1451	500	<1/9 C	14.75	541	7.58	62.32	brown cloudy – air lift only
1514	700	2 A	14.62	603	7.64	59.81	lighter brown cloudy, ≈ 8.7 gpm
—	—	—	—	—	—	—	– air lift only after surge cycle
1535	900	3 C	15.03	635	7.52	52.34	light brown cloudy – surge & air lift
1556	1100	<1 A	14.95	701	7.48	56.05	very light tan cloudy
1518	1350	<1 B	14.95	708	7.49	53.86	almost clear ≈ 16.4 gpm
1523	1400	—	—	—	—	—	stopped development
1525	—	—	—	—	—	42.30	Recovery
1526	—	—	—	—	—	39.50	
1528	—	—	—	—	—	34.32	↓
1650	—	—	—	—	—	28.61	DTB = 97.11'
	3/4/10						
0815	1400	—	—	—	—	—	Set up w/ Grundfos pump
0919	1400	—	—	—	—	26.25	Start pump test – throttled to 0%
0924	1450	—	—	—	—	42.50	
0927	≈1500	<1 A	14.91	730	7.22	56.87	very light tan cloudy, ~~to 15 gpm~~
0933	1800	—	—	—	—	61.78	throttled to 50 gpm
0938	2050	<1 B	15.52	740	7.10	63.35	almost clear
0945	2400	<1 C	15.35	737	7.14	63.84	clear
0951	2700	<1	15.53	739	7.11	64.23	clear
0957	3000	<1	15.62	736	7.10	64.43	clear
~~0955~~ 1003	3300	<1	15.49	738	6.84	64.52	clear
1009	3600	<1	15.64	739	7.06	64.56	clear, may increase flow
1015	3900	—	—	—	—	64.91	continue @ 50 gpm
1021	4200	<1	15.47	734	7.09	65.06	clear – development OK, pump & cord down
1027	4500	—	—	—	—	65.13	—
1033	4800	—	—	—	—	65.28	clear
1039	5100	<1	15.44	727	7.08	65.42	

WELL DEVELOPMENT FORM

ANCHOR QEA

Project No.	000029-02.23	Date: 3/4/10 Well: PW-9	
Site Location:	7900 NW St. Helens Rd., Portland	Initial DTB: 96.97	Final DTB: 97.47'
Name:	GASCO, Capture Zone Field Test	Initial DTW: 26.48	Final DTW: 28.88'
Development Method:	~~Waterra peri-pump~~ Grundfos	Casing Volume:	
Total Water Removed:	8310 gal	Casing Diameter:	8" =2.608 gal/ft
Water Contained ?	YES	Meter #:	23069
Estimate of specific capacity or recharge to well:	50 gpm	OWRD#:	L 102843

Gal/ft = (dia./2)^2 x 0.163	1"=0.041	2"=0.163	3"=0.367	4"=0.653	6"=1.469	8"=2.608	10"=4.080	12"=5.875

Time	Cum. Vol. Removed	Sand/Silt (ml/1000ml)	Temp.	EC	pH	DTW (TOC)	Appearance/Comments
1045	5400	—	—	—	~~65.43~~	65.43	—
1051	5700	<1	15.60	731	7.05	65.48	clear
1057	6000	—	—	—	—	65.77	continuous well measurement
1103	6300	—	—	—	—	65.71	
1105	6400	—	—	—	—	65.87	
1107	6500	—	—	—	—	65.76	
1109	6600	—	—	—	—	65.94	
1111	6700	—	—	—	—	65.96	
1113	6800	—	—	—	—	66.04	
1115	6900	—	—	—	—	66.04	
1117	7000	—	—	—	—	66.06	
1119	7100	<1	15.59	726	7.07	66.08	clear
1121	7200	—	—	—	—	66.11	Pump is at full open
1122	—	—	—	—	—	69.40	
1123	—	—	—	—	—	72.60	
1124	—	—	—	—	—	74.00	Pump off, start recovery
1125	—	—	—	—	—	58.55	Recovery
1126	—	—	—	—	—	45.70	
1128	—	—	—	—	—	33.20	- started
1133	—	—	—	—	—	27.52	Restart after repairs
1136	7290	—	—	—	—	32.92	~~at~~ flow rate @ 30 gpm 34.41 @ 1138
1140	7410	—	—	—	—	34.78	34.98 @ 1142
1145	7560	—	—	—	—	35.09	35.12 @ 1147
1150	7710	—	—	—	—	35.15	35.16 @ 1152
1155	7860	—	—	—	—	35.20	35.22 @ 1157
1200	8010	—	—	—	—	35.24	35.26 @ 1202
1205	8160	—	—	—	—	35.30	
1210	8310	<1	15.24	737	7.19	35.34	clear, development complete
1513	—	—	—	—	—	28.88	DTB = 97.47'

WELL DEVELOPMENT FORM

ANCHOR QEA

Project No.	000029-02.23	Date: 3/5/10 Well: OW-7	
Site Location:	7900 NW St. Helens Rd., Portland	Initial DTB: 18.32	Final DTB: 19.96
Name:	GASCO, Capture Zone Field Test	Initial DTW: 14.59	Final DTW: 14.64
Development Method: Waterra peri-pump		Casing Volume: 3.73' = 0.61 gal	
Total Water Removed: 60		Casing Diameter: 2" = 0.163 gal/ft	
Water Contained ? YES		Meter #: 23069	
Estimate of specific capacity or recharge to well: >2 gpm		OWRD#: L 102838	

Time	Cum. Vol. Removed	Sand/Silt (ml/1000ml)	Temp.	EC	pH	DTW (TOC)	Appearance/Comments
0937	—	—	—	—	—	14.59	Setup to develope w/surge block
1005	—	—	—	—	—	—	Start manually surging
1020	0	—	—	—	—	—	Start waterra - pump/surge
1025	1	950 A	—	—	—	14.66	*Dark chocolate brown milky @ 3.5' FB
1029	2	—	—	—	—	14.73	*dark brown milky, moved to 2.5' FB
1036	4	—	—	—	—	14.65	*dark brown milky, moved to 1.5' FB
1040	6	—	—	—	—	14.72	*dark brown milky, moved to 0.5' FB
1045	8	13/800 B	20.96	324	7.88	14.70	*dark brown milky, moved to bottom
1054	13	—	—	—	—	—	dark brown milky, removed surge
—	—	—	—	—	—	—	block & placed @ 2.5' FB
1100	15	~~340~~ 2/160 C	20.72	274	7.51	—	dark brown cloudy
1104	17.5	3 A	21.07	264	7.27	14.71	mid brown cloudy
1111	21	1 B	20.82	258	7.44	14.73	lighter brown cloudy, moved to bottom
1119	25	—	—	—	—	14.73	dark brown milk to brown cloudy
1127	30	10/2 C	21.04	236	7.50	14.78	brown/grey cloudy - clean sump
1133	34	—	21.68	229	7.21	14.75	light brown/grey cloudy
1142	40	1.5 A	21.73	227	7.48	14.77	light brown/grey cloudy
1150	45	0.6 C	21.69	226	7.49	—	lighter brown/grey cloudy
1156	48	—	21.88	225	7.48	14.76	lighter brown/grey cloudy
1200	51	<0.5 B	21.06	282	7.46	—	very light grey/brown cloudy
1206	54	<0.5 C	21.64	225	7.51	14.78	very light grey/brown cloudy
1210	56	<0.5 A	22.07	223	7.54	—	very light grey/brown cloudy
1214	60	<0.5 B	22.04	222	7.46	14.80	very light grey/brown cloudy
1320	—	—	—	—	—	14.64	DTB = 19.96

FB = From bottom

* - slight sheen

WELL DEVELOPMENT FORM

ANCHOR QEA

Project No.	000029-02.23	Date: 2/18/10	Well: OW-8
Site Location:	7900 NW St. Helens Rd., Portland	Initial DTB: 17.15 @ 1355	Final DTB: 17.19 @ 1558
Name:	GASCO, Capture Zone Field Test	Initial DTW: 14.24' @ 1353	Final DTW: 14.28 @ 1555
Development Method:	Waterra peri-pump	Casing Volume: 2.91' = 0.474	
Total Water Removed:	25 gal	Casing Diameter:	2" = 0.163 gal/ft
Water Contained ?	YES	Meter #:	23069
Estimate of specific capacity or recharge to well:	≈0.6 gpm	OWRD#:	102835

Time	Cum. Vol. Removed	Sand/Silt (ml/1000ml)	Temp.	EC	pH	DTW (TOC)	Appearance/Comments	
1357	0	–	–	–	–	14.24	Start manually surging w/ blue check valve	
1415	0	–	–	–	–		Stopped surging, set-up to pump	
1424	0	–	–	–	–	14.14	Start surging w/ waterra & check vlv	2' fr bottom
1428	8.02	–	–	–	–	14.48	moved vlv to 1' from bottom	
–	–	–	–	–	–	–	dark brown milky, increased speed	1430
1433	0.5	850 A	–	–	–	14.72	dark brown milky, increased speed	1435
1437	1.5	–	–	–	–	15.10	" " "	
1440	3	–	15.34	560	7.02	15.25	" " "	
1445	5	44 B	14.94	551	6.76	15.34	cloudy brown	
1450	7.5	<1 C	15.06	549	6.72	15.34	light tan cloudy	
1458	10	<1 A	14.99	554	6.67	15.36	almost clear, move vlv to 1" off bottom	
1500	11	67 C	–	–	–	–	dark cloudy brown	
1503	12.5	–	15.22	552	6.65	15.57	mid cloudy brown	
1508	15	1 A	15.12	554	6.67	15.23	almost clear	
1514	17.5	<1 B	15.17	550	6.75	15.24	almost clear	
1520	22	<0.5 C	14.79	553	6.62	15.22	clear	
1525	25	–	–	–	–	15.20	stopped, clear. Recovery	
1526	25	–	–	–	–	14.67	Recovery	
1527	25	–	–	–	–	14.48		
1528	25	–	–	–	–	14.39		
1529	25	–	–	–	–	14.37		
1530	25	–	–	–	–	14.34		

Note – Sand/Silt at 20-25 gals = approx. 3 ml/5 gal

WELL DEVELOPMENT FORM

ANCHOR QEA

Project No.	000029-02.23	Date: 3/9/10	Well: OW-9
Site Location:	7900 NW St. Helens Rd., Portland	Initial DTB: 27.58 @ 1255	Final DTB: 27.60'
Name:	GASCO, Capture Zone Field Test	Initial DTW: 25.55 @ 1253	Final DTW: 25.58'
Development Method:	Waterra/peri-pump	Casing Volume: 2.03 L =	0.53 gal
Total Water Removed:	30 gal	Casing Diameter:	2" = 0.163 gal/ft
Water Contained ?	YES	Meter #:	23069
Estimate of specific capacity or recharge to well:	<0.5 gpm	OWRD#:	L 102843

Time	Cum. Vol. Removed	Sand/Silt (ml/1000ml)	Temp.	EC	pH	DTW (TOC)	Appearance/Comments
1305	0	—	—	—	—	25.55	Start manually surging
1327	~~1327~~	—	—	—	—	—	Start Waterra w/surge block 1.5' FB
1330	1	~~25.85~~	—	—	—	25.85	black/brown muddy, move to 0.5 FB
1332	2	—	—	—	—	26.15	black/brown milky, move to Bottom
1335	3	—	—	—	—	26.54	black/brown milky, move to 1' FB
1345	7	200 A	—	—	—	—	black/brown milky, Remove surge block
1351	10	—	12.99	106	6.57	26.33	black/brown dark cloudy, left @ 1' FB
1355	12	<0.5 B	10.90	93	8.64	26.17	brown/grey lighter cloudy, move to bottom
1400	15	<0.5 C	12.08	133	6.80	26.74	very light brown cloudy, stop to recharge
1402	15	—	—	—	—	25.75	Restart @ bottom
1406	17	<0.5 A	13.30	160	6.31	26.75	almost clear
1410	20	<0.5 B	15.98	225	6.55	26.81	clear, stop to recharge
1412	20	—	—	—	—	25.70	restart to bottom
1415	22	<0.5 C	16.47	239	6.59	26.68	clear
1419	25	<0.5 A	16.51	240	6.64	26.72	clear, stop to allow recharge
1423	25	<0.5 A	—	—	—	25.61	restart @ bottom
1427	27	<0.5 C	17.63	256	6.65	26.62	clear
1432	30	<0.5 A	18.31	271	6.64	26.68	clear, end development
1502	—	—	—	—	—	25.58'	DTB = 27.60'

WELL DEVELOPMENT FORM

ANCHOR QEA

Project No.	000029-02.23	Date: 2/19/10 Well: MW-22-80	
Site Location:	7900 NW St. Helens Rd., Portland	Initial DTB: 82.44 @ 1038	Final DTB: 83.20
Name:	GASCO, Capture Zone Field Test	Initial DTW: 28.23 @ 1035	Final DTW: 29.46
Development Method:	Waterra peri-pump	Casing Volume: 54.21' = 8.84 gal	
Total Water Removed:	100 gal	Casing Diameter:	2" = 0.163 gal/ft
Water Contained ?	Y	Meter #:	23069
Estimate of specific capacity or recharge to well:	>1 gpm	OWRD#:	L102834

Time	Cum. Vol. Removed	Sand/Silt (ml/1000ml)	Temp.	EC	pH	DTW (TOC)	Appearance/Comments
1035	—	—	—	—	—	—	Setup, installing tubing w/ chk vlv & surge block
1055	0	—	—	—	—	28.23	Started at 1' BTS, slow
1108	0	—	—	—	—	—	Increased pump speed
1110	2	50 A	16.92	586	7.20	—	Dark grey, cloudy
1115	5	—	—	—	—	28.85	grey cloudy, moved to 3' BTS,
1117	6	—	—	—	—	—	muddy dark grey, consistency of milk
1121	10	—	—	—	—	29.00	dark grey cloudy, moved to 5' BTS
1123	12	175 B	17.12	604	6.61	—	dark grey cloudy, milky
1127	15	—	—	—	—	29.07	dark grey cloudy, milky; moved to 7' BTS
1133	20	—	—	—	—	28.95	dark grey cloudy, moved to 9' BTS
1138	25	—	17.50	657	6.55	—	dark grey cloudy, moved to 2" off bottom
1140	27	180 C	—	—	—	—	dark grey milky
1145	30	—	17.22	660	6.57	28.80	dark grey cloudy, remove surge
—	—	—	—	—	—	—	block & placed at 1' BTS
1151	35	17 A	17.16	672	6.60	—	mid cloudy grey
1156	40	—	17.66	676	6.61	28.95	almost clear, moved to 3' BTS
1205	50	<0.5 B	17.98	672	6.69	28.98	clear, moved to 5' BTS
1215	60	<0.5 C	17.83	686	6.75	29.16	clear, moved to 7' BTS, stopped to
—	—	—	—	—	—	—	empty buckets / lunch.
1330	60	—	—	—	—	29.09	restarted, light grey cloudy @ 1gal
1340	70	<0.5 A	17.73	694	6.57	29.46	almost clear, moved to 9' BTS
1349	80	<0.5 B	17.41	694	6.51	29.53	almost clear, moved to bottom
1356	85	34* C	—	—	—	—	operated valve by hand moved bottom
—	—	—	—	—	—	—	dark grey cloudy, sandy
1400	90	0.6 A	17.31	692	6.52	—	light grey cloudy
1410	100	B	17.54	690	6.55	29.53	clear, stop developement
—	—	—	—	—	—	—	Complete
1420	—	—	—	—	—	29.32	Recovery
1430	—	—	—	—	—	29.36	↓
1448	—	—	—	—	—	29.46	↓

Page 1 of 1

BTS = below top of screen

* 18 - sand, 16 silt

WELL DEVELOPMENT FORM

ANCHOR QEA

Project No.	000029-02.23	Date: 8/24/10	Well: MW-23-27
Site Location:	7900 NW St. Helens Rd., Portland	Initial DTB: 30.11 @ 1235	Final DTB: 30.29 @ 1620
Name:	GASCO, Capture Zone Field Test	Initial DTW: 25.48 @ 1234	Final DTW: 25.67 @ 1618
Development Method:	Waterra peri-pump	Casing Volume: 4.63 = 0.75 gal	
Total Water Removed:	12 gal	Casing Diameter:	2" = 0.163 gal/ft
Water Contained ?	Yes	Meter #:	23069
Estimate of specific capacity or recharge to well:	<0.25 gpm	OWRD#:	L102841

Time	Cum. Vol. Removed	Sand/Silt (ml/1000ml)	Temp.	EC	pH	DTW (TOC)	Appearance/Comments
1305	0	—	—	—	—	—	Manually surged well
1320	0	—	—	—	—	—	Started w/ surge block @ 4' ~~BTS~~ TOC from
~~1325~~	1	—	—	—	—	—	bottom of well
1323	1	—	—	—	—	—	no water, move to 3' from bottom
1327	2	400 A	—	—	—	26.35	run out of water moved to 2' from bottom
—	—	—	—	—	—	—	all water is very dark grey milky
1334	3	600 B	—	—	—	27.25	cycling pumps, moved to 1' off bottom
—	—	—	—	—	—	—	very dark grey milky, low pump speed
1338	4	—	—	—	—	28.27	still cycling pumps, moved to bottom
—	—	—	—	—	—	—	very dark grey milky, lower pump speed
1350	5	500 C	14.48	607	6.93	29.16	very dark grey milky, slight sheen
—	—	—	—	—	—	—	remove surge block, move to 2' from bottom
1358	5	—	—	—	—	27.34	no water after starting, move to 1' from bottom
1402	6	—	—	—	—	—	intermittent pumping, light grey cloudy
1408	7	22 A	13.80	607	7.22	—	lighter grey cloudy, moved to bottom
1412	8	64 B	—	—	—	—	very dark grey cloudy, intermittent pump
1420	9	50 C	14.52	614	7.07	29.34	grey cloudy, stopped to recharge
1433	9	—	—	—	—	26.05	Restart @ bottom - no flow
1439	9	—	—	—	—	25.45	made repair to check valve, restart
1442	9.5	30 A	14.53	593	6.90	—	grey cloudy
1445	10	8 B	14.17	588	7.02	29.87	light grey cloudy, stopped to recharge
1550	10	—	—	—	—	25.81	Restart at bottom
1553	11	20.5 A	14.30	584	7.08	—	clear
1557	12	0.8 B	14.50	579	7.21	29.48	clear, stop development

WELL DEVELOPMENT FORM

ANCHOR QEA

Project No.	000029-02.23	Date: 2/24/10 Well: MW-23-75	
Site Location:	7900 NW St. Helens Rd., Portland	Initial DTB: 77.69 @ 0155	Final DTB: 78.15 @ 1621
Name:	GASCO, Capture Zone Field Test	Initial DTW: 28.40 @ 0150	Final DTW: 27.10 @ 1617
Development Method:	Waterra peri-pump	Casing Volume: 49.29 = 8.03 gal	
Total Water Removed:	95 gal	Casing Diameter:	2" = 0.163 gal/ft
Water Contained ?	YES	Meter #:	23069
Estimate of specific capacity or recharge to well:	>1 gpm	OWRD#:	L102840

Time	Cum. Vol. Removed	Sand/Silt (ml/1000ml)	Temp.	EC	pH	DTW (TOC)	Appearance/Comments
1005	0	—	—	—	—	28.40	Started @ 1' BTS with surge block
1008	5	—	—	—	—	—	moved to 3' BTS, very dark dirty gray
1019	10	11 A	15.12	840	7.51	—	dark gray cloudy, moved to 5' BTS
1024	15	—	—	—	—	28.36	dark gray cloudy, moved to 7' BTS
1028	20	19 B	15.25	754	7.32	—	dark gray cloudy, moved to 9' BTS
1037	25	—	—	—	—		very dark gray cloudy, moved to bottom
1041	30	100 C	—	—	—	—	very dark gray milky
1045	35	—	14.89	684	7.35	27.91	started dark, end light gray cloudy
—	—	—	—	—	—	—	stopped to remove surge block
1108	35	—	—	—	—	27.32	after excavating, restarted at 1'
1112	40	—	—	—	—	—	almost clear
1116	45	<0.5 A	15.24	630	7.30	27.36	clear, moved to 3' BTS
1127	55	<0.5 A	15.29	628	7.30	27.28	clear, moved to 5' BTS
1132	60	—	—	—	—	—	stopped to empty buckets, lunch
1232	60	—	—	—	—	—	restarted, still at 5' BTS
65' 1235	~~[illegible]~~	<0.5	15.44	614	7.20	—	clear, moved to 7' BTS
75' 1248	~~[illegible]~~	<0.5	15.43	624	7.22	—	clear, moved to 9' BTS
1255	85'	<0.5	15.19	647	7.20	26.47	clear, moved to bottom
1303	95'	<0.5	15.41	656	7.18	—	clear, end development

WELL DEVELOPMENT FORM

ANCHOR QEA

Project No.	000029-02.23	Date:	Well: MW-23-123
Site Location:	7900 NW St. Helens Rd., Portland	Initial DTB: 119.79 @ 0850	Final DTB: 121.47 @ 1011 2/24
Name:	GASCO, Capture Zone Field Test	Initial DTW: 28.81 @ 0842	Final DTW: 28.51 @ 0911 2/24
Development Method: Waterra peri-pump		Casing Volume: 90.98' = 14.83	
Total Water Removed: 155 gal		Casing Diameter: 2" = 0.163 gal/ft	
Water Contained ? YES		Meter #: 23069	
Estimate of specific capacity or recharge to well: >1 gpm		OWRD#: L 102859	

Time	Cum. Vol. Removed	Sand/Silt (ml/1000ml)	Temp.	EC	pH	DTW (TOC)	Appearance/Comments
0830	—	—	—	—	—	—	Setting up
0915	0	—	—	—	—	—	Started @ 1' BTS, Surge block installed
0917	1.5	—	14.05	213	7.00	—	light cloudy tan
0921	5	37 A	—	—	—	—	very cloudy, grey
0930	10	2 B	14.23	355	6.80	28.70	mod cloudy grey, moved to 3' BTS
0945	20	—	13.18	363	7.34	28.47	lighter cloudy grey, moved to 5' BTS
0958	30	<0.5 C	14.89	355	7.43	28.46	very light cloudy grey, moved to 7' BTS
1011	40	<0.5 A	14.84	352	7.39	27.98	very light cloudy grey, moved to 9' BTS
1014	42	42 B	—	—	—	—	very dark grey, milky
1023	50	3 C	14.73	355	7.50	28.01	grey cloudy
1025	52	62 A	—	—	—	—	very dark grey, milky
1037	60	17 B	15.11	355	7.58	—	dark grey, cloudy - stopped to
—	—	—	—	—	—	—	empty buckets, remove surge block
1101	60	—	—	—	—	27.14	Restarted, valve at 1' BTS
1114	75	<0.5 C	14.96	356	7.16	27.81	clear, moved to 3' BTS
1122	85	<0.5	14.34	358	7.50	—	clear, moved to 5' BTS
1133	100	<0.5	15.31	369	7.37	27.66	clear, moved to 7' BTS
1144	115	<0.5	15.24	384	7.48	27.76	clear, moved to 9' BTS
1148	120	1.5	15.20	385	7.53	—	almost clear, very light grey. Stopped
—	—	—	—	—	—	—	to empty buckets, lunch.
1335	120	—	—	—	—	27.37	Restarted, still at 9' BTS
1342	130	<0.5	14.45	386	7.44	—	Clear, moved to bottom.
1407	140	—	14.84	388	7.60	—	almost clear, had check valve problem
1414	145	<0.5	15.06	395	7.57	—	Clear
1423	155	<0.5	15.18	397	7.69	28.38	Clear, stopped, end

WELL DEVELOPMENT FORM

ANCHOR QEA

Project No.	000029-02.23	Date: 2/9/10	Well: MW-24-70		
Site Location:	7900 NW St. Helens Rd., Portland	Initial DTB: 72.77		Final DTB: 72.55	
Name:	GASCO, Capture Zone Field Test	Initial DTW: 22.17'		Final DTW: 25.96	
Development Method:	Waterra peri-pump	Casing Volume: 45.62' = 7.44 gal			
Total Water Removed:	90 gal	Casing Diameter:	2" = 0.163 gal/ft		
Water Contained ?	YES	Meter #:	23069		
Estimate of specific capacity or recharge to well:	<.1 gpm	OWRD#:	102833		

Time	Cum. Vol. Removed	Sand/Silt (ml/1000ml)	Temp.	EC	pH	DTW (TOC)	Appearance/Comments
1049						22.17	Measured DTW/DTB, initial
1108	Ø						Started w/ surge block @ 1' BTS
1114	3	250 C	13.84	277	5.40		cloudy brown/gray
1116	4						lighter brown/gray, moved to 3' BTS
1120	6	150 A					dark gray cloudy
1125	8		14.01	546	6.81	41.10	dark gray cloudy, moved to 5' BTS
1133	12					42.11	dark gray cloudy, moved to 7' BTS
1139	16	125 B					dark gray cloudy, moved to 9' BTS
1146	20		14.49	1038	7.08		dark gray cloudy, moved to 10' BTS (bottom)
1152	25	500 C					dark gray cloudy, removed surge block and place at 1' BTS, started gray cloudy
—	—	—	—	—	—	—	
1200	30		14.46	751	7.19		light gray cloudy
1206	35	3 B	14.48	835	7.13	43.67	very light cloudy
1212	40	11 C					stopped to empty buckets, moved to 3' BTS
1224	—						restarted @ 3' BTS, very light cloudy
1235	50	1.5 A	14.70	838	7.29	44.59	almost clear, moved to 5' BTS
1239	55	C				~~45~~	light cloudy
1245	60	3 B	14.54	813	7.08	45.61	almost clear, moved to 7' BTS
1248	65						almost clear
1252	70	4 C	14.55	822	6.90	46.28	almost clear, moved to 9' BTS
1259	75	2 A	14.63	810	7.26		almost clear, moved to bottom (10' BTS)
1310	80						cloudy gray, adjusted to bottom
1315	85	2 B	14.56	781	7.29		almost clear
1326	90	2 C	14.39	787	7.37		clear stopped
1450	—	—	—	—	—	25.96	Final DTW

WELL DEVELOPMENT FORM

ANCHOR QEA

Project No.	000029-02.23	Date: 2/16/10 Well: MW-24-130	
Site Location:	7900 NW St. Helens Rd., Portland	Initial DTB: 131.74'	Final DTB: 133.5' @ 1420
Name:	GASCO, Capture Zone Field Test	Initial DTW: 25.55'	Final DTW: 27.11 @ 1421
Development Method:	Waterra peri-pump	Casing Volume: 106.19' = 17.31 gal	
Total Water Removed:	190 gallons	Casing Diameter: 2" = 0.163 gal/ft	
Water Contained ?	YES	Meter #: 23069	
Estimate of specific capacity or recharge to well:	<1 gpm	OWRD#: 102832	

Time	Cum. Vol. Removed	Sand/Silt (ml/1000ml)	Temp.	EC	pH	DTW (TOC)	Appearance/Comments
0840	0	—	—	—	—	25.55	Initial DTW, set-up & surge block
0922	0	—	—	—	—	—	started, set @ 1' BTS*
0925	2	—	14.25	367	7.09	—	light cloudy brown/grey
0929	5	300 A	—	—	—	—	dark, muddy grey
0939	10	—	—	—	—	37.43	dark, mud grey, move to 3' BTS
0944	13	400 B	—	—	—	—	very cloudy, dark grey
0954	20	—	14.41	1146	6.70	37.00	mud cloudy grey, move to 5' BTS
0957	23	500 C	—	—	—	—	very dark cloudy, grey
1009	30	39 A	14.44	1260	6.72	39.37	mud cloudy grey, move to 7' BTS
1013	33	250 B	—	—	—	—	very dark cloudy grey
1024	40	34 C	14.47	1184	6.75	39.43	lighter cloudy grey, move to 9' BTS
1028	43	400 A					very dark, muddy grey
1039	50	*	14.34	1157	6.75	39.94	light cloudy grey, move to 2" off bottom
1043	53	950 B	—	—	—	—	dark grey mud w/ chunks
1056	60	76 A	14.17	1163	6.72	—	mud light cloudy grey, move to 6' BTS
—	—	—	—	—	—	—	↓ pump speed to slow to empty buckets
1113	65	1 B	14.22	981	6.80	—	light milky grey, stopped to remove surge block, restart at 1' BTS-1118
—	—	—	—	—	—	—	
1126	75	1 A	14.25	966	6.78	—	light grey cloudy
1134	85	<1 B	14.27	944	6.77	42.93	clear, moved to 3' BTS
1139	95	<1 C	—	—	—	~~43.89~~	almost clear
1147	105	<1 B	14.38	938	6.79	43.59	clear, moved to 5' BTS
1155	115	<1 C	14.29	917	6.78		almost clear
1159	120	<1 A	14.28	914	6.77	44.61	clear, stopped to empty buckets
1250	120	—	—	—	—	—	moved to 7' BTS, started pumping
1300	130	<1 A	14.67	887	6.89	—	almost clear
1308	140	<1 B	14.57	899	6.79	41.14	clear, moved to 9' BTS
1316	150	<1 C	14.44	907	6.78	—	almost clear
1324	160	<1 A	14.47	899	6.78	42.36	clear, moved to 1" off bottom
1332	170	<1 B	14.34	890	6.79	—	very light cloudy
1335	175	<1 C	14.29	911	6.78	—	almost clear
1338	180	<1 A	14.27	896	6.79	—	clear
1341	185	<1 B	14.19	895	6.79	42.34	clear
1345	190	<1 C	14.17	898	6.79	—	clear, stop development

* — BTS = below top of screen

FIELD SAMPLING DATA SHEET

ANCHOR QEA
6650 SW Redwood Lane, Suite 333
Portland, OR 97224
Office: (503) 670-1108 Fax: (503) 670-1128

PROJECT NAME: Gosco - Seg 2 CZ **WELL ID:** PW-7-93
SITE ADDRESS: 7900 NW St Helens Rd Portland **BLIND ID:** GS-110810-1
DUP ID: NA

WIND FROM:	N	NE	E	SE	S	SW	W	NW	LIGHT	MEDIUM	HEAVY
WEATHER:	SUNNY		CLOUDY	RAIN		?	TEMPERATURE:	°F 50.	°C		

[Circle appropriate units]

HYDROLOGY/LEVEL MEASUREMENTS (Nearest 0.01 ft)

Date	Time	DT-Bottom	DT-Product	DT-Water	DTP-DTW [Product Thickness]	DTB-DTW [Water Column]		Volume (gal) [Water Column x Gal/ft]
11/08/10	11:02	~~93.0~~	— . 19.16	~~[illegible]~~	— .	76.84	X 1	200.55
11/08/10	11:56	96.0	— . 19.46	~~[illegible]~~	.	76.54	X 3	601.66

Gal/ft = (dia./2)^2 x 0.163	1" = 0.041	2" = 0.163	3" = 0.367	4" = 0.653	5" = 1.469	10" = 4.080	12" = 5.875

§ METHODS: (A) Submersible Pump (B) Peristaltic Pump (C) Disposable Bailer (D) PVC/Teflon Bailer (E) Dedicated Bailer (F) Dedicated Pump (G) Other = Grab

GROUNDWATER SAMPLING DATA (if product is detected, do NOT sample) Sample Depth: [√ if used]

Bottle Type	Date	Time	Method §	Amount & Volume mL		Preservative [circle]	Ice	Filter	pH	√
VOA Glass	/ /	:		~~2~~	40 ml	HCl	YES	NO		
Amber Glass	/ /	:			250, 500, 1L	(None) (HCl) (H_2SO_4)	YES	NO		
White Poly	11/08/10	12:30	G	~~1~~ 2	250, 500, 1L	None	YES	~~NO~~ YES	NA	X
Yellow Poly	/ /	:			250, 500, 1L	H_2SO_4	YES	NO		
Green Poly	11/08/10	12:30	G	~~2~~ 1	250, 500, 1L	NaOH + NO pres.	YES	NO	—	X
Red Total Poly	11/08/10	12:30	G	1	250, 500, 1L	HNO_3	YES	NO	—	X
Red Diss. Poly	11/08/10	12:30	G	1	250, 500, 1L	HNO_3	YES	YES	—	X
	/ /	:			250, 500, 1L		YES			

Total Bottles (include duplicate count): 5

Analysis Allowed per Bottle Type

BOTTLE TYPE	TYPICAL ANALYSIS ALLOWED PER BOTTLE TYPE (Circle applicable or write non-standard analysis below)
VOA - Glass	(8021) (8260B) (BTEX) (NWTPH-Gx)
AMBER - Glass	(PAH) (TPH-HCID) (NWTPH-Dx) (TPH-418.1) (Oil &Crease) (8081A)
WHITE - Poly	(pH) (Conductivity) (TDS) (TSS) (BOD) (Turbidity) (Alkalinity) (HCO_3/CO_3) (Cl) (SO_4) (NO_3) (NO_2) (F) (K)
YELLOW - Poly	(COD) (TOC) (Total PO_4) (Total Keldahl Nitrogen) (NH_3) (NO_3/NO_2)
GREEN - Poly	(Cyanide) - free, total, weak-acid dissociable
RED TOTAL - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na)
RED DISSOLVED - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na) (Hardness) (Silica)

WATER QUALITY DATA Purge Start Time: 12:00 ORP Pump/Bailer Inlet Depth:

Meas.	Method §	Purged (gal)	pH	E Cond (µS)	°F Temp °C	~~Other~~	Diss O_2 (mg/l)	Water Quality
4		.	.		.		.	
3		.	.		.		.	
2		.	.		.		0.34	
1	F	981.0	7.14	802	16.33	~~37.2~~	~~0.39~~	clear, colorless
0		0.00	.		.		.	

[Casing] [Select A-G] [Cumulative Total] [Circle units] [Clarity, Color]

Starting Totalizer Reading 303064 — 0 G
~~303092 — 303135~~
1200

Pump Test started at 1200 on 11/08/10

SAMPLER: Matt Wilson / J Renda
(PRINTED NAME)

(SIGNATURE)

FIELD SAMPLING DATA SHEET

ANCHOR QEA
6650 SW Redwood Lane, Suite 333
Portland, OR 97224
Office: (503) 670-1108 Fax: (503) 670-1128

PROJECT NAME: Gasco Segment 2 CZ **WELL ID:** PW-8-68
SITE ADDRESS: 7900 NW St Helens Rd Portland OR **BLIND ID:** GS-110810-2
DUP ID: NA

WIND FROM:	N	NE	E	SE	S	SW	W	NW	LIGHT	MEDIUM	HEAVY
WEATHER:	SUNNY		CLOUDY		RAIN		?		TEMPERATURE:	°F 50	°C

[Circle appropriate units]

HYDROLOGY/LEVEL MEASUREMENTS (Nearest 0.01 ft)

Date	Time	DT-Bottom	DT-Product	DT-Water	DTP-DTW [Product Thickness]	DTB-DTW [Water Column]		Volume (gal) [Water Column x Gal/ft]
11/08/10	11:02	~~68.0~~	—	19.55	—	51.45	X1	134.28
11/08/10	11:55	71.0	—	19.84	—		X3	402.84

Gal/ft = (dia./2)² x 0.163	1" = 0.041	2" = 0.163	3" = 0.367	4" = 0.653	6" = 1.469	10" = 4.080	12" = 5.875

§ METHODS: (A) Submersible Pump (B) Peristaltic Pump (C) Disposable Bailer (D) PVC/Teflon Bailer (E) Dedicated Bailer (F) Dedicated Pump (G) Other = Grab 8'1 2.61 [N/If used]

GROUNDWATER SAMPLING DATA (if product is detected, do NOT sample) Sample Depth:

Bottle Type	Date	Time	Method §	Amount & Volume mL		Preservative [circle]	Ice	Filter	pH	√
VOA Glass	/ /	:			40 ml	HCl	YES	NO		
Amber Glass	/ /	:			250, 500, 1L	(None) (HCl) (H_2SO_4)	YES	NO		
White Poly	11/08/10	12:20	G	2	250, 500, 1L	None	YES	~~NO~~ YES	NA	X
Yellow Poly	/ /	:			250, 500, 1L	H_2SO_4	YES	NO		
Green Poly	11/08/10	12:20	G	1	250, 500, 1L	NaOH	YES	NO	—	X
Red Total Poly	11/08/10	12:20	G	1	250, 500, 1L	HNO_3	YES	NO	—	X
Red Diss. Poly	11/08/10	12:20	G	1	250, 500, 1L	HNO_3	YES	YES	—	X
	/ /	:			250, 500, 1L		YES			

Total Bottles (include duplicate count): 5

Analysis Allowed per Bottle Type	BOTTLE TYPE	TYPICAL ANALYSIS ALLOWED PER BOTTLE TYPE (Circle applicable or write non-standard analysis below)
	VOA - Glass	(8021) (8260B) (BTEX) (NWTPH-Gx)
	AMBER - Glass	(PAH) (TPH-HCID) (NWTPH-Dx) (TPH-418.1) (Oil &Grease) (8081A)
	WHITE - Poly	(pH) (Conductivity) (TDS) (TSS) (BOD) (Turbidity) (Alkalinity) (HCO_3/CO_3) (Cl) (SO_4) (NO_3) (NO_2) (F)
	YELLOW - Poly	(COD) (TOC) (Total PO_4) (Total Keldahl Nitrogen) (NH_3) (NO_3/NO_2)
	GREEN - Poly	(Cyanide) - free, total, weak-acid dissociable
	RED TOTAL - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na)
	RED DISSOLVED - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na) (Hardness) (Silica)

WATER QUALITY DATA Purge Start Time: 12:00 ORP Pump/Bailer Inlet Depth:

Meas. [Casing]	Method § [Select A-G]	Purged (gal) [Cumulative Totals]	pH	E Cond (µS)	°F Temp °C [Circle units]	~~Other~~	Diss O_2 (mg/l)	Water Quality [Clarity, Color]
4		.	.		.		.	
3		.	.		.		.	
2		.	.		.		.	
1	F	577.0	7.06	767	17.22	51.8	2.33	clear, colorless
0		0.00	.		.		.	

Starting Totalizer Reading → Totalizer - OG ~~302393~~ - ~~Totalizer~~ ~~302473~~
Pump test started at 1200 on 11/08/10

SAMPLER: Matt Nelson (PRINTED NAME) Matt Nel (SIGNATURE)

FIELD SAMPLING DATA SHEET

ANCHOR QEA
6650 SW Redwood Lane, Suite 333
Portland, OR 97224
Office: (503) 670-1108 Fax: (503) 670-1128

PROJECT NAME: Gosco Segment 2 C Z **WELL ID:** PW-8-39
SITE ADDRESS: 7900 NW St Helens Rd Portland OR **BLIND ID:** GS-110810-3
DUP ID: NA

WIND FROM:	N	NE	E	SE	S	SW	W	NW	LIGHT	MEDIUM	HEAVY
WEATHER:	SUNNY		CLOUDY		RAIN		?		TEMPERATURE:	°F 50.	°C

[Circle appropriate units]

HYDROLOGY/LEVEL MEASUREMENTS (Nearest 0.01 ft)

Date	Time	DT-Bottom	DT-Product	DT-Water	DTP-DTW [Product Thickness]	DTB-DTW [Water Column]		Volume (gal) [Water Column x Gal/ft]
11/08/10	11:02	~~39.0~~	—	17.51	—	24.49	X1	35.98
11/08/10	11:55	42.0	—	17.95	—		X3	107.94

Gal/ft = (dia./2)^2 x 0.163	1" = 0.041	2" = 0.163	3" = 0.367	4" = 0.653	6" = 1.469	10" = 4.080	12" = 5.875

§ METHODS: (A) Submersible Pump (B) Peristaltic Pump (C) Disposable Bailer (D) PVC/Teflon Bailer (E) Dedicated Bailer (F) Dedicated Pump (G) Other = Grab ~~8" = 2.61~~

GROUNDWATER SAMPLING DATA (if product is detected, do NOT sample) Sample Depth: [√ if used]

Bottle Type	Date	Time	Method §	Amount	Volume mL	Preservative [circle]	Ice	Filter	pH	√
VOA Glass	/ /	:			40 ml	HCl	YES	NO		
Amber Glass	/ /	:			250, 500, 1L	(None) (HCl) (H_2SO_4)	YES	NO		
White Poly	11/08/10	13:00	G	2	250, 500, 1L	None	YES	~~NO~~ YES	NA	X
Yellow Poly	/ /	:			250, 500, 1L	H_2SO_4	YES	NO		
Green Poly	11/08/10	13:00	G	1	250, 500, 1L	NaOH	YES	NO	—	X
Red Total Poly	11/08/10	13:00	G	1	250, 500, 1L	HNO_3	YES	NO	—	X
Red Diss. Poly	11/08/10	13:00	G	1	250, 500, 1L	HNO_3	YES	YES	—	X
	/ /	:			250, 500, 1L		YES			

Total Bottles (include duplicate count): 5

Analysis Allowed per Bottle Type

BOTTLE TYPE	TYPICAL ANALYSIS ALLOWED PER BOTTLE TYPE (Circle applicable or write non-standard analysis below)
VOA - Glass	(8021) (8260B) (BTEX) (NWTPH-Gx)
AMBER - Glass	(PAH) (TPH-HCID) (NWTPH-Dx) (TPH-418.1) (Oil &Grease) (8081A)
WHITE - Poly	(pH) (Conductivity) (TDS) (TSS) (BOD) (Turbidity) (Alkalinity) (HCO_3/CO_3) (Cl) (SO_4) (NO_3) (NO_2) (F)
YELLOW - Poly	(COD) (TOC) (Total PO_4) (Total Keldahl Nitrogen) (NH_3) (NO_3/NO_2)
GREEN - Poly	(Cyanide) — Total, free, weak-acid dissociable
RED TOTAL - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na)
RED DISSOLVED - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na) (Hardness) (Silica)

WATER QUALITY DATA Purge Start Time: 12:00 ORP Pump/Bailer Inlet Depth:

Meas.	Method §	Purged (gal)	pH	E Cond (µS)	°F Temp °C	~~Other~~ ORP	Diss O_2 (mg/l)	Water Quality
4		.	.		.		.	
3		.	.		.		.	
2		.	.		.		.	
1	G	110.0	7.26	982	17.04	34.2	0.19	clear, colorless
0		0.00	.		.		.	

[Casing] [Select A-G] [Cumulative Totals] [Circle units] [Clarity, Color]

Starting Totalizer Readings → Totalizer - #1 ~~18842~~ ~~18868~~ 18868
#2 ~~15254~~ ~~15278~~ 15278

Pump test started at 1200 on 11/08/10

SAMPLER: Matt Wilson, Dlaffoon (PRINTED NAME) Matthew Wilson (SIGNATURE)

FIELD SAMPLING DATA SHEET

ANCHOR QEA
6650 SW Redwood Lane, Suite 333
Portland, OR 97224
Office: (503) 670-1108 Fax: (503) 670-1128

PROJECT NAME: Gosco Segment 2 GZ **WELL ID:** PW-9-92
SITE ADDRESS: 7400 NW St Helens Rd Portland OR **BLIND ID:** GS-110810-4
DUP ID: NA

WIND FROM:	N	NE	E	SE	S	SW	W	NW	LIGHT	MEDIUM	HEAVY
WEATHER:	SUNNY	CLOUDY	RAIN		?				TEMPERATURE:	°F 50.	°C

[Circle appropriate units]

HYDROLOGY/LEVEL MEASUREMENTS (Nearest 0.01 ft)

Date	Time	DT-Bottom	DT-Product	DT-Water	DTP-DTW [Product Thickness]	DTB-DTW [Water Column]		Volume (gal) [Water Column x Gal/ft]
11/08/10	11:08	96.0	—	28.35	—	67.65	X 1	176.6
11/08/10	11:56	96.0	—	28.65	—	67.35	X 3	529.8

Gal/ft = (dia./2)^2 x 0.163 | 1" = 0.041 | 2" = 0.163 | 3" = 0.367 | 4" = 0.653 | 6" = 1.469 | 10" = 4.080 | 12" = 5.875

§ METHODS: (A) Submersible Pump (B) Peristaltic Pump (C) Disposable Bailer (D) PVC/Teflon Bailer (E) Dedicated Bailer (F) Dedicated Pump (G) Other = Grab 8' = 2.61

GROUNDWATER SAMPLING DATA (if product is detected, do NOT sample) Sample Depth:

Bottle Type	Date	Time	Method §	Amount	Volume mL	Preservative [circle]	Ice	Filter	pH	√ [√ if used]
VOA Glass	/ /	~~12:25~~		~~2~~	40 ml	HCl	YES	NO		
Amber Glass	/ /	:			250, 500, 1L	(None) (HCl) (H_2SO_4)	YES	NO		
White Poly	11/08/10	12:25	G	2	250, 500, 1L	None	YES	NO yes	NA	—
Yellow Poly	/ /	:			250, 500, 1L	H_2SO_4	YES	NO		
Green Poly	11/08/10	12:25	G	1	250, 500, 1L	NaOH	YES	NO	—	X
Red Total Poly	11/08/10	12:25	G	1	250, 500, 1L	HNO_3	YES	NO	—	X
Red Diss. Poly	11/08/10	12:25	G	1	250, 500, 1L	HNO_3	YES	YES	—	X
	/ /	:			250, 500, 1L		YES			

Total Bottles (include duplicate count): 5

Analysis Allowed per Bottle Type	BOTTLE TYPE	TYPICAL ANALYSIS ALLOWED PER BOTTLE TYPE (Circle applicable or write non-standard analysis below)
	VOA - Glass	(8021) (8260B) (BTEX) (NWTPH-Gx)
	AMBER - Glass	(PAH) (TPH-HCID) (NWTPH-Dx) (TPH-418.1) (Oil &Grease) (8081A)
	WHITE - Poly	(pH) (Conductivity) (TDS) (TSS) (BOD) (Turbidity) (Alkalinity) (HCO_3/CO_3) (Cl) (SO_4) (NO_3) (NO_2) (F)
	YELLOW - Poly	(COD) (TOC) (Total PO_4) (Total Keldahl Nitrogen) (NH_3) (NO_3/NO_2)
	GREEN - Poly	(Cyanide) – Total, free, weak-acid dissociable
	RED TOTAL - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na)
	RED DISSOLVED - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na) (Hardness) (Silica)

WATER QUALITY DATA Purge Start Time: 12:00 ORP Pump/Bailer Inlet Depth:

Meas.	Method §	Purged (gal)	pH	E Cond (µS)	°F Temp °C	~~Other~~	Diss O_2 (mg/l)	Water Quality
4		.	.		.		.	
3		.	.		.		.	
2		.	.		.		.	
1	F	540.0	7.05	719	15.87	73.5	0.99	clear, colorless
0		0.00	.		.		.	

[Casing] [Select A-G] [Cumulative Totals] [Circle units] [Clarity, Color]

Starting Totalizer Reading → totalizer ~~3031.98~~ 0 G
Pump test started at 1200 on 11/08/10

SAMPLER: Nelson / Tstone (PRINTED NAME) (SIGNATURE)

FIELD SAMPLING DATA SHEET

ANCHOR QEA
6650 SW Redwood Lane, Suite 333
Portland, OR 97224
Office: (503) 670-1108 Fax: (503) 670-1128

PROJECT NAME: Gosco Seg 2 Capture Zone **WELL ID:** Willamette River
SITE ADDRESS: 7900 NW St. Helens Rd Portland OR **BLIND ID:** GS-110810-5
DUP ID: NA

WIND FROM:	N	NE	E	SE	S	SW	W	NW	LIGHT	MEDIUM	HEAVY
WEATHER:	SUNNY		CLOUDY		RAIN		?		**TEMPERATURE:**	°F 50.	°C

[Circle appropriate units]

HYDROLOGY/LEVEL MEASUREMENTS (Nearest 0.01 ft)

Date	Time	DT-Bottom	DT-Product	DT-Water	DTP-DTW [Product Thickness]	DTB-DTW [Water Column]		Volume (gal) [Water Column x Gal/ft]
/ /	:	.	.	.	.	.	X 1	NA
/ /	:	.	.	.	.		X 3	RIVER

Gal/ft = (dia./2)^2 x 0.163	1" =	0.041	2" =	0.163	3" =	0.367	4" =	0.653	6" =	1.469	10" =	4.080	12" =	5.875

§ METHODS: (A) Submersible Pump (B) Peristaltic Pump (C) Disposable Bailer (D) PVC/Teflon Bailer (E) Dedicated Bailer (F) Dedicated Pump (G) Other = Grab

GROUNDWATER SAMPLING DATA (if product is detected, do NOT sample) Sample Depth:

Bottle Type	Date	Time	Method §	Amount & Volume mL		Preservative [circle]	Ice	Filter	pH	√ [√ if used]
VOA Glass	/ /	13:30		2	40 ml	HCl	YES	NO		
Amber Glass	/ /	:			250, 500, 1L	(None) (HCl) (H_2SO_4)	YES	NO		
White Poly	11/08/10	13:30	G	2	250, 500, 1L	None	YES	NO	NA	X
Yellow Poly	/ /	:			250, 500, 1L	H_2SO_4	YES	NO		
Green Poly	11/08/10	13:30	G	1	250, 500, 1L	NaOH	YES	NO	—	X
Red Total Poly	11/08/10	13:30	G	1	250, 500, 1L	HNO_3	YES	NO	—	X
Red Diss. Poly	11/08/10	13:30	G	1	250, 500, 1L	HNO_3	YES	YES	—	X
	/ /	:			250, 500, 1L		YES			

Total Bottles (include duplicate count): 5

Analysis Allowed per Bottle Type

BOTTLE TYPE	TYPICAL ANALYSIS ALLOWED PER BOTTLE TYPE (Circle applicable or write non-standard analysis below)
VOA - Glass	(8021) (8260B) (BTEX) (NWTPH-Gx)
AMBER - Glass	(PAH) (TPH-HCID) (NWTPH-Dx) (TPH-418.1) (Oil &Grease) (8081A)
WHITE - Poly	(pH) (Conductivity) (TDS) (TSS) (BOD) (Turbidity) (Alkalinity) (HCO_3/CO_3) (Cl) (SO_4) (NO_3) (NO_2) (F)
YELLOW - Poly	(COD) (TOC) (Total PO_4) (Total Keldahl Nitrogen) (NH_3) (NO_3/NO_2)
GREEN - Poly	(Cyanide) — total, free, weak-acid dissociable
RED TOTAL - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na)
RED DISSOLVED - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na) (Hardness) (Silica)

WATER QUALITY DATA Purge Start Time: NA Pump/Bailer Inlet Depth:

Meas.	Method §	Purged (gal)	pH	E Cond (µS)	°F Temp °C	Other	Diss O_2 (mg/l)	Water Quality
4		.	.		.		.	
3		.	.		.		.	
2		.	.		.		.	
1	G	NA	7.32	78	12.22	130.8	9.98	sl. cloudy, pale tint
0		0.00	.		.		.	

[Casing] [Select A-G] [Cumulative Totals] [Circle units] [Clarity, Color]

River surface water sample collected in FAMM boat house
Pump test started at 1200 on 11/08/10

SAMPLER: MWilson, DLaffoon (PRINTED NAME) (SIGNATURE)

FIELD SAMPLING DATA SHEET

ANCHOR QEA
6650 SW Redwood Lane, Suite 333
Portland, OR 97224
Office: (503) 670-1108 Fax: (503) 670-1128

PROJECT NAME: Gasco Segment 2 Capture Zone Field Test **WELL ID:** PW-7-93
SITE ADDRESS: 7900 NW St. Helens Rd, Portland OR **BLIND ID:** 65-11010-6
DUP ID:

WIND FROM:	N	NE	E	SE	S	SW	W	NW	LIGHT	MEDIUM	HEAVY
WEATHER:	SUNNY		CLOUDY		RAIN			?	TEMPERATURE:	°F 45.	°C

[Circle appropriate units]

HYDROLOGY/LEVEL MEASUREMENTS (Nearest 0.01 ft)

Date	Time	DT-Bottom	DT-Product	DT-Water	DTP-DTW [Product Thickness]	DTB-DTW [Water Column]		Volume (gal) [Water Column x Gal/ft]
11/10/10	~~07:34~~	96.0	—	~~[illegible]~~	—	—	X 1	NA (see below)
/ /	07:29	96.0	—	24.80	—	71.2	X 3	

Gal/ft = (dia./2)² x 0.163	1" =	0.041	2" =	0.163	3" =	0.367	4" =	0.653	6" =	1.469	10" =	4.080	12" =	5.875

§ METHODS: (A) Submersible Pump (B) Peristaltic Pump (C) Disposable Bailer (D) PVC/Teflon Bailer (E) Dedicated Bailer (F) Dedicated Pump (G) Other = Grab

GROUNDWATER SAMPLING DATA (if product is detected, do NOT sample) Sample Depth: [√ if used]

Bottle Type	Date	Time	Method §	Amount	Volume mL	Preservative [circle]	Ice	Filter	pH	√
VOA Glass	/ /	:			40 ml	HCl	YES	NO		
Amber Glass	/ /	:			250, 500, 1L	(None) (HCl) (H_2SO_4)	YES	NO		
White Poly	11/10/10	07:30	G	2	250, 500, 1L	None	YES	NO	NA	—
Yellow Poly	/ /	:			250, 500, 1L	H_2SO_4	YES	NO		
Green Poly	11/10/10	07:30	G	1	250, 500, 1L	NaOH	YES	NO	—	X
Red Total Poly	11/10/10	07:30	G	1	250, 500, 1L	HNO_3	YES	NO	—	X
Red Diss. Poly	11/10/10	07:30	G	1	250, 500, 1L	HNO_3	YES	YES	—	X
	/ /	:			250, 500, 1L		YES			

Total Bottles (include duplicate count): 5

Analysis Allowed per Bottle Type

BOTTLE TYPE	TYPICAL ANALYSIS ALLOWED PER BOTTLE TYPE (Circle applicable or write non-standard analysis below)
VOA - Glass	(8021) (8260B) (BTEX) (NWTPH-Gx)
AMBER - Glass	(PAH) (TPH-HCID) (NWTPH-Dx) (TPH-418.1) (Oil &Grease) (8081A)
WHITE - Poly	(pH) (Conductivity) (TDS) (TSS) (BOD) (Turbidity) (Alkalinity) (HCO_3/CO_3) (Cl) (SO_4) (NO_3) (NO_2) (F)
YELLOW - Poly	(COD) (TOC) (Total PO_4) (Total Keldahl Nitrogen) (NH_3) (NO_3/NO_2)
GREEN - Poly	(Cyanide) - Total, Free, weak-acid dissociable
RED TOTAL - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na)
RED DISSOLVED - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na) (Hardness) (Silica)

WATER QUALITY DATA Purge Start Time: 1200: 11/08/10 ORP Pump/Bailer Inlet Depth:

Meas.	Method §	Purged (gal)	pH	E Cond (µS)	°F Temp °C	~~Other~~	Diss O_2 (mg/l)	Water Quality
4		.	.		.		.	
3		.	.		.		.	
2	F	65 780	7.09	848	15.92	-8.4	0.36	↑clear, colorless
1	~~F~~	~~65,472~~	.		.		.	~~clear~~
0		0.00	.		.		.	

[Casing] [Select A-G] [Cumulative Totals] [Circle units] [Clarity, Color]

Pump has been in operation for ~~35~~ 44 hours at 25 gpm
Mid Test Sample

SAMPLER: Matt Wilson / D Loffoon (PRINTED NAME) Matt Wilson (SIGNATURE)

FIELD SAMPLING DATA SHEET

ANCHOR QEA
6650 SW Redwood Lane, Suite 333
Portland, OR 97224
Office: (503) 670-1108 Fax: (503) 670-1128

PROJECT NAME: Gasco Segment 2 Capture Zone Field Test **WELL ID:** PW-8-68
SITE ADDRESS: 7900 NW St. Helens Rd, Portland OR **BLIND ID:** GS-111010-7
DUP ID:

WIND FROM:	N	NE	E	SE	(S)	SW	W	NW	(LIGHT)	MEDIUM	HEAVY
WEATHER:	SUNNY		(CLOUDY)		RAIN			?	**TEMPERATURE:**	°F 45 .	°C

(Circle appropriate units)

HYDROLOGY/LEVEL MEASUREMENTS (Nearest 0.01 ft)

Date	Time	DT-Bottom	DT-Product	DT-Water	DTP-DTW [Product Thickness]	DTB-DTW [Water Column]		Volume (gal) [Water Column x Gal/ft]
11/10/10	07:34	71.00	—	22.39	—	48.61	X 1	NA - See
/ /	:	.	.	.	.		X 3	Below

Gal/ft = (dia./2)^2 x 0.163	1" =	0.041	2" =	0.163	3" =	0.367	4" =	0.653	6" =	1.469	10" =	4.080	12"	5.875

§ METHODS: (A) Submersible Pump (B) Peristaltic Pump (C) Disposable Bailer (D) PVC/Teflon Bailer (E) Dedicated Bailer (F) Dedicated Pump (G) Other = Grab (8" = 2.61)

GROUNDWATER SAMPLING DATA (if product is detected, do NOT sample) Sample Depth:

Bottle Type	Date	Time	Method §	Amount & Volume mL		Preservative [circle]	Ice	Filter	pH	√ [√ if used]
VOA Glass	/ /	:			40 ml	HCl	YES	NO		
Amber Glass	/ /	:			250, 500, 1L	(None) (HCl) (H_2SO_4)	YES	NO		
White Poly	11/10/10	07:35	G	2	250, 500, 1L	None	YES	NO (Mid)	NA	X
Yellow Poly	/ /	:			250, 500, 1L	H_2SO_4	YES	NO		
Green Poly	11/10/10	07:35	G	1	250, 500, 1L	NaOH	YES	NO	—	X
Red Total Poly	11/10/10	07:35	G	1	250, 500, 1L	HNO_3	YES	NO	—	X
Red Diss. Poly	11/10/10	07:35	G	1	250, 500, 1L	HNO_3	YES	YES	—	X
	/ /	:			250, 500, 1L		YES			

Total Bottles (include duplicate count): 5

Analysis Allowed per Bottle Type

BOTTLE TYPE	TYPICAL ANALYSIS ALLOWED PER BOTTLE TYPE (Circle applicable or write non-standard analysis below)
VOA - Glass	(8021) (8260B) (BTEX) (NWTPH-Gx)
AMBER - Glass	(PAH) (TPH-HCID) (NWTPH-Dx) (TPH-418.1) (Oil &Grease) (8081A)
WHITE - Poly	(pH) (Conductivity) (TDS) (TSS) (BOD) (Turbidity) (Alkalinity) (HCO_3/CO_3) (Cl) (SO_4) (NO_3) (NO_2) (F)
YELLOW - Poly	(COD) (TOC) (Total PO_4) (Total Keldahl Nitrogen) (NH_3) (NO_3/NO_2)
GREEN - Poly	(Cyanide) (Total/Free/weak-acid dissociable)
RED TOTAL - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na)
RED DISSOLVED - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na) (Hardness) (Silica)

WATER QUALITY DATA Purge Start Time: 1200 11/08/10 ORP Pump/Bailer Inlet Depth:

Meas.	Method §	Purged (gal)	pH	E Cond (µS)	°F Temp °C	~~Other~~	Diss O_2 (mg/l)	Water Quality
4		.	.		.		.	
3		.	.		.		.	
2	F	65,472.0	7.05	711	16.12	2.6	0.51	↑ ↑
1	F	~~65,472.0~~	~~7.06~~	~~712~~	~~16.48~~	~~7.4~~	~~0.58~~	~~clear, colorless~~
0		0.00	.		.		.	

[Casing] [Select A-G] [Cumulative Totals] [Circle units] [Clarity, Color]

Well has been pumping for 44 hours at 25 gpm
Mid Test sample

SAMPLER: Matt Wilson / DLoffon
(PRINTED NAME)

(SIGNATURE)

FIELD SAMPLING DATA SHEET

ANCHOR QEA
6650 SW Redwood Lane, Suite 333
Portland, OR 97224
Office: (503) 670-1108 Fax: (503) 670-1128

PROJECT NAME: Gasco Segment 2 Capture Zone Field Test **WELL ID:** PW-8-39
SITE ADDRESS: 7900 NW St. Helens Rd, Portland OR **BLIND ID:** G5-111010-8
DUP ID: G5-111010-9 (0750)

WIND FROM:	N	NE	E	SE	S	SW	W	NW	LIGHT	MEDIUM	HEAVY

WEATHER:	SUNNY	CLOUDY	RAIN	?	TEMPERATURE:	°F 45. °C

[Circle appropriate units]

HYDROLOGY/LEVEL MEASUREMENTS (Nearest 0.01 ft)

Date	Time	DT-Bottom	DT-Product	DT-Water	DTP-DTW [Product Thickness]	DTB-DTW [Water Column]		Volume (gal) [Water Column x Gal/ft]
11/10/10	07:44	42.0	—	33.98	—	8.02	X 1	NA See
/ /	:	.	.	.	.		X 3	Below

Gal/ft = (dia./2)² x 0.163	1" = 0.041	2" = 0.163	3" = 0.367	4" = 0.653	6" = 1.469	10" = 4.080	12" = 5.875

§ METHODS: (A) Submersible Pump (B) Peristaltic Pump (C) Disposable Bailer (D) PVC/Teflon Bailer (E) Dedicated Bailer (F) Dedicated Pump (G) Other = Grab

GROUNDWATER SAMPLING DATA (if product is detected, do NOT sample) Sample Depth:

Bottle Type	Date	Time	Method §	Amount & Volume mL		Preservative [circle]	Ice	Filter	pH	√ [√ if used]
VOA Glass	/ /	:			40 ml	HCl	YES	NO		
Amber Glass	/ /	:			250, 500, 1L	(None) (HCl) (H_2SO_4)	YES	NO		
White Poly	11/10/10	07:45	G	2	250, 500, 1L	None	YES	NO (Test)	NA	
Yellow Poly	/ /	:			250, 500, 1L	H_2SO_4	YES	NO		
Green Poly	11/10/10	07:45	G	1	250, 500, 1L	NaOH	YES	NO	—	X
Red Total Poly	11/10/10	07:45	G	1	250, 500, 1L	HNO_3	YES	NO	—	X
Red Diss. Poly	11/10/10	07:45	G	1	250, 500, 1L	HNO_3	YES	YES	—	X
	/ /	:			250, 500, 1L		YES			

Total Bottles (include duplicate count): ~~8~~ 10

Analysis Allowed per Bottle Type

BOTTLE TYPE	TYPICAL ANALYSIS ALLOWED PER BOTTLE TYPE (Circle applicable or write non-standard analysis below)
VOA - Glass	(8021) (8260B) (BTEX) (NWTPH-Gx)
AMBER - Glass	(PAH) (TPH-HCID) (NWTPH-Dx) (TPH-418.1) (Oil &Crease) (8081A)
WHITE - Poly	(pH) (Conductivity) (TDS) (TSS) (BOD) (Turbidity) (Alkalinity) (HCO_3/CO_3) (Cl) (SO_4) (NO_3) (NO_2) (F)
YELLOW - Poly	(COD) (TOC) (Total PO_4) (Total Keldahl Nitrogen) (NH_3) (NO_3/NO_2)
GREEN - Poly	(Cyanide) - Total, Free, weak-acid dissociable
RED TOTAL - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na)
RED DISSOLVED - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na) (Hardness) (Silica)

WATER QUALITY DATA Purge Start Time: 1200 11/08/10 ORP Pump/Bailer Inlet Depth:

Meas.	Method §	Purged (gal)	pH	E Cond (µS)	°F Temp °C	~~Other~~	Diss O_2 (mg/l)	Water Quality
4		.	.		.		.	
3		.	.		.		.	
2		5167.0	.		.		.	
1	F	~~7~~ ↓	7.15	844	17.06	10.4	0.28	clear, colorless
0		0.00	.		.		.	

[Casing] [Select A-G] [Cumulative Totals] [Circle units] [Clarity, Color]

Pump has been in operation at 2 GPM for 44 hours
Mid Test Sample

Totalizer Readings #2 20455
#1 24088

SAMPLER: M Wilson / D Loffman (PRINTED NAME) Matthew Wil (SIGNATURE)

FIELD SAMPLING DATA SHEET

ANCHOR QEA
6650 SW Redwood Lane, Suite 333
Portland, OR 97224
Office: (503) 670-1108 Fax: (503) 670-1128

PROJECT NAME: Gasco Segment 2 Capture Zone Field Test **WELL ID:** PW-9-92
SITE ADDRESS: 7900 NW St. Helens Rd, Portland OR **BLIND ID:** GS-111010-10
DUP ID:

WIND FROM:	N	NE	E	SE	S	SW	W	NW	LIGHT	MEDIUM	HEAVY
WEATHER:	SUNNY	CLOUDY	RAIN		?				**TEMPERATURE:**	°F 45.	°C

[Circle appropriate units]

HYDROLOGY/LEVEL MEASUREMENTS (Nearest 0.01 ft)

Date	Time	DT-Bottom	DT-Product	DT-Water	DTP-DTW [Product Thickness]	DTB-DTW [Water Column]		Volume (gal) [Water Column x Gal/ft]
11/10/10	08:05	95.0	—	39.84	—	55.16	X 1	NA See
/ /	:	.	.	.	.		X 3	Below

Gal/ft = (dia./2)^2 x 0.163	1" =	0.041	2" =	0.163	3" =	0.367	4" =	0.653	6" =	1.469	10" =	4.080	12" =	5.875

§ METHODS: (A) Submersible Pump (B) Peristaltic Pump (C) Disposable Bailer (D) PVC/Teflon Bailer (E) Dedicated Bailer (F) Dedicated Pump (G) Other = GRAB 8" = 2.61

GROUNDWATER SAMPLING DATA (if product is detected, do NOT sample) Sample Depth: [√ if used]

Bottle Type	Date	Time	Method §	Amount & Volume mL		Preservative [circle]	Ice	Filter	pH	√
VOA Glass	/ /	:			40 ml	HCl	YES	NO		
Amber Glass	/ /	:			250, 500, 1L	(None) (HCl) (H_2SO_4)	YES	NO		
White Poly	11/10/10	08:10	G	2	250, 500, 1L	None	YES	NO	NA	✓
Yellow Poly	/ /	:			250, 500, 1L	H_2SO_4	YES	NO		
Green Poly	11/10/10	08:10	G	1	250, 500, 1L	NaOH	YES	NO	—	X
Red Total Poly	11/10/10	08:10	G	1	250, 500, 1L	HNO_3	YES	NO	—	X
Red Diss. Poly	11/10/10	08:10	G	1	250, 500, 1L	HNO_3	YES	YES	—	X
	/ /	:			250, 500, 1L		YES			

Total Bottles (include duplicate count): 5

Analysis Allowed per Bottle Type	BOTTLE TYPE	TYPICAL ANALYSIS ALLOWED PER BOTTLE TYPE (Circle applicable or write non-standard analysis below)
	VOA - Glass	(8021) (8260B) (BTEX) (NWTPH-Gx)
	AMBER - Glass	(PAH) (TPH-HCID) (NWTPH-Dx) (TPH-418.1) (Oil &Grease) (8081A)
	WHITE - Poly	(pH) (Conductivity) (TDS) (TSS) (BOD) (Turbidity) (Alkalinity) (HCO_3/CO_3) (Cl) (SO_4) (NO_3) (NO_2) (F)
	YELLOW - Poly	(COD) (TOC) (Total PO_4) (Total Keldahl Nitrogen) (NH_3) (NO_3/NO_2)
	GREEN - Poly	(Cyanide) - Total / Free, weak-acid dissociable
	RED TOTAL - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na)
	RED DISSOLVED - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na) (Hardness) (Silica)

WATER QUALITY DATA Purge Start Time: 1200 11/08/10 ORP Pump/Bailer Inlet Depth:

Meas.	Method §	Purged (gal)	pH	E Cond (µS)	°F Temp °C	~~Other~~	Diss O_2 (mg/l)	Water Quality
4		.	.		.		.	
3		.	.		.		.	
2		.	.		.		.	
1	F	66 362.0	7.13	702	15.60	9.1	0.24	clean, colorless
0		0.00	.		.		.	

[Casing] [Select A-G] [Cumulative Totals] [Circle units] [Clarity, Color]

pump has been in operation at 25 GPM for 44 hours
Mid Test Sample

SAMPLER: MWilson / D Laffoon
(PRINTED NAME)

Matthew Wilson
(SIGNATURE)

FIELD SAMPLING DATA SHEET

ANCHOR QEA
6650 SW Redwood Lane, Suite 333
Portland, OR 97224
Office: (503) 670-1108 Fax: (503) 670-1128

PROJECT NAME: Gasco Segment 2 Capture Zone Field Test **WELL ID:** FIELD BLANK
SITE ADDRESS: 7900 NW St. Helens Rd, Portland OR **BLIND ID:** GS-111010-11
DUP ID:

WIND FROM:	N	NE	E	SE	S	SW	W	NW	LIGHT	MEDIUM	HEAVY
WEATHER:	SUNNY	CLOUDY	RAIN	?					TEMPERATURE:	°F 45.	°C

[Circle appropriate units]

HYDROLOGY/LEVEL MEASUREMENTS (Nearest 0.01 ft)

Date	Time	DT-Bottom	DT-Product	DT-Water	DTP-DTW [Product Thickness]	DTB-DTW [Water Column]		Volume (gal) [Water Column x Gal/ft]
/ /	:	.	.	.	.	.	X 1	
/ /	:	.	.	.	.		X 3	NA

Gal/ft = (dia./2)^2 x 0.163	1" = 0.041	2" = 0.163	3" = 0.367	4" = 0.653	6" = 1.469	10" = 4.080	12" = 5.875

§ METHODS: (A) Submersible Pump (B) Peristaltic Pump (C) Disposable Bailer (D) PVC/Teflon Bailer (E) Dedicated Bailer (F) Dedicated Pump (G) Other: POUR GRAB

GROUNDWATER SAMPLING DATA (if product is detected, do NOT sample) Sample Depth: [√ if used]

Bottle Type	Date	Time	Method §	Amount & Volume mL		Preservative [circle]	Ice	Filter	pH	√
VOA Glass	/ /	:			40 ml	HCl	YES	NO		
Amber Glass	/ /	:			250, 500, 1L	(None) (HCl) (H_2SO_4)	YES	NO		
White Poly	11/10/10	08:30	B	2	250, 500, 1L	None	YES	NO (YES)	NA	—
Yellow Poly	/ /	:			250, 500, 1L	H_2SO_4	YES	NO		
Green Poly	11/10/10	08:30	B	1	250, 500, 1L	NaOH	YES	NO	—	X
Red Total Poly	11/10/10	08:30	B	1	250, 500, 1L	HNO_3	YES	NO	—	X
Red Diss. Poly	11/10/10	08:30	B	1	250, 500, 1L	HNO_3	YES	YES	—	X
	/ /	:			250, 500, 1L		YES			

Total Bottles (include duplicate count): 5

Analysis Allowed per Bottle Type	BOTTLE TYPE	TYPICAL ANALYSIS ALLOWED PER BOTTLE TYPE (Circle applicable or write non-standard analysis below)
	VOA - Glass	(8021) (8260B) (BTEX) (NWTPH-Gx)
	AMBER - Glass	(PAH) (TPH-HCID) (NWTPH-Dx) (TPH-418.1) (Oil &Grease) (8081A)
	WHITE - Poly	(pH) (Conductivity) (TDS) (TSS) (BOD) (Turbidity) (Alkalinity) (HCO_3/CO_3) (Cl) (SO_4) (NO_3) (NO_2) (F)
	YELLOW - Poly	(COD) (TOC) (Total PO_4) (Total Keldahl Nitrogen) (NH_3) (NO_3/NO_2)
	GREEN - Poly	(Cyanide) (Total) (Free) (weak-acid dissociable)
	RED TOTAL - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na)
	RED DISSOLVED - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na) (Hardness) (Silica)

WATER QUALITY DATA Purge Start Time: NA: Pump/Bailer Inlet Depth:

Meas.	Method §	Purged (gal)	pH	E Cond (µS)	°F Temp °C	Other	Diss O_2 (mg/l)	Water Quality
4		.	.		.		.	
3		.	.		.		.	
2		.	.		.		.	
1	B	NA	5.37	1	9.23	227.1	10.13	clear, colorless
0		0.00	.		.		.	

[Casing] [Select A-G] [Cumulative Totals] [Circle units] [Clarity, Color]

Sample collected by pumping laboratory provided deionized water through a new, clean section of Phormed tubing with a peristaltic pump into sample bottles

SAMPLER: M Wilson / D Jaffoon (PRINTED NAME) (SIGNATURE)

FIELD SAMPLING DATA SHEET

ANCHOR QEA
6650 SW Redwood Lane, Suite 333
Portland, OR 97224
Office: (503) 670-1108 Fax: (503) 670-1128

PROJECT NAME: Gasco Segment 2 Capture Zone Field Test **WELL ID:** WILLAMETTE RIVER
SITE ADDRESS: 7900 NW St. Helens Rd, Portland OR **BLIND ID:** GS-111010-12
DUP ID:

WIND FROM:	N	NE	E	SE	S	SW	W	NW	LIGHT	MEDIUM	HEAVY
WEATHER:	SUNNY		CLOUDY		RAIN		?		**TEMPERATURE:**	°F 45 .	°C

[Circle appropriate units]

HYDROLOGY/LEVEL MEASUREMENTS (Nearest 0.01 ft)

Date	Time	DT-Bottom	DT-Product	DT-Water	DTP-DTW [Product Thickness]	DTB-DTW [Water Column]		Volume (gal) [Water Column x Gal/ft]
/ /	:	.	.	.	.	.	X 1	NA
/ /	:	.		.	.		X 3	.

Gal/ft = (dia./2)² x 0.163	1" = 0.041	2" = 0.163	3" = 0.367	4" = 0.653	6" = 1.469	10" = 4.080	12" = 5.875

§ METHODS: (A) Submersible Pump (B) Peristaltic Pump (C) Disposable Bailer (D) PVC/Teflon Bailer (E) Dedicated Bailer (F) Dedicated Pump (G) Other = GRAB

GROUNDWATER SAMPLING DATA (if product is detected, do NOT sample) Sample Depth:

Bottle Type	Date	Time	Method §	Amount	Volume mL	Preservative [circle]	Ice	Filter	pH	[√ if used] √
VOA Glass	/ /	:			40 ml	HCl	YES	NO		
Amber Glass	/ /	:			250, 500, 1L	(None) (HCl) (H_2SO_4)	YES	NO		
White Poly	11/10/10	09:00	B	2	250, 500, 1L	None	YES	NO (Yes)	NA	X
Yellow Poly	/ /	:			250, 500, 1L	H_2SO_4	YES	NO		
Green Poly	11/10/10	09:00	B	1	250, 500, 1L	NaOH	YES	NO	—	X
Red Total Poly	11/10/10	09:00	B	1	250, 500, 1L	HNO_3	YES	NO	—	X
Red Diss. Poly	11/10/10	09:00	B	1	250, 500, 1L	HNO_3	YES	YES	—	X
	/ /	:			250, 500, 1L		YES			

Total Bottles (include duplicate count): 5

Analysis Allowed per Bottle Type

BOTTLE TYPE	TYPICAL ANALYSIS ALLOWED PER BOTTLE TYPE (Circle applicable or write non-standard analysis below)
VOA - Glass	(8021) (8260B) (BTEX) (NWTPH-Gx)
AMBER - Glass	(PAH) (TPH-HCID) (NWTPH-Dx) (TPH-418.1) (Oil & Grease) (8081A)
WHITE - Poly	(pH) (Conductivity) (TDS) (TSS) (BOD) (Turbidity) (Alkalinity) (HCO_3/CO_3) (Cl) (SO_4) (NO_3) (NO_2) (F)
YELLOW - Poly	(COD) (TOC) (Total PO_4) (Total Keldahl Nitrogen) (NH_3) (NO_3/NO_2)
GREEN - Poly	(Cyanide) (Total) (Free) (weak-acid dissociable)
RED TOTAL - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na)
RED DISSOLVED - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na) (Hardness) (Silica)

WATER QUALITY DATA Purge Start Time: NA ORP Pump/Bailer Inlet Depth:

Meas.	Method §	Purged (gal)	pH	E Cond (µS)	°F Temp °C	~~Other~~ ORP	Diss O_2 (mg/l)	Water Quality
4		.	.		.		.	
3		.	.		.		.	
2		.	.		.		.	
1	B	NA	7.16	80	11.30	132.6	11.62	Sl. cloudy, L brown tint
0		0.00	.		.		.	

[Casing] [Select A-G] [Cumulative Totals] [Circle units] [Clarity, Color]

Sample collected from boathouse on Olympic Tug floating dock.
Mid Test Sample

SAMPLER: M Wilson / D Coffman (PRINTED NAME) (SIGNATURE)

FIELD SAMPLING DATA SHEET

ANCHOR QEA
6650 SW Redwood Lane, Suite 333
Portland, OR 97224
Office: (503) 670-1108 Fax: (503) 670-1128

PROJECT NAME: Gasco Segment 2 Capture Zone Field Test **WELL ID:** ~~MW~~ PW-8-68

SITE ADDRESS: 7900 NW St. Helens Rd, Portland OR **BLIND ID:** GS-111110-13

DUP ID:

WIND FROM:	N	NE	E	SE	S	SW	W	NW	LIGHT	MEDIUM	HEAVY
WEATHER:	SUNNY		CLOUDY		RAIN		?		**TEMPERATURE:**	°F 50.	°C

[Circle appropriate units]

HYDROLOGY/LEVEL MEASUREMENTS (Nearest 0.01 ft)

Date	Time	DT-Bottom	DT-Product	DT-Water	DTP-DTW [Product Thickness]	DTB-DTW [Water Column]		Volume (gal) [Water Column x Gal/ft]
10/11/10	11:49	71.0	—	23.18	—	47.82	X 1	see below
/ /	:	.	.	.	.		X 3	NA

Gal/ft = (dia./2)^2 x 0.163	1" = 0.041	2" = 0.163	3" = 0.367	4" = 0.653	6" = 1.469	10" = 4.080	12" = 5.875

§ METHODS: (A) Submersible Pump (B) Peristaltic Pump (C) Disposable Bailer (D) PVC/Teflon Bailer (E) Dedicated Bailer (F) Dedicated Pump (G) Other = Grab 8" = 2.61

GROUNDWATER SAMPLING DATA (if product is detected, do NOT sample) Sample Depth:

Bottle Type	Date	Time	Method §	Amount	Volume mL	Preservative [circle]	Ice	Filter	pH	√ [√ if used]
VOA Glass	/ /	:			40 ml	HCl	YES	NO		
Amber Glass	/ /	:			250, 500, 1L	(None) (HCl) (H_2SO_4)	YES	NO		
White Poly	11/10/10	11:50	G	2	250, 500, 1L	None	YES	NO	NA	X
Yellow Poly	/ /	:			250, 500, 1L	H_2SO_4	YES	NO		
Green Poly	11/10/10	11:50	G	1	250, 500, 1L	NaOH	YES	NO	—	X
Red Total Poly	11/11/10	11:50	G	1	250, 500, 1L	HNO_3	YES	NO	—	X
Red Diss. Poly	11/11/10	11:50	G	1	250, 500, 1L	HNO_3	YES	YES	—	X
	/ /	:			250, 500, 1L		YES			

Total Bottles (include duplicate count): 5

Analysis Allowed per Bottle Type

BOTTLE TYPE	TYPICAL ANALYSIS ALLOWED PER BOTTLE TYPE (Circle applicable or write non-standard analysis below)
VOA - Glass	(8021) (8260B) (BTEX) (NWTPH-Gx)
AMBER - Glass	(PAH) (TPH-HCID) (NWTPH-Dx) (TPH-418.1) (Oil &Grease) (8081A)
WHITE - Poly	(pH) (Conductivity) (TDS) (TSS) (BOD) (Turbidity) (Alkalinity) (HCO_3/CO_3) (Cl) (SO_4) (NO_3) (NO_2) (F)
YELLOW - Poly	(COD) (TOC) (Total PO_4) (Total Keldahl Nitrogen) (NH_3) (NO_3/NO_2)
GREEN - Poly	(Cyanide) - Total, Free, weak-acid dissociable
RED TOTAL - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na)
RED DISSOLVED - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na) (Hardness) (Silica)

WATER QUALITY DATA Purge Start Time: 1200 11/08/10 ORP Pump/Bailer Inlet Depth:

Meas. [Casing]	Method § [Select A-G]	Purged (gal) [Cumulative Totals]	pH	E Cond (µS)	°F Temp °C [Circle units]	~~Other~~ ORP	Diss O_2 (mg/l)	Water Quality [Clarity, Color]
4		.	.		.		.	
3		.	.		.		.	
2		.	.		.		.	
1	F	107797.0	7.32	710	17.12	26.6	0.16	clear, colorless
0		0.00	.		.		.	

Pump has been operating at 25 GPM for 72 hours
Ending Totalizer Reading 109055 Gallons

SAMPLER: Matt Wilson (PRINTED NAME) Matt Wilson (SIGNATURE)

FIELD SAMPLING DATA SHEET

ANCHOR QEA
6650 SW Redwood Lane, Suite 333
Portland, OR 97224
Office: (503) 670-1108 Fax: (503) 670-1128

PROJECT NAME: Gasco Segment 2 Capture Zone Field Test **WELL ID:** PW-8-39
SITE ADDRESS: 7900 NW St. Helens Rd, Portland OR **BLIND ID:** GS-111110-14
DUP ID:

WIND FROM:	N	NE	E	SE	S	SW	W	NW	LIGHT	MEDIUM	HEAVY
WEATHER:	SUNNY		CLOUDY		RAIN			?	**TEMPERATURE:**	°F 50.	°C

[Circle appropriate units]

HYDROLOGY/LEVEL MEASUREMENTS (Nearest 0.01 ft)

Date	Time	DT-Bottom	DT-Product	DT-Water	DTP-DTW [Product Thickness]	DTB-DTW [Water Column]		Volume (gal) [Water Column x Gal/ft]
11/10/10	12:09	42.0	—	34.16	—	7.84	X 1	See below
/ /	:	.	.	.	.		X 3	.

Gal/ft = (dia./2)^2 x 0.163	1" =	0.041	2" =	0.163	3" =	0.367	4" =	0.653	6" =	1.469	10" =	4.080	12" =	5.875

§ METHODS: (A) Submersible Pump (B) Peristaltic Pump (C) Disposable Bailer (D) PVC/Teflon Bailer (E) Dedicated Bailer (F) Dedicated Pump (G) Other GRAB

GROUNDWATER SAMPLING DATA (if product is detected, do NOT sample) Sample Depth:

Bottle Type	Date	Time	Method §	Amount	Volume mL	Preservative [circle]	Ice	Filter	pH	√ [√ if used]
VOA Glass	/ /	:			40 ml	HCl	YES	NO		
Amber Glass	/ /	:			250, 500, 1L	(None) (HCl) (H_2SO_4)	YES	NO		
White Poly	11/11/10	12:10	G	2	250, 500, 1L	None	YES	NO (YES)	NA	X
Yellow Poly	/ /	:			250, 500, 1L	H_2SO_4	YES	NO		
Green Poly	11/11/10	12:10	G	1	250, 500, 1L	NaOH	YES	NO	—	X
Red Total Poly	11/11/10	12:10	G	1	250, 500, 1L	HNO_3	YES	NO	—	X
Red Diss. Poly	11/11/10	12:10	G	1	250, 500, 1L	HNO_3	YES	YES	—	X
	/ /	:			250, 500, 1L		YES			

Total Bottles (include duplicate count): 5

Analysis Allowed per Bottle Type

BOTTLE TYPE	TYPICAL ANALYSIS ALLOWED PER BOTTLE TYPE (Circle applicable or write non-standard analysis below)
VOA - Glass	(8021) (8260B) (BTEX) (NWTPH-Gx)
AMBER - Glass	(PAH) (TPH-HCID) (NWTPH-Dx) (TPH-418.1) (Oil &Grease) (8081A)
WHITE - Poly	(pH) (Conductivity) (TDS) (TSS) (BOD) (Turbidity) (Alkalinity) (HCO_3/CO_3) (Cl) (SO_4) (NO_3) (NO_2) (F)
YELLOW - Poly	(COD) (TOC) (Total PO_4) (Total Keldahl Nitrogen) (NH_3) (NO_3/NO_2)
GREEN - Poly	(Cyanide) - Total, Free, weak-acid dissociable
RED TOTAL - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na)
RED DISSOLVED - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na) (Hardness) (Silica)

WATER QUALITY DATA Purge Start Time: 1200: 11/08/10 ORP Pump/Bailer Inlet Depth:

Meas.	Method §	Purged (gal)	pH	E Cond (µS)	°F Temp °C	~~Other~~	Diss O_2 (mg/l)	Water Quality
4		.	.		.		.	
3		.	.		.		.	
2		.	.		.		.	
1	F	8457	7.32	827	17.22	42.6	0.13	clear, colorless
0		0.00	.		.		.	

[Casing] [Select A-G] [Cumulative Totals] [Circle units] [Clarity, Color]

Pump has been in operation for 72 hours at 2 GPM

Ending Totalizer Readings #1 Totalizer ~~23735~~ 23789 Total Gallons Purged → 8511 G-T#1
#2 Totalizer ~~27412~~ 27468 8600 G-T#2

SAMPLER: Matt Wilson (PRINTED NAME) Matt Wil (SIGNATURE)

FIELD SAMPLING DATA SHEET

ANCHOR QEA
6650 SW Redwood Lane, Suite 333
Portland, OR 97224
Office: (503) 670-1108 Fax: (503) 670-1128

PROJECT NAME: Gasco Segment 2 Capture Zone Field Test **WELL ID:** PW-7-93
SITE ADDRESS: 7900 NW St. Helens Rd, Portland OR **BLIND ID:** GS-111110-15
DUP ID:

WIND FROM:	N	NE	E	SE	S	SW	W	NW	LIGHT	MEDIUM	HEAVY

WEATHER:	SUNNY	CLOUDY	RAIN	?	TEMPERATURE: °F 50 . °C

[Circle appropriate units]

HYDROLOGY/LEVEL MEASUREMENTS (Nearest 0.01 ft)

Date	Time	DT-Bottom	DT-Product	DT-Water	DTP-DTW [Product Thickness]	DTB-DTW [Water Column]		Volume (gal) [Water Column x Gal/ft]
11/10/10	12:18	96.0	—	26.00	—	70.00	X 1	See below
/ /	:	.	.	.	.		X 3	.

Gal/ft = (dia./2)^2 x 0.163	1" = 0.041	2" = 0.163	3" = 0.367	4" = 0.653	6" = 1.469	10" = 4.080	12" = 5.875

§ METHODS: (A) Submersible Pump (B) Peristaltic Pump (C) Disposable Bailer (D) PVC/Teflon Bailer (E) Dedicated Bailer (F) Dedicated Pump (G) Other = GRAB 8" = 2.61

GROUNDWATER SAMPLING DATA (if product is detected, do NOT sample) Sample Depth: [√ if used]

Bottle Type	Date	Time	Method §	Amount	Volume mL	Preservative [circle]	Ice	Filter	pH	√
VOA Glass	/ /	:			40 ml	HCl	YES	NO		
Amber Glass	/ /	:			250, 500, 1L	(None) (HCl) (H_2SO_4)	YES	NO		
White Poly	11/11/10	12:20	G	2	250, 500, 1L	None	YES	NO	NA	✓
Yellow Poly	/ /	:			250, 500, 1L	H_2SO_4	YES	NO		
Green Poly	11/11/10	12:20	G	1	250, 500, 1L	NaOH	YES	NO	—	X
Red Total Poly	11/11/10	12:20	G	1	250, 500, 1L	HNO_3	YES	NO	—	X
Red Diss. Poly	11/11/10	12:20	G	1	250, 500, 1L	HNO_3	YES	YES	—	X
	/ /	:			250, 500, 1L		YES			

Total Bottles (include duplicate count): 5

Analysis Allowed per Bottle Type	BOTTLE TYPE	TYPICAL ANALYSIS ALLOWED PER BOTTLE TYPE (Circle applicable or write non-standard analysis below)
	VOA - Glass	(8021) (8260B) (BTEX) (NWTPH-Gx)
	AMBER - Glass	(PAH) (TPH-HCID) (NWTPH-Dx) (TPH-418.1) (Oil &Grease) (8081A)
	WHITE - Poly	(pH) (Conductivity) (TDS) (TSS) (BOD) (Turbidity) (Alkalinity) (HCO_3/CO_3) (Cl) (SO_4) (NO_3) (NO_2) (F)
	YELLOW - Poly	(COD) (TOC) (Total PO_4) (Total Keldahl Nitrogen) (NH_3) (NO_3/NO_2)
	GREEN - Poly	(Cyanide) - Total, Free, weak-acid dissociable
	RED TOTAL - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na)
	RED DISSOLVED - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na) (Hardness) (Silica)

WATER QUALITY DATA Purge Start Time: 1200 11/08/10 ORP Pump/Bailer Inlet Depth:

Meas.	Method §	Purged (gal)	pH	E Cond (µS)	°F Temp °C	~~Other~~	Diss O_2 (mg/l)	Water Quality
4		.	.		.		.	
3		.	.		.		.	
2		.	7.34	860	15.97	25.1	0.18	↑ ↑
1	F	108912.0	7.35	860	15.97		~~0.25~~	clear, colorless
0		0.00	.		.		.	

[Casing] [Select A-G] [Cumulative Totals] [Circle units] [Clarity, Color]

~~Pump has~~ Well has been pumping for 72 hours at 25 GPM
Final Totalizer Reading = 109063 G

SAMPLER: Matt Wilson (PRINTED NAME) Matthew Wilson (SIGNATURE)

FIELD SAMPLING DATA SHEET

ANCHOR QEA
6650 SW Redwood Lane, Suite 333
Portland, OR 97224
Office: (503) 670-1108 Fax: (503) 670-1128

PROJECT NAME: Gasco Segment 2 Capture Zone Field Test **WELL ID:** WILLAMETTE RIVER
SITE ADDRESS: 7900 NW St. Helens Rd, Portland OR **BLIND ID:** GS-111110-16
DUP ID:

WIND FROM:	N	NE	E	SE	S	SW	W	NW	LIGHT	MEDIUM	HEAVY
WEATHER:	SUNNY		CLOUDY	RAIN		?			TEMPERATURE:	°F 50 .	°C

[Circle appropriate units]

HYDROLOGY/LEVEL MEASUREMENTS (Nearest 0.01 ft)

Date	Time	DT-Bottom	DT-Product	DT-Water	DTP-DTW [Product Thickness]	DTB-DTW [Water Column]		Volume (gal) [Water Column x Gal/ft]
/ /	:	.	.	.	.	.	X 1	NA - RIVER
/ /	:	.	.	.	.		X 3	.

Gal/ft = (dia./2)^2 x 0.163	1" = 0.041	2" = 0.163	3" = 0.367	4" = 0.653	6" = 1.469	10" = 4.080	12" = 5.875

§ METHODS: (A) Submersible Pump (B) Peristaltic Pump (C) Disposable Bailer (D) PVC/Teflon Bailer (E) Dedicated Bailer (F) Dedicated Pump (G) Other ~~GRA~~

GROUNDWATER SAMPLING DATA (if product is detected, do NOT sample) Sample Depth:

Bottle Type	Date	Time	Method §	Amount	Volume mL	Preservative (circle)	Ice	Filter	pH	√ [√ if used]
VOA Glass	/ /	:			40 ml	HCl	YES	NO		
Amber Glass	/ /	:			250, 500, 1L	(None) (HCl) (H_2SO_4)	YES	NO		
White Poly	11/11/10	13:10	B	2	250, 500, 1L	None	YES	NO	NA	X
Yellow Poly	/ /	:			250, 500, 1L	H_2SO_4	YES	NO		
Green Poly	11/11/10	13:10	B	1	250, 500, 1L	NaOH	YES	NO	—	X
Red Total Poly	11/11/10	13:10	B	1	250, 500, 1L	HNO_3	YES	NO	—	X
Red Diss. Poly	11/11/10	13:10	B	1	250, 500, 1L	HNO_3	YES	YES	—	X
	/ /	:			250, 500, 1L		YES			

Total Bottles (include duplicate count): 5

Analysis Allowed per Bottle Type

BOTTLE TYPE	TYPICAL ANALYSIS ALLOWED PER BOTTLE TYPE (Circle applicable or write non-standard analysis below)
VOA - Glass	(8021) (8260B) (BTEX) (NWTPH-Gx)
AMBER - Glass	(PAH) (TPH-HCID) (NWTPH-Dx) (TPH-418.1) (Oil &Grease) (8081A)
WHITE - Poly	(pH) (Conductivity) (TDS) (TSS) (BOD) (Turbidity) (Alkalinity) (HCO_3/CO_3) (Cl) (SO_4) (NO_3) (NO_2) (F)
YELLOW - Poly	(COD) (TOC) ~~(Total-PO_4)~~ ~~(Total Keldahl Nitrogen)~~ (NH_3) (NO_3/NO_2)
GREEN - Poly	(Cyanide) - Total, Free, weak-acid dissociable
RED TOTAL - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na)
RED DISSOLVED - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na) (Hardness) (Silica)

WATER QUALITY DATA Purge Start Time: NA ORP Pump/Bailer Inlet Depth:

Meas. [Casing]	Method § [Select A-G]	Purged (gal) [Cumulative Totals]	pH	E Cond (µS)	°F Temp °C [Circle units]	~~Other~~ ORP	Diss O_2 (mg/l)	Water Quality [Clarity, Color]
4		.	.		.		.	
3		.	.		.		.	
2		.	.		.		.	
1	B	NA	7.08	78	10.84	198.3	12.33	sl. cloudy, L brown tint
0		0.00	.		.		.	

Sample collected from FAMM boathouse on floating dock

SAMPLER: Matt Wilson (PRINTED NAME) Matt Wilson (SIGNATURE)

FIELD SAMPLING DATA SHEET

ANCHOR QEA
6650 SW Redwood Lane, Suite 333
Portland, OR 97224
Office: (503) 670-1108 Fax: (503) 670-1128

PROJECT NAME: Gasco Segment 2 Capture Zone Field Test **WELL ID:** PW-9-92
SITE ADDRESS: 7900 NW St. Helens Rd, Portland OR **BLIND ID:** GS-111110-17
DUP ID:

WIND FROM:	N	NE	E	SE	S	SW	W	NW	LIGHT	MEDIUM	HEAVY
WEATHER:	SUNNY		CLOUDY		RAIN		?		**TEMPERATURE:**	°F 45.	°C

[Circle appropriate units]

HYDROLOGY/LEVEL MEASUREMENTS (Nearest 0.01 ft)

Date	Time	DT-Bottom	DT-Product	DT-Water	DTP-DTW [Product Thickness]	DTB-DTW [Water Column]		Volume (gal) [Water Column x Gal/ft]
11/11/10	11:19	95.0	—	40.90	—	54.10	X 1	See Below
/ /	:	.	.	.	.		X 3	.

Gal/ft = (dia./2)^2 x 0.163	1" =	0.041	2" =	0.163	3" =	0.367	4" =	0.653	6" =	1.469	10" =	4.080	12" =	5.875

§ METHODS: (A) Submersible Pump (B) Peristaltic Pump (C) Disposable Bailer (D) PVC/Teflon Bailer (E) Dedicated Bailer (F) Dedicated Pump (G) Other = GRAB 8" = 2.61

GROUNDWATER SAMPLING DATA (if product is detected, do NOT sample) Sample Depth: [√ if used]

Bottle Type	Date	Time	Method §	Amount	Volume mL	Preservative [circle]	Ice	Filter	pH	√
VOA Glass	/ /	:			40 ml	HCl	YES	NO		
Amber Glass	/ /	:			250, 500, 1L	(None) (HCl) (H_2SO_4)	YES	NO		
White Poly	11/11/10	11:20	G	2	250, 500, 1L	None	YES	NO (Resp)	NA	X
Yellow Poly	/ /	:			250, 500, 1L	H_2SO_4	YES	NO		
Green Poly	11/11/10	:	G	1	250, 500, 1L	NaOH	YES	NO	—	X
Red Total Poly	11/11/10	:	G	1	250, 500, 1L	HNO_3	YES	NO	—	X
Red Diss. Poly	11/11/10	:	G	1	250, 500, 1L	HNO_3	YES	YES	—	X
	/ /	:			250, 500, 1L		YES			

Total Bottles (include duplicate count): 5

Analysis Allowed per Bottle Type

BOTTLE TYPE	TYPICAL ANALYSIS ALLOWED PER BOTTLE TYPE (Circle applicable or write non-standard analysis below)
VOA - Glass	(8021) (8260B) (BTEX) (NWTPH-Gx)
AMBER - Glass	(PAH) (TPH-HCID) (NWTPH-Dx) (TPH-418.1) (Oil &Grease) (8081A)
WHITE - Poly	(pH) (Conductivity) (TDS) (TSS) (BOD) (Turbidity) (Alkalinity) (HCO_3/CO_3) (Cl) (SO_4) (NO_3) (NO_2) (F)
YELLOW - Poly	(COD) (TOC) (Total PO_4) (Total Keldahl Nitrogen) (NH_3) (NO_3/NO_2)
GREEN - Poly	(Cyanide) - Total, ~~Free, weak-acid dissociable~~
RED TOTAL - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na)
RED DISSOLVED - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na) (Hardness) (Silica)

WATER QUALITY DATA Purge Start Time: 12:00 11/08/10 ORP Pump/Bailer Inlet Depth:

Meas.	Method §	Purged (gal)	pH	E Cond (µS)	°F Temp °C	~~Other~~	Diss O_2 (mg/l)	Water Quality
4		.	.		.		.	
3		.	.		.		.	
2		.	.		.		.	
1	F	107167.0	7.16	703	15.78	92.4	0.18	clear, colorless
0		0.00	.		.		.	

[Casing] [Select A-G] [Cumulative Totals] [Circle units] [Clarity, Color]

Well has been pumping for 72 hours at 25 GPM
Final Totalizer Reading = 109109 G

SAMPLER: Matt Wilson (PRINTED NAME) Matthew Wilson (SIGNATURE)

APEX LABS

CHAIN OF CUSTODY

COC 1 of 1

Lab # _____

12232 S.W. Garden Place, Tigard, OR 97223 Ph: 503-718-2323 Fax: 503-718-0333

Company: Anchor QEA | Project Mgr: John Renda | Project Name: Gosen Soa 2 CZ | Project # 000029-02,283

Address: 6650 SW Redwood Ln #333 Portland OR 97224 | Phone: 5036701108 | Fax: 5036701128 | Email: JRenda@anchorqea.com

Sampled by: Matthew Wilson

Site Location: (OR) WA

Other: _____

ANALYSIS REQUEST

SAMPLE ID	LAB ID #	DATE	TIME	MATRIX	# OF CONTAINERS	NWTPH-HCID	NWTPH-Dx	NWTPH-Gx	BTEX	8260 RBDM VOCs	8260 Halo VOCs	8260 VOCs	8270 SIM PAHs	8082 PCBs	8081 Chlor. Pest	RCRA Metals (8)	Priority Metals (13)	Al, Sb, As, Ba, Be, Cd (Ca), Cr, Co, Cu, (Fe), Pb, Hg, (Mg), (Mn), Mo, Ni, (K), Se, Ag, (Na), Tl, V, Zn	TCLP Metals (8)	1200- COLS	1200-Z	Free Cyanide	Total Cyanide	Weak-acid dissociable Cyanide	Sulfate, chloride, bicarbonate, carbonate, Nitrate		
GS-111010-6		11/10/10	0730	W	5													X				X	X	X	X		
GS-111010-7			0735	W	5													X				X	X	X	X		
GS-111010-8			0745	W	5													X				X	X	X	X		
GS-111010-9			0750	W	5													X				X	X	X	X		
GS-111010-10			0810	W	5													X				X	X	X	X		
GS-111010-11			0830	W	5													X				X	X	X	X		
GS-111010-12		↓	0900	W	5													X				X	X	X	X		

Normal Turn Around Time (TAT) = 7-10 Business Days (YES) NO

TAT Requested (circle): 24 HR 48 HR 72 HR 4 DAY 5 DAY Other: _____

SAMPLES ARE HELD FOR 30 DAYS

SPECIAL INSTRUCTIONS:
Total and Dissolved metals.
Dissolved Metals and Cations & Anions filtered in the field
Cyanide → 48 hr hold time

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Signature: Matthew Wilson Date: 11/10/10	Signature: [illegible] Date: 11/10/10	Signature: Date:	Signature: Date:
Printed Name: Matt Wilson Time: 1040	Printed Name: Dennis [illegible] Time: 10:40	Printed Name: Time:	Printed Name: Time:
Company: Anchor QEA	Company: Apex	Company:	Company:

APEX LABS

CHAIN OF CUSTODY

COC 1 of 1

Lab # _____

12232 S.W. Garden Place, Tigard, OR 97223 Ph: 503-718-2323 Fax: 503-718-0333

Company: Anchor QEA | Project Mgr: John Renda | Project Name: Gosco Seg 2 CZ | Project # 000029-02

Address: 6650 SW Redwood Ln #333 Portland OR 97224 | Phone: 503 670 1108 | Fax: 503 670 1178 | Email: JRenda@anchorqea.com

Sampled by: Matthew Wilson

Site Location: (OR) WA

Other: _____

ANALYSIS REQUEST

SAMPLE ID	LAB ID #	DATE	TIME	MATRIX	# OF CONTAINERS	NWTPH-HCID	NWTPH-Dx	NWTPH-Gx	BTEX	8260 RBDM VOCs	8260 Halo VOCs	8260 VOCs	8270 SIM PAHs	8082 PCBs	8081 Chlor. Pest	RCRA Metals (8)	Priority Metals (13)	Al, Sb, As, Ba, Be, Cd, (Ca), Cr, Co, Cu, (Fe), Pb, Hg, (Mg), (Mn), Mo, Ni, (K), Se, Ag, (Na), Tl, V, Zn	TCLP Metals (8)	1200-COLS	1200-Z	Total Cyanide	Free Cyanide	Weak-acid dissociable CN	Sulfate, chloride, bicarbonate	Carbonate, nitrate	
GS-110810-1		11/08/10	1230	W	5													X				X	X	X	X		
GS-110810-2		↓	1220	W	5													X				X	X	X	X		
GS-110810-3		↓	1300	W	5													X				X	X	X	X		
GS-110810-4		↓	1225	W	5													X				X	X	X	X		
GS-110810-5		↓	1330	W	5													X				X	X	X	X		

Normal Turn Around Time (TAT) = 7-10 Business Days (YES) NO

TAT Requested (circle): 24 HR 48 HR 72 HR 4 DAY 5 DAY Other: _____

SAMPLES ARE HELD FOR 30 DAYS

SPECIAL INSTRUCTIONS:
Total and Dissolved Metals.
Dissolved metals and Cations and Anions filtered in the field

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Signature: Matthew Wilson	Signature: [illegible]	Signature:	Signature:
Date: 11/08/10	Date: 11/8/10	Date:	Date:
Printed Name: Matt Wilson	Printed Name: Jennifer [illegible]	Printed Name:	Printed Name:
Time: 1330	Time: 13:20	Time:	Time:
Company: Anchor QEA	Company: APEX	Company:	Company:

APEX LABS

CHAIN OF CUSTODY

COC 1 of 1

Lab # _____

12232 S.W. Garden Place, Tigard, OR 97223 Ph: 503-718-2323 Fax: 503-718-0333

Company: Anchor QEA | Project Mgr: John Renda | Project Name: Gasco Sea 2 CZ | Project # 000029-02.28 3A

Address: 6650 SW Redwood Ln #333 Portland OR 97224 | Phone: 5036701108 | Fax: 5036701128 | Email: JRenda@anchorqea.com

Sampled by: Matthew Wilson

Site Location: (OR) WA

Other: _____

ANALYSIS REQUEST

SAMPLE ID	LAB ID #	DATE	TIME	MATRIX	# OF CONTAINERS	NWTPH-HCID	NWTPH-Dx	NWTPH-Gx	BTEX	8260 RBDM VOCs	8260 Halo VOCs	8260 VOCs	8270 SIM PAHs	8082 PCBs	8081 Chlor. Pest	RCRA Metals (8)	Priority Metals (13)	Al, Sb, As, Ba, Be, Cd (Ca), Cr, Co, Cu, (Fe), Pb, Hg, (Mg), (Mn), Mo, Ni, (K), Se, Ag, (Na), Tl, V, Zn	TCLP Metals (8)	1200- COLS	1200-Z	Total Cyanide	Free Cyanide	Weak-acid dissociable Cyanide	Sulfate, Chloride, Bicarbonate, Carbonate, Nitrate		
GS-111110-13		11/11/10	1150	W	5													X				X	X	X	X		
GS-111110-14			1210	W	5													X				X	X	X	X		
GS-111110-15			1220	W	5													X				X	X	X	X		
GS-111110-16			1310	W	5													X				X	X	X	X		
GS-111110-17			1120	W	5													X				X	X	X	X		

Normal Turn Around Time (TAT) = 5-10 Business Days

TAT Requested (circle): 24 HR 48 HR 72 HR 4 DAY 5 DAY Other: _____

SAMPLES ARE HELD FOR 30 DAYS

SPECIAL INSTRUCTIONS:
Cyanide 48 hour hold time
Total and dissolved Metals
Dissolved metals & cations & anions filtered in field

RELINQUISHED BY:		RECEIVED BY:	RELINQUISHED BY:		RECEIVED BY:
Signature: Matthew Wil	Date: 11/11/10	Signature: Jennifer Sutt	Signature:	Date:	Signature:
Printed Name: Matt Wilson	Time: 1500	Printed Name: Jennifer Sutt	Printed Name:	Time:	Printed Name:
Company: Anchor QEA		Company: Apex	Company:		Company:

APPENDIX C
DATA CD

APPENDIX D
LABORATORY REPORTS

Apex Labs

12232 S.W. Garden Place
Tigard, OR 97223
503-718-2323 Phone
503-718-0333 Fax

Friday, December 3, 2010

John Renda
Anchor QEA, LLC Portland
6650 SW Redwood Lane Ste. 333
Portland, OR 97224

RE: GASCO-1DW-SEQ 2 C 2 / 000029-02

Enclosed are the results of analyses for work order A10K140, which was received by the laboratory on 11/8/2010 at 3:30:00PM.

Thank you for using Apex Labs. We appreciate your business and strive to provide the highest quality services to the environmental industry.

If you have any questions concerning this report or the services we offer, please feel free to contact me by email at: dthomas@apex-labs.com, or by phone at 503-718-2323.

Apex Laboratories

Darwin Thomas, Business Development Director

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Apex Labs

12232 S.W. Garden Place
Tigard, OR 97223
503-718-2323 Phone
503-718-0333 Fax

Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/03/10 10:28

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
GS-110810-1	A10K140-01	Water	11/08/10 12:30	11/08/10 15:30
GS-110810-2	A10K140-02	Water	11/08/10 12:20	11/08/10 15:30
GS-110810-3	A10K140-03	Water	11/08/10 13:00	11/08/10 15:30
GS-110810-4	A10K140-04	Water	11/08/10 12:25	11/08/10 15:30
GS-110810-5	A10K140-05	Water	11/08/10 13:30	11/08/10 15:30

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/03/10 10:28

ANALYTICAL SAMPLE RESULTS

Anions by EPA 300.0/9056A (Ion Chromatography)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-110810-1 (A10K140-01)			**Matrix: Water**		**Batch: 1011177**			
Chloride	**7.08**	1.00	1.00	mg/L	1	11/09/10 14:45	300.0/9056A	
Nitrate-Nitrogen	ND	0.250	0.250	"	"	"	"	
Sulfate	ND	1.00	1.00	"	"	"	"	
GS-110810-2 (A10K140-02)			**Matrix: Water**		**Batch: 1011177**			
Chloride	**17.1**	1.00	1.00	mg/L	1	11/09/10 15:46	300.0/9056A	
Nitrate-Nitrogen	ND	0.250	0.250	"	"	"	"	
Sulfate	ND	1.00	1.00	"	"	"	"	
GS-110810-3 (A10K140-03)			**Matrix: Water**		**Batch: 1011177**			
Nitrate-Nitrogen	ND	0.250	0.250	mg/L	1	11/09/10 16:07	300.0/9056A	
Sulfate	**28.5**	1.00	1.00	"	"	"	"	
GS-110810-3 (A10K140-03RE1)			**Matrix: Water**		**Batch: 1011225**			
Chloride	**79.9**	5.00	5.00	mg/L	1	11/12/10 01:38	300.0/9056A	
GS-110810-4 (A10K140-04)			**Matrix: Water**		**Batch: 1011177**			
Chloride	**25.4**	1.00	1.00	mg/L	1	11/09/10 16:27	300.0/9056A	
Nitrate-Nitrogen	ND	0.250	0.250	"	"	"	"	
Sulfate	ND	1.00	1.00	"	"	"	"	
GS-110810-5 (A10K140-05)			**Matrix: Water**		**Batch: 1011177**			
Chloride	**4.65**	1.00	1.00	mg/L	1	11/09/10 16:48	300.0/9056A	
Nitrate-Nitrogen	**0.536**	0.250	0.250	"	"	"	"	
Sulfate	**3.53**	1.00	1.00	"	"	"	"	

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/03/10 10:28

ANALYTICAL SAMPLE RESULTS

Cyanide - Total (Aqueous)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-110810-1 (A10K140-01)			**Matrix: Water**		**Batch: 1011322**			
Cyanide, Total	**0.100**	0.00250	0.00500	mg/L	1	11/17/10 15:41	EPA 335.4	
GS-110810-2 (A10K140-02)			**Matrix: Water**		**Batch: 1011322**			
Cyanide, Total	**0.122**	0.00250	0.00500	mg/L	1	11/17/10 15:43	EPA 335.4	
GS-110810-3 (A10K140-03)			**Matrix: Water**		**Batch: 1011322**			
Cyanide, Total	**0.0788**	0.00250	0.00500	mg/L	1	11/17/10 15:52	EPA 335.4	
GS-110810-4 (A10K140-04)			**Matrix: Water**		**Batch: 1011322**			
Cyanide, Total	**0.150**	0.00250	0.00500	mg/L	1	11/17/10 15:53	EPA 335.4	
GS-110810-5 (A10K140-05)			**Matrix: Water**		**Batch: 1011322**			
Cyanide, Total	**0.0225**	0.00250	0.00500	mg/L	1	11/17/10 15:55	EPA 335.4	
GS-110810-5 (A10K140-05RE1)			**Matrix: Water**		**Batch: 1011322**			
Cyanide, Total	**0.0251**	0.00250	0.00500	mg/L	1	11/17/10 16:17	EPA 335.4	

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/03/10 10:28

ANALYTICAL SAMPLE RESULTS

Cyanide - Weak Acid Dissociable (WAD) (Aqueous)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-110810-1 (A10K140-01)			**Matrix: Water**		**Batch: 1011304**			
Cyanide, WAD	**0.0282**	0.00500	0.0100	mg/L	1	11/16/10 16:49	SM 4500-CN (I/E)	R-08
GS-110810-2 (A10K140-02)			**Matrix: Water**		**Batch: 1011304**			
Cyanide, WAD	**0.0209**	0.00500	0.0100	mg/L	1	11/16/10 16:53	SM 4500-CN (I/E)	R-08
GS-110810-3 (A10K140-03)			**Matrix: Water**		**Batch: 1011304**			
Cyanide, WAD	**0.0198**	0.00500	0.0100	mg/L	1	11/16/10 16:55	SM 4500-CN (I/E)	R-08
GS-110810-4 (A10K140-04)			**Matrix: Water**		**Batch: 1011304**			
Cyanide, WAD	**0.0309**	0.00500	0.0100	mg/L	1	11/16/10 16:56	SM 4500-CN (I/E)	R-08
GS-110810-5 (A10K140-05)			**Matrix: Water**		**Batch: 1011304**			
Cyanide, WAD	**0.0297**	0.00500	0.0100	mg/L	1	11/16/10 17:01	SM 4500-CN (I/E)	R-08

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/03/10 10:28

ANALYTICAL SAMPLE RESULTS

Cyanide - Free (Aqueous)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-110810-1 (A10K140-01)			**Matrix: Water**		**Batch: 1011198**			
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	11/10/10 16:05	ASTM D 4282	
GS-110810-2 (A10K140-02)			**Matrix: Water**		**Batch: 1011198**			
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	11/10/10 16:07	ASTM D 4282	
GS-110810-3 (A10K140-03)			**Matrix: Water**		**Batch: 1011198**			
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	11/10/10 16:07	ASTM D 4282	
GS-110810-4 (A10K140-04)			**Matrix: Water**		**Batch: 1011198**			
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	11/10/10 16:12	ASTM D 4282	
GS-110810-5 (A10K140-05)			**Matrix: Water**		**Batch: 1011198**			
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	11/10/10 16:12	ASTM D 4282	

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/03/10 10:28

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-110810-1 (A10K140-01)			**Matrix: Water**		**Batch: 1011233**			
Calcium	**71.6**	0.250	1.00	mg/L	10	11/12/10 16:00	EPA 6020	
Iron	**40.5**	0.100	0.500					
Magnesium	**26.3**	0.100	0.500					
Manganese	**3.01**	0.00333	0.0100					
Potassium	**6.23**	0.100	1.00					
Sodium	**17.2**	0.200	1.00					
GS-110810-2 (A10K140-02)			**Matrix: Water**		**Batch: 1011233**			
Calcium	**54.1**	0.250	1.00	mg/L	10	11/12/10 16:18	EPA 6020	
Iron	**43.0**	0.100	0.500					
Magnesium	**39.0**	0.100	0.500					
Manganese	**1.96**	0.00333	0.0100					
Potassium	**3.90**	0.100	1.00					
Sodium	**19.7**	0.200	1.00					
GS-110810-3 (A10K140-03)			**Matrix: Water**		**Batch: 1011233**			
Calcium	**58.5**	0.250	1.00	mg/L	10	11/12/10 16:21	EPA 6020	
Iron	**31.1**	0.100	0.500					
Magnesium	**29.2**	0.100	0.500					
Manganese	**2.60**	0.00333	0.0100					
Potassium	**2.71**	0.100	1.00					
Sodium	**76.8**	0.200	1.00					
GS-110810-4 (A10K140-04)			**Matrix: Water**		**Batch: 1011233**			
Calcium	**56.2**	0.250	1.00	mg/L	10	11/12/10 16:24	EPA 6020	
Iron	**43.5**	0.100	0.500					
Magnesium	**29.1**	0.100	0.500					
Manganese	**3.29**	0.00333	0.0100					
Potassium	**3.29**	0.100	1.00					
Sodium	**15.3**	0.200	1.00					
GS-110810-5 (A10K140-05)			**Matrix: Water**		**Batch: 1011233**			
Calcium	**6.13**	0.0250	0.100	mg/L	1	11/12/10 16:27	EPA 6020	
Iron	**0.383**	0.0100	0.0500					
Magnesium	**2.08**	0.0100	0.0500					
Manganese	**0.0181**	0.000333	0.00100					
Potassium	**0.938**	0.0100	0.100					
Sodium	**4.92**	0.0200	0.100					

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/03/10 10:28

ANALYTICAL SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-110810-1 (A10K140-01)			**Matrix: Water**		**Batch: 1011223**			
Calcium	**77.2**	0.250	1.00	mg/L	10	11/12/10 14:01	EPA 6020 (Diss)	
Iron	**42.2**	0.100	0.500					
Magnesium	**27.9**	0.100	0.500					
Manganese	**3.15**	0.00333	0.0100					
Potassium	**6.45**	0.0100	0.100		1	11/11/10 16:45		
Sodium	**18.2**	0.200	1.00		10	11/12/10 14:01		
GS-110810-2 (A10K140-02)			**Matrix: Water**		**Batch: 1011223**			
Calcium	**57.7**	0.250	1.00	mg/L	10	11/12/10 14:07	EPA 6020 (Diss)	
Iron	**42.5**	0.100	0.500					
Magnesium	**39.9**	0.100	0.500					
Manganese	**2.05**	0.00333	0.0100					
Potassium	**3.89**	0.0100	0.100		1	11/11/10 16:54		
Sodium	**20.1**	0.200	1.00		10	11/12/10 14:07		
GS-110810-3 (A10K140-03)			**Matrix: Water**		**Batch: 1011223**			
Calcium	**62.7**	0.250	1.00	mg/L	10	11/12/10 14:10	EPA 6020 (Diss)	
Iron	**31.9**	0.100	0.500					
Magnesium	**30.8**	0.100	0.500					
Manganese	**2.75**	0.00333	0.0100					
Potassium	**2.80**	0.0100	0.100		1	11/11/10 16:57		
Sodium	**81.2**	0.200	1.00		10	11/12/10 14:10		
GS-110810-4 (A10K140-04)			**Matrix: Water**		**Batch: 1011223**			
Calcium	**58.8**	0.250	1.00	mg/L	10	11/12/10 14:30	EPA 6020 (Diss)	
Iron	**43.4**	0.100	0.500					
Magnesium	**30.0**	0.100	0.500					
Manganese	**3.34**	0.00333	0.0100					
Potassium	**3.32**	0.0100	0.100		1	11/11/10 17:00		
Sodium	**15.6**	0.200	1.00		10	11/12/10 14:30		
GS-110810-5 (A10K140-05)			**Matrix: Water**		**Batch: 1011223**			
Calcium	**6.68**	0.0250	0.100	mg/L	1	11/11/10 17:06	EPA 6020 (Diss)	
Iron	**0.156**	0.0100	0.0500					
Magnesium	**2.15**	0.0100	0.0500					
Manganese	**0.0111**	0.000333	0.00100			11/12/10 14:33		
Potassium	**1.04**	0.0100	0.100			11/11/10 17:06		
Sodium	**5.22**	0.0200	0.100					

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/03/10 10:28

ANALYTICAL SAMPLE RESULTS

Conventional Chemistry Parameters

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-110810-1 (A10K140-01)			**Matrix: Water**		**Batch: 1011197**			
Total Alkalinity	**374**	20.0	20.0	mg CaCO3/L	1	11/10/10 11:30	SM 2320 B	
Bicarbonate Alkalinity	**374**	20.0	20.0					
Carbonate Alkalinity	ND	20.0	20.0					
Hydroxide Alkalinity	ND	20.0	20.0					
GS-110810-2 (A10K140-02)			**Matrix: Water**		**Batch: 1011197**			
Total Alkalinity	**359**	20.0	20.0	mg CaCO3/L	1	11/10/10 11:30	SM 2320 B	
Bicarbonate Alkalinity	**359**	20.0	20.0					
Carbonate Alkalinity	ND	20.0	20.0					
Hydroxide Alkalinity	ND	20.0	20.0					
GS-110810-3 (A10K140-03)			**Matrix: Water**		**Batch: 1011197**			
Total Alkalinity	**353**	20.0	20.0	mg CaCO3/L	1	11/10/10 11:30	SM 2320 B	
Bicarbonate Alkalinity	**353**	20.0	20.0					
Carbonate Alkalinity	ND	20.0	20.0					
Hydroxide Alkalinity	ND	20.0	20.0					
GS-110810-4 (A10K140-04)			**Matrix: Water**		**Batch: 1011197**			
Total Alkalinity	**299**	20.0	20.0	mg CaCO3/L	1	11/10/10 11:30	SM 2320 B	
Bicarbonate Alkalinity	**299**	20.0	20.0					
Carbonate Alkalinity	ND	20.0	20.0					
Hydroxide Alkalinity	ND	20.0	20.0					
GS-110810-5 (A10K140-05)			**Matrix: Water**		**Batch: 1011197**			
Total Alkalinity	**27.6**	20.0	20.0	mg CaCO3/L	1	11/10/10 11:30	SM 2320 B	
Bicarbonate Alkalinity	**27.6**	20.0	20.0					
Carbonate Alkalinity	ND	20.0	20.0					
Hydroxide Alkalinity	ND	20.0	20.0					

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/03/10 10:28

QUALITY CONTROL (QC) SAMPLE RESULTS

Anions by EPA 300.0/9056A (Ion Chromatography)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011177 - Method Prep: Aq							**Water**					
Blank (1011177-BLK1)					Prepared: 11/09/10 12:23		Analyzed: 11/09/10 14:04					
300.0/9056A												
Chloride	ND	1.00	1.00	mg/L	1	---	---	---	---	---	---	
Nitrate-Nitrogen	ND	0.250	0.250			---	---	---	---	---	---	
Sulfate	ND	1.00	1.00			---	---	---	---	---	---	
LCS (1011177-BS1)					Prepared: 11/09/10 12:23		Analyzed: 11/09/10 14:25					
300.0/9056A												
Chloride	3.74	1.00	1.00	mg/L	1	4.00	---	94	90-110%		---	---
Nitrate-Nitrogen	0.919	0.250	0.250			1.00	---	92		---	---	
Sulfate	4.10	1.00	1.00			4.00	---	102		---	---	
Duplicate (1011177-DUP1)					Prepared: 11/09/10 12:23		Analyzed: 11/09/10 15:06					
QC Source Sample: GS-110810-1 (A10K140-01)												
300.0/9056A												
Chloride	**7.06**	1.00	1.00	mg/L	1	---	7.08	---	---	0.3	15%	
Nitrate-Nitrogen	ND	0.250	0.250			---	ND	---	---		15%	
Sulfate	ND	1.00	1.00			---	ND	---	---		15%	
Matrix Spike (1011177-MS1)					Prepared: 11/09/10 12:23		Analyzed: 11/09/10 15:26					
QC Source Sample: GS-110810-1 (A10K140-01)												
300.0/9056A												
Chloride	11.3	1.11	1.11	mg/L	1	4.44	7.08	95	80-120%	---	---	
Nitrate-Nitrogen	1.05	0.278	0.278			1.11	ND	95		---	---	
Sulfate	4.62	1.11	1.11			4.44	ND	104		---	---	
Batch 1011225 - Method Prep: Aq							**Water**					
Blank (1011225-BLK1)					Prepared: 11/11/10 11:39		Analyzed: 11/12/10 01:58					
300.0/9056A												
Chloride	ND	1.00	1.00	mg/L	1	---	---	---	---	---	---	
Nitrate-Nitrogen	ND	0.250	0.250			---	---	---	---	---	---	
Sulfate	ND	1.00	1.00			---	---	---	---	---	---	
LCS (1011225-BS1)					Prepared: 11/11/10 11:39		Analyzed: 11/12/10 02:19					
300.0/9056A												
Chloride	3.67	1.00	1.00	mg/L	1	4.00	---	92	90-110%	---	---	
Nitrate-Nitrogen	0.908	0.250	0.250			1.00	---	91		---	---	

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/03/10 10:28

QUALITY CONTROL (QC) SAMPLE RESULTS

Anions by EPA 300.0/9056A (Ion Chromatography)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011225 - Method Prep: Aq							**Water**					
LCS (1011225-BS1)					Prepared: 11/11/10 11:39		Analyzed: 11/12/10 02:19					
Sulfate	4.33	1.00	1.00	mg/L		4.00	---	108		---	---	
Duplicate (1011225-DUP1)					Prepared: 11/11/10 11:39		Analyzed: 11/12/10 02:40					
QC Source Sample: Other (A10K151-01RE1)												
300.0/9056A												
Chloride	**31.7**	5.00	5.00	mg/L	1	---	31.6	---	---	0.5	15%	
Nitrate-Nitrogen	**2.50**	1.25	1.25			---	2.50	---	---	0.2	15%	
Sulfate	**110**	5.00	5.00			---	110	---	---	0.3	15%	
Duplicate (1011225-DUP2)					Prepared: 11/11/10 11:39		Analyzed: 11/12/10 04:02					
QC Source Sample: Other (A10K177-06)												
300.0/9056A												
Chloride	ND	1.00	1.00	mg/L	1	---	ND	---	---		15%	
Nitrate-Nitrogen	ND	0.250	0.250			---	ND	---	---		15%	
Sulfate	ND	1.00	1.00			---	ND	---	---		15%	
Matrix Spike (1011225-MS1)					Prepared: 11/11/10 11:39		Analyzed: 11/12/10 03:00					
QC Source Sample: Other (A10K151-01RE1)												
300.0/9056A												
Chloride	51.4	5.00	5.00	mg/L	1	20.0	31.6	99	80-120%	---	---	
Nitrate-Nitrogen	7.20	1.25	1.25			5.00	2.50	94		---	---	
Sulfate	130	5.00	5.00			20.0	110	97		---	---	
Matrix Spike (1011225-MS2)					Prepared: 11/11/10 11:39		Analyzed: 11/12/10 04:22					
QC Source Sample: Other (A10K177-06)												
300.0/9056A												
Chloride	4.23	1.11	1.11	mg/L	1	4.44	ND	95	80-120%	---	---	
Nitrate-Nitrogen	1.04	0.278	0.278			1.11	ND	94			---	---
Sulfate	4.88	1.11	1.11			4.44	ND	110		---	---	

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/03/10 10:28

QUALITY CONTROL (QC) SAMPLE RESULTS

Cyanide - Total (Aqueous)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011322 - Latchat Micro Dist - aqueous							**Water**					
Blank (1011322-BLK2)					Prepared: 11/17/10 09:30		Analyzed: 11/17/10 15:47					
EPA 335.4												
Cyanide, Total	ND	0.00250	0.00500	mg/L	1	---	---	---	---	---	---	
LCS (1011322-BS1)					Prepared: 11/17/10 09:30		Analyzed: 11/17/10 15:29					
EPA 335.4												
Cyanide, Total	0.189	0.00250	0.00500	mg/L	1	0.200	---	95	90-110%	---	---	
Duplicate (1011322-DUP2)					Prepared: 11/17/10 09:30		Analyzed: 11/17/10 15:59					
QC Source Sample: Other (A10K200-02)												
EPA 335.4												
Cyanide, Total	**0.0826**	0.00250	0.00500	mg/L	1	---	0.0839	---	---	2	10%	
Duplicate (1011322-DUP3)					Prepared: 11/17/10 09:30		Analyzed: 11/17/10 16:16					
QC Source Sample: Other (A10K132-01)												
EPA 335.4												
Cyanide, Total	**0.0450**	0.00250	0.00500	mg/L	1	---	0.0456	---	---	1	10%	
Matrix Spike (1011322-MS2)					Prepared: 11/17/10 09:30		Analyzed: 11/17/10 16:01					
QC Source Sample: Other (A10K200-02)												
EPA 335.4												
Cyanide, Total	0.268	0.00255	0.00510	mg/L	1	0.204	0.0839	90	90-110%	---	---	
Matrix Spike (1011322-MS3)					Prepared: 11/17/10 09:30		Analyzed: 11/17/10 16:14					
QC Source Sample: Other (A10K132-01)												
EPA 335.4												
Cyanide, Total	0.179	0.00255	0.00510	mg/L	1	0.204	0.0456	66	90-110%	---	---	Q-01

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/03/10 10:28

QUALITY CONTROL (QC) SAMPLE RESULTS

Cyanide - Weak Acid Dissociable (WAD) (Aqueous)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011304 - Latchat Micro Dist - aqueous							**Water**					
Blank (1011304-BLK1)					Prepared: 11/16/10 09:27		Analyzed: 11/16/10 16:46					
SM 4500-CN (I/E)												
Cyanide, WAD	ND	0.00500	0.0100	mg/L	1	---	---	---	---	---	---	R-08
LCS (1011304-BS2)					Prepared: 11/16/10 09:27		Analyzed: 11/16/10 17:32					
SM 4500-CN (I/E)												
Cyanide, WAD	0.214	0.0300	0.0600	mg/L	6	0.200	---	107	90-110%	---	---	R-08
Duplicate (1011304-DUP1)					Prepared: 11/16/10 09:27		Analyzed: 11/16/10 16:50					
QC Source Sample: GS-110810-1 (A10K140-01)												
SM 4500-CN (I/E)												
Cyanide, WAD	**0.0190**	0.00500	0.0100	mg/L	1	---	0.0282	---	---	39	10%	Q-17, R-08
Duplicate (1011304-DUP2)					Prepared: 11/16/10 09:27		Analyzed: 11/16/10 17:29					
QC Source Sample: Other (A10K200-05)												
SM 4500-CN (I/E)												
Cyanide, WAD	**0.0339**	0.00500	0.0100	mg/L	1	---	0.0387	---	---	13	10%	Q-17, R-08
Matrix Spike (1011304-MS1)					Prepared: 11/16/10 09:27		Analyzed: 11/16/10 16:52					
QC Source Sample: GS-110810-1 (A10K140-01)												
SM 4500-CN (I/E)												
Cyanide, WAD	0.210	0.00521	0.0104	mg/L	1	0.208	0.0282	87	80-120%	---	---	R-08
Matrix Spike (1011304-MS2)					Prepared: 11/16/10 09:27		Analyzed: 11/16/10 17:31					
QC Source Sample: Other (A10K200-05)												
SM 4500-CN (I/E)												
Cyanide, WAD	0.227	0.00521	0.0104	mg/L	1	0.208	0.0387	90	80-120%	---	---	R-08

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/03/10 10:28

QUALITY CONTROL (QC) SAMPLE RESULTS

Cyanide - Free (Aqueous)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011198 - Microdiffusion							**Water**					
Blank (1011198-BLK1)					Prepared: 11/10/10 10:30		Analyzed: 11/10/10 16:00					
ASTM D 4282												
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	---	---	---	---	---	---	
LCS (1011198-BS1)					Prepared: 11/10/10 10:30		Analyzed: 11/10/10 16:00					
ASTM D 4282												
Cyanide, Free	0.0643	0.00200	0.00500	mg/L	1	0.0667	---	96	85-115%	---	---	
Duplicate (1011198-DUP1)					Prepared: 11/10/10 10:30		Analyzed: 11/10/10 16:06					
QC Source Sample: GS-110810-1 (A10K140-01)												
ASTM D 4282												
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	---	ND	---	---		20%	
Matrix Spike (1011198-MS1)					Prepared: 11/10/10 10:30		Analyzed: 11/10/10 16:06					
QC Source Sample: GS-110810-1 (A10K140-01)												
ASTM D 4282												
Cyanide, Free	0.0604	0.00200	0.00500	mg/L	1	0.0667	ND	91	80-120%	---	---	

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/03/10 10:28

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011233 - EPA 3015A							**Water**					
Blank (1011233-BLK1)					Prepared: 11/11/10 14:46		Analyzed: 11/12/10 15:19					
EPA 6020												
Calcium	**0.0336**	0.0250	0.100	mg/L	1	---	---	---	---	---	---	J
Iron	ND	0.0100	0.0500			---	---	---	---	---	---	
Magnesium	ND	0.0100	0.0500			---	---	---	---	---	---	
Manganese	ND	0.000333	0.00100			---	---	---	---	---	---	
Potassium	ND	0.0100	0.100			---	---	---	---	---	---	
Sodium	ND	0.0200	0.100			---	---	---	---	---	---	
LCS (1011233-BS1)					Prepared: 11/11/10 14:46		Analyzed: 11/12/10 15:22					
EPA 6020												
Calcium	5.59	0.0250	0.100	mg/L	1	5.56	---	101	80-120%	---	---	
Iron	5.58	0.0100	0.0500				---	100		---	---	
Magnesium	5.61	0.0100	0.0500				---	101		---	---	
Manganese	0.0526	0.000333	0.00100			0.0556	---	95		---	---	
Potassium	5.63	0.0100	0.100			5.56	---	101		---	---	
Sodium	5.58	0.0200	0.100				---	100		---	---	
Duplicate (1011233-DUP1)					Prepared: 11/11/10 14:46		Analyzed: 11/12/10 16:12					
QC Source Sample: GS-110810-1 (A10K140-01)												
EPA 6020												
Calcium	**73.5**	0.250	1.00	mg/L	10	---	71.6	---	---	3	20%	
Iron	**41.9**	0.100	0.500			---	40.5	---	---	3	20%	
Magnesium	**27.2**	0.100	0.500			---	26.3	---	---	3	20%	
Manganese	**3.11**	0.00333	0.0100			---	3.01	---	---	3	20%	
Potassium	**6.36**	0.100	1.00			---	6.23	---	---	2	20%	
Sodium	**17.8**	0.200	1.00			---	17.2	---	---	3	20%	
Matrix Spike (1011233-MS1)					Prepared: 11/11/10 14:46		Analyzed: 11/12/10 16:15					
QC Source Sample: GS-110810-1 (A10K140-01)												
EPA 6020												
Calcium	78.6	0.250	1.00	mg/L	10	5.56	71.6	126	75-125%	---	---	Q-03
Iron	46.7	0.100	0.500				40.5	112		---	---	
Magnesium	32.4	0.100	0.500				26.3	110			---	---
Manganese	3.10	0.00333	0.0100			0.0556	3.01	154		---	---	Q-02
Potassium	12.0	0.100	1.00			5.56	6.23	103		---	---	
Sodium	23.1	0.200	1.00				17.2	105		---	---	

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/03/10 10:28

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011233 - EPA 3015A							**Water**					
Matrix Spike (1011233-MS2)					Prepared: 11/11/10 14:46		Analyzed: 11/12/10 16:52					
QC Source Sample: Other (A10K177-01)												
EPA 6020												
Calcium	83.5	0.250	1.00	mg/L	10	5.56	76.5	126	75-125%	---	---	Q-03
Iron	48.4	0.100	0.500				42.4	107		---	---	
Magnesium	34.6	0.100	0.500				28.5	110		---	---	
Manganese	3.32	0.00333	0.0100			0.0556	3.24	152		---	---	Q-03
Potassium	12.5	0.100	1.00			5.56	6.69	104		---	---	
Sodium	24.0	0.200	1.00				18.2	104		---	---	
Post Spike (1011233-PS1)					Prepared: 11/12/10 16:58		Analyzed: 11/12/10 17:26					
QC Source Sample: GS-110810-1 (A10K140-01)												
EPA 6020												
Calcium	84200			ug/L	10	23300	60000	104	75-125%		---	
Post Spike (1011233-PS2)					Prepared: 11/12/10 16:58		Analyzed: 11/12/10 17:31					
QC Source Sample: Post Spike (A10K177-01)												
EPA 6020												
Calcium	84400			ug/L	10	22200	61200	104	75-125%		---	
Manganese	3470					889	2590	99	80-120%		---	
Post Spike (1011233-PS3)					Prepared: 11/15/10 21:40		Analyzed: 11/15/10 21:45					
QC Source Sample: GS-110810-1 (A10K140-01)												
EPA 6020												
Manganese	2060			ug/L	10	1000	1350	71	80-120%		---	Q-02

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/03/10 10:28

QUALITY CONTROL (QC) SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011223 - EPA 3015A - Dissolved							**Water**					
Blank (1011223-BLK1)					Prepared: 11/11/10 10:04		Analyzed: 11/11/10 16:18					
EPA 6020 (Diss)												
Calcium	ND	0.0250	0.100	mg/L	1	---	---	---	---	---	---	
Iron	ND	0.0100	0.0500			---	---	---	---	---	---	
Magnesium	ND	0.0100	0.0500			---	---	---	---	---	---	
Manganese	ND	0.000333	0.00100			---	---	---	---	---	---	
Potassium	**0.0157**	0.0100	0.100			---	---	---	---	---	---	J
Sodium	ND	0.0200	0.100			---	---	---	---	---	---	
Blank (1011223-BLK2)					Prepared: 11/11/10 10:04		Analyzed: 11/11/10 16:21					
EPA 6020 (Diss)												
Calcium	ND	0.0250	0.100	mg/L	1	---	---	---	---	---	---	
Iron	ND	0.0100	0.0500			---	---	---	---	---	---	
Magnesium	ND	0.0100	0.0500			---	---	---	---	---	---	
Manganese	ND	0.000333	0.00100			---	---	---	---	---	---	
Potassium	**0.0196**	0.0100	0.100			---	---	---	---	---	---	J
Sodium	ND	0.0200	0.100			---	---	---	---	---	---	
LCS (1011223-BS1)					Prepared: 11/11/10 10:04		Analyzed: 11/11/10 16:24					
EPA 6020 (Diss)												
Calcium	5.50	0.0250	0.100	mg/L	1	5.56	---	99	80-120%	---	---	
Iron	5.44	0.0100	0.0500				---	98		---	---	
Magnesium	5.63	0.0100	0.0500				---	101		---	---	
Manganese	0.0515	0.000333	0.00100			0.0556	---	93		---	---	
Potassium	5.70	0.0100	0.100			5.56	---	102	85-115%	---	---	
Sodium	5.61	0.0200	0.100				---	101	80-120%	---	---	
Duplicate (1011223-DUP1)					Prepared: 11/11/10 10:04		Analyzed: 11/11/10 16:39					
QC Source Sample: Other (A10K043-04)												
EPA 6020 (Diss)												
Calcium	**3.52**	0.0250	0.100	mg/L	1	---	3.42	---	---	3	20%	
Iron	**0.0382**	0.0100	0.0500			---	0.0432	---	---	12	20%	J
Magnesium	**3.17**	0.0100	0.0500			---	3.09	---	---	3	20%	
Manganese	**0.0127**	0.000333	0.00100			---	0.0126	---	---	1	20%	
Potassium	**0.839**	0.0100	0.100			---	0.810	---	---	4	20%	
Sodium	**2.73**	0.0200	0.100			---	2.66	---	---	2	20%	

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/03/10 10:28

QUALITY CONTROL (QC) SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011223 - EPA 3015A - Dissolved							**Water**					
Matrix Spike (1011223-MS1)					Prepared: 11/11/10 10:04		Analyzed: 11/11/10 16:42					
QC Source Sample: Other (A10K043-04)												
EPA 6020 (Diss)												
Calcium	9.05	0.0250	0.100	mg/L	1	5.56	3.42	101	75-125%	---	---	
Iron	5.51	0.0100	0.0500				0.0432	98		---	---	
Magnesium	8.75	0.0100	0.0500				3.09	102		---	---	
Manganese	0.0642	0.000333	0.00100			0.0556	0.0126	93		---	---	
Potassium	6.53	0.0100	0.100			5.56	0.810	103	70-130%	---	---	
Sodium	8.30	0.0200	0.100				2.66	101	75-125%	---	---	
Matrix Spike (1011223-MS2)					Prepared: 11/11/10 10:04		Analyzed: 11/11/10 17:46					
QC Source Sample: Other (A10K177-07)												
EPA 6020 (Diss)												
Iron	5.53	0.0100	0.0500	mg/L	1	5.56	0.132	97	75-125%	---	---	
Magnesium	7.80	0.0100	0.0500				2.07	103		---	---	
Manganese	0.0624	0.000333	0.00100			0.0556	0.0116	91			---	---
Potassium	6.96	0.0100	0.100			5.56	1.04	106	70-130%	---	---	
Sodium	10.6	0.0200	0.100				4.88	102	75-125%	---	---	
Matrix Spike (1011223-MS3)					Prepared: 11/11/10 10:04		Analyzed: 11/12/10 14:57					
QC Source Sample: Other (A10K177-07)												
EPA 6020 (Diss)												
Calcium	12.0	0.125	0.500	mg/L	5	5.56	6.55	97	75-125%	---	---	Q-16

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/03/10 10:28

QUALITY CONTROL (QC) SAMPLE RESULTS

Conventional Chemistry Parameters

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011197 - Method Prep: Aq							**Water**					
Blank (1011197-BLK1)						Prepared: 11/10/10 09:44	Analyzed: 11/10/10 11:30					
SM 2320 B												
Total Alkalinity	ND	20.0	20.0	mg CaCO3/L	1	---	---	---	---	---	---	
Bicarbonate Alkalinity	ND	20.0	20.0			---	---	---	---	---	---	
Carbonate Alkalinity	ND	20.0	20.0			---	---	---	---	---	---	
Hydroxide Alkalinity	ND	20.0	20.0			---	---	---	---	---	---	
LCS (1011197-BS1)						Prepared: 11/10/10 09:44	Analyzed: 11/10/10 11:30					
SM 2320 B												
Total Alkalinity	239	20.0	20.0	mg CaCO3/L	1	236	---	101	85-115%	---	---	
Bicarbonate Alkalinity	ND	20.0	20.0			0.00100	---		0-200%	---	---	
Carbonate Alkalinity	238	20.0	20.0			236	---	101		---	---	
Hydroxide Alkalinity	ND	20.0	20.0			0.00100	---			---	---	
Duplicate (1011197-DUP1)						Prepared: 11/10/10 09:44	Analyzed: 11/10/10 11:30					
QC Source Sample: Other (A10K155-07)												
SM 2320 B												
Total Alkalinity	**39.4**	20.0	20.0	mg CaCO3/L	1	---	47.0	---	---	18	20%	
Bicarbonate Alkalinity	**39.4**	20.0	20.0			---	47.0	---	---	18	20%	
Carbonate Alkalinity	ND	20.0	20.0			---	ND	---	---		20%	
Hydroxide Alkalinity	ND	20.0	20.0			---	ND	---	---		20%	

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/03/10 10:28

SAMPLE PREPARATION INFORMATION

Anions by EPA 300.0/9056A (Ion Chromatography)

Prep: Method Prep: Aq

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1011177							
A10K140-01	Water	300.0/9056A	11/08/10 12:30	11/09/10 13:31	10mL/10mL	10mL/10mL	1.00
A10K140-02	Water	300.0/9056A	11/08/10 12:20	11/09/10 13:31	10mL/10mL	10mL/10mL	1.00
A10K140-03	Water	300.0/9056A	11/08/10 13:00	11/09/10 13:31	10mL/10mL	10mL/10mL	1.00
A10K140-04	Water	300.0/9056A	11/08/10 12:25	11/09/10 13:31	10mL/10mL	10mL/10mL	1.00
A10K140-05	Water	300.0/9056A	11/08/10 13:30	11/09/10 13:31	10mL/10mL	10mL/10mL	1.00
Batch: 1011225							
A10K140-03RE1	Water	300.0/9056A	11/08/10 13:00	11/11/10 11:39	2mL/10mL	10mL/10mL	5.00

Cyanide - Total (Aqueous)

Prep: Latchat Micro Dist - aqueous

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1011322							
A10K140-01	Water	EPA 335.4	11/08/10 12:30	11/17/10 09:30	6mL/6mL	6mL/6mL	1.00
A10K140-02	Water	EPA 335.4	11/08/10 12:20	11/17/10 09:30	6mL/6mL	6mL/6mL	1.00
A10K140-03	Water	EPA 335.4	11/08/10 13:00	11/17/10 09:30	6mL/6mL	6mL/6mL	1.00
A10K140-04	Water	EPA 335.4	11/08/10 12:25	11/17/10 09:30	6mL/6mL	6mL/6mL	1.00
A10K140-05	Water	EPA 335.4	11/08/10 13:30	11/17/10 09:30	6mL/6mL	6mL/6mL	1.00
A10K140-05RE1	Water	EPA 335.4	11/08/10 13:30	11/17/10 09:30	6mL/6mL	6mL/6mL	1.00

Cyanide - Weak Acid Dissociable (WAD) (Aqueous)

Prep: Latchat Micro Dist - aqueous

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1011304							
A10K140-01	Water	SM 4500-CN (I/E)	11/08/10 12:30	11/16/10 09:27	6mL/6mL	6mL/6mL	1.00
A10K140-02	Water	SM 4500-CN (I/E)	11/08/10 12:20	11/16/10 09:27	6mL/6mL	6mL/6mL	1.00
A10K140-03	Water	SM 4500-CN (I/E)	11/08/10 13:00	11/16/10 09:27	6mL/6mL	6mL/6mL	1.00
A10K140-04	Water	SM 4500-CN (I/E)	11/08/10 12:25	11/16/10 09:27	6mL/6mL	6mL/6mL	1.00
A10K140-05	Water	SM 4500-CN (I/E)	11/08/10 13:30	11/16/10 09:27	6mL/6mL	6mL/6mL	1.00

Cyanide - Free (Aqueous)

Prep: Microdiffusion

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1011198							
A10K140-01	Water	ASTM D 4282	11/08/10 12:30	11/10/10 10:30	3mL/3mL	3mL/3mL	1.00

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503-718-0333 Fax

Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/03/10 10:28

SAMPLE PREPARATION INFORMATION

Cyanide - Free (Aqueous)

Prep: Microdiffusion

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
A10K140-02	Water	ASTM D 4282	11/08/10 12:20	11/10/10 10:30	3mL/3mL	3mL/3mL	1.00
A10K140-03	Water	ASTM D 4282	11/08/10 13:00	11/10/10 10:30	3mL/3mL	3mL/3mL	1.00
A10K140-04	Water	ASTM D 4282	11/08/10 12:25	11/10/10 10:30	3mL/3mL	3mL/3mL	1.00
A10K140-05	Water	ASTM D 4282	11/08/10 13:30	11/10/10 10:30	3mL/3mL	3mL/3mL	1.00

Total Metals by EPA 6020 (ICPMS)

Prep: EPA 3015A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1011233							
A10K140-01	Water	EPA 6020	11/08/10 12:30	11/11/10 14:46	45mL/50mL	45mL/50mL	1.00
A10K140-02	Water	EPA 6020	11/08/10 12:20	11/11/10 14:46	45mL/50mL	45mL/50mL	1.00
A10K140-03	Water	EPA 6020	11/08/10 13:00	11/11/10 14:46	45mL/50mL	45mL/50mL	1.00
A10K140-04	Water	EPA 6020	11/08/10 12:25	11/11/10 14:46	45mL/50mL	45mL/50mL	1.00
A10K140-05	Water	EPA 6020	11/08/10 13:30	11/11/10 14:46	45mL/50mL	45mL/50mL	1.00

Dissolved Metals by EPA 6020 (ICPMS)

Prep: EPA 3015A - Dissolved

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1011223							
A10K140-01	Water	EPA 6020 (Diss)	11/08/10 12:30	11/11/10 10:04	45mL/50mL	45mL/50mL	1.00
A10K140-02	Water	EPA 6020 (Diss)	11/08/10 12:20	11/11/10 10:04	45mL/50mL	45mL/50mL	1.00
A10K140-03	Water	EPA 6020 (Diss)	11/08/10 13:00	11/11/10 10:04	45mL/50mL	45mL/50mL	1.00
A10K140-04	Water	EPA 6020 (Diss)	11/08/10 12:25	11/11/10 10:04	45mL/50mL	45mL/50mL	1.00
A10K140-05	Water	EPA 6020 (Diss)	11/08/10 13:30	11/11/10 10:04	45mL/50mL	45mL/50mL	1.00

Conventional Chemistry Parameters

Prep: Method Prep: Aq

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1011197							
A10K140-01	Water	SM 2320 B	11/08/10 12:30	11/10/10 09:44	50mL/50mL	50mL/50mL	NA
A10K140-02	Water	SM 2320 B	11/08/10 12:20	11/10/10 09:44	50mL/50mL	50mL/50mL	NA
A10K140-03	Water	SM 2320 B	11/08/10 13:00	11/10/10 09:44	50mL/50mL	50mL/50mL	NA
A10K140-04	Water	SM 2320 B	11/08/10 12:25	11/10/10 09:44	50mL/50mL	50mL/50mL	NA
A10K140-05	Water	SM 2320 B	11/08/10 13:30	11/10/10 09:44	50mL/50mL	50mL/50mL	NA

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Darwin Thomas, Business Development Director

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/03/10 10:28

Notes and Definitions

Qualifiers:

J	Estimated Result . Result detected below the lowest point of the calibration curve, but above the specified MDL.
Q-01	Percent recovery and/or RPD is outside acceptance limits.
Q-02	Spike recovery is outside of established control limits due to sample matrix interference.
Q-03	Percent recovery and/or RPD is outside control limits due to the high concentration of analyte present in the sample.
Q-16	Reanalysis of an original Batch QC sample.
Q-17	RPD between original and duplicate sample is outside of established control limits.
R-08	Reporting level raised due to potential high bias associated with the low end of the calibration curve.

Notes and Conventions:

DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis. Results listed as 'wet' or without 'dry'designation are not dry weight corrected.
RPD	Relative Percent Difference
MDL	If MDL is not listed, data has been evaluated to the Method Reporting Limit only.
WMSC	Water Miscible Solvent Correction has been applied to Results and MRLs for volatiles soil samples per EPA 8000C.
Batch QC	In cases where there is insufficient sample provided for Sample Duplicates and/or Matrix Spikes, a Lab Control Sample Duplicate (LCS Dup) is analyzed to demonstrate accuracy and precision of the extraction and analysis.
Blank Policy	Apex assesses blank data for potential high bias down to a level equal to ½ the method reporting limit (MRL), except for conventional chemistry and HCID analyses which are assessed only to the MRL. Sample results flagged with a B or B-02 qualifier are potentially biased high if they are less than ten times the level found in the blank for inorganic analyses or less than five times the level found in the blank for organic analyses. For accurate comparison of volatile results to the level found in the blank; water sample results should be divided by the dilution factor, and soil sample results should be divided by 1/50 of the sample dilution to account for the sample prep factor. Results qualified as reported below the MRL may include a potential high bias if associated with a B or B-02 qualified blank. B and B-02 qualifications are not applied to J qualified results reported below the MRL.

Apex Laboratories

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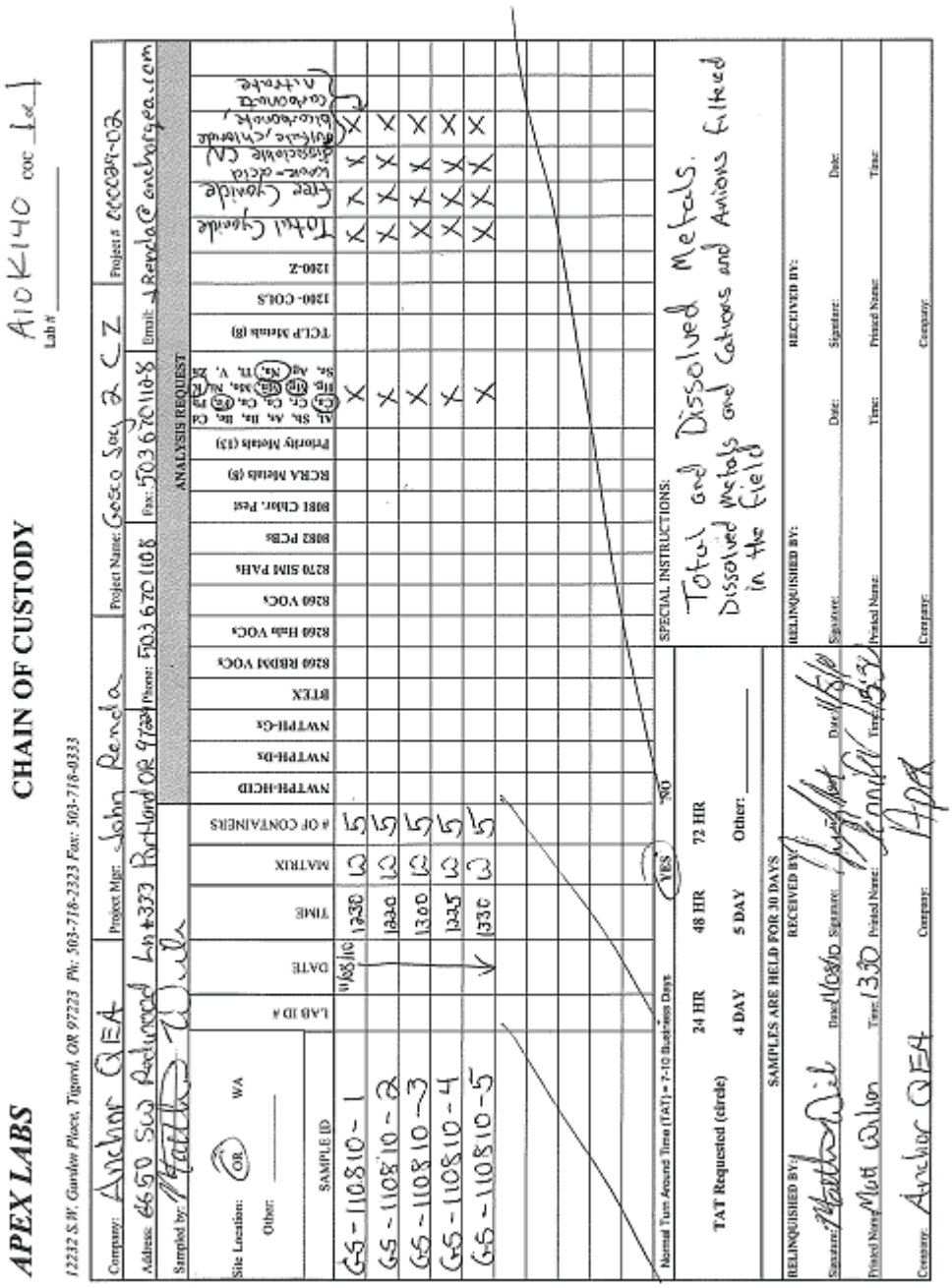
Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/03/10 10:28



APEX LABS — **CHAIN OF CUSTODY**

12232 S.W. Garden Place, Tigard, OR 97223 Ph: 503-718-2323 Fax: 503-718-0333

A10K140 coc 1of1

Lab #: _____

Company: Anchor QEA | Project Mgr.: John Renda | Project Name: Gasco Seq 2 C 2 | Project #: 000029-02

Address: 6650 SW Redwood Ln #333 Portland OR 97224 | Phone: 503 670 1108 | Fax: 503 670 1108 | Email: JRenda@anchorqea.com

Sampled by: Matthew Wilder

Site Location: (OR) WA

Other: _____

ANALYSIS REQUEST

SAMPLE ID	LAB ID #	DATE	TIME	MATRIX	# OF CONTAINERS	NWTPH-HCID	NWTPH-Dx	NWTPH-Gx	BTEX	8260 RBDM VOCs	8260 Halo VOCs	8260 VOCs	8270 SIM PAHs	8082 PCBs	8081 Chlor. Pest	RCRA Metals (8)	Priority Metals (13)	Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Hg, Mo, Ni, K, Se, Ag, Na, Tl, V, Zn	TCLP Metals (8)	1200-COLS	1200-Z	Total Cyanide	Free Cyanide	Sulfide-Acid Insoluble (CN)	Sulfide/Chloride Distillable Cyanide	Cyanide Amenable to Chlorine
GS-110810-1		11/08/10	1330	W	5													X				X	X	X	X	X	
GS-110810-2			1320	W	5													X				X	X	X	X	X	
GS-110810-3			1300	W	5													X				X	X	X	X	X	
GS-110810-4			1225	W	5													X				X	X	X	X	X	
GS-110810-5			1330	W	5													X				X	X	X	X	X	

Normal Turn Around Time (TAT) = 7-10 Business Days — YES / NO

TAT Requested (circle): 24 HR, 48 HR, 72 HR, 4 DAY, 5 DAY, Other: _____

SPECIAL INSTRUCTIONS: Total and Dissolved Metals. Dissolved Metals and Cations and Anions Filtered in the Field

SAMPLES ARE HELD FOR 30 DAYS

RELINQUISHED BY: Signature: Matthew Wilder Date: 11/08/10 Time: 1330 Printed Name: Matt Wilder Company: Anchor QEA

RECEIVED BY: Signature: [illegible] Date: 11/8/10 Time: 1330 Printed Name: [illegible] Company: APEX

RELINQUISHED BY: Signature: _____ Date: _____ Time: _____ Printed Name: _____ Company: _____

RECEIVED BY: Signature: _____ Date: _____ Time: _____ Printed Name: _____ Company: _____

12232 S.W. Garden Place
Tigard, OR 97223
503-718-2323 Phone
503-718-0333 Fax

Anchor QEA, LLC Portland 6650 SW Redwood Lane Ste. 333 Portland, OR 97224	Project: **GASCO-1DW-SEQ 2 C 2** Project Number: 000029-02 Project Manager: John Renda	**Reported:** 12/03/10 10:28

APEX LABS COOLER RECEIPT FORM

Client: Anchor Element WO#: A10 K140

Project/Project #: Gasco Seg 2 C2 / 000029-02

Delivery info:

Date/Time Received: 11/8/10 @ 15:30 By: JS

Delivered by: Apex Courier ✓ Client ___ FedEx ___ UPS ___ DHL ___ Other ___

Courier/Client Name or Air Bill # ___

Cooler Inspection Inspected by: JS @ 17:05

Chain of Custody:

Included? Yes ✓ No ___ Signed/Dated by Client? Yes ✓ No ___

Signed/Dated by Apex Personnel? Yes ✓ No ___

Coolers: No. of Coolers: 1

	Cooler #1	Cooler #2	Cooler #3	Cooler #4
Temperature (deg. C)	4.1	5.7		
Received on Ice? (Y/N)	y	y		
Temp. Blanks? (Y/N)	N	N		
Ice Type: (Gel/Real/Other)	real	real		
Condition:	frozen ice	frozen ice		

Samples Inspection: Inspected by: JS @ 17:30

All Samples Intact? Yes ✓ No ___ Comments: ___

Bottle Labels/COCs agree? Yes ✓ No ___ Comments: ___

Containers Appropriate for Analysis? Yes ✓ No ___ Comments: ___

Do VOA Vials have Visible Headspace? Yes ___ No ✓ NA ___

Comments ___

Water Samples: pH Checked and Appropriate (except VOAs): Yes ✓ No ___ NA ___

Comments: ___

Additional Information:

Apex Labs

12232 S.W. Garden Place
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503-718-2323 Phone
503-718-0333 Fax

Wednesday, December 15, 2010

John Renda
Anchor QEA, LLC Portland
6650 SW Redwood Lane Ste. 333
Portland, OR 97224

RE: GASCO-1DW-SEQ 2 C 2 / 000029-02.28 3A

Enclosed are the results of analyses for work order A10K177, which was received by the laboratory on 11/10/2010 at 10:40:00AM.

Thank you for using Apex Labs. We appreciate your business and strive to provide the highest quality services to the environmental industry.

If you have any questions concerning this report or the services we offer, please feel free to contact me by email at: dthomas@apex-labs.com, or by phone at 503-718-2323.

Apex Laboratories

Darwin Thomas, Business Development Director

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
GS-111010-6	A10K177-01	Water	11/10/10 07:30	11/10/10 10:40
GS-111010-7	A10K177-02	Water	11/10/10 07:35	11/10/10 10:40
GS-111010-8	A10K177-03	Water	11/10/10 07:45	11/10/10 10:40
GS-111010-9	A10K177-04	Water	11/10/10 07:50	11/10/10 10:40
GS-111010-10	A10K177-05	Water	11/10/10 08:10	11/10/10 10:40
GS-111010-11	A10K177-06	Water	11/10/10 08:30	11/10/10 10:40
GS-111010-12	A10K177-07	Water	11/10/10 09:00	11/10/10 10:40

Apex Laboratories

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

ANALYTICAL CASE NARRATIVE

Work Order: A10K177

-- Total Metals --

Sample GS-111010-12 has two sets of results reported for total metals.

Two nitric acid preserved 250 mL poly bottles were received for this sample, and Apex was unable to determine which bottle had been field filtered for dissolved metals. The dissolved metals for this sample are reported from a lab filtered bottle. Both of the nitric bottles received were digested and analyzed for total metals, and the results from both tests are reported. One result reflects total metals, the other field filtered dissolved metals. A comparison with the lab filtered dissolved metals indicates that results reported as A10K177-07RE1 are probably from the field filtered bottle.

Evan Holloway
QA Manager
December 3, 2010

Apex Labs

12232 S.W. Garden Place
Tigard, OR 97223
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503-718-0333 Fax

Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

ANALYTICAL SAMPLE RESULTS

Anions by EPA 300.0/9056A (Ion Chromatography)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-111010-6 (A10K177-01)			**Matrix: Water**		**Batch: 1011225**			
Chloride	**7.30**	1.00	1.00	mg/L	1	11/11/10 15:11	300.0/9056A	
Nitrate-Nitrogen	ND	0.250	0.250					
Sulfate	**24.2**	1.00	1.00					
GS-111010-7 (A10K177-02)			**Matrix: Water**		**Batch: 1011225**			
Chloride	**8.01**	1.00	1.00	mg/L	1	11/11/10 15:32	300.0/9056A	
Nitrate-Nitrogen	ND	0.250	0.250					
Sulfate	ND	1.00	1.00					
GS-111010-8 (A10K177-03)			**Matrix: Water**		**Batch: 1011225**			
Nitrate-Nitrogen	ND	0.250	0.250	mg/L	1	11/11/10 16:15	300.0/9056A	
Sulfate	**13.0**	1.00	1.00					
GS-111010-8 (A10K177-03RE1)			**Matrix: Water**		**Batch: 1011225**			
Chloride	**54.2**	5.00	5.00	mg/L	1	11/12/10 05:23	300.0/9056A	
GS-111010-9 (A10K177-04)			**Matrix: Water**		**Batch: 1011225**			
Nitrate-Nitrogen	ND	0.250	0.250	mg/L	1	11/11/10 16:35	300.0/9056A	
Sulfate	**13.0**	1.00	1.00					
GS-111010-9 (A10K177-04RE1)			**Matrix: Water**		**Batch: 1011225**			
Chloride	**53.7**	5.00	5.00	mg/L	1	11/12/10 05:44	300.0/9056A	
GS-111010-10 (A10K177-05)			**Matrix: Water**		**Batch: 1011225**			
Chloride	**17.6**	1.00	1.00	mg/L	1	11/11/10 16:56	300.0/9056A	
Nitrate-Nitrogen	ND	0.250	0.250					
Sulfate	ND	1.00	1.00					
GS-111010-11 (A10K177-06)			**Matrix: Water**		**Batch: 1011225**			
Chloride	ND	1.00	1.00	mg/L	1	11/11/10 17:16	300.0/9056A	
Nitrate-Nitrogen	ND	0.250	0.250					
Sulfate	ND	1.00	1.00					
GS-111010-12 (A10K177-07)			**Matrix: Water**		**Batch: 1011225**			
Chloride	**4.29**	1.00	1.00	mg/L	1	11/11/10 18:18	300.0/9056A	
Nitrate-Nitrogen	**0.572**	0.250	0.250					
Sulfate	**3.44**	1.00	1.00					

Apex Laboratories

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

ANALYTICAL SAMPLE RESULTS

Cyanide - Total (Aqueous)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-111010-6 (A10K177-01)			**Matrix: Water**		**Batch: 1011398**			
Cyanide, Total	**0.0742**	0.00500	0.00500	mg/L	1	11/19/10 15:43	EPA 335.4	
GS-111010-7 (A10K177-02)			**Matrix: Water**		**Batch: 1011398**			
Cyanide, Total	**0.0877**	0.00500	0.00500	mg/L	1	11/19/10 15:45	EPA 335.4	
GS-111010-8 (A10K177-03)			**Matrix: Water**		**Batch: 1011398**			
Cyanide, Total	**0.0709**	0.00500	0.00500	mg/L	1	11/19/10 15:46	EPA 335.4	
GS-111010-9 (A10K177-04)			**Matrix: Water**		**Batch: 1011398**			
Cyanide, Total	**0.0659**	0.00500	0.00500	mg/L	1	11/19/10 15:48	EPA 335.4	
GS-111010-10 (A10K177-05)			**Matrix: Water**		**Batch: 1011398**			
Cyanide, Total	**0.165**	0.00500	0.00500	mg/L	1	11/19/10 15:49	EPA 335.4	
GS-111010-11 (A10K177-06)			**Matrix: Water**		**Batch: 1011398**			
Cyanide, Total	**0.00820**	0.00500	0.00500	mg/L	1	11/19/10 15:57	EPA 335.4	
GS-111010-12 (A10K177-07)			**Matrix: Water**		**Batch: 1011398**			
Cyanide, Total	**0.00760**	0.00500	0.00500	mg/L	1	11/19/10 15:58	EPA 335.4	

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

ANALYTICAL SAMPLE RESULTS

Cyanide - Weak Acid Dissociable (WAD) (Aqueous)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-111010-6 (A10K177-01)			**Matrix: Water**		**Batch: 1011304**			
Cyanide, WAD	**0.0141**	0.00500	0.0100	mg/L	1	11/16/10 17:02	SM 4500-CN (I/E)	R-08
GS-111010-7 (A10K177-02)			**Matrix: Water**		**Batch: 1011304**			
Cyanide, WAD	**0.0249**	0.00500	0.0100	mg/L	1	11/16/10 17:07	SM 4500-CN (I/E)	R-08
GS-111010-8 (A10K177-03)			**Matrix: Water**		**Batch: 1011304**			
Cyanide, WAD	**0.0278**	0.00500	0.0100	mg/L	1	11/16/10 17:08	SM 4500-CN (I/E)	R-08
GS-111010-9 (A10K177-04)			**Matrix: Water**		**Batch: 1011304**			
Cyanide, WAD	**0.0334**	0.00500	0.0100	mg/L	1	11/16/10 17:10	SM 4500-CN (I/E)	R-08
GS-111010-10 (A10K177-05)			**Matrix: Water**		**Batch: 1011304**			
Cyanide, WAD	**0.0416**	0.00500	0.0100	mg/L	1	11/16/10 17:11	SM 4500-CN (I/E)	R-08
GS-111010-11 (A10K177-06)			**Matrix: Water**		**Batch: 1011304**			
Cyanide, WAD	**0.0273**	0.00500	0.0100	mg/L	1	11/16/10 17:13	SM 4500-CN (I/E)	R-08
GS-111010-12 (A10K177-07)			**Matrix: Water**		**Batch: 1011304**			
Cyanide, WAD	**0.0351**	0.00500	0.0100	mg/L	1	11/16/10 17:14	SM 4500-CN (I/E)	R-08

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

ANALYTICAL SAMPLE RESULTS

Cyanide - Free (Aqueous)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-111010-6 (A10K177-01)			**Matrix: Water**		**Batch: 1011230**			
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	11/11/10 19:03	ASTM D 4282	
GS-111010-7 (A10K177-02)			**Matrix: Water**		**Batch: 1011230**			
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	11/11/10 19:11	ASTM D 4282	
GS-111010-8 (A10K177-03)			**Matrix: Water**		**Batch: 1011230**			
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	11/11/10 19:11	ASTM D 4282	
GS-111010-9 (A10K177-04)			**Matrix: Water**		**Batch: 1011230**			
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	11/11/10 19:11	ASTM D 4282	
GS-111010-10 (A10K177-05)			**Matrix: Water**		**Batch: 1011230**			
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	11/11/10 19:12	ASTM D 4282	
GS-111010-11 (A10K177-06)			**Matrix: Water**		**Batch: 1011230**			
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	11/11/10 19:19	ASTM D 4282	
GS-111010-12 (A10K177-07)			**Matrix: Water**		**Batch: 1011230**			
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	11/11/10 19:20	ASTM D 4282	

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-111010-6 (A10K177-01)			**Matrix: Water**		**Batch: 1011233**			
Calcium	**76.5**	0.250	1.00	mg/L	10	11/12/10 16:48	EPA 6020	
Iron	**42.4**	0.100	0.500					
Magnesium	**28.5**	0.100	0.500					
Manganese	**3.24**	0.00333	0.0100					
Potassium	**6.69**	0.100	1.00					
Sodium	**18.2**	0.200	1.00					
GS-111010-7 (A10K177-02)			**Matrix: Water**		**Batch: 1011233**			
Calcium	**64.1**	0.250	1.00	mg/L	10	11/12/10 16:55	EPA 6020	
Iron	**41.1**	0.100	0.500					
Magnesium	**23.9**	0.100	0.500					
Manganese	**4.25**	0.00333	0.0100					
Potassium	**5.17**	0.100	1.00					
Sodium	**15.9**	0.200	1.00					
GS-111010-8 (A10K177-03)			**Matrix: Water**		**Batch: 1011233**			
Calcium	**55.7**	0.250	1.00	mg/L	10	11/12/10 16:58	EPA 6020	
Iron	**20.9**	0.100	0.500					
Magnesium	**33.3**	0.100	0.500					
Manganese	**1.96**	0.00333	0.0100					
Potassium	**3.03**	0.100	1.00					
Sodium	**54.8**	0.200	1.00					
GS-111010-9 (A10K177-04)			**Matrix: Water**		**Batch: 1011233**			
Calcium	**56.1**	0.250	1.00	mg/L	10	11/12/10 17:01	EPA 6020	
Iron	**20.5**	0.100	0.500					
Magnesium	**33.2**	0.100	0.500					
Manganese	**1.94**	0.00333	0.0100					
Potassium	**3.03**	0.100	1.00					
Sodium	**54.8**	0.200	1.00					
GS-111010-10 (A10K177-05)			**Matrix: Water**		**Batch: 1011233**			
Calcium	**56.2**	0.250	1.00	mg/L	10	11/12/10 17:03	EPA 6020	
Iron	**41.1**	0.100	0.500					
Magnesium	**28.2**	0.100	0.500					
Manganese	**3.16**	0.00333	0.0100					
Potassium	**3.46**	0.100	1.00					
Sodium	**15.3**	0.200	1.00					

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-111010-11 (A10K177-06)			**Matrix: Water**		**Batch: 1011233**			
Calcium	**0.0478**	0.0250	0.100	mg/L	1	11/12/10 17:07	EPA 6020	J
Iron	ND	0.0100	0.0500					
Magnesium	ND	0.0100	0.0500					
Manganese	ND	0.000333	0.00100					
Potassium	**0.0139**	0.0100	0.100					J
Sodium	**0.0461**	0.0200	0.100					J
GS-111010-12 (A10K177-07)			**Matrix: Water**		**Batch: 1011233**			
Calcium	**6.64**	0.0250	0.100	mg/L	1	11/12/10 17:10	EPA 6020	X
Iron	**0.431**	0.0100	0.0500					X
Magnesium	**2.20**	0.0100	0.0500					X
Manganese	**0.0214**	0.000333	0.00100					X
Potassium	**1.06**	0.0100	0.100					X
Sodium	**5.01**	0.0200	0.100					X
GS-111010-12 (A10K177-07RE1)			**Matrix: Water**		**Batch: 1011233**			
Calcium	**6.37**	0.0250	0.100	mg/L	1	11/12/10 17:13	EPA 6020	X
Iron	**0.156**	0.0100	0.0500					X
Magnesium	**2.10**	0.0100	0.0500					X
Manganese	**0.0133**	0.000333	0.00100					X
Potassium	**1.01**	0.0100	0.100					X
Sodium	**4.86**	0.0200	0.100					X

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

ANALYTICAL SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-111010-6 (A10K177-01)			**Matrix: Water**		**Batch: 1011223**			
Calcium	**79.3**	0.250	1.00	mg/L	10	11/12/10 14:36	EPA 6020 (Diss)	
Iron	**43.5**	0.100	0.500					
Magnesium	**29.0**	0.100	0.500					
Manganese	**3.32**	0.00333	0.0100					
Potassium	**6.83**	0.0100	0.100	"	1	11/11/10 17:19		
Sodium	**18.3**	0.200	1.00	"	10	11/12/10 14:36		
GS-111010-7 (A10K177-02)			**Matrix: Water**		**Batch: 1011223**			
Calcium	**64.6**	0.250	1.00	mg/L	10	11/12/10 14:39	EPA 6020 (Diss)	
Iron	**42.0**	0.100	0.500					
Magnesium	**23.6**	0.100	0.500					
Manganese	**4.36**	0.00333	0.0100					
Potassium	**5.00**	0.100	1.00					
Sodium	**15.5**	0.200	1.00					
GS-111010-8 (A10K177-03)			**Matrix: Water**		**Batch: 1011223**			
Calcium	**59.0**	0.250	1.00	mg/L	10	11/12/10 14:42	EPA 6020 (Diss)	
Iron	**21.4**	0.100	0.500					
Magnesium	**34.7**	0.100	0.500					
Manganese	**2.00**	0.00333	0.0100					
Potassium	**2.97**	0.100	1.00					
Sodium	**56.6**	0.200	1.00					
GS-111010-9 (A10K177-04)			**Matrix: Water**		**Batch: 1011223**			
Calcium	**58.3**	0.250	1.00	mg/L	10	11/12/10 14:45	EPA 6020 (Diss)	
Iron	**21.2**	0.100	0.500					
Magnesium	**33.9**	0.100	0.500					
Manganese	**1.98**	0.00333	0.0100					
Potassium	**2.94**	0.100	1.00					
Sodium	**55.5**	0.200	1.00					
GS-111010-10 (A10K177-05)			**Matrix: Water**		**Batch: 1011223**			
Calcium	**58.8**	0.250	1.00	mg/L	10	11/12/10 14:48	EPA 6020 (Diss)	
Iron	**42.7**	0.100	0.500					
Magnesium	**29.2**	0.100	0.500					
Manganese	**3.28**	0.00333	0.0100					
Potassium	**3.53**	0.100	1.00					
Sodium	**15.6**	0.200	1.00					

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

ANALYTICAL SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-111010-11 (A10K177-06)			**Matrix: Water**		**Batch: 1011223**			
Calcium	**0.0306**	0.0250	0.100	mg/L	1	11/12/10 14:51	EPA 6020 (Diss)	J
Iron	**0.0162**	0.0100	0.0500	"		11/11/10 17:40		J
Magnesium	ND	0.0100	0.0500			11/12/10 14:51		
Manganese	**0.000467**	0.000333	0.00100					J
Potassium	ND	0.0100	0.100					
Sodium	ND	0.0200	0.100					
GS-111010-12 (A10K177-07)			**Matrix: Water**		**Batch: 1011223**			
Calcium	**6.55**	0.0250	0.100	mg/L	1	11/11/10 17:43	EPA 6020 (Diss)	
Iron	**0.132**	0.0100	0.0500					
Magnesium	**2.07**	0.0100	0.0500					
Manganese	**0.0116**	0.000333	0.00100	"		11/12/10 14:54		
Potassium	**1.04**	0.0100	0.100	"		11/11/10 17:43		
Sodium	**4.88**	0.0200	0.100					

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

ANALYTICAL SAMPLE RESULTS

Conventional Chemistry Parameters

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-111010-6 (A10K177-01)			**Matrix: Water**		**Batch: 1011277**			
Total Alkalinity	**347**	20.0	20.0	mg CaCO3/L	1	11/14/10 14:00	SM 2320 B	
Bicarbonate Alkalinity	**347**	20.0	20.0					
Carbonate Alkalinity	ND	20.0	20.0					
Hydroxide Alkalinity	ND	20.0	20.0					
GS-111010-7 (A10K177-02)			**Matrix: Water**		**Batch: 1011277**			
Total Alkalinity	**320**	20.0	20.0	mg CaCO3/L	1	11/14/10 14:00	SM 2320 B	
Bicarbonate Alkalinity	**320**	20.0	20.0					
Carbonate Alkalinity	ND	20.0	20.0					
Hydroxide Alkalinity	ND	20.0	20.0					
GS-111010-8 (A10K177-03)			**Matrix: Water**		**Batch: 1011277**			
Total Alkalinity	**327**	20.0	20.0	mg CaCO3/L	1	11/14/10 14:00	SM 2320 B	
Bicarbonate Alkalinity	**327**	20.0	20.0					
Carbonate Alkalinity	ND	20.0	20.0					
Hydroxide Alkalinity	ND	20.0	20.0					
GS-111010-9 (A10K177-04)			**Matrix: Water**		**Batch: 1011277**			
Total Alkalinity	**318**	20.0	20.0	mg CaCO3/L	1	11/14/10 14:00	SM 2320 B	
Bicarbonate Alkalinity	**318**	20.0	20.0					
Carbonate Alkalinity	ND	20.0	20.0					
Hydroxide Alkalinity	ND	20.0	20.0					
GS-111010-10 (A10K177-05)			**Matrix: Water**		**Batch: 1011277**			
Total Alkalinity	**306**	20.0	20.0	mg CaCO3/L	1	11/14/10 14:00	SM 2320 B	
Bicarbonate Alkalinity	**306**	20.0	20.0					
Carbonate Alkalinity	ND	20.0	20.0					
Hydroxide Alkalinity	ND	20.0	20.0					
GS-111010-11 (A10K177-06)			**Matrix: Water**		**Batch: 1011277**			
Total Alkalinity	ND	20.0	20.0	mg CaCO3/L	1	11/14/10 14:00	SM 2320 B	
Bicarbonate Alkalinity	ND	20.0	20.0					
Carbonate Alkalinity	ND	20.0	20.0					
Hydroxide Alkalinity	ND	20.0	20.0					
GS-111010-12 (A10K177-07)			**Matrix: Water**		**Batch: 1011277**			
Total Alkalinity	**27.6**	20.0	20.0	mg CaCO3/L	1	11/14/10 14:00	SM 2320 B	
Bicarbonate Alkalinity	**27.6**	20.0	20.0					
Carbonate Alkalinity	ND	20.0	20.0					
Hydroxide Alkalinity	ND	20.0	20.0					

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

QUALITY CONTROL (QC) SAMPLE RESULTS

Anions by EPA 300.0/9056A (Ion Chromatography)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011225 - Method Prep: Aq							**Water**					
Blank (1011225-BLK1)					Prepared: 11/11/10 11:39		Analyzed: 11/12/10 01:58					
300.0/9056A												
Chloride	ND	1.00	1.00	mg/L	1	---	---	---	---	---	---	
Nitrate-Nitrogen	ND	0.250	0.250			---	---	---	---	---	---	
Sulfate	ND	1.00	1.00			---	---	---	---	---	---	
LCS (1011225-BS1)					Prepared: 11/11/10 11:39		Analyzed: 11/12/10 02:19					
300.0/9056A												
Chloride	3.67	1.00	1.00	mg/L	1	4.00	---	92	90-110%	---	---	
Nitrate-Nitrogen	0.908	0.250	0.250			1.00	---	91		---	---	
Sulfate	4.33	1.00	1.00			4.00	---	108		---	---	
Duplicate (1011225-DUP1)					Prepared: 11/11/10 11:39		Analyzed: 11/12/10 02:40					
QC Source Sample: Other (A10K151-01RE1)												
300.0/9056A												
Chloride	**31.7**	5.00	5.00	mg/L	1	---	31.6	---	---	0.5	15%	
Nitrate-Nitrogen	**2.50**	1.25	1.25			---	2.50	---	---	0.2	15%	
Sulfate	**110**	5.00	5.00			---	110	---	---	0.3	15%	
Duplicate (1011225-DUP2)					Prepared: 11/11/10 11:39		Analyzed: 11/12/10 04:02					
QC Source Sample: GS-111010-11 (A10K177-06)												
300.0/9056A												
Chloride	ND	1.00	1.00	mg/L	1	---	ND	---	---		15%	
Nitrate-Nitrogen	ND	0.250	0.250			---	ND	---	---		15%	
Sulfate	ND	1.00	1.00			---	ND	---	---		15%	
Matrix Spike (1011225-MS1)					Prepared: 11/11/10 11:39		Analyzed: 11/12/10 03:00					
QC Source Sample: Other (A10K151-01RE1)												
300.0/9056A												
Chloride	51.4	5.00	5.00	mg/L	1	20.0	31.6	99	80-120%	---	---	
Nitrate-Nitrogen	7.20	1.25	1.25			5.00	2.50	94		---	---	
Sulfate	130	5.00	5.00			20.0	110	97		---	---	
Matrix Spike (1011225-MS2)					Prepared: 11/11/10 11:39		Analyzed: 11/12/10 04:22					
QC Source Sample: GS-111010-11 (A10K177-06)												
300.0/9056A												
Chloride	4.23	1.11	1.11	mg/L	1	4.44	ND	95	80-120%	---	---	

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

QUALITY CONTROL (QC) SAMPLE RESULTS

Anions by EPA 300.0/9056A (Ion Chromatography)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011225 - Method Prep: Aq							**Water**					
Matrix Spike (1011225-MS2)						Prepared: 11/11/10 11:39	Analyzed: 11/12/10 04:22					
QC Source Sample: GS-111010-11 (A10K177-06)												
Nitrate-Nitrogen	1.04	0.278	0.278	mg/L		1.11	ND	94		---	---	
Sulfate	4.88	1.11	1.11			4.44	ND	110		---	---	

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

QUALITY CONTROL (QC) SAMPLE RESULTS

Cyanide - Total (Aqueous)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011398 - Latchat Micro Dist - aqueous							**Water**					
Blank (1011398-BLK1)					Prepared: 11/19/10 11:28		Analyzed: 11/19/10 15:36					
EPA 335.4												
Cyanide, Total	ND	0.00500	0.00500	mg/L	1	---	---	---	---	---	---	B-02
LCS (1011398-BS1)					Prepared: 11/19/10 11:28		Analyzed: 11/19/10 15:37					
EPA 335.4												
Cyanide, Total	0.216	0.00500	0.00500	mg/L	1	0.200	---	108	90-110%	---	---	
Duplicate (1011398-DUP1)					Prepared: 11/19/10 11:28		Analyzed: 11/19/10 15:40					
QC Source Sample: Other (A10K143-01)												
EPA 335.4												
Cyanide, Total	**0.00620**	0.00500	0.00500	mg/L	1	---	0.00590	---	---	5	10%	
Duplicate (1011398-DUP2)					Prepared: 11/19/10 11:28		Analyzed: 11/19/10 16:13					
QC Source Sample: Other (A10K283-02)												
EPA 335.4												
Cyanide, Total	**0.160**	0.00500	0.00500	mg/L	1	---	0.179	---	---	11	10%	Q-01
Matrix Spike (1011398-MS1)					Prepared: 11/19/10 11:28		Analyzed: 11/19/10 15:42					
QC Source Sample: Other (A10K143-01)												
EPA 335.4												
Cyanide, Total	0.197	0.00510	0.00510	mg/L	1	0.204	0.00590	93	90-110%	---	---	
Matrix Spike (1011398-MS2)					Prepared: 11/19/10 11:28		Analyzed: 11/19/10 16:18					
QC Source Sample: Other (A10K283-02)												
EPA 335.4												
Cyanide, Total	0.393	0.00510	0.00510	mg/L	1	0.204	0.179	105	90-110%	---	---	

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

QUALITY CONTROL (QC) SAMPLE RESULTS

Cyanide - Weak Acid Dissociable (WAD) (Aqueous)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011304 - Latchat Micro Dist - aqueous							**Water**					
Blank (1011304-BLK1)					Prepared: 11/16/10 09:27		Analyzed: 11/16/10 16:46					
SM 4500-CN (I/E)												
Cyanide, WAD	ND	0.00500	0.0100	mg/L	1	---	---	---	---	---	---	R-08
LCS (1011304-BS2)					Prepared: 11/16/10 09:27		Analyzed: 11/16/10 17:32					
SM 4500-CN (I/E)												
Cyanide, WAD	0.214	0.0300	0.0600	mg/L	6	0.200	---	107	90-110%	---	---	R-08
Duplicate (1011304-DUP1)					Prepared: 11/16/10 09:27		Analyzed: 11/16/10 16:50					
QC Source Sample: Other (A10K140-01)												
SM 4500-CN (I/E)												
Cyanide, WAD	**0.0190**	0.00500	0.0100	mg/L	1	---	0.0282	---	---	39	10%	Q-17, R-08
Duplicate (1011304-DUP2)					Prepared: 11/16/10 09:27		Analyzed: 11/16/10 17:29					
QC Source Sample: Other (A10K200-05)												
SM 4500-CN (I/E)												
Cyanide, WAD	**0.0339**	0.00500	0.0100	mg/L	1	---	0.0387	---	---	13	10%	Q-17, R-08
Matrix Spike (1011304-MS1)					Prepared: 11/16/10 09:27		Analyzed: 11/16/10 16:52					
QC Source Sample: Other (A10K140-01)												
SM 4500-CN (I/E)												
Cyanide, WAD	0.210	0.00521	0.0104	mg/L	1	0.208	0.0282	87	80-120%	---	---	R-08
Matrix Spike (1011304-MS2)					Prepared: 11/16/10 09:27		Analyzed: 11/16/10 17:31					
QC Source Sample: Other (A10K200-05)												
SM 4500-CN (I/E)												
Cyanide, WAD	0.227	0.00521	0.0104	mg/L	1	0.208	0.0387	90	80-120%	---	---	R-08

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

QUALITY CONTROL (QC) SAMPLE RESULTS

Cyanide - Free (Aqueous)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011230 - Microdiffusion							**Water**					
Blank (1011230-BLK1)					Prepared: 11/11/10 14:05		Analyzed: 11/11/10 18:56					
ASTM D 4282												
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	---	---	---	---	---	---	
LCS (1011230-BS1)					Prepared: 11/11/10 14:05		Analyzed: 11/11/10 19:02					
ASTM D 4282												
Cyanide, Free	0.103	0.00200	0.00500	mg/L	1	0.100	---	103	85-115%	---	---	
Duplicate (1011230-DUP1)					Prepared: 11/11/10 14:05		Analyzed: 11/11/10 19:03					
QC Source Sample: GS-111010-6 (A10K177-01)												
ASTM D 4282												
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	---	ND	---	---		20%	
Matrix Spike (1011230-MS1)					Prepared: 11/11/10 14:05		Analyzed: 11/11/10 19:04					
QC Source Sample: GS-111010-6 (A10K177-01)												
ASTM D 4282												
Cyanide, Free	0.0651	0.00203	0.00507	mg/L	1	0.0676	ND	96	80-120%	---	---	

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011233 - EPA 3015A							**Water**					
Blank (1011233-BLK1)					Prepared: 11/11/10 14:46		Analyzed: 11/12/10 15:19					
EPA 6020												
Calcium	**0.0336**	0.0250	0.100	mg/L	1	---	---	---	---	---	---	J
Iron	ND	0.0100	0.0500			---	---	---	---	---	---	
Magnesium	ND	0.0100	0.0500			---	---	---	---	---	---	
Manganese	ND	0.000333	0.00100			---	---	---	---	---	---	
Potassium	ND	0.0100	0.100			---	---	---	---	---	---	
Sodium	ND	0.0200	0.100			---	---	---	---	---	---	
LCS (1011233-BS1)					Prepared: 11/11/10 14:46		Analyzed: 11/12/10 15:22					
EPA 6020												
Calcium	5.59	0.0250	0.100	mg/L	1	5.56	---	101	80-120%	---	---	
Iron	5.58	0.0100	0.0500				---	100		---	---	
Magnesium	5.61	0.0100	0.0500				---	101		---	---	
Manganese	0.0526	0.000333	0.00100			0.0556	---	95		---	---	
Potassium	5.63	0.0100	0.100			5.56	---	101		---	---	
Sodium	5.58	0.0200	0.100				---	100		---	---	
Duplicate (1011233-DUP1)					Prepared: 11/11/10 14:46		Analyzed: 11/12/10 16:12					
QC Source Sample: Other (A10K140-01)												
EPA 6020												
Calcium	**73.5**	0.250	1.00	mg/L	10	---	71.6	---	---	3	20%	
Iron	**41.9**	0.100	0.500			---	40.5	---	---	3	20%	
Magnesium	**27.2**	0.100	0.500			---	26.3	---	---	3	20%	
Manganese	**3.11**	0.00333	0.0100			---	3.01	---	---	3	20%	
Potassium	**6.36**	0.100	1.00			---	6.23	---	---	2	20%	
Sodium	**17.8**	0.200	1.00			---	17.2	---	---	3	20%	
Matrix Spike (1011233-MS1)					Prepared: 11/11/10 14:46		Analyzed: 11/12/10 16:15					
QC Source Sample: Other (A10K140-01)												
EPA 6020												
Calcium	78.6	0.250	1.00	mg/L	10	5.56	71.6	126	75-125%	---	---	Q-03
Iron	46.7	0.100	0.500				40.5	112		---	---	
Magnesium	32.4	0.100	0.500				26.3	110		---	---	
Manganese	3.10	0.00333	0.0100			0.0556	3.01	154		---	---	Q-02
Potassium	12.0	0.100	1.00			5.56	6.23	103		---	---	
Sodium	23.1	0.200	1.00				17.2	105		---	---	

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011233 - EPA 3015A							**Water**					
Matrix Spike (1011233-MS2)					Prepared: 11/11/10 14:46		Analyzed: 11/12/10 16:52					
QC Source Sample: GS-111010-6 (A10K177-01)												
EPA 6020												
Calcium	83.5	0.250	1.00	mg/L	10	5.56	76.5	126	75-125%	---	---	Q-03
Iron	48.4	0.100	0.500				42.4	107		---	---	
Magnesium	34.6	0.100	0.500				28.5	110		---	---	
Manganese	3.32	0.00333	0.0100			0.0556	3.24	152		---	---	Q-03
Potassium	12.5	0.100	1.00			5.56	6.69	104		---	---	
Sodium	24.0	0.200	1.00				18.2	104		---	---	
Post Spike (1011233-PS1)					Prepared: 11/12/10 16:58		Analyzed: 11/12/10 17:26					
QC Source Sample: Post Spike (A10K140-01)												
EPA 6020												
Calcium	84200			ug/L	10	23300	60000	104	75-125%		---	
Post Spike (1011233-PS2)					Prepared: 11/12/10 16:58		Analyzed: 11/12/10 17:31					
QC Source Sample: GS-111010-6 (A10K177-01)												
EPA 6020												
Calcium	84400			ug/L	10	22200	61200	104	75-125%		---	
Manganese	3470					889	2590	99	80-120%		---	
Post Spike (1011233-PS3)					Prepared: 11/15/10 21:40		Analyzed: 11/15/10 21:45					
QC Source Sample: Post Spike (A10K140-01)												
EPA 6020												
Manganese	2060			ug/L	10	1000	1350	71	80-120%		---	Q-02

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

QUALITY CONTROL (QC) SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011223 - EPA 3015A - Dissolved							**Water**					
Blank (1011223-BLK1)					Prepared: 11/11/10 10:04		Analyzed: 11/11/10 16:18					
EPA 6020 (Diss)												
Calcium	ND	0.0250	0.100	mg/L	1	---	---	---	---	---	---	
Iron	ND	0.0100	0.0500			---	---	---	---	---	---	
Magnesium	ND	0.0100	0.0500			---	---	---	---	---	---	
Manganese	ND	0.000333	0.00100			---	---	---	---	---	---	
Potassium	**0.0157**	0.0100	0.100			---	---	---	---	---	---	J
Sodium	ND	0.0200	0.100			---	---	---	---	---	---	
Blank (1011223-BLK2)					Prepared: 11/11/10 10:04		Analyzed: 11/11/10 16:21					
EPA 6020 (Diss)												
Calcium	ND	0.0250	0.100	mg/L	1	---	---	---	---	---	---	
Iron	ND	0.0100	0.0500			---	---	---	---	---	---	
Magnesium	ND	0.0100	0.0500			---	---	---	---	---	---	
Manganese	ND	0.000333	0.00100			---	---	---	---	---	---	
Potassium	**0.0196**	0.0100	0.100			---	---	---	---	---	---	J
Sodium	ND	0.0200	0.100			---	---	---	---	---	---	
LCS (1011223-BS1)					Prepared: 11/11/10 10:04		Analyzed: 11/11/10 16:24					
EPA 6020 (Diss)												
Calcium	5.50	0.0250	0.100	mg/L	1	5.56	---	99	80-120%	---	---	
Iron	5.44	0.0100	0.0500				---	98		---	---	
Magnesium	5.63	0.0100	0.0500				---	101		---	---	
Manganese	0.0515	0.000333	0.00100			0.0556	---	93		---	---	
Potassium	5.70	0.0100	0.100			5.56	---	102	85-115%	---	---	
Sodium	5.61	0.0200	0.100				---	101	80-120%	---	---	
Duplicate (1011223-DUP1)					Prepared: 11/11/10 10:04		Analyzed: 11/11/10 16:39					
QC Source Sample: Other (A10K043-04)												
EPA 6020 (Diss)												
Calcium	**3.52**	0.0250	0.100	mg/L	1	---	3.42	---	---	3	20%	
Iron	**0.0382**	0.0100	0.0500			---	0.0432	---	---	12	20%	J
Magnesium	**3.17**	0.0100	0.0500			---	3.09	---	---	3	20%	
Manganese	**0.0127**	0.000333	0.00100			---	0.0126	---	---	1	20%	
Potassium	**0.839**	0.0100	0.100			---	0.810	---	---	4	20%	
Sodium	**2.73**	0.0200	0.100			---	2.66	---	---	2	20%	

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

QUALITY CONTROL (QC) SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011223 - EPA 3015A - Dissolved							**Water**					
Matrix Spike (1011223-MS1)					Prepared: 11/11/10 10:04		Analyzed: 11/11/10 16:42					
QC Source Sample: Other (A10K043-04)												
EPA 6020 (Diss)												
Calcium	9.05	0.0250	0.100	mg/L	1	5.56	3.42	101	75-125%	---	---	
Iron	5.51	0.0100	0.0500				0.0432	98		---	---	
Magnesium	8.75	0.0100	0.0500				3.09	102		---	---	
Manganese	0.0642	0.000333	0.00100			0.0556	0.0126	93		---	---	
Potassium	6.53	0.0100	0.100			5.56	0.810	103	70-130%	---	---	
Sodium	8.30	0.0200	0.100				2.66	101	75-125%	---	---	
Matrix Spike (1011223-MS2)					Prepared: 11/11/10 10:04		Analyzed: 11/11/10 17:46					
QC Source Sample: GS-111010-12 (A10K177-07)												
EPA 6020 (Diss)												
Iron	5.53	0.0100	0.0500	mg/L	1	5.56	0.132	97	75-125%	---	---	
Magnesium	7.80	0.0100	0.0500				2.07	103		---	---	
Manganese	0.0624	0.000333	0.00100			0.0556	0.0116	91		---	---	
Potassium	6.96	0.0100	0.100			5.56	1.04	106	70-130%	---	---	
Sodium	10.6	0.0200	0.100				4.88	102	75-125%	---	---	
Matrix Spike (1011223-MS3)					Prepared: 11/11/10 10:04		Analyzed: 11/12/10 14:57					
QC Source Sample: GS-111010-12 (A10K177-07)												
EPA 6020 (Diss)												
Calcium	12.0	0.125	0.500	mg/L	5	5.56	6.55	97	75-125%	---	---	Q-16

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

QUALITY CONTROL (QC) SAMPLE RESULTS

Conventional Chemistry Parameters

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011277 - Method Prep: Aq							**Water**					
Blank (1011277-BLK1)						Prepared: 11/14/10 11:58	Analyzed: 11/14/10 14:00					
SM 2320 B												
Total Alkalinity	ND	20.0	20.0	mg CaCO3/L	1	---	---	---	---	---	---	
Bicarbonate Alkalinity	ND	20.0	20.0			---	---	---	---	---	---	
Carbonate Alkalinity	ND	20.0	20.0			---	---	---	---	---	---	
Hydroxide Alkalinity	ND	20.0	20.0			---	---	---	---	---	---	
LCS (1011277-BS1)						Prepared: 11/14/10 11:58	Analyzed: 11/14/10 14:00					
SM 2320 B												
Total Alkalinity	239	20.0	20.0	mg CaCO3/L	1	236	---	101	85-115%	---	---	
Bicarbonate Alkalinity	ND	20.0	20.0			0.00100	---		0-200%	---	---	
Carbonate Alkalinity	237	20.0	20.0			236	---	101		---	---	
Hydroxide Alkalinity	ND	20.0	20.0			0.00100	---			---	---	
Duplicate (1011277-DUP1)						Prepared: 11/14/10 11:58	Analyzed: 11/14/10 14:00					
QC Source Sample: GS-111010-6 (A10K177-01)												
SM 2320 B												
Total Alkalinity	**354**	20.0	20.0	mg CaCO3/L	1	---	347	---	---	2	20%	
Bicarbonate Alkalinity	**354**	20.0	20.0			---	347	---	---	2	20%	
Carbonate Alkalinity	ND	20.0	20.0			---	ND	---	---		20%	
Hydroxide Alkalinity	ND	20.0	20.0			---	ND	---	---		20%	
Duplicate (1011277-DUP2)						Prepared: 11/14/10 11:58	Analyzed: 11/14/10 14:00					
QC Source Sample: Other (A10K200-05)												
SM 2320 B												
Total Alkalinity	**304**	20.0	20.0	mg CaCO3/L	1	---	312	---	---	2	20%	
Bicarbonate Alkalinity	**304**	20.0	20.0			---	312	---	---	2	20%	
Carbonate Alkalinity	ND	20.0	20.0			---	ND	---	---		20%	
Hydroxide Alkalinity	ND	20.0	20.0			---	ND	---	---		20%	

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

SAMPLE PREPARATION INFORMATION

Anions by EPA 300.0/9056A (Ion Chromatography)

Prep: Method Prep: Aq

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1011225							
A10K177-01	Water	300.0/9056A	11/10/10 07:30	11/11/10 11:39	10mL/10mL	10mL/10mL	1.00
A10K177-02	Water	300.0/9056A	11/10/10 07:35	11/11/10 11:39	10mL/10mL	10mL/10mL	1.00
A10K177-03	Water	300.0/9056A	11/10/10 07:45	11/11/10 11:39	10mL/10mL	10mL/10mL	1.00
A10K177-03RE1	Water	300.0/9056A	11/10/10 07:45	11/11/10 11:39	2mL/10mL	10mL/10mL	5.00
A10K177-04	Water	300.0/9056A	11/10/10 07:50	11/11/10 11:39	10mL/10mL	10mL/10mL	1.00
A10K177-04RE1	Water	300.0/9056A	11/10/10 07:50	11/11/10 11:39	2mL/10mL	10mL/10mL	5.00
A10K177-05	Water	300.0/9056A	11/10/10 08:10	11/11/10 11:39	10mL/10mL	10mL/10mL	1.00
A10K177-06	Water	300.0/9056A	11/10/10 08:30	11/11/10 11:39	10mL/10mL	10mL/10mL	1.00
A10K177-07	Water	300.0/9056A	11/10/10 09:00	11/11/10 11:39	10mL/10mL	10mL/10mL	1.00

Cyanide - Total (Aqueous)

Prep: Latchat Micro Dist - aqueous

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1011398							
A10K177-01	Water	EPA 335.4	11/10/10 07:30	11/19/10 11:28	6mL/6mL	6mL/6mL	1.00
A10K177-02	Water	EPA 335.4	11/10/10 07:35	11/19/10 11:28	6mL/6mL	6mL/6mL	1.00
A10K177-03	Water	EPA 335.4	11/10/10 07:45	11/19/10 11:28	6mL/6mL	6mL/6mL	1.00
A10K177-04	Water	EPA 335.4	11/10/10 07:50	11/19/10 11:28	6mL/6mL	6mL/6mL	1.00
A10K177-05	Water	EPA 335.4	11/10/10 08:10	11/19/10 11:28	6mL/6mL	6mL/6mL	1.00
A10K177-06	Water	EPA 335.4	11/10/10 08:30	11/19/10 11:28	6mL/6mL	6mL/6mL	1.00
A10K177-07	Water	EPA 335.4	11/10/10 09:00	11/19/10 11:28	6mL/6mL	6mL/6mL	1.00

Cyanide - Weak Acid Dissociable (WAD) (Aqueous)

Prep: Latchat Micro Dist - aqueous

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1011304							
A10K177-01	Water	SM 4500-CN (I/E)	11/10/10 07:30	11/16/10 09:27	6mL/6mL	6mL/6mL	1.00
A10K177-02	Water	SM 4500-CN (I/E)	11/10/10 07:35	11/16/10 09:27	6mL/6mL	6mL/6mL	1.00
A10K177-03	Water	SM 4500-CN (I/E)	11/10/10 07:45	11/16/10 09:27	6mL/6mL	6mL/6mL	1.00
A10K177-04	Water	SM 4500-CN (I/E)	11/10/10 07:50	11/16/10 09:27	6mL/6mL	6mL/6mL	1.00
A10K177-05	Water	SM 4500-CN (I/E)	11/10/10 08:10	11/16/10 09:27	6mL/6mL	6mL/6mL	1.00
A10K177-06	Water	SM 4500-CN (I/E)	11/10/10 08:30	11/16/10 09:27	6mL/6mL	6mL/6mL	1.00
A10K177-07	Water	SM 4500-CN (I/E)	11/10/10 09:00	11/16/10 09:27	6mL/6mL	6mL/6mL	1.00

Cyanide - Free (Aqueous)

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503-718-0333 Fax

Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

SAMPLE PREPARATION INFORMATION

Cyanide - Free (Aqueous)

Prep: Microdiffusion

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1011230							
A10K177-01	Water	ASTM D 4282	11/10/10 07:30	11/11/10 14:05	3mL/3mL	3mL/3mL	1.00
A10K177-02	Water	ASTM D 4282	11/10/10 07:35	11/11/10 14:05	3mL/3mL	3mL/3mL	1.00
A10K177-03	Water	ASTM D 4282	11/10/10 07:45	11/11/10 14:05	3mL/3mL	3mL/3mL	1.00
A10K177-04	Water	ASTM D 4282	11/10/10 07:50	11/11/10 14:05	3mL/3mL	3mL/3mL	1.00
A10K177-05	Water	ASTM D 4282	11/10/10 08:10	11/11/10 14:05	3mL/3mL	3mL/3mL	1.00
A10K177-06	Water	ASTM D 4282	11/10/10 08:30	11/11/10 14:05	3mL/3mL	3mL/3mL	1.00
A10K177-07	Water	ASTM D 4282	11/10/10 09:00	11/11/10 14:05	3mL/3mL	3mL/3mL	1.00

Total Metals by EPA 6020 (ICPMS)

Prep: EPA 3015A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1011233							
A10K177-01	Water	EPA 6020	11/10/10 07:30	11/11/10 14:46	45mL/50mL	45mL/50mL	1.00
A10K177-02	Water	EPA 6020	11/10/10 07:35	11/11/10 14:46	45mL/50mL	45mL/50mL	1.00
A10K177-03	Water	EPA 6020	11/10/10 07:45	11/11/10 14:46	45mL/50mL	45mL/50mL	1.00
A10K177-04	Water	EPA 6020	11/10/10 07:50	11/11/10 14:46	45mL/50mL	45mL/50mL	1.00
A10K177-05	Water	EPA 6020	11/10/10 08:10	11/11/10 14:46	45mL/50mL	45mL/50mL	1.00
A10K177-06	Water	EPA 6020	11/10/10 08:30	11/11/10 14:46	45mL/50mL	45mL/50mL	1.00
A10K177-07	Water	EPA 6020	11/10/10 09:00	11/11/10 14:46	45mL/50mL	45mL/50mL	1.00
A10K177-07RE1	Water	EPA 6020	11/10/10 09:00	11/11/10 14:46	45mL/50mL	45mL/50mL	1.00

Dissolved Metals by EPA 6020 (ICPMS)

Prep: EPA 3015A - Dissolved

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1011223							
A10K177-01	Water	EPA 6020 (Diss)	11/10/10 07:30	11/11/10 10:04	45mL/50mL	45mL/50mL	1.00
A10K177-02	Water	EPA 6020 (Diss)	11/10/10 07:35	11/11/10 10:04	45mL/50mL	45mL/50mL	1.00
A10K177-03	Water	EPA 6020 (Diss)	11/10/10 07:45	11/11/10 10:04	45mL/50mL	45mL/50mL	1.00
A10K177-04	Water	EPA 6020 (Diss)	11/10/10 07:50	11/11/10 10:04	45mL/50mL	45mL/50mL	1.00
A10K177-05	Water	EPA 6020 (Diss)	11/10/10 08:10	11/11/10 10:04	45mL/50mL	45mL/50mL	1.00
A10K177-06	Water	EPA 6020 (Diss)	11/10/10 08:30	11/11/10 10:04	45mL/50mL	45mL/50mL	1.00
A10K177-07	Water	EPA 6020 (Diss)	11/10/10 09:00	11/11/10 10:04	45mL/50mL	45mL/50mL	1.00

Conventional Chemistry Parameters

Prep: Method Prep: Aq

Sample	Default	RL Prep

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

SAMPLE PREPARATION INFORMATION

Conventional Chemistry Parameters

Lab Number	Matrix	Method	Sampled	Prepared	Initial/Final	Initial/Final	Factor
Batch: 1011277							
A10K177-01	Water	SM 2320 B	11/10/10 07:30	11/14/10 11:58	50mL/50mL	50mL/50mL	NA
A10K177-02	Water	SM 2320 B	11/10/10 07:35	11/14/10 11:58	50mL/50mL	50mL/50mL	NA
A10K177-03	Water	SM 2320 B	11/10/10 07:45	11/14/10 11:58	50mL/50mL	50mL/50mL	NA
A10K177-04	Water	SM 2320 B	11/10/10 07:50	11/14/10 11:58	50mL/50mL	50mL/50mL	NA
A10K177-05	Water	SM 2320 B	11/10/10 08:10	11/14/10 11:58	50mL/50mL	50mL/50mL	NA
A10K177-06	Water	SM 2320 B	11/10/10 08:30	11/14/10 11:58	50mL/50mL	50mL/50mL	NA
A10K177-07	Water	SM 2320 B	11/10/10 09:00	11/14/10 11:58	50mL/50mL	50mL/50mL	NA

Lab Filtration

Prep: Lab Filtration

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1011214							
A10K177-07	Water	NA	11/10/10 09:00	11/10/10 16:50	50mL/50mL		NA

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 07:35

Notes and Definitions

Qualifiers:

B-02	Analyte detected in an associated blank at a level between one-half the MRL and the MRL. (See Notes and Conventions below.)
J	Estimated Result . Result detected below the lowest point of the calibration curve, but above the specified MDL.
Q-01	Percent recovery and/or RPD is outside acceptance limits.
Q-02	Spike recovery is outside of established control limits due to sample matrix interference.
Q-03	Percent recovery and/or RPD is outside control limits due to the high concentration of analyte present in the sample.
Q-16	Reanalysis of an original Batch QC sample.
Q-17	RPD between original and duplicate sample is outside of established control limits.
R-08	Reporting level raised due to potential high bias associated with the low end of the calibration curve.
X	See Case Narrative.

Notes and Conventions:

DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis. Results listed as 'wet' or without 'dry'designation are not dry weight corrected.
RPD	Relative Percent Difference
MDL	If MDL is not listed, data has been evaluated to the Method Reporting Limit only.
WMSC	Water Miscible Solvent Correction has been applied to Results and MRLs for volatiles soil samples per EPA 8000C.
Batch QC	In cases where there is insufficient sample provided for Sample Duplicates and/or Matrix Spikes, a Lab Control Sample Duplicate (LCS Dup) is analyzed to demonstrate accuracy and precision of the extraction and analysis.
Blank Policy	Apex assesses blank data for potential high bias down to a level equal to ½ the method reporting limit (MRL), except for conventional chemistry and HCID analyses which are assessed only to the MRL. Sample results flagged with a B or B-02 qualifier are potentially biased high if they are less than ten times the level found in the blank for inorganic analyses or less than five times the level found in the blank for organic analyses. For accurate comparison of volatile results to the level found in the blank; water sample results should be divided by the dilution factor, and soil sample results should be divided by 1/50 of the sample dilution to account for the sample prep factor. Results qualified as reported below the MRL may include a potential high bias if associated with a B or B-02 qualified blank. B and B-02 qualifications are not applied to J qualified results reported below the MRL.

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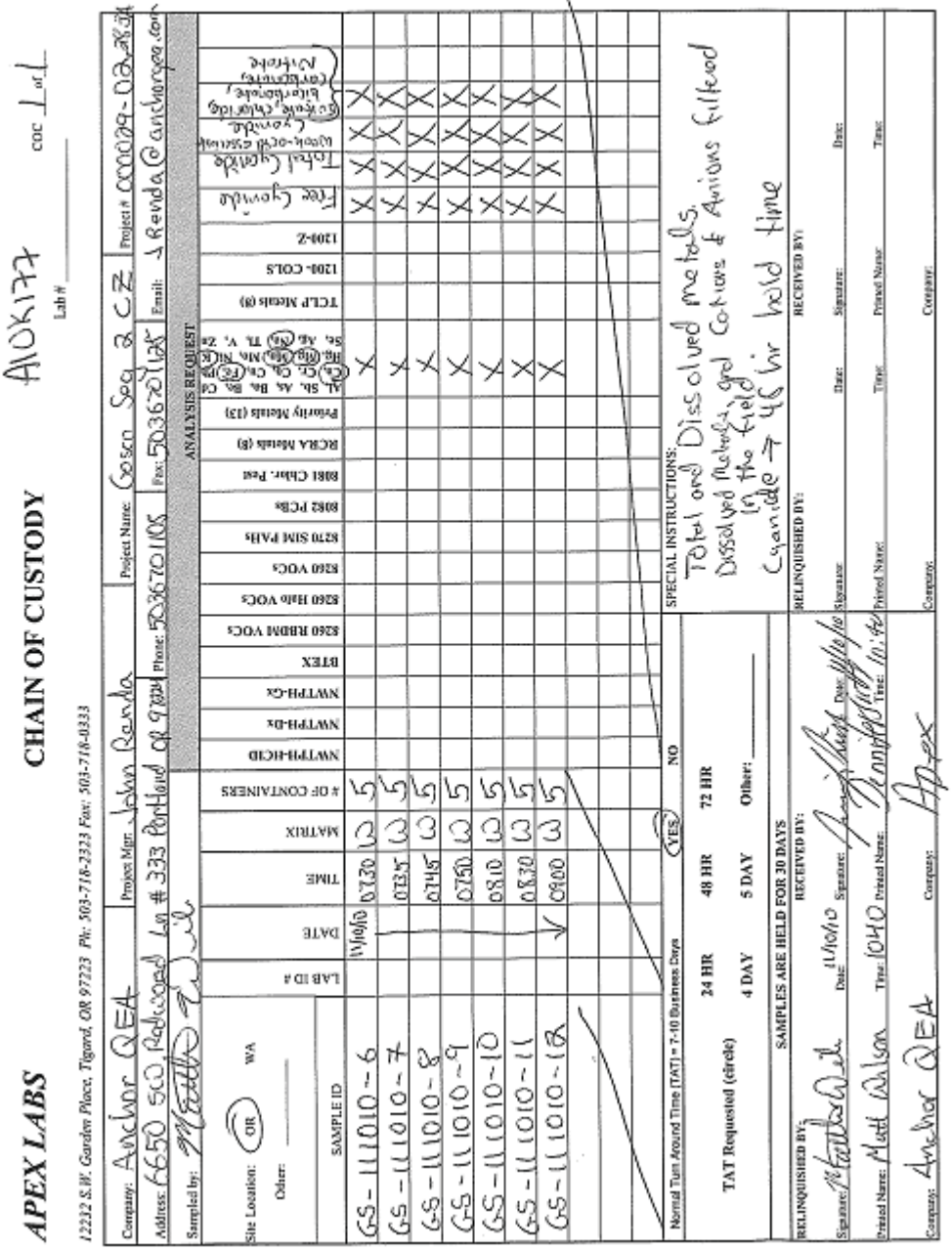

APEX LABS — CHAIN OF CUSTODY

12232 S.W. Garden Place, Tigard, OR 97223 Ph: 503-718-2323 Fax: 503-718-0333

Lab # A10K177 COC 1 of 1

Company: Anchor QEA | Project Mgr.: John Renda | Project Name: Gasco Seq 2 C 2 | Project #: 000029-02.28 3A

Address: 6650 SW Redwood Ln #333 Portland OR 97224 | Phone: 5036720125 | Fax: 5036720125 | Email: jrenda@anchorqea.com

Sampled by: Matt Wilson

Site Location: OR WA Other: ____

ANALYSIS REQUEST

SAMPLE ID	LAB ID #	DATE	TIME	MATRIX	# OF CONTAINERS	NWTPH-HCID	NWTPH-Dx	NWTPH-Gx	BTEX	8260 RBDM VOCs	8260 Halo VOCs	8260 VOCs	8270 SIM PAHs	8082 PCBs	8081 Chlor. Pest	RCRA Metals (8)	Priority Metals (13)	Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Tl, V, Zn	TCLP Metals (8)	1200- COLS	1200-Z	Free Cyanide	Total Cyanide	Hexavalent Chromium	Sulfide, Cyanide, Chloride, Bicarbonate, Carbonate, Nitrate
GS-111010-6		11/10/10	0730	W	5													X				X	X	X	X	
GS-111010-7			0735	W	5													X				X	X	X	X	
GS-111010-8			0745	W	5													X				X	X	X	X	
GS-111010-9			0750	W	5													X				X	X	X	X	
GS-111010-10			0810	W	5													X				X	X	X	X	
GS-111010-11			0820	W	5													X				X	X	X	X	
GS-111010-18			0900	W	5													X				X	X	X	X	

Normal Turn Around Time (TAT) = 7-10 Business Days — YES / NO

TAT Requested (circle): 24 HR 48 HR 72 HR 4 DAY 5 DAY Other: ____

SPECIAL INSTRUCTIONS: Total and Dissolved metals. Dissolved Metals and Cations & Anions filtered in the field. Cyanide → 48 hr hold time

SAMPLES ARE HELD FOR 30 DAYS

RELINQUISHED BY: Signature: Matt Wilson Date: 11/10/10 Time: 1040 Printed Name: Matt Wilson Company: Anchor QEA

RECEIVED BY: Signature: [illegible] Date: [illegible] Time: 10:40 Printed Name: [illegible] Company: Apex

RELINQUISHED BY: Signature: [illegible] Date: Time: Printed Name: Company:

RECEIVED BY: Signature: Date: Time: Printed Name: Company:

Apex Laboratories

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Anchor QEA, LLC Portland 6650 SW Redwood Lane Ste. 333 Portland, OR 97224	Project: **GASCO-1DW-SEQ 2 C 2** Project Number: 000029-02.28 3A Project Manager: John Renda	**Reported:** 12/04/10 07:35

APEX LABS COOLER RECEIPT FORM

Client: Anchor QEA Element WO#: A10K177

Project/Project #: Gasco Seg 2 C2 / 000029-02.28 3A

Delivery info:

Date/Time Received: 11/10/10 @ 10:40 By: JS

Delivered by: Apex Courier X Client ___ FedEx ___ UPS ___ Senvoy ___ SDS ___ Other ___

Cooler Inspection Inspected by: JS @ 11:10

Chain of Custody:

Included? Yes X No ___ Signed/Dated by Client? Yes X No ___

Signed/Dated by Apex Personnel? Yes X No ___

Coolers: No. of Coolers: 2

	Cooler #1	Cooler #2	Cooler #3	Cooler #4
Temperature (deg. C)	3.10	1.6		
Received on Ice? (Y/N)	Y	Y		
Temp. Blanks? (Y/N)	N	N		
Ice Type: (Gel/Real/Other)	real	real		
Condition:	good	good		

Cooler out of temp? (Y/(N)) Possible reason why: ___

Samples Inspection: Inspected by: Josie 11/10/10 @ 1233

All Samples Intact? Yes X No ___ Comments: ___

Bottle Labels/COCs agree? Yes X No ___ Comments: ___

Containers Appropriate for Analysis? Yes ___ No X Comments: sample GS-111010-12 doesn't indicate aff nitric

Do VOA Vials have Visible Headspace? Yes ___ No ___ NA X

Comments ___

Water Samples: pH Checked and Appropriate (except VOAs): Yes X No ___ NA ___

Comments: ___

Additional Information:

GS111010-12 500mL poly on FE indicated

Labeled by: JMH See Client Contact Form: (Y) N

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Saturday, December 4, 2010

John Renda
Anchor QEA, LLC Portland
6650 SW Redwood Lane Ste. 333
Portland, OR 97224

RE: GASCO-1DW-SEQ 2 C 2 / 000029-02.28 3A

Enclosed are the results of analyses for work order A10K200, which was received by the laboratory on 11/11/2010 at 3:00:00PM.

Thank you for using Apex Labs. We appreciate your business and strive to provide the highest quality services to the environmental industry.

If you have any questions concerning this report or the services we offer, please feel free to contact me by email at: dthomas@apex-labs.com, or by phone at 503-718-2323.

Apex Laboratories

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 11:16

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
GS-111110-13	A10K200-01	Water	11/11/10 11:50	11/11/10 15:00
GS-111110-14	A10K200-02	Water	11/11/10 12:10	11/11/10 15:00
GS-111110-15	A10K200-03	Water	11/11/10 12:20	11/11/10 15:00
GS-111110-16	A10K200-04	Water	11/11/10 13:10	11/11/10 15:00
GS-111110-17	A10K200-05	Water	11/11/10 11:20	11/11/10 15:00

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 11:16

ANALYTICAL SAMPLE RESULTS

Anions by EPA 300.0/9056A (Ion Chromatography)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-111110-13 (A10K200-01)			**Matrix: Water**		**Batch: 1011242**			
Chloride	**8.05**	1.00	1.00	mg/L	1	11/12/10 08:07	300.0/9056A	
Nitrate-Nitrogen	ND	0.250	0.250					
Sulfate	ND	1.00	1.00					
GS-111110-14 (A10K200-02)			**Matrix: Water**		**Batch: 1011242**			
Nitrate-Nitrogen	ND	0.250	0.250	mg/L	1	11/12/10 09:08	300.0/9056A	
Sulfate	**9.84**	1.00	1.00					
GS-111110-14 (A10K200-02RE1)			**Matrix: Water**		**Batch: 1011335**			
Chloride	**51.7**	2.00	2.00	mg/L	1	11/17/10 13:07	300.0/9056A	
GS-111110-15 (A10K200-03)			**Matrix: Water**		**Batch: 1011242**			
Chloride	**7.33**	1.00	1.00	mg/L	1	11/12/10 09:29	300.0/9056A	
Nitrate-Nitrogen	ND	0.250	0.250					
Sulfate	**33.2**	1.00	1.00					
GS-111110-16 (A10K200-04)			**Matrix: Water**		**Batch: 1011242**			
Chloride	**3.76**	1.00	1.00	mg/L	1	11/12/10 09:49	300.0/9056A	
Nitrate-Nitrogen	**0.715**	0.250	0.250					
Sulfate	**3.69**	1.00	1.00					
GS-111110-17 (A10K200-05)			**Matrix: Water**		**Batch: 1011242**			
Chloride	**17.0**	1.00	1.00	mg/L	1	11/12/10 10:09	300.0/9056A	
Nitrate-Nitrogen	ND	0.250	0.250					
Sulfate	ND	1.00	1.00					

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 11:16

ANALYTICAL SAMPLE RESULTS

Cyanide - Total (Aqueous)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-111110-13 (A10K200-01)			**Matrix: Water**		**Batch: 1011322**			
Cyanide, Total	**0.120**	0.00250	0.00500	mg/L	1	11/17/10 15:56	EPA 335.4	
GS-111110-14 (A10K200-02)			**Matrix: Water**		**Batch: 1011322**			
Cyanide, Total	**0.0839**	0.00250	0.00500	mg/L	1	11/17/10 15:58	EPA 335.4	
GS-111110-15 (A10K200-03)			**Matrix: Water**		**Batch: 1011322**			
Cyanide, Total	**0.0781**	0.00250	0.00500	mg/L	1	11/17/10 16:05	EPA 335.4	
GS-111110-16 (A10K200-04)			**Matrix: Water**		**Batch: 1011322**			
Cyanide, Total	**0.0246**	0.00250	0.00500	mg/L	1	11/17/10 16:07	EPA 335.4	
GS-111110-17 (A10K200-05)			**Matrix: Water**		**Batch: 1011322**			
Cyanide, Total	**0.185**	0.00250	0.00500	mg/L	1	11/17/10 16:08	EPA 335.4	

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 11:16

ANALYTICAL SAMPLE RESULTS

Cyanide - Weak Acid Dissociable (WAD) (Aqueous)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-111110-13 (A10K200-01)			**Matrix: Water**		**Batch: 1011304**			
Cyanide, WAD	**0.0309**	0.00500	0.0100	mg/L	1	11/16/10 17:19	SM 4500-CN (I/E)	R-08
GS-111110-14 (A10K200-02)			**Matrix: Water**		**Batch: 1011304**			
Cyanide, WAD	**0.0364**	0.00500	0.0100	mg/L	1	11/16/10 17:20	SM 4500-CN (I/E)	R-08
GS-111110-15 (A10K200-03)			**Matrix: Water**		**Batch: 1011304**			
Cyanide, WAD	**0.0388**	0.00500	0.0100	mg/L	1	11/16/10 17:22	SM 4500-CN (I/E)	R-08
GS-111110-16 (A10K200-04)			**Matrix: Water**		**Batch: 1011304**			
Cyanide, WAD	**0.0128**	0.00500	0.0100	mg/L	1	11/16/10 17:23	SM 4500-CN (I/E)	R-08
GS-111110-17 (A10K200-05)			**Matrix: Water**		**Batch: 1011304**			
Cyanide, WAD	**0.0387**	0.00500	0.0100	mg/L	1	11/16/10 17:28	SM 4500-CN (I/E)	R-08

Apex Laboratories

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 11:16

ANALYTICAL SAMPLE RESULTS

Cyanide - Free (Aqueous)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-111110-13 (A10K200-01)			**Matrix: Water**		**Batch: 1011265**			
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	11/12/10 21:22	ASTM D 4282	
GS-111110-14 (A10K200-02)			**Matrix: Water**		**Batch: 1011265**			
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	11/12/10 21:29	ASTM D 4282	
GS-111110-15 (A10K200-03)			**Matrix: Water**		**Batch: 1011265**			
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	11/12/10 21:30	ASTM D 4282	
GS-111110-16 (A10K200-04)			**Matrix: Water**		**Batch: 1011265**			
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	11/12/10 21:30	ASTM D 4282	
GS-111110-17 (A10K200-05)			**Matrix: Water**		**Batch: 1011265**			
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	11/12/10 21:36	ASTM D 4282	

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 11:16

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-111110-13 (A10K200-01)			**Matrix: Water**		**Batch: 1011260**			
Calcium	**66.5**	0.250	1.00	mg/L	10	11/15/10 19:55	EPA 6020	
Iron	**40.7**	0.100	0.500					
Magnesium	**23.4**	0.100	0.500					
Manganese	**4.13**	0.00333	0.0100					
Potassium	**4.77**	0.0100	0.100	"	1	11/15/10 21:10		
Sodium	**15.5**	0.200	1.00	"	10	11/15/10 19:55		
GS-111110-14 (A10K200-02)			**Matrix: Water**		**Batch: 1011260**			
Calcium	**59.7**	0.250	1.00	mg/L	10	11/15/10 20:10	EPA 6020	
Iron	**20.9**	0.100	0.500					
Magnesium	**35.1**	0.100	0.500					
Manganese	**1.87**	0.00333	0.0100					
Potassium	**2.80**	0.0100	0.100	"	1	11/15/10 20:31		
Sodium	**48.6**	0.200	1.00	"	10	11/15/10 20:10		
GS-111110-15 (A10K200-03)			**Matrix: Water**		**Batch: 1011260**			
Calcium	**59.7**	0.250	1.00	mg/L	10	11/15/10 20:13	EPA 6020	
Iron	**42.5**	0.100	0.500					
Magnesium	**28.6**	0.100	0.500					
Manganese	**3.21**	0.00333	0.0100					
Potassium	**6.70**	0.0100	0.100	"	1	11/15/10 20:33		
Sodium	**15.3**	0.200	1.00	"	10	11/15/10 20:13		
GS-111110-16 (A10K200-04)			**Matrix: Water**		**Batch: 1011260**			
Calcium	**6.81**	0.0250	0.100	mg/L	1	11/15/10 20:16	EPA 6020	
Iron	**0.646**	0.0100	0.0500					
Magnesium	**2.16**	0.0100	0.0500					
Manganese	**0.0218**	0.000333	0.00100					
Potassium	**1.17**	0.0100	0.100					
Sodium	**4.62**	0.0200	0.100					
GS-111110-17 (A10K200-05)			**Matrix: Water**		**Batch: 1011260**			
Calcium	**83.3**	0.250	1.00	mg/L	10	11/15/10 20:19	EPA 6020	
Iron	**44.6**	0.100	0.500					
Magnesium	**29.5**	0.100	0.500					
Manganese	**3.37**	0.00333	0.0100					
Potassium	**3.29**	0.0100	0.100	"	1	11/15/10 20:37		
Sodium	**18.3**	0.200	1.00	"	10	11/15/10 20:19		

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 11:16

ANALYTICAL SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-111110-13 (A10K200-01)			**Matrix: Water**		**Batch: 1011294**			
Calcium	**65.8**	0.250	1.00	mg/L	10	11/17/10 13:14	EPA 6020 (Diss)	
Iron	**41.2**	0.100	1.00					
Magnesium	**23.8**	0.100	0.500					
Manganese	**4.28**	0.00333	0.0100					B
Potassium	**4.61**	0.0100	0.100	"	1	11/16/10 17:53		
Sodium	**15.7**	0.200	1.00	"	10	11/17/10 13:14		
GS-111110-14 (A10K200-02)			**Matrix: Water**		**Batch: 1011294**			
Calcium	**56.8**	0.250	1.00	mg/L	10	11/17/10 13:17	EPA 6020 (Diss)	
Iron	**21.5**	0.100	1.00					
Magnesium	**34.6**	0.100	0.500					
Manganese	**1.91**	0.00333	0.0100					B
Potassium	**2.78**	0.0100	0.100	"	1	11/16/10 17:56		
Sodium	**46.2**	0.200	1.00	"	10	11/17/10 13:17		
GS-111110-15 (A10K200-03)			**Matrix: Water**		**Batch: 1011294**			
Calcium	**81.2**	0.250	1.00	mg/L	10	11/17/10 13:20	EPA 6020 (Diss)	
Iron	**44.4**	0.100	1.00					
Magnesium	**29.6**	0.100	0.500					
Manganese	**3.45**	0.00333	0.0100					B
Potassium	**6.47**	0.0100	0.100	"	1	11/16/10 17:58		
Sodium	**18.6**	0.200	1.00	"	10	11/17/10 13:20		
GS-111110-16 (A10K200-04)			**Matrix: Water**		**Batch: 1011294**			
Calcium	**6.69**	0.0250	0.100	mg/L	1	11/16/10 18:01	EPA 6020 (Diss)	
Iron	**0.218**	0.0100	0.0500					
Magnesium	**2.11**	0.0100	0.0500					
Manganese	**0.0124**	0.000333	0.00100	"		11/17/10 13:08		B
Potassium	**1.15**	0.0100	0.100	"		11/16/10 18:01		
Sodium	**4.58**	0.0200	0.100					
GS-111110-17 (A10K200-05)			**Matrix: Water**		**Batch: 1011294**			
Calcium	**58.0**	0.250	1.00	mg/L	10	11/17/10 13:23	EPA 6020 (Diss)	
Iron	**41.3**	0.100	1.00					
Magnesium	**28.3**	0.100	0.500					
Manganese	**3.21**	0.00333	0.0100					B
Potassium	**3.21**	0.0100	0.100	"	1	11/16/10 18:04		
Sodium	**15.2**	0.200	1.00	"	10	11/17/10 13:23		

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 11:16

ANALYTICAL SAMPLE RESULTS

Conventional Chemistry Parameters

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
GS-111110-13 (A10K200-01)			**Matrix: Water**		**Batch: 1011277**			
Total Alkalinity	**317**	20.0	20.0	mg CaCO3/L	1	11/14/10 14:00	SM 2320 B	
Bicarbonate Alkalinity	**317**	20.0	20.0					
Carbonate Alkalinity	ND	20.0	20.0					
Hydroxide Alkalinity	ND	20.0	20.0					
GS-111110-14 (A10K200-02)			**Matrix: Water**		**Batch: 1011277**			
Total Alkalinity	**319**	20.0	20.0	mg CaCO3/L	1	11/14/10 14:00	SM 2320 B	
Bicarbonate Alkalinity	**319**	20.0	20.0					
Carbonate Alkalinity	ND	20.0	20.0					
Hydroxide Alkalinity	ND	20.0	20.0					
GS-111110-15 (A10K200-03)			**Matrix: Water**		**Batch: 1011277**			
Total Alkalinity	**352**	20.0	20.0	mg CaCO3/L	1	11/14/10 14:00	SM 2320 B	
Bicarbonate Alkalinity	**352**	20.0	20.0					
Carbonate Alkalinity	ND	20.0	20.0					
Hydroxide Alkalinity	ND	20.0	20.0					
GS-111110-16 (A10K200-04)			**Matrix: Water**		**Batch: 1011277**			
Total Alkalinity	**24.2**	20.0	20.0	mg CaCO3/L	1	11/14/10 14:00	SM 2320 B	
Bicarbonate Alkalinity	**24.2**	20.0	20.0					
Carbonate Alkalinity	ND	20.0	20.0					
Hydroxide Alkalinity	ND	20.0	20.0					
GS-111110-17 (A10K200-05)			**Matrix: Water**		**Batch: 1011277**			
Total Alkalinity	**312**	20.0	20.0	mg CaCO3/L	1	11/14/10 14:00	SM 2320 B	
Bicarbonate Alkalinity	**312**	20.0	20.0					
Carbonate Alkalinity	ND	20.0	20.0					
Hydroxide Alkalinity	ND	20.0	20.0					

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 11:16

QUALITY CONTROL (QC) SAMPLE RESULTS

Anions by EPA 300.0/9056A (Ion Chromatography)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011242 - Method Prep: Aq							**Water**					
Blank (1011242-BLK1)					Prepared: 11/12/10 02:49		Analyzed: 11/12/10 07:26					
300.0/9056A												
Chloride	ND	1.00	1.00	mg/L	1	---	---	---	---	---	---	
Nitrate-Nitrogen	ND	0.250	0.250			---	---	---	---	---	---	
Sulfate	ND	1.00	1.00			---	---	---	---	---	---	
LCS (1011242-BS1)					Prepared: 11/12/10 02:49		Analyzed: 11/12/10 07:46					
300.0/9056A												
Chloride	3.66	1.00	1.00	mg/L	1	4.00	---	91	90-110%	---	---	
Nitrate-Nitrogen	0.902	0.250	0.250			1.00	---	90		---	---	
Sulfate	4.39	1.00	1.00			4.00	---	110		---	---	
Duplicate (1011242-DUP1)					Prepared: 11/12/10 02:49		Analyzed: 11/12/10 08:27					
QC Source Sample: GS-111110-13 (A10K200-01)												
300.0/9056A												
Chloride	**8.05**	1.00	1.00	mg/L	1	---	8.05	---	---	0.01	15%	
Nitrate-Nitrogen	ND	0.250	0.250			---	ND	---	---		15%	
Sulfate	ND	1.00	1.00			---	ND	---	---		15%	
Matrix Spike (1011242-MS1)					Prepared: 11/12/10 02:49		Analyzed: 11/12/10 08:48					
QC Source Sample: GS-111110-13 (A10K200-01)												
300.0/9056A												
Chloride	12.2	1.11	1.11	mg/L	1	4.44	8.05	94	80-120%	---	---	
Nitrate-Nitrogen	1.03	0.278	0.278			1.11	ND	93		---	---	
Sulfate	4.61	1.11	1.11			4.44	ND	104		---	---	
Batch 1011335 - Method Prep: Aq							**Water**					
Blank (1011335-BLK1)					Prepared: 11/17/10 11:31		Analyzed: 11/17/10 12:26					
300.0/9056A												
Chloride	ND	1.00	1.00	mg/L	1	---	---	---	---	---	---	
Nitrate-Nitrogen	ND	0.250	0.250			---	---	---	---	---	---	
Sulfate	ND	1.00	1.00			---	---	---	---	---	---	
LCS (1011335-BS1)					Prepared: 11/17/10 11:31		Analyzed: 11/17/10 12:47					
300.0/9056A												
Chloride	3.69	1.00	1.00	mg/L	1	4.00	---	92	90-110%	---	---	
Nitrate-Nitrogen	0.918	0.250	0.250			1.00	---	92		---	---	

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 11:16

QUALITY CONTROL (QC) SAMPLE RESULTS

Anions by EPA 300.0/9056A (Ion Chromatography)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011335 - Method Prep: Aq							**Water**					
LCS (1011335-BS1)					Prepared: 11/17/10 11:31		Analyzed: 11/17/10 12:47					
Sulfate	4.09	1.00	1.00	mg/L		4.00	---	102		---	---	
Duplicate (1011335-DUP1)					Prepared: 11/17/10 11:31		Analyzed: 11/17/10 13:28					
QC Source Sample: GS-111110-14 (A10K200-02RE1)												
300.0/9056A												
Chloride	**51.8**	2.00	2.00	mg/L	1	---	51.7	---	---	0.2	15%	
Nitrate-Nitrogen	ND	0.500	0.500			---	ND	---	---		15%	
Sulfate	**9.70**	2.00	2.00			---	9.68	---	---	0.2	15%	
Matrix Spike (1011335-MS1)					Prepared: 11/17/10 11:31		Analyzed: 11/17/10 13:48					
QC Source Sample: GS-111110-14 (A10K200-02RE1)												
300.0/9056A												
Chloride	60.0	2.00	2.00	mg/L	1	8.00	51.7	104	80-120%	---	---	
Nitrate-Nitrogen	1.86	0.500	0.500			2.00	ND	93		---	---	
Sulfate	17.8	2.00	2.00			8.00	9.68	101		---	---	

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 11:16

QUALITY CONTROL (QC) SAMPLE RESULTS

Cyanide - Total (Aqueous)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011322 - Latchat Micro Dist - aqueous							**Water**					
Blank (1011322-BLK2)					Prepared: 11/17/10 09:30		Analyzed: 11/17/10 15:47					
EPA 335.4												
Cyanide, Total	ND	0.00250	0.00500	mg/L	1	---	---	---	---	---	---	
LCS (1011322-BS1)					Prepared: 11/17/10 09:30		Analyzed: 11/17/10 15:29					
EPA 335.4												
Cyanide, Total	0.189	0.00250	0.00500	mg/L	1	0.200	---	95	90-110%	---	---	
Duplicate (1011322-DUP2)					Prepared: 11/17/10 09:30		Analyzed: 11/17/10 15:59					
QC Source Sample: GS-111110-14 (A10K200-02)												
EPA 335.4												
Cyanide, Total	**0.0826**	0.00250	0.00500	mg/L	1	---	0.0839	---	---	2	10%	
Duplicate (1011322-DUP3)					Prepared: 11/17/10 09:30		Analyzed: 11/17/10 16:16					
QC Source Sample: Other (A10K132-01)												
EPA 335.4												
Cyanide, Total	**0.0450**	0.00250	0.00500	mg/L	1	---	0.0456	---	---	1	10%	
Matrix Spike (1011322-MS2)					Prepared: 11/17/10 09:30		Analyzed: 11/17/10 16:01					
QC Source Sample: GS-111110-14 (A10K200-02)												
EPA 335.4												
Cyanide, Total	0.268	0.00255	0.00510	mg/L	1	0.204	0.0839	90	90-110%	---	---	
Matrix Spike (1011322-MS3)					Prepared: 11/17/10 09:30		Analyzed: 11/17/10 16:14					
QC Source Sample: Other (A10K132-01)												
EPA 335.4												
Cyanide, Total	0.179	0.00255	0.00510	mg/L	1	0.204	0.0456	66	90-110%	---	---	Q-01

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 11:16

QUALITY CONTROL (QC) SAMPLE RESULTS

Cyanide - Weak Acid Dissociable (WAD) (Aqueous)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011304 - Latchat Micro Dist - aqueous							**Water**					
Blank (1011304-BLK1)					Prepared: 11/16/10 09:27		Analyzed: 11/16/10 16:46					
SM 4500-CN (I/E)												
Cyanide, WAD	ND	0.00500	0.0100	mg/L	1	---	---	---	---	---	---	R-08
LCS (1011304-BS2)					Prepared: 11/16/10 09:27		Analyzed: 11/16/10 17:32					
SM 4500-CN (I/E)												
Cyanide, WAD	0.214	0.0300	0.0600	mg/L	6	0.200	---	107	90-110%	---	---	R-08
Duplicate (1011304-DUP1)					Prepared: 11/16/10 09:27		Analyzed: 11/16/10 16:50					
QC Source Sample: Other (A10K140-01)												
SM 4500-CN (I/E)												
Cyanide, WAD	**0.0190**	0.00500	0.0100	mg/L	1	---	0.0282	---	---	39	10%	Q-17, R-08
Duplicate (1011304-DUP2)					Prepared: 11/16/10 09:27		Analyzed: 11/16/10 17:29					
QC Source Sample: GS-111110-17 (A10K200-05)												
SM 4500-CN (I/E)												
Cyanide, WAD	**0.0339**	0.00500	0.0100	mg/L	1	---	0.0387	---	---	13	10%	Q-17, R-08
Matrix Spike (1011304-MS1)					Prepared: 11/16/10 09:27		Analyzed: 11/16/10 16:52					
QC Source Sample: Other (A10K140-01)												
SM 4500-CN (I/E)												
Cyanide, WAD	0.210	0.00521	0.0104	mg/L	1	0.208	0.0282	87	80-120%	---	---	R-08
Matrix Spike (1011304-MS2)					Prepared: 11/16/10 09:27		Analyzed: 11/16/10 17:31					
QC Source Sample: GS-111110-17 (A10K200-05)												
SM 4500-CN (I/E)												
Cyanide, WAD	0.227	0.00521	0.0104	mg/L	1	0.208	0.0387	90	80-120%	---	---	R-08

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 11:16

QUALITY CONTROL (QC) SAMPLE RESULTS

Cyanide - Free (Aqueous)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011265 - Microdiffusion							**Water**					
Blank (1011265-BLK1)					Prepared: 11/12/10 16:55		Analyzed: 11/12/10 21:15					
ASTM D 4282												
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	---	---	---	---	---	---	
LCS (1011265-BS1)					Prepared: 11/12/10 16:55		Analyzed: 11/12/10 21:15					
ASTM D 4282												
Cyanide, Free	0.0843	0.00200	0.00500	mg/L	1	0.0833	---	101	85-115%	---	---	
Duplicate (1011265-DUP1)					Prepared: 11/12/10 16:55		Analyzed: 11/12/10 21:22					
QC Source Sample: GS-111110-13 (A10K200-01)												
ASTM D 4282												
Cyanide, Free	ND	0.00200	0.00500	mg/L	1	---	ND	---	---		20%	
Matrix Spike (1011265-MS1)					Prepared: 11/12/10 16:55		Analyzed: 11/12/10 21:23					
QC Source Sample: GS-111110-13 (A10K200-01)												
ASTM D 4282												
Cyanide, Free	0.0842	0.00203	0.00508	mg/L	1	0.0847	ND	99	80-120%	---	---	

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 11:16

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011260 - EPA 3015A							**Water**					
Blank (1011260-BLK1)					Prepared: 11/12/10 13:32		Analyzed: 11/12/10 17:38					
EPA 6020												
Calcium	ND	0.0250	0.100	mg/L	1	---	---	---	---	---	---	
Iron	ND	0.0100	0.0500			---	---	---	---	---	---	
Magnesium	ND	0.0100	0.0500			---	---	---	---	---	---	
Manganese	ND	0.000333	0.00100			---	---	---	---	---	---	
Potassium	**0.0199**	0.0100	0.100			---	---	---	---	---	---	J
Sodium	ND	0.0200	0.100			---	---	---	---	---	---	
LCS (1011260-BS1)					Prepared: 11/12/10 13:32		Analyzed: 11/12/10 17:41					
EPA 6020												
Calcium	5.56	0.0250	0.100	mg/L	1	5.56	---	100	80-120%	---	---	
Iron	5.58	0.0100	0.0500				---	100		---	---	
Magnesium	5.58	0.0100	0.0500				---	100		---	---	
Manganese	0.0518	0.000333	0.00100			0.0556	---	93		---	---	
Potassium	5.64	0.0100	0.100			5.56	---	101		---	---	
Sodium	5.57	0.0200	0.100				---	100		---	---	
Duplicate (1011260-DUP1)					Prepared: 11/12/10 13:32		Analyzed: 11/15/10 20:25					
QC Source Sample: GS-111110-13 (A10K200-01)												
EPA 6020												
Potassium	**4.71**	0.0100	0.100	mg/L	1	---	4.77	---	---	1	20%	
Duplicate (1011260-DUP2)					Prepared: 11/12/10 13:32		Analyzed: 11/15/10 19:58					
QC Source Sample: GS-111110-13 (A10K200-01)												
EPA 6020												
Calcium	**66.5**	0.250	1.00	mg/L	10	---	66.5	---	---	0.1	20%	Q-16
Iron	**39.8**	0.100	0.500			---	40.7	---	---	2	20%	Q-16
Manganese	**4.07**	0.00333	0.0100			---	4.13	---	---	2	20%	Q-16
Sodium	**15.5**	0.200	1.00			---	15.5	---	---	0.1	20%	Q-16
Matrix Spike (1011260-MS1)					Prepared: 11/12/10 13:32		Analyzed: 11/15/10 20:28					
QC Source Sample: GS-111110-13 (A10K200-01)												
EPA 6020												
Potassium	10.7	0.0100	0.100	mg/L	1	5.56	4.77	107	75-125%	---	---	
Matrix Spike (1011260-MS2)					Prepared: 11/12/10 13:32		Analyzed: 11/15/10 18:53					

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 11:16

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011260 - EPA 3015A							**Water**					
Matrix Spike (1011260-MS2)					Prepared: 11/12/10 13:32		Analyzed: 11/15/10 18:53					
QC Source Sample: Other (A10K208-01)												
EPA 6020												
Calcium	108	11.2	45.0	mg/L	50	50.0	55.6	105	75-125%	---	---	
Iron	67.2	4.50	22.5				18.4	98		---	---	
Magnesium	51.4	4.50	22.5				ND	103		---	---	
Manganese	187	0.150	0.450			0.500	189	-370		---	---	Q-03
Potassium	56.0	4.50	45.0			50.0	ND	112		---	---	
Sodium	487	9.00	45.0				440	96		---	---	
Matrix Spike (1011260-MS4)					Prepared: 11/12/10 13:32		Analyzed: 11/15/10 20:01					
QC Source Sample: GS-111110-13 (A10K200-01)												
EPA 6020												
Calcium	74.2	0.250	1.00	mg/L	10	5.56	66.5	137	75-125%	---	---	Q-03, Q-16
Iron	46.1	0.100	0.500				40.7	97		---	---	Q-16
Manganese	4.17	0.00333	0.0100			0.0556	4.13	68		---	---	Q-03, Q-16
Sodium	21.2	0.200	1.00			5.56	15.5	103		---	---	Q-16
Post Spike (1011260-PS1)					Prepared: 11/15/10 21:48		Analyzed: 11/15/10 21:53					
QC Source Sample: GS-111110-13 (A10K200-01)												
EPA 6020												
Calcium	80600			ug/L	10	50000	29900	101	75-125%		---	
Manganese	2410					500	1860	110	80-120%		---	
Post Spike (1011260-PS2)					Prepared: 11/15/10 21:48		Analyzed: 11/15/10 22:14					
QC Source Sample: Post Spike (A10K208-01)												
EPA 6020												
Manganese	10300			ug/L	50	10000	849	95	80-120%		---	

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Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 11:16

QUALITY CONTROL (QC) SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011294 - EPA 3015A - Dissolved							**Water**					
Blank (1011294-BLK1)					Prepared: 11/15/10 14:05		Analyzed: 11/15/10 22:20					
EPA 6020 (Diss)												
Calcium	**0.0269**	0.0250	0.100	mg/L	1	---	---	---	---	---	---	J
Iron	ND	0.0100	0.0500			---	---	---	---	---	---	
Magnesium	ND	0.0100	0.0500			---	---	---	---	---	---	
Manganese	ND	0.000333	0.00100			---	---	---	---	---	---	
Potassium	ND	0.0100	0.100			---	---	---	---	---	---	
Sodium	ND	0.0200	0.100			---	---	---	---	---	---	
Blank (1011294-BLK2)					Prepared: 11/15/10 14:05		Analyzed: 11/15/10 22:29					
EPA 6020 (Diss)												
Calcium	**0.0275**	0.0250	0.100	mg/L	1	---	---	---	---	---	---	J
Iron	ND	0.0100	0.0500			---	---	---	---	---	---	
Magnesium	ND	0.0100	0.0500			---	---	---	---	---	---	
Manganese	**0.000711**	0.000333	0.00100			---	---	---	---	---	---	B-02, J
Potassium	ND	0.0100	0.100			---	---	---	---	---	---	
Sodium	ND	0.0200	0.100			---	---	---	---	---	---	
LCS (1011294-BS1)					Prepared: 11/15/10 14:05		Analyzed: 11/15/10 22:32					
EPA 6020 (Diss)												
Calcium	5.79	0.0250	0.100	mg/L	1	5.56	---	104	80-120%	---	---	
Iron	5.32	0.0100	0.0500				---	96		---	---	
Magnesium	5.42	0.0100	0.0500				---	98		---	---	
Manganese	0.0521	0.000333	0.00100			0.0556	---	94		---	---	B
Potassium	5.63	0.0100	0.100			5.56	---	101	85-115%	---	---	
Sodium	5.42	0.0200	0.100				---	97	80-120%	---	---	
Duplicate (1011294-DUP1)					Prepared: 11/15/10 14:05		Analyzed: 11/16/10 17:19					
QC Source Sample: Other (A10K159-06)												
EPA 6020 (Diss)												
Iron	**9.02**	0.0100	0.0500	mg/L	1	---	9.10	---	---	0.8	20%	
Potassium	**2.05**	0.0100	0.100			---	2.03	---	---	1	20%	
Duplicate (1011294-DUP2)					Prepared: 11/15/10 14:05		Analyzed: 11/16/10 17:40					
QC Source Sample: Other (A10K159-06)												
EPA 6020 (Diss)												
Calcium	**54.6**	0.500	2.00	mg/L	20	---	57.2	---	---	5	20%	Q-16

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 11:16

QUALITY CONTROL (QC) SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011294 - EPA 3015A - Dissolved							**Water**					
Duplicate (1011294-DUP2)					Prepared: 11/15/10 14:05		Analyzed: 11/16/10 17:40					
QC Source Sample: Other (A10K159-06)												
Magnesium	**22.9**	0.200	1.00	mg/L		---	23.6	---	---	3	20%	Q-16
Manganese	**5.73**	0.00666	0.0200			---	6.01	---	---	5	20%	Q-16, B
Sodium	**16.6**	0.400	2.00			---	17.2	---	---	3	20%	Q-16
Matrix Spike (1011294-MS1)					Prepared: 11/15/10 14:05		Analyzed: 11/16/10 17:43					
QC Source Sample: Other (A10K159-06)												
EPA 6020 (Diss)												
Calcium	61.9	0.500	2.00	mg/L	20	5.56	57.2	85	75-125%	---	---	
Iron	14.1	0.200	1.00				9.10	90		---	---	
Magnesium	29.0	0.200	1.00				23.6	97		---	---	
Manganese	5.75	0.00666	0.0200			0.0556	6.01	-464		---	---	Q-03, B
Potassium	8.09	0.200	2.00			5.56	2.03	109	70-130%	---	---	
Sodium	22.3	0.400	2.00				17.2	93	75-125%	---	---	
Matrix Spike (1011294-MS2)					Prepared: 11/15/10 14:05		Analyzed: 11/15/10 22:38					
QC Source Sample: Other (A10K210-01)												
EPA 6020 (Diss)												
Iron	5.54	0.0100	0.0500	mg/L	1	5.56	0.261	95	75-125%	---	---	
Magnesium	9.94	0.0100	0.0500				4.62	96		---	---	
Matrix Spike (1011294-MS4)					Prepared: 11/15/10 14:05		Analyzed: 11/15/10 22:48					
QC Source Sample: Other (A10K210-01)												
EPA 6020 (Diss)												
Calcium	20.0	0.250	1.00	mg/L	10	5.56	14.5	100	75-125%	---	---	Q-16
Magnesium	10.6	0.100	0.500				4.62	107		---	---	Q-16
Manganese	0.988	0.00333	0.0100			0.0556	0.953	62		---	---	B, Q-03, Q-16
Potassium	40.4	0.100	1.00			5.56	34.8	100	70-130%	---	---	
Sodium	96.8	0.200	1.00				91.6	94	75-125%	---	---	Q-16
Post Spike (1011294-PS1)					Prepared: 11/17/10 13:35		Analyzed: 11/17/10 13:44					
QC Source Sample: Post Spike (A10K159-06)												
EPA 6020 (Diss)												
Manganese	3660			ug/L	10	1000	2700	95	75-125%		---	B

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 11:16

QUALITY CONTROL (QC) SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011294 - EPA 3015A - Dissolved							**Water**					
Post Spike (1011294-PS2)					Prepared: 11/17/10 13:35		Analyzed: 11/17/10 13:47					
QC Source Sample: Post Spike (A10K210-01)												
EPA 6020 (Diss)												
Manganese	1660			ug/L	10	909	780	97	75-125%		---	B

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Portland, OR 97224	Project Manager: John Renda	12/04/10 11:16

QUALITY CONTROL (QC) SAMPLE RESULTS

Conventional Chemistry Parameters

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1011277 - Method Prep: Aq							**Water**					
Blank (1011277-BLK1)						Prepared: 11/14/10 11:58	Analyzed: 11/14/10 14:00					
SM 2320 B												
Total Alkalinity	ND	20.0	20.0	mg CaCO3/L	1	---	---	---	---	---	---	
Bicarbonate Alkalinity	ND	20.0	20.0			---	---	---	---	---	---	
Carbonate Alkalinity	ND	20.0	20.0			---	---	---	---	---	---	
Hydroxide Alkalinity	ND	20.0	20.0			---	---	---	---	---	---	
LCS (1011277-BS1)						Prepared: 11/14/10 11:58	Analyzed: 11/14/10 14:00					
SM 2320 B												
Total Alkalinity	239	20.0	20.0	mg CaCO3/L	1	236	---	101	85-115%	---	---	
Bicarbonate Alkalinity	ND	20.0	20.0			0.00100	---		0-200%	---	---	
Carbonate Alkalinity	237	20.0	20.0			236	---	101		---	---	
Hydroxide Alkalinity	ND	20.0	20.0			0.00100	---			---	---	
Duplicate (1011277-DUP1)						Prepared: 11/14/10 11:58	Analyzed: 11/14/10 14:00					
QC Source Sample: Other (A10K177-01)												
SM 2320 B												
Total Alkalinity	**354**	20.0	20.0	mg CaCO3/L	1	---	347	---	---	2	20%	
Bicarbonate Alkalinity	**354**	20.0	20.0			---	347	---	---	2	20%	
Carbonate Alkalinity	ND	20.0	20.0			---	ND	---	---		20%	
Hydroxide Alkalinity	ND	20.0	20.0			---	ND	---	---		20%	
Duplicate (1011277-DUP2)						Prepared: 11/14/10 11:58	Analyzed: 11/14/10 14:00					
QC Source Sample: GS-111110-17 (A10K200-05)												
SM 2320 B												
Total Alkalinity	**304**	20.0	20.0	mg CaCO3/L	1	---	312	---	---	2	20%	
Bicarbonate Alkalinity	**304**	20.0	20.0			---	312	---	---	2	20%	
Carbonate Alkalinity	ND	20.0	20.0			---	ND	---	---		20%	
Hydroxide Alkalinity	ND	20.0	20.0			---	ND	---	---		20%	

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 11:16

SAMPLE PREPARATION INFORMATION

Anions by EPA 300.0/9056A (Ion Chromatography)

Prep: Method Prep: Aq

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1011242							
A10K200-01	Water	300.0/9056A	11/11/10 11:50	11/12/10 02:49	10mL/10mL	10mL/10mL	1.00
A10K200-02	Water	300.0/9056A	11/11/10 12:10	11/12/10 02:49	10mL/10mL	10mL/10mL	1.00
A10K200-03	Water	300.0/9056A	11/11/10 12:20	11/12/10 02:49	10mL/10mL	10mL/10mL	1.00
A10K200-04	Water	300.0/9056A	11/11/10 13:10	11/12/10 02:49	10mL/10mL	10mL/10mL	1.00
A10K200-05	Water	300.0/9056A	11/11/10 11:20	11/12/10 02:49	10mL/10mL	10mL/10mL	1.00
Batch: 1011335							
A10K200-02RE1	Water	300.0/9056A	11/11/10 12:10	11/17/10 11:31	5mL/10mL	10mL/10mL	2.00

Cyanide - Total (Aqueous)

Prep: Latchat Micro Dist - aqueous

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1011322							
A10K200-01	Water	EPA 335.4	11/11/10 11:50	11/17/10 09:30	6mL/6mL	6mL/6mL	1.00
A10K200-02	Water	EPA 335.4	11/11/10 12:10	11/17/10 09:30	6mL/6mL	6mL/6mL	1.00
A10K200-03	Water	EPA 335.4	11/11/10 12:20	11/17/10 09:30	6mL/6mL	6mL/6mL	1.00
A10K200-04	Water	EPA 335.4	11/11/10 13:10	11/17/10 09:30	6mL/6mL	6mL/6mL	1.00
A10K200-05	Water	EPA 335.4	11/11/10 11:20	11/17/10 09:30	6mL/6mL	6mL/6mL	1.00

Cyanide - Weak Acid Dissociable (WAD) (Aqueous)

Prep: Latchat Micro Dist - aqueous

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1011304							
A10K200-01	Water	SM 4500-CN (I/E)	11/11/10 11:50	11/16/10 09:27	6mL/6mL	6mL/6mL	1.00
A10K200-02	Water	SM 4500-CN (I/E)	11/11/10 12:10	11/16/10 09:27	6mL/6mL	6mL/6mL	1.00
A10K200-03	Water	SM 4500-CN (I/E)	11/11/10 12:20	11/16/10 09:27	6mL/6mL	6mL/6mL	1.00
A10K200-04	Water	SM 4500-CN (I/E)	11/11/10 13:10	11/16/10 09:27	6mL/6mL	6mL/6mL	1.00
A10K200-05	Water	SM 4500-CN (I/E)	11/11/10 11:20	11/16/10 09:27	6mL/6mL	6mL/6mL	1.00

Cyanide - Free (Aqueous)

Prep: Microdiffusion

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1011265							
A10K200-01	Water	ASTM D 4282	11/11/10 11:50	11/12/10 16:55	3mL/3mL	3mL/3mL	1.00
A10K200-02	Water	ASTM D 4282	11/11/10 12:10	11/12/10 16:55	3mL/3mL	3mL/3mL	1.00

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6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 11:16

SAMPLE PREPARATION INFORMATION

Cyanide - Free (Aqueous)

Prep: Microdiffusion

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
A10K200-03	Water	ASTM D 4282	11/11/10 12:20	11/12/10 16:55	3mL/3mL	3mL/3mL	1.00
A10K200-04	Water	ASTM D 4282	11/11/10 13:10	11/12/10 16:55	3mL/3mL	3mL/3mL	1.00
A10K200-05	Water	ASTM D 4282	11/11/10 11:20	11/12/10 16:55	3mL/3mL	3mL/3mL	1.00

Total Metals by EPA 6020 (ICPMS)

Prep: EPA 3015A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1011260							
A10K200-01	Water	EPA 6020	11/11/10 11:50	11/12/10 13:32	45mL/50mL	45mL/50mL	1.00
A10K200-02	Water	EPA 6020	11/11/10 12:10	11/12/10 13:32	45mL/50mL	45mL/50mL	1.00
A10K200-03	Water	EPA 6020	11/11/10 12:20	11/12/10 13:32	45mL/50mL	45mL/50mL	1.00
A10K200-04	Water	EPA 6020	11/11/10 13:10	11/12/10 13:32	45mL/50mL	45mL/50mL	1.00
A10K200-05	Water	EPA 6020	11/11/10 11:20	11/12/10 13:32	45mL/50mL	45mL/50mL	1.00

Dissolved Metals by EPA 6020 (ICPMS)

Prep: EPA 3015A - Dissolved

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1011294							
A10K200-01	Water	EPA 6020 (Diss)	11/11/10 11:50	11/15/10 14:05	45mL/50mL	45mL/50mL	1.00
A10K200-02	Water	EPA 6020 (Diss)	11/11/10 12:10	11/15/10 14:05	45mL/50mL	45mL/50mL	1.00
A10K200-03	Water	EPA 6020 (Diss)	11/11/10 12:20	11/15/10 14:05	45mL/50mL	45mL/50mL	1.00
A10K200-04	Water	EPA 6020 (Diss)	11/11/10 13:10	11/15/10 14:05	45mL/50mL	45mL/50mL	1.00
A10K200-05	Water	EPA 6020 (Diss)	11/11/10 11:20	11/15/10 14:05	45mL/50mL	45mL/50mL	1.00

Conventional Chemistry Parameters

Prep: Method Prep: Aq

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1011277							
A10K200-01	Water	SM 2320 B	11/11/10 11:50	11/14/10 11:58	50mL/50mL	50mL/50mL	NA
A10K200-02	Water	SM 2320 B	11/11/10 12:10	11/14/10 11:58	50mL/50mL	50mL/50mL	NA
A10K200-03	Water	SM 2320 B	11/11/10 12:20	11/14/10 11:58	50mL/50mL	50mL/50mL	NA
A10K200-04	Water	SM 2320 B	11/11/10 13:10	11/14/10 11:58	50mL/50mL	50mL/50mL	NA
A10K200-05	Water	SM 2320 B	11/11/10 11:20	11/14/10 11:58	50mL/50mL	50mL/50mL	NA

Apex Laboratories

Darwin Thomas, Business Development Director

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Apex Labs

12232 S.W. Garden Place
Tigard, OR 97223
503-718-2323 Phone
503-718-0333 Fax

Anchor QEA, LLC Portland	Project: **GASCO-1DW-SEQ 2 C 2**	
6650 SW Redwood Lane Ste. 333	Project Number: 000029-02.28 3A	**Reported:**
Portland, OR 97224	Project Manager: John Renda	12/04/10 11:16

Notes and Definitions

Qualifiers:

B	Analyte detected in an associated blank at a level above the MRL. (See Notes and Conventions below.)
B-02	Analyte detected in an associated blank at a level between one-half the MRL and the MRL. (See Notes and Conventions below.)
J	Estimated Result . Result detected below the lowest point of the calibration curve, but above the specified MDL.
Q-01	Percent recovery and/or RPD is outside acceptance limits.
Q-03	Percent recovery and/or RPD is outside control limits due to the high concentration of analyte present in the sample.
Q-16	Reanalysis of an original Batch QC sample.
Q-17	RPD between original and duplicate sample is outside of established control limits.
R-08	Reporting level raised due to potential high bias associated with the low end of the calibration curve.

Notes and Conventions:

DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis. Results listed as 'wet' or without 'dry'designation are not dry weight corrected.
RPD	Relative Percent Difference
MDL	If MDL is not listed, data has been evaluated to the Method Reporting Limit only.
WMSC	Water Miscible Solvent Correction has been applied to Results and MRLs for volatiles soil samples per EPA 8000C.
Batch QC	In cases where there is insufficient sample provided for Sample Duplicates and/or Matrix Spikes, a Lab Control Sample Duplicate (LCS Dup) is analyzed to demonstrate accuracy and precision of the extraction and analysis.
Blank Policy	Apex assesses blank data for potential high bias down to a level equal to ½ the method reporting limit (MRL), except for conventional chemistry and HCID analyses which are assessed only to the MRL. Sample results flagged with a B or B-02 qualifier are potentially biased high if they are less than ten times the level found in the blank for inorganic analyses or less than five times the level found in the blank for organic analyses. For accurate comparison of volatile results to the level found in the blank; water sample results should be divided by the dilution factor, and soil sample results should be divided by 1/50 of the sample dilution to account for the sample prep factor. Results qualified as reported below the MRL may include a potential high bias if associated with a B or B-02 qualified blank. B and B-02 qualifications are not applied to J qualified results reported below the MRL.

Apex Laboratories

Darwin Thomas, Business Development Director

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Apex Labs

12232 S.W. Garden Place
Tigard, OR 97223
503-718-2323 Phone
503-718-0333 Fax

Anchor QEA, LLC Portland 6650 SW Redwood Lane Ste. 333 Portland, OR 97224	Project: **GASCO-1DW-SEQ 2 C 2** Project Number: 000029-02.28 3A Project Manager: John Renda	**Reported:** 12/04/10 11:16

APEX LABS — **CHAIN OF CUSTODY** — A10K200 — COC 1 of 1

12232 S.W. Garden Place, Tigard, OR 97223 Ph: 503-718-2323 Fax: 503-718-0333

Company: Anchor QEA | Project Mgr: John Renda | Project Name: Gasco Seq 2 C2 | Project #: 000029-02.28 3A
Address: 6650 SW Redwood Ln #333 Portland OR 97224 | Phone: 5036701108 | Fax: 5036701108 | Email: JRenda@anchorqea.com
Sampled by: Matthew Dill

Site Location: OR WA
Other: _____

ANALYSIS REQUEST

#	SAMPLE ID	LAB ID #	DATE	TIME	MATRIX	# OF CONTAINERS	NWTPH-HCID	NWTPH-Dx	NWTPH-Gx	BTEX	8260 RBDM VOCs	8260 Halo VOCs	8260 VOCs	8270 SIM PAHs	8082 PCBs	8081 Chlor. Pest	RCRA Metals (8)	Priority Metals (13)	As Sb, As, Ba, Be, Cd, Pb, Hg, Cr, Co, Cu, Mo, Ni, Se, Ag, Tl, V, Zn	TCLP Metals (8)	1280-COLS	1280-Z	Total Cyanide	Free Cyanide	Hexavalent Chromium	Sulfide, Chloride, Fluoride, Bicarbonate, Carbonate, Nitrate			
1	GS-111110-13		11/10	1150	W	5													X				X	X	X	X			
2	GS-111110-14			1210	W	5													X				X	X	X	X			
3	GS-111110-15			1220	W	5													X				X	X	X	X			
4	GS-111110-16			1310	W	5													X				X	X	X	X			
5	GS-111110-17			1130	W	5													X				X	X	X	X			

Normal Turn Around Time (TAT) 5-10 Business Days

TAT Requested (circle): 24 HR 48 HR 72 HR 4 DAY 5 DAY Other: _____

SPECIAL INSTRUCTIONS:
Cyanide 48 hour hold time
Total and dissolved Metals
Dissolved metals & cations & anions filtered in field

SAMPLES ARE HELD FOR 30 DAYS

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Signature: Matthew Dill	Signature:	Signature:	Signature:
Date: 11/11/10		Date:	
Time: 1500		Time:	
Printed Name: Matt Wilson	Printed Name:	Printed Name:	Printed Name:
Company: Anchor QEA	Company: Apex	Company:	Company:

Apex Laboratories

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Darwin Thomas, Business Development Director

Apex Labs

12232 S.W. Garden Place
Tigard, OR 97223
503-718-2323 Phone
503-718-0333 Fax

Anchor QEA, LLC Portland 6650 SW Redwood Lane Ste. 333 Portland, OR 97224	Project: **GASCO-1DW-SEQ 2 C 2** Project Number: 000029-02.28 3A Project Manager: John Renda	**Reported:** 12/04/10 11:16

APEX LABS COOLER RECEIPT FORM

Client: Anchor QEA Element WO#: A10

Project/Project #: Gasco Seq 2 C2 / 000029-02.28 3A

Delivery info:

Date/Time Received: 11/11/10 @ 1500 By: JS

Delivered by: Apex Courier X Client ___ FedEx ___ UPS ___ Senvoy ___ SDS ___ Other ___

Cooler Inspection Inspected by: COB @ 1657

Chain of Custody:

Included? Yes X No ___ Signed/Dated by Client? Yes X No ___

Signed/Dated by Apex Personnel? Yes X No ___

Coolers: No. of Coolers: 1

	Cooler #1	Cooler #2	Cooler #3	Cooler #4
Temperature (deg. C)	2.6			
Received on Ice? (Y/N)				
Temp. Blanks? (Y/N)				
Ice Type: (Gel/Real/Other)				
Condition:	good			

Cooler out of temp? (Y/N) Possible reason why: ___

Samples Inspection: Inspected by: COB @ 1715

All Samples Intact? Yes X No ___ Comments: ___

Bottle Labels/COCs agree? Yes X No ___ Comments: ___

Containers Appropriate for Analysis? Yes X No ___ Comments: ___

Do VOA Vials have Visible Headspace? Yes ___ No ___ NA Y

Comments ___

Water Samples: pH Checked and Appropriate (except VOAs): Yes X No ___ NA ___

Comments: ___

Additional Information: ___

Labeled by: COB See Client Contact Form: Y N

APPENDIX E
DATA VALIDATION REVIEW MEMORANDUM

ANCHOR QEA

1423 Third Avenue, Suite 300
Seattle, Washington 98101
Phone 206.287.9130
Fax 206.287.9131
www.anchorqea.com

DATA VALIDATION REVIEW REPORT – EPA LEVEL 2

Project:	Gasco Segment 2 Capture Zone
Project Number:	000029-01
Date:	December 22, 2010

This report summarizes the review of analytical results for 16 water samples collected November 8, 10, 11, 2010. The samples were collected by Anchor QEA, LLC and submitted to Apex Laboratories, LLC (Apex) in Tigard, Oregon. The samples were analyzed for the following analyses:

- Total cyanide (TCN) by United States Environmental Protection Agency (USEPA) method 335.4
- Weak acid dissociable cyanide (WADCN) by Standard Method (SM) 4500-CN I
- Free cyanide (FCN) by ASTM method D4282
- Anions by USEPA method 300.0
- Alkalinity by SM 2320B
- Total and dissolved metals by USEPA method 6020

Apex sample data group (SDG) numbers A10K140, A10K177, and A10K200 were reviewed in this report. Samples reviewed are presented in Table 1.

Table 1
Samples Reviewed

Sample ID	Well ID	Lab ID	Matrix	Analyses Requested
GS-110810-1	PW-7-93	A10K140-01	Water	TCN, WADCN, FCN, anions, alkalinity, metals
GS-110810-2	PW-8-68	A10K140-02	Water	TCN, WADCN, FCN, anions, alkalinity, metals
GS-110810-3	PW8-39	A10K140-03	Water	TCN, WADCN, FCN, anions, alkalinity, metals
GS-110810-4	PW-9-92	A10K140-04	Water	TCN, WADCN, FCN, anions, alkalinity, metals
GS-110810-5	Willamette River	A10K140-05	Water	TCN, WADCN, FCN, anions, alkalinity, metals
GS-111010-6	PW-7-93	A10K177-01	Water	TCN, WADCN, FCN, anions, alkalinity, metals
GS-111010-7	PW-8-68	A10K177-02	Water	TCN, WADCN, FCN, anions, alkalinity, metals
GS-111010-8	PW-8-39	A10K177-03	Water	TCN, WADCN, FCN, anions, alkalinity, metals
GS-111010-10	PW-9-92	A10K177-05	Water	TCN, WADCN, FCN, anions, alkalinity, metals
GS-111010-12	Willamette River	A10K177-07	Water	TCN, WADCN, FCN, anions, alkalinity, metals

Sample ID	Well ID	Lab ID	Matrix	Analyses Requested
GS-111110-13	PW-8-68	A10K200-01	Water	TCN, WADCN, FCN, anions, alkalinity, metals
GS-111110-14	PW-8-39	A10K200-02	Water	TCN, WADCN, FCN, anions, alkalinity, metals
GS-111110-15	PW-7-93	A10K200-03	Water	TCN, WADCN, FCN, anions, alkalinity, metals
GS-111110-16	Willamette River	A10K200-04	Water	TCN, WADCN, FCN, anions, alkalinity, metals
GS-111110-17	PW-9-92	A10K200-05	Water	TCN, WADCN, FCN, anions, alkalinity, metals

Data Validation and Qualifications

The following comments refer to the laboratory's performance in meeting the quality assurance/quality control (QA/QC) guidelines outlined in the analytical procedures and data quality objective sections of the Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP). Laboratory results were reviewed using *USEPA Contract Laboratory Program National Functional Guidelines for Inorganics Data Review* (USEPA 2004) and laboratory and method QC criteria as stated in USEPA (1986; SW 846, Third Edition), *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*, update 1, July 1992; update IIA, August 1993; update II, September 1994; update IIB, January 1995; update III, December 1996; update IIIA, April 1998. Unless noted in this report, laboratory results for the samples listed above were within QC criteria.

Field Documentation

Field documentation was checked for completeness and accuracy. The chain-of-custody forms were signed by Apex at the time of sample receipt; the samples were received cold and in good condition.

Holding Times and Sample Preservation and Analytical Methods

Samples were appropriately preserved and analyzed within holding times with the exception of the free cyanide analyses of samples in SDG A10K140 which were analyzed between three and four hours past the 48-hour hold time. Associated sample results have been qualified "UJ" to indicate they are estimated. See Table 4 for qualified data.

Laboratory Method Blanks

Laboratory method blanks were analyzed at the required frequencies. All method blanks were free of target analytes with the following exceptions:

- SDG A10K140 and A10K177 Total Metals – Calcium was detected in the method blank at a level between the MDL and the MRL. Associated sample results were significantly greater than (>5x) the level detected in the method blank with one exception. This result has been qualified as a non-detect. See Table 4 for qualified data.
- SDG A10K140 and A10K177 Dissolved Metals – Potassium was detected in both method blanks at levels between the MDL and the MRL. Associated sample results were either below detection or were significantly greater than (>5x) the higher level detected in the method blanks so no data were qualified.
- SDG A10K200 total metals – Potassium was detected in the method blank at a level between the MDL and the MRL. Sample results were significantly greater than (>5x) the level detected in the method blank so no data were qualified.
- SDG A10K200 Dissolved Metals – Calcium was detected in both method blanks and manganese was detected in one of the method blanks at levels between the MDL and the MRL. Associated sample results were significantly greater than (>5x) the levels detected in the blanks so no data were qualified.

Field Quality Control

Field Blanks

One field blank (GS-111010-11) was collected in association with these samples and was free of target analytes with a few exceptions. Detected results are summarized in Table 2.

Table 2

Analytes Detected in Field Blank

Analyte	Result
Cyanide	0.0082 mg/L
WAD Cyanide	0.0273 mg/L
Iron	0.0162J mg/L
Manganese	0.000467J mg/L
Calcium	0.0306J mg/L
Potassium	0.0139J mg/L
Sodium	0.0461J mg/L

Field Duplicates

One set of field duplicates were collected in association with these sample sets. Detected results are summarized in Table 3.

Table 3

Field Duplicate Results

Analyte	GS-111010-8	GS-111010-9	RPD
Alkalinity, as Calcium carbonate (CaCO3)	327 mg CaCO3/L	318 mg CaCO3/L	3%
Alkalinity, Bicarbonate	327 mg CaCO3/L	318 mg CaCO3/L	3%
Calcium	59D mg/L	58.3D mg/L	1%
Calcium	55.7D mg/L	56.1D mg/L	1%
Chloride (total)	54.2 mg/L	53.7 mg/L	1%
Cyanide	0.0709 mg/L	0.0659 mg/L	7%
Cyanide, Weak acid dissociable (WAD)	0.0278 mg/L	0.0334 mg/L	18%
Iron	21.4D mg/L	21.2D mg/L	1%
Iron	20.9D mg/L	20.5D mg/L	2%
Magnesium	34.7D mg/L	33.9D mg/L	2%
Magnesium	33.3D mg/L	33.2D mg/L	0%
Manganese	2D mg/L	1.98D mg/L	1%
Manganese	1.96D mg/L	1.94D mg/L	1%
Potassium	2.97D mg/L	2.94D mg/L	1%
Potassium	3.03D mg/L	3.03D mg/L	0%
Sodium	56.6D mg/L	55.5D mg/L	2%
Sodium	54.8D mg/L	54.8D mg/L	0%
Sulfate	13 mg/L	13 mg/L	0%

Concentrations at or near the reporting limit (RL) may have exaggerated relative percent difference (RPD) values. No data were qualified based on field quality control.

Surrogate Recoveries

All surrogate recoveries were within the laboratory control limits.

Laboratory Control Sample and LCS Duplicate

Laboratory control samples (LCSs) and LCS Duplicates (LCSDs) were analyzed at the required frequencies. All LCS/LCSD analyses yielded percent recoveries (%R)s and/or relative percent difference (RPD) values within laboratory control limits.

Matrix Spike and Matrix Spike Duplicate

Matrix spike (MS) and matrix spike duplicate (MSD) samples were analyzed at the required frequencies or laboratory duplicates were analyzed in place of MSDs. All %Rs and/or RPD values were within laboratory control limits with the following exceptions:

- SDG A10K140 and A10K200 Conventionals – Total cyanide recovered below control limits in one of the MS samples, however; the MS was performed on a non-project sample so no data were qualified.
- SDG A10K140 and A10K177 Total Metals – Calcium and manganese recovered above control limits in the MS, however; sample results were significantly greater than (>4x) the spike amount so no data were qualified.
- SDG A10K200 Total Metals – Manganese did not recover in one of the matrix spike samples, which was performed on a non-project sample. Calcium recovered above the control limit and manganese recovered below the control limit in the project MS. All sample concentrations were significantly greater than (>4x) the spike level so no data were qualified. Data were not qualified based on non-project MS/MSD results.
- SDG A10K200 Dissolved Metals – Manganese recovered below control limits in two of the MS samples. The MSs were performed on non-project samples and the sample concentrations were significantly greater than (>4x) the spiking levels so no data were qualified.

Laboratory Duplicates

Laboratory duplicates were analyzed at the required frequencies. RPD control limits do not apply if the sample and/or duplicate result is less than 5x the MRL. For results <5x the MRL, the difference between the sample and duplicate result must be <2x the MRL for solid matrices and <MRL for water matrices. All duplicate results were within control limits.

Sample Analysis

Two nitric acid preserved bottles were received at the laboratory for sample GS-111010-12 without any indication about which one had been field-filtered for the dissolved metals analysis. The laboratory filtered an unpreserved aliquot and analyzed that as the dissolved fraction. Both of the nitric bottles received were digested and analyzed for total metals, and the results from both tests are reported. One result reflects total metals, the other field-filtered dissolved metals. A comparison with the lab-filtered dissolved metals indicates that results reported as laboratory sample A10K177-07RE1 are probably from the field-filtered bottle and will be reported as the dissolved fraction.

Method Reporting Limits

Reporting limits were deemed acceptable as reported. All values were reported using the laboratory reporting limits. Values were reported as undiluted, or when reported as diluted, the reporting limit accurately reflects the dilution factor.

Overall Assessment

As was determined by this evaluation, the laboratory followed the specified analytical methods and all requested sample analyses were completed. Accuracy was acceptable as demonstrated by the surrogate, LCS/LCSD, and MS/MSD %R values, with the exceptions noted above. Precision was also acceptable as demonstrated by the laboratory duplicates, MS/MSD, and LCS/LCSD RPD values. Most data were deemed acceptable as reported; all other data are acceptable as qualified. Table 4 summarizes the qualifiers applied to samples reviewed in this report.

Data Qualifier Definitions

U Indicates the compound or analyte was analyzed for but not detected at or above the specified limit.

J Indicates an estimated value.

R Indicates data is rejected and unusable

UJ Indicates the compound or analyte was analyzed for but not detected and the specified limit reported is estimated

DNR Do not report

Table 4
Data Qualification Summary

Sample ID	Parameter	Analyte	Reported Result	Qualified Result	Reason
GS-111010-11	Total metals	Calcium	0.0478J mg/L	0.100U mg/L	Method blank contamination
GS-111010-12	Dissolved metals	Iron	0.132 mg/L	DNR	Report from field filtered sample
		Magnesium	2.07 mg/L	DNR	
		Potassium	1.04 mg/L	DNR	
		Sodium	4.88 mg/L	DNR	
		Calcium	6.55 mg/L	DNR	
		Manganese	0.0116 mg/L	DNR	
GS-111010-12 (A10K177-07RE1)	Total metals	All	All	Report as dissolved metals	Bottle not initially labeled as filtered
GS-110810-1	Conventionals	Free cyanide	0.005U mg/L	0.005UJ mg/L	Analyzed past hold time
GS-110810-2	Conventionals	Free cyanide	0.005U mg/L	0.005UJ mg/L	Analyzed past hold time
GS-110810-3	Conventionals	Free cyanide	0.005U mg/L	0.005UJ mg/L	Analyzed past hold time
GS-110810-4	Conventionals	Free cyanide	0.005U mg/L	0.005UJ mg/L	Analyzed past hold time

REFERENCES

USEPA. 1983. Methods for Chemical Analysis of Water and Wastes. U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio. EPA 600/4 79-020.

USEPA. 1986. Test methods for Evaluating Solid Waste: Physical/Chemical Methods. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. EPA 530/SW-846.

USEPA. 2004. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. U.S. Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation (OSRTI). EPA 540-R-04-004. October.

USEPA. 1999. USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. USEPA 540/R-99/008. October.

USEPA. 2008. USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review. U.S. Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation. USEPA 540-R-08-01. June.

APPENDIX J
FILL WBZ INTERCEPTOR TRENCH DESIGN REPORT AND DRAWINGS

NW Natural Gas Company

NW Natural and Siltronic
Interceptor Trench Design Report

April 2011

Prepared by

Glynn Geotechnical Engineering

for

Sevenson Environmental Services, Inc.

NW NATURAL GASCO SITE – PORTLAND OREGON April 6, 2011
INTERCEPTOR TRENCH DESIGN REPORT

INTRODUCTION This section of the overall project design report provides the technical and logistical information that pertains to the design of the 1855 feet of interceptor trench that is to be constructed along the eastern boundary of the NW Natural Gasco / Siltronic site in Portland Oregon.

PROJECT DESCRIPTION

Objective The primary objective of the interceptor trench is to collect the groundwater in the upper soil fill layer and prevent the migration of DNAPL from the site to the Willamette River.

PERFORMANCE STANDARDS

System Permeability On an overall basis the in place hydraulic conductivity, or permeability, of the barrier wall is in the range of 1.0 E+0 to +2 cm/sec. or approximately 2 orders of magnitude greater than the soil in which the sewer is to be installed.

Interceptor Depths In general the interceptor will be at a site elevation of 5.0 COP down to 0.0 COP. The invert of the interceptor pipe has been established at a level of about 8 inches into the native soil layer. The trench detail indicates there will be 4 inches of bedding stone below the pipe invert. As a result the invert of the trench will be about 12 inches into the first layer of native soil.

Excavation Limits GGE has performed a fundamental review of the stability of the excavation. Pending the proper use of a trench support scheme, the existing slope to the Willamette River will be stable under the current design. However, the stability of the completed interceptor trench must be reevaluated once the nature and scope of the river cleanup is decided. This is because the river cleanup will likely include dredging of sediments near the toe of the riverbank. Dredging of sediment near the toe of the riverbank would alter the factors considered in a stability analysis of the riverbank.

EXISTING CONDITIONS

Topography The site contours shown on sheets S1 through S3 of the GGE design drawings provide an indication of the variability of grades along the alignment of the proposed interceptor trench. In general the top of the bank along the length of the interceptor varies from approximate elevation +32 COP datum to elevation +22 COP datum. In general, the slope of the river bank in the area of station 0+00 to 15+00 is on the order of 2.25H to 1.0V. From station 15+00 to the end at station 18+55, specifically the Siltronic portion of the alignment of the interceptor trench, the slope of the river bank is approximately 1.75H to 1.0V.

Geotechnical Multiple soil borings were advanced along the top of slope in the region where the interceptor will be installed. These test borings were conducted in accordance with ASTM procedures and included the measuring of resistance to a standard penetration-sampling tool hence providing an indication of the relative density

in terms of the blow counts. Below a thick layer of manmade fill the native soils consist of alternating layers of silt - saturated, loose to medium dense, sand and silty sand. The profile for the interceptor trench was selected on the basis of the interpreted contact between the manmade fill and the initial layer of native SILT and SANDY SILT.

Groundwater The free groundwater surface measured in the test borings along the alignment of the interceptor was found to vary from 5 feet below grade near station 5+50 to 17 feet below grade in the region of station 1+50. This equates to approximately elevation +13 COP datum, which indicates the water level in the fill zone is slightly above the level of the Willamette River.

Chemistry The interceptor will be installed into soils and groundwater that contain hydrocarbon based contaminants, plus cyanide. The nature and composition of the contamination has been studied by others and the information provided to GGE for consideration in the evaluation of the interceptor design. The site DNAPL consists of medium to light hydrocarbons. This information was considered in the selection of the materials presented in the interceptor design.

WALL DESIGN

Excavation The soil and manmade fill along the proposed alignment of the interceptor trench consists of a percentage of debris; wood, concrete, boulders, rip rap and brick. The debris, which extends to an average depth of 30 feet below existing grade, could preclude, or at best seriously hinder, the driving of steel sheet piling. Because of the nature of the material to be excavated, in addition to the consideration of all the existing structures and utilities, the excavation support method considered for the interceptor is a combination of partial open cut, to a limited depth, and a specialized highly viscous fluid, a Bio-Polymer. The specialized fluid product is equivalent to drilling mud and will serve to support the trench walls during excavation and interceptor installation. Upon completion of the pipe and pump well installation the Bio-Polymer will be chemically reduced to water and simple sugars, subsequently activating the interceptor trench. Unlike drilling mud the bio-polymer will not degrade the horizontal permeability of the finished excavation walls. The activities associated with the use and maintenance of the Bio-Polymer requires the service of a full time site inspector that can monitor and direct the process.

Sheet Sections Based on the need to limit the potential for river water to flow into the interceptor trench, a line of non-structural PVC sheeting will be installed along the outboard face of the trench. This light weight sheeting wall will be tapped – lightly pressed - into the underlying native soil layer to create a barrier to the intrusion of river water into the system.

Piping and Pump Risers All piping; including the 8 inch diameter perforated interceptor, clean outs, force mains and pump risers; is specified as high density polyethylene – HDPE. These components of the design have been selected on the basis of the depth of installation, backfill materials and the fluids to be collected.

Backfill Once the pipe, manholes and other facilities are installed the trench will be filled to within 12 inches of the existing grade with poorly graded small diameter gravel or crushed stone product. This material has a demonstrated permeability of approximately 1.0E+0 cm/sec, approximately 2 orders of magnitude greater than the fill materials into which the interceptor will be installed. The “pea stone” sized material will be protected from intrusion of fill material with a geotextile having the properties suited to the installation.

Clay Barriers In order to separate the ground waters of the Siltronics site from the remainder of the interceptor sewer a clay barrier has been positioned in the interceptor trench just north of the Siltronics property line. The barrier is to be constructed of soil having properties that will provide an impermeable shield along the excavation alignment. The specialized soil must have a demonstrated installed permeability of not greater than 1.0E-007 cm/sec.

In addition to the clay barrier to be installed in the interceptor trench, a pair of clay barriers shall be installed around the Siltronic stormwater outfall sewer to preclude the entrance of excess water from upstream and downstream of the interceptor. In all cases the barrier is to be socketed into the surrounding soils a distance of not less than 4 feet.

Alignment In general the interceptor trench will be located along the top of the riverbank, set back from the top of slope a distance adequate to permit safe and efficient installation. The exact location of the barrier wall will accommodate existing site conditions, location of existing wells and the known underground facilities; however certain existing facilities will require temporary interruption and/or maintenance during construction. Detailed work around and maintenance plans must be prepared in anticipation of the actual construction. It will be the contractor’s responsibility to investigate, locate and protect all existing facilities whether above or below ground.

INSTALLATION AND SCHEDULE

Equipment A CAT 325 excavator (or similar) will be used to excavate the overburden material. A pump and mixer will be used to install and control the excavation support fluid. Triaxle trucks will haul the soil off site for disposal. Similarly, trucks will be used to transport the fill materials to the site and a loader will be used to place the materials as shown on the design drawings. A team of medium sized cranes will be used to install the piping, pump risers and PVC sheeting.

Sequencing Installation of the interceptor will begin at the lowest points of the excavation, at the location of the pump risers and proceed to move upslope, installing the materials as the excavation proceeds. In as much as there are three (3) pump risers, there will be 3 points of beginning and ending.

Production Rates and Schedules The planned workweek will be Monday through Saturday at 12 hours per day. The complete works will take on the order of 40 to 60 days depending on the difficulties encountered with the excavation and utility work around practices required.

REFERENCES

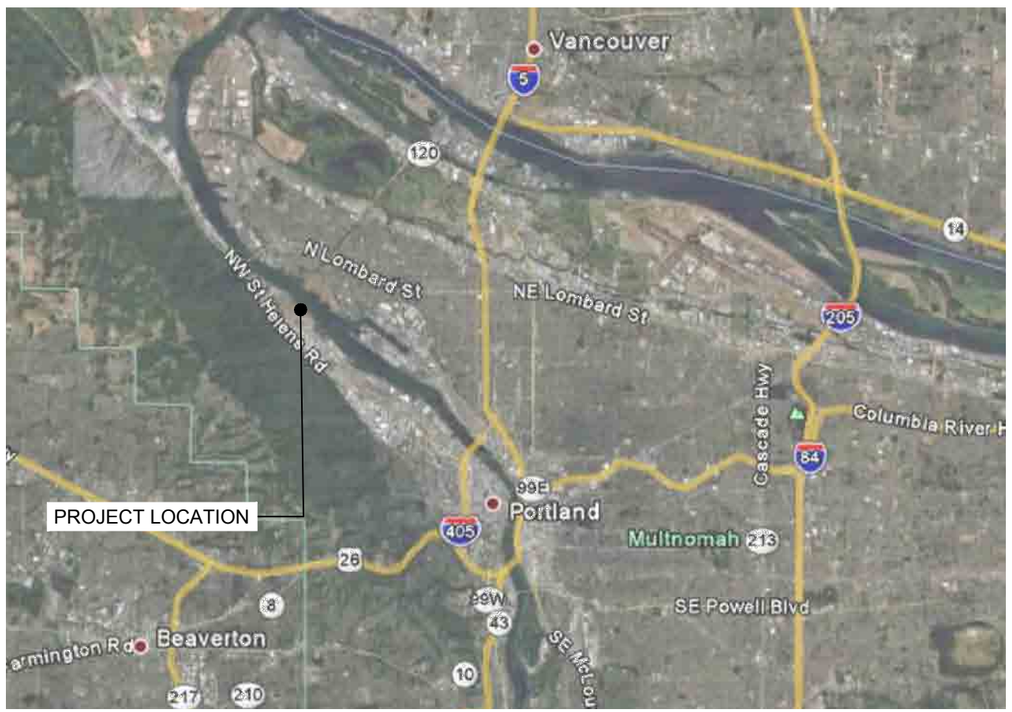
a. GGE design drawings S1 through S10, dated 4-6-11, rev 0.
b. Soil Profile developed from Geologic Cross Section A-A', figures 2-3a through 2-3c by Anchor QEA
c. Contour mapping from Figure 1 Site Plan NW Natural – Gasco Site, by Anchor Environmental, LLC

NW NATURAL, GASCO FACILITY
INTERCEPTOR TRENCH DRAWINGS

at 7900 NW ST. HELENS ROAD
PORTLAND, OREGON
APRIL 6, 2011
ISSUED FOR REVIEW - NOT FOR CONSTRUCTION

DRAWING LIST

S0 - COVER SHEET
S1 - SITE PLAN - STA. 0□00 to 5□50
S2 - SITE PLAN - STA. 5□50 to 12□50
S3 - SITE PLAN - STA. 12□50 to 19□00
S4 - MAIN TREATMENT □ PRE-TREATMENT FACILITY
S5 - DETAIL SHEET
S6 - DETAIL SHEET
S7 - DETAIL SHEET
S8 - EXISTING 24" STORM SEWER OUTFALL TO RIVER
S9 - SPECIFICATIONS
S10 - SPECIFICATIONS



VICINITY MAP
NOT TO SCALE:

LOCATION MAP
NOT TO SCALE:

CLIENT

Sevenson Environmental Services, Inc.
2749 LOCKPORT ROAD
NIAGARA FALLS, NEW YORK
14305

ENGINEER

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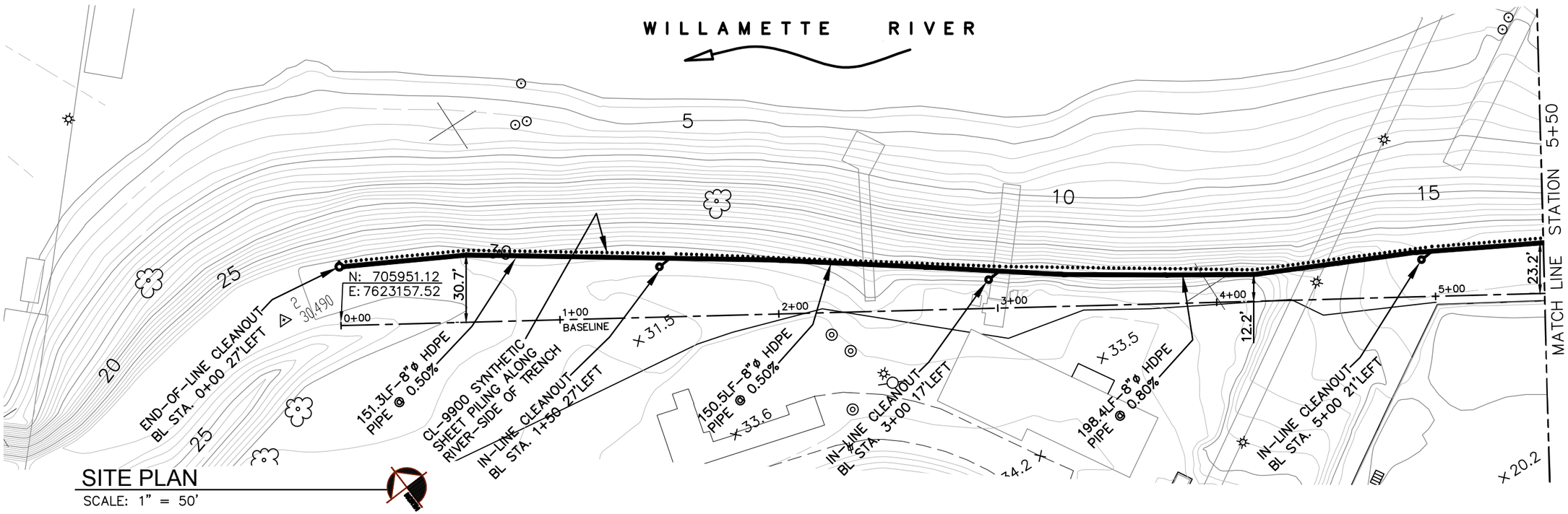
250 DICKSON POINT ROAD
PLATTSBURGH, NEW YORK 12901

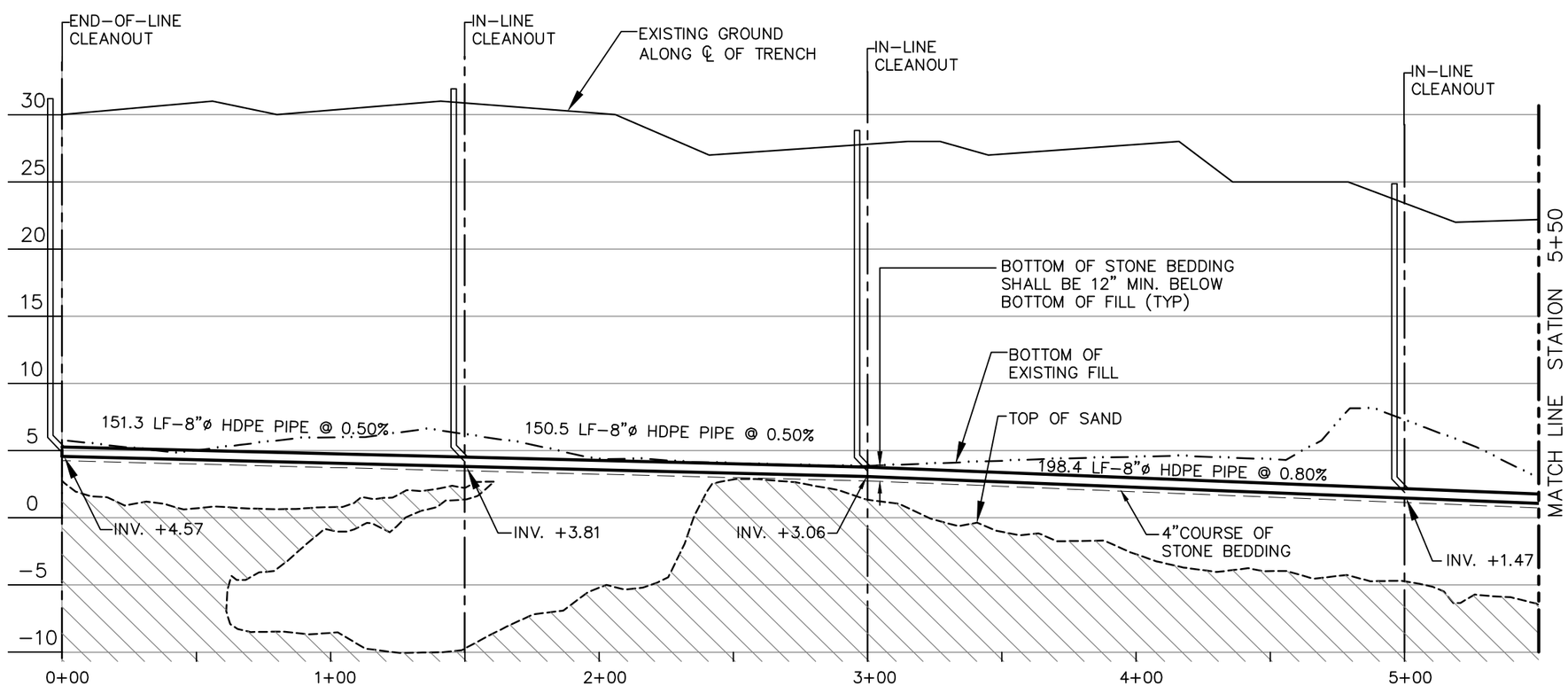
MARK W. GLYNN, PE.

ITEM:	DATE:	REVISION:
1	4.6.11	ISSUED FOR REVIEW - NOT FOR CONSTRUCTION



SITE PLAN

SCALE: 1" = 50'



NOTE:
IMPORTANT TO MAINTAIN
SLOPE OF 8" PIPING (TYP)

PROFILE ALONG ALIGNMENT

SCALE: 1" = 50' (HORIZ.)
1"= 10' (VERTICAL)

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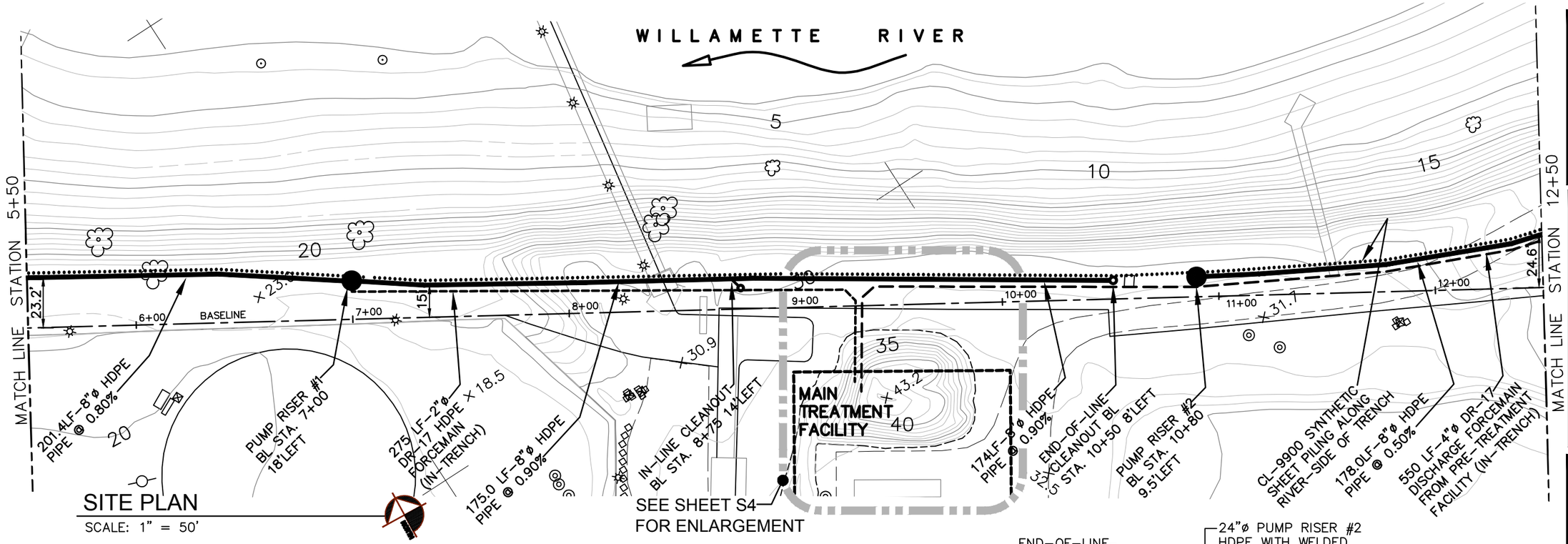
GGE PROJ. # 05-1043D
FILE NAME: SITE PLAN
DATE: REV.0 4.6.11
DRAWN BY: EMP
CHECKED BY: MWG

CLIENT: SEVENSON ENVIR. SERVICES
PROJECT: GASCO SITE - INTERCEPTOR TRENCH

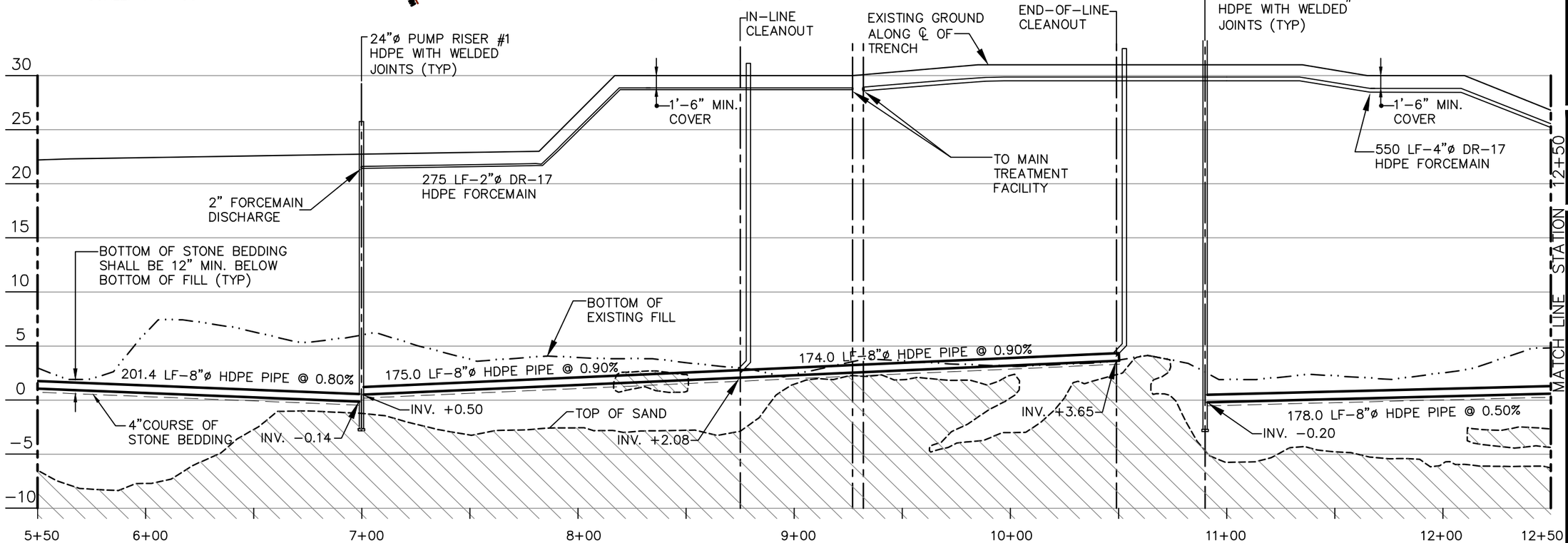
TITLE: SITE PLAN STA. 0□00 to 5□50

DWG : S1



SITE PLAN

SCALE: 1" = 50'



PROFILE ALONG ALIGNMENT

SCALE: 1" = 50' (HORIZ.)
1"= 10' (VERTICAL)

NOTE:
IMPORTANT TO MAINTAIN SLOPE OF 8" PIPING (TYP)

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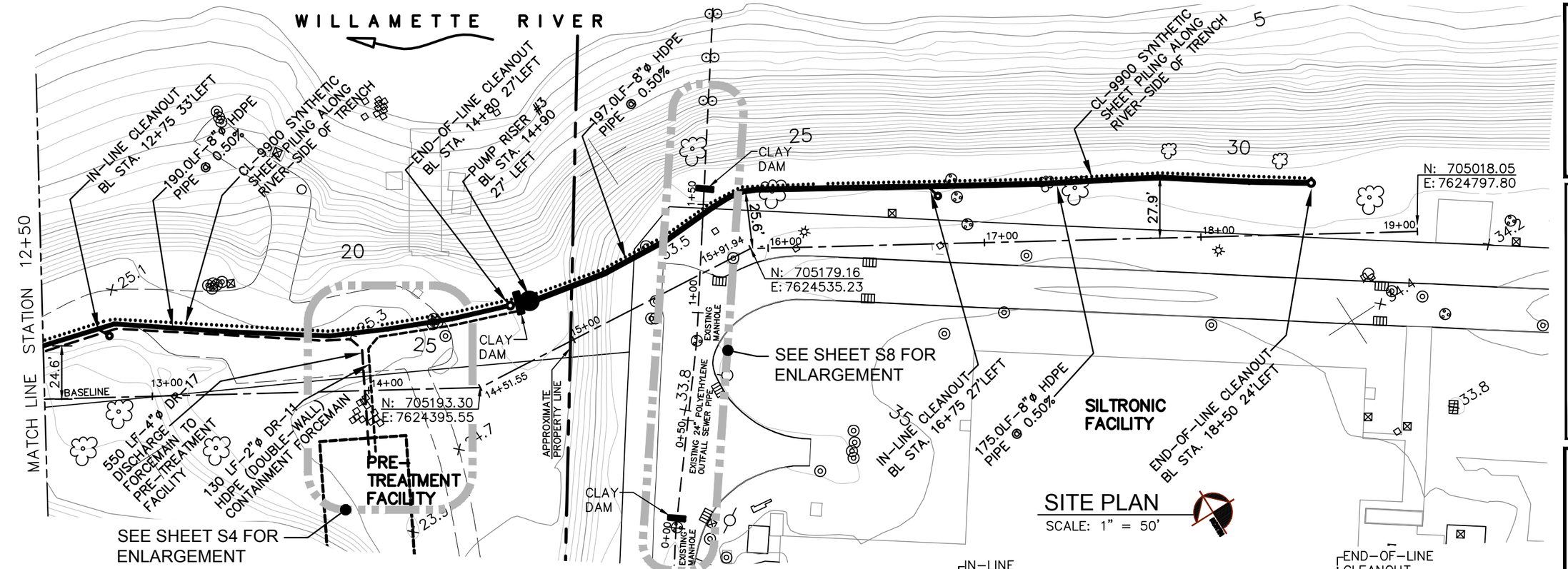
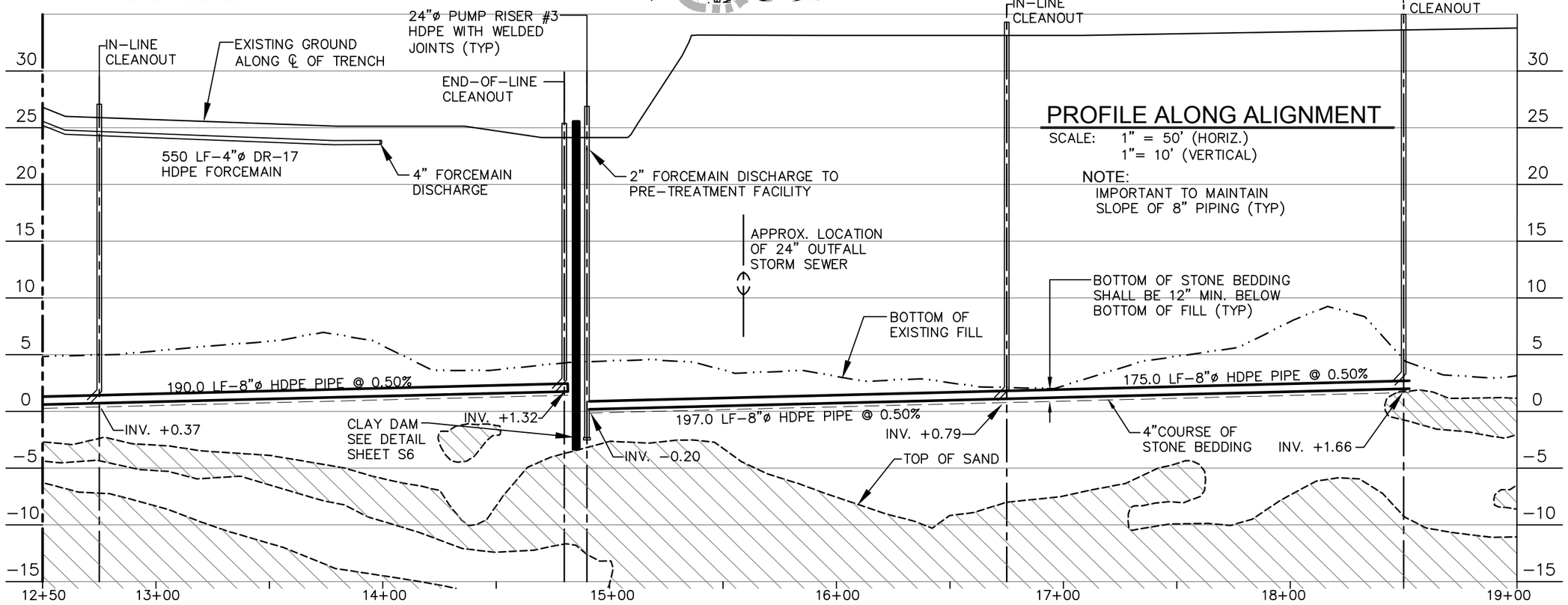
PROJECT: GASCO SITE - INTERCEPTOR TRENCH

TITLE: SITE PLAN STA. 5□50 to 12□50

DWG : S2





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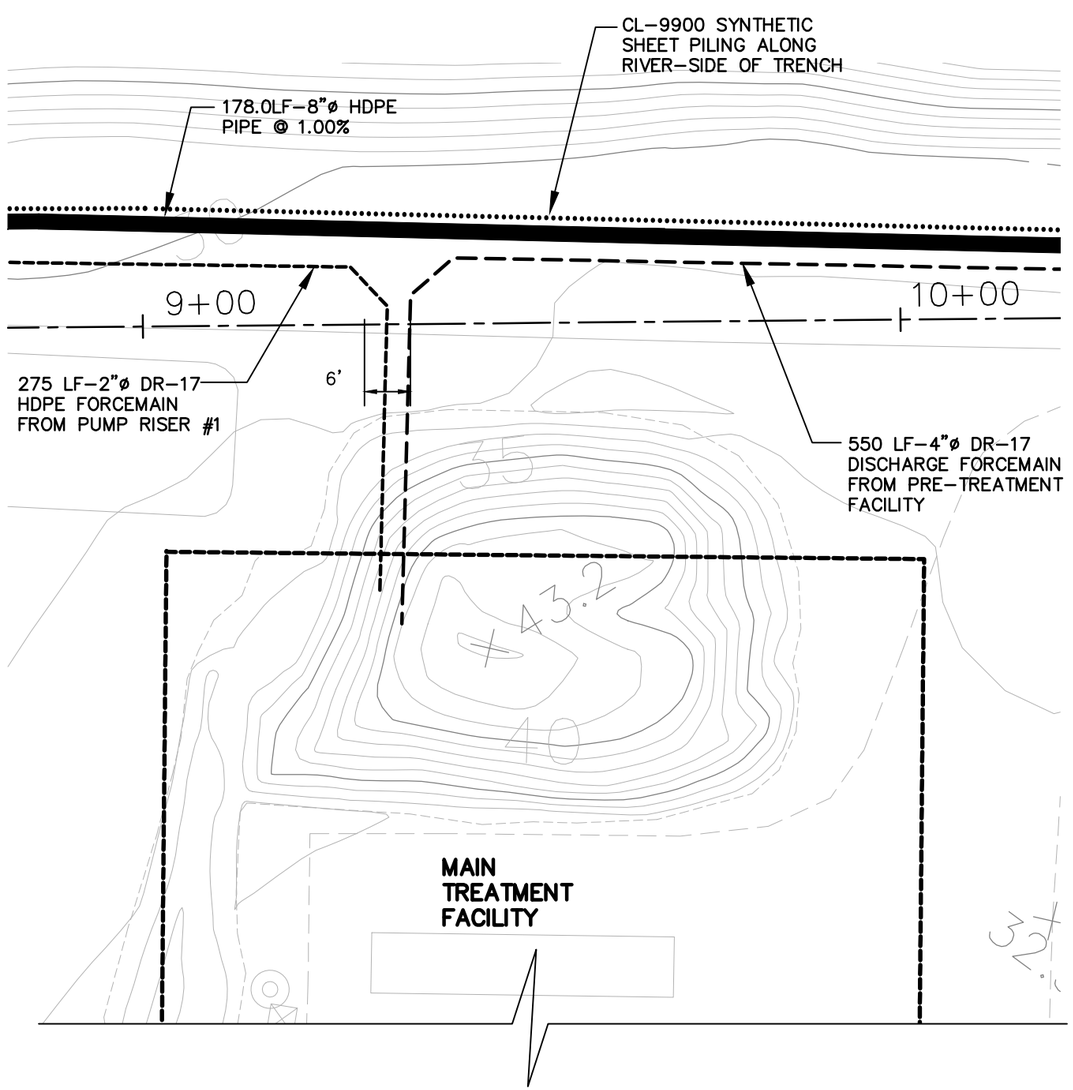
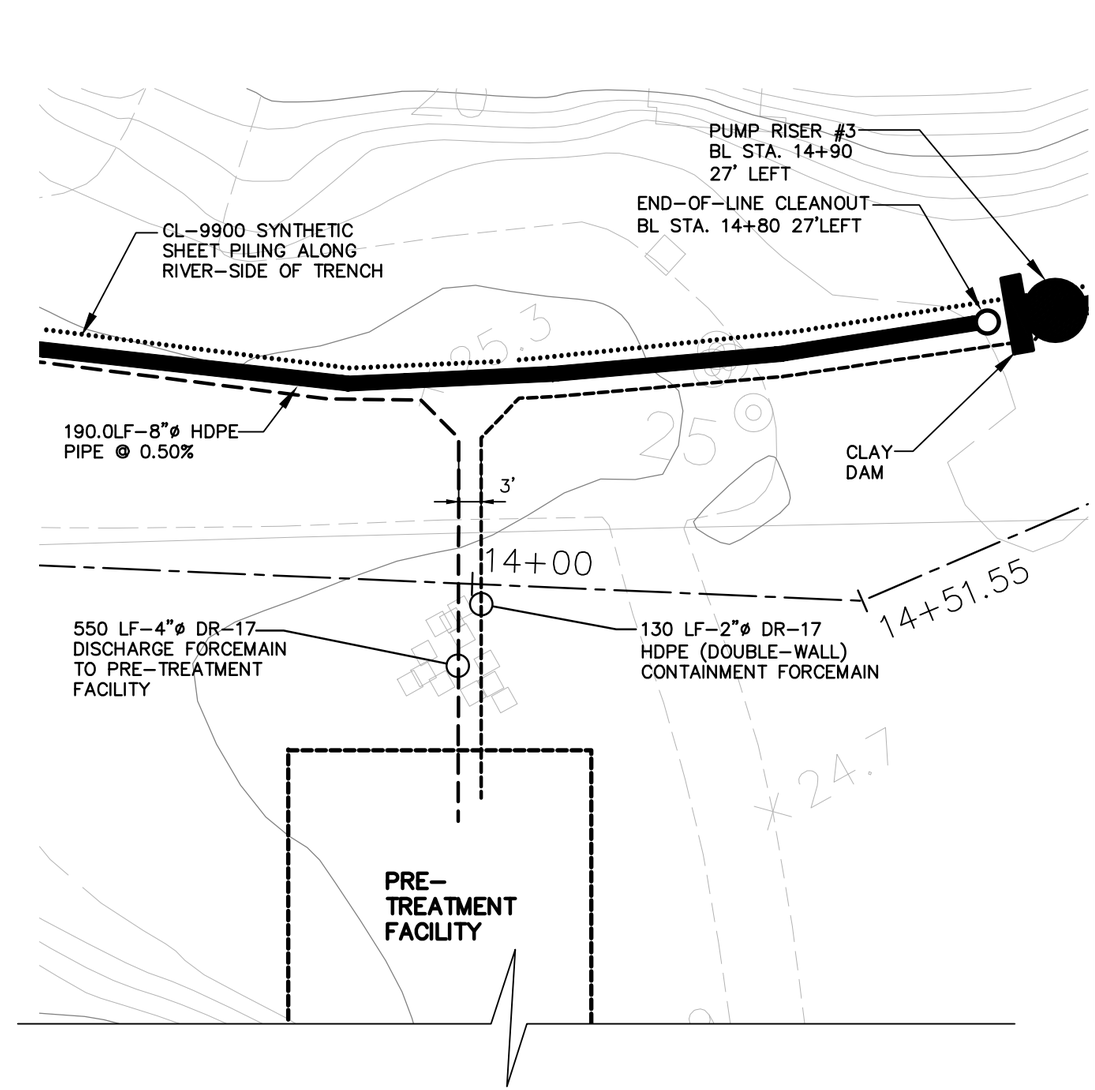
CLIENT: SEVENSON ENVIR. SERVICES
PROJECT: GASCO SITE - INTERCEPTOR TRENCH

TITLE: SITE PLAN STA. 12□50 to 19□00

DWG : S3





SCHEMATIC SITE PLANS

SCALE: 1" = 20'

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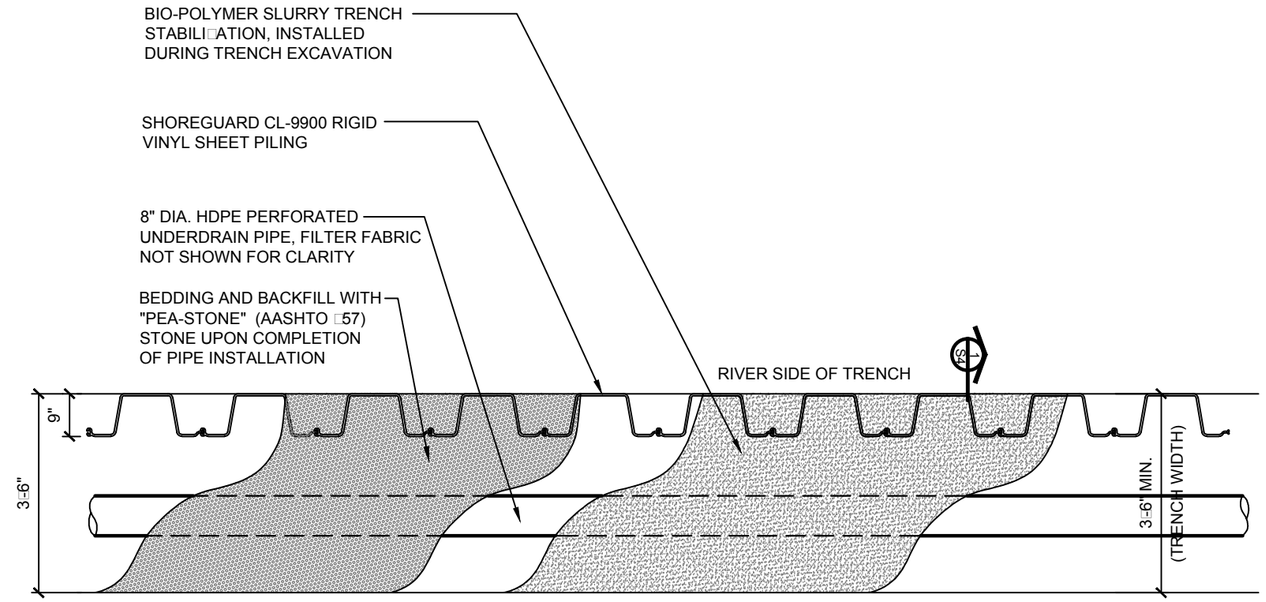
CLIENT: SEVENSON ENVIR. SERVICES

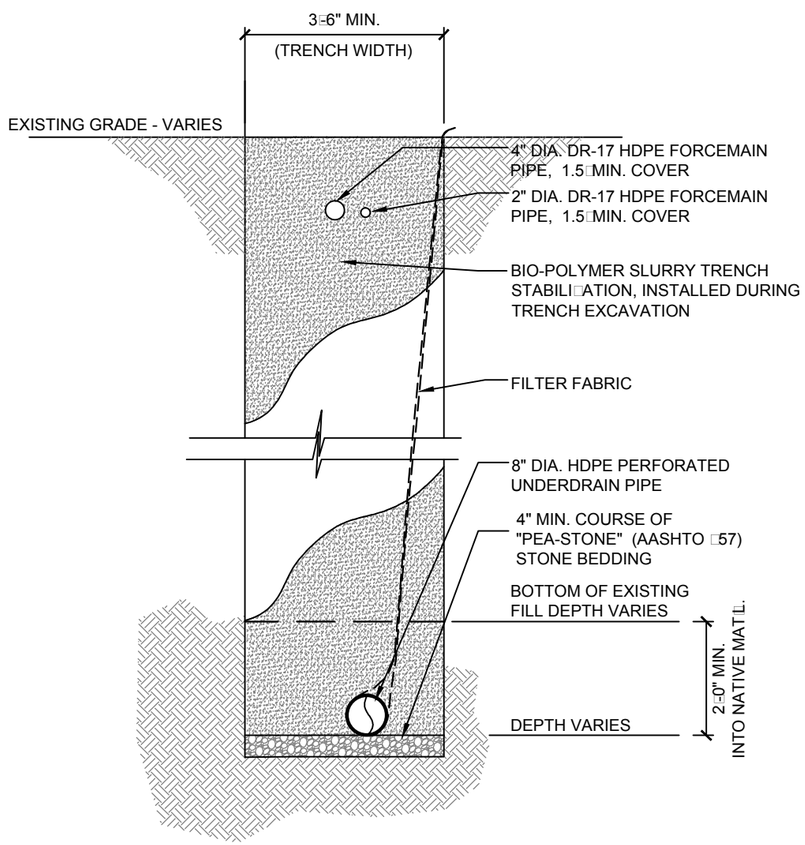
PROJECT: GASCO SITE - INTERCEPTOR TRENCH

TITLE: MAIN TREATMENT FACILITY ☐ PRE-TREATMENT FACILITY

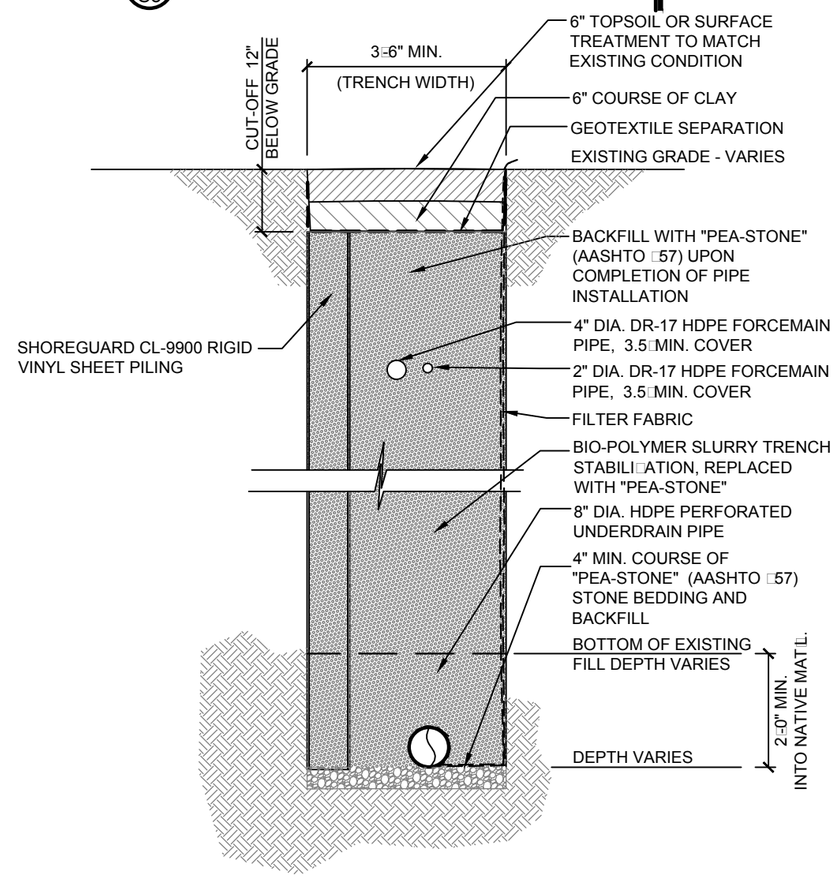
DWG : S4



A S5 PLAN VIEW: TYP. TRENCH
SCALE: 3/8" □1□0"



1 S5 EXCAVATION TRENCH DETAIL
SCALE: 3/8" □1□0"



2 S5 BACKFILLED TRENCH DETAIL
SCALE: 3/8" □1□0"

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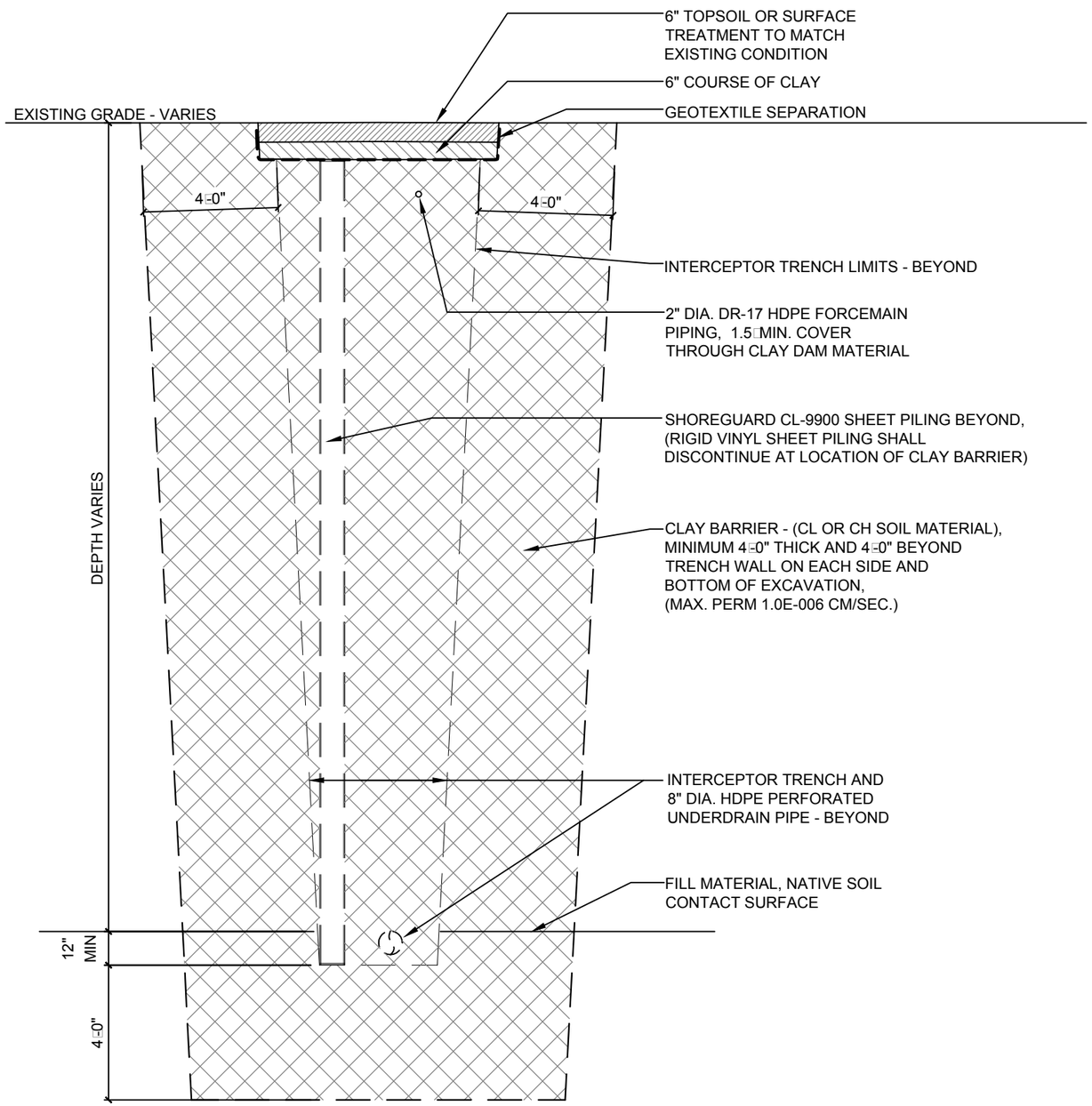
CLIENT: SEVENSON ENVIR. SERVICES
PROJECT: GASCO SITE - INTERCEPTOR TRENCH

TITLE: DETAIL SHEET

DWG : S5



S6 CLAY CUT-OFF WALL DETAIL (SEE SHEET S3)
SCALE: 1/4" = 1'-0"

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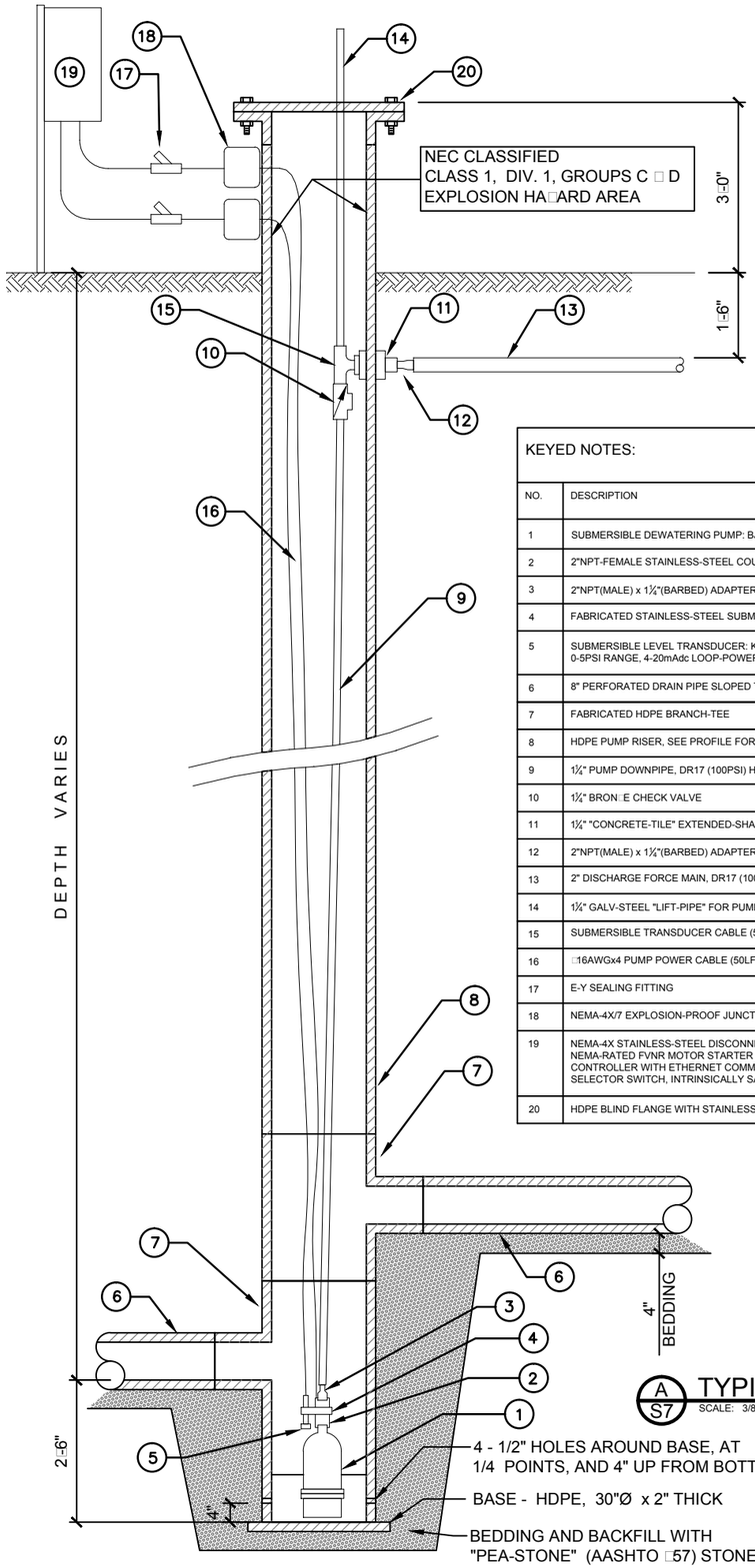
PROJECT: GASCO SITE - INTERCEPTOR TRENCH

TITLE: DETAIL SHEET

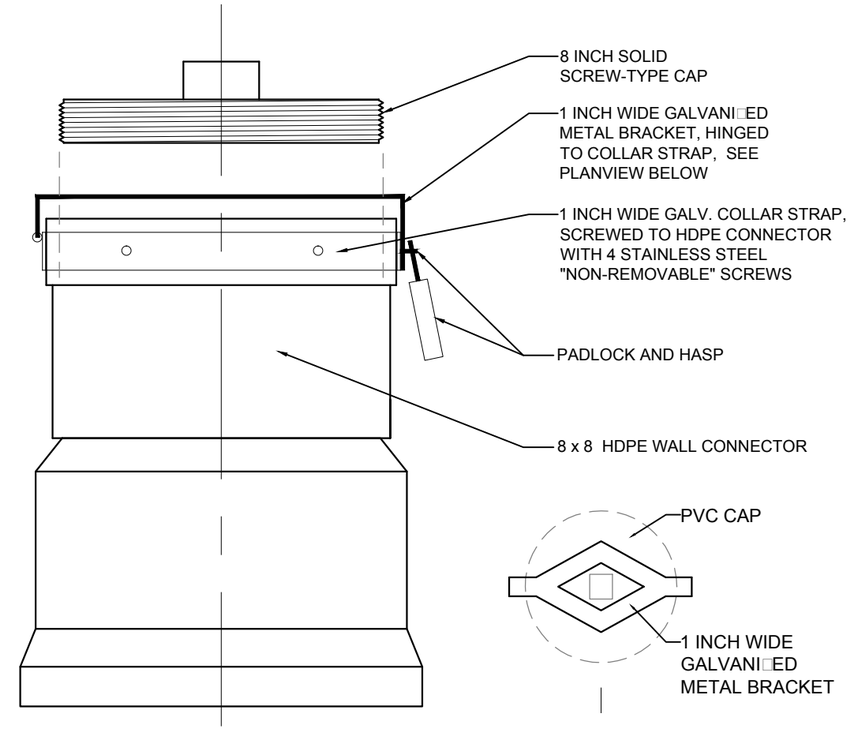
DWG : S6



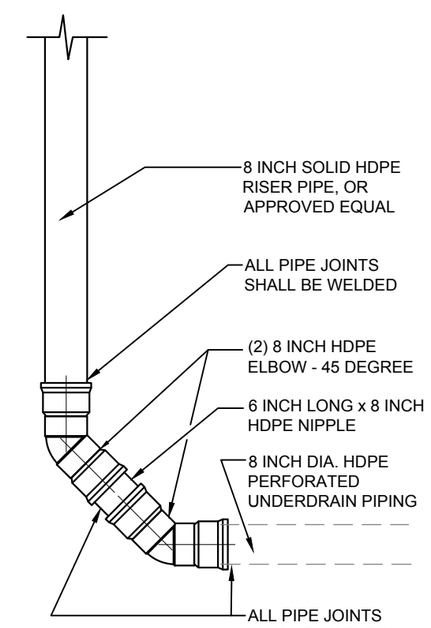
A S7 TYPICAL PUMP RISER - 24" DIAMETER
SCALE: 3/8" □1□0"

KEYED NOTES:

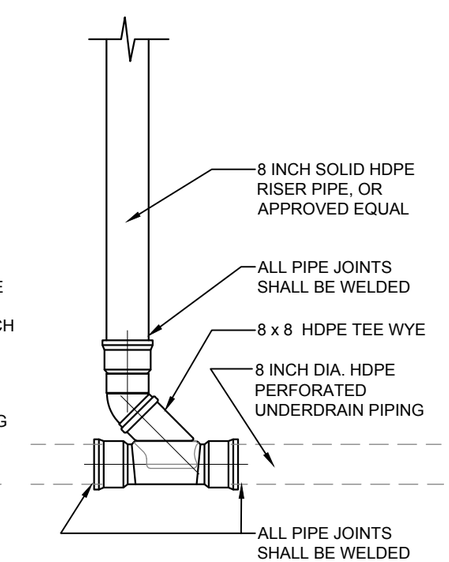
NO.	DESCRIPTION
1	SUBMERSIBLE DEWATERING PUMP: BJM MODEL RX15SS, 316 STAINLESS-STEEL, 25GPM□60□TDH, 2HP, 480V, 3PH, 3.0 FLA, 23 LRA
2	2"NPT-FEMALE STAINLESS-STEEL COUPLING
3	2"NPT(MALE) x 1¼"(BARBED) ADAPTER WITH DOUBLE STAINLESS-STEEL HEAVY-DUTY HOSE CLAMPS
4	FABRICATED STAINLESS-STEEL SUBMERSIBLE TRANSDUCER BRACKET
5	SUBMERSIBLE LEVEL TRANSDUCER: KPSI SERIES 700 316 STAINLESS-STEEL WITH INTEGRAL SURGE/LIGHTNING PROTECTION, 0-5PSI RANGE, 4-20mAdc LOOP-POWERED, 50□FACTORY INSTALLED CABLE AND INTRINSICALLY SAFE ISOLATION BARRIER
6	8" PERFORATED DRAIN PIPE SLOPED TO SUMP (SEE PROFILE)
7	FABRICATED HDPE BRANCH-TEE
8	HDPE PUMP RISER, SEE PROFILE FOR DIAMETER (12" MIN) AND DR CLASS
9	1¼" PUMP DOWNPIPE, DR17 (100PSI) HDPE
10	1¼" BRON□E CHECK VALVE
11	1¼" "CONCRETE-TILE" EXTENDED-SHAFT PITLESS ADAPTER
12	2"NPT(MALE) x 1¼"(BARBED) ADAPTER WITH DOUBLE STAINLESS-STEEL HEAVY-DUTY HOSE CLAMPS
13	2" DISCHARGE FORCE MAIN, DR17 (100PSI) HDPE (DOUBLE-WALL CONTAINMENT STYLE FOR SILTRONIC)
14	1¼" GALV-STEEL "LIFT-PIPE" FOR PUMP AND DOWNPIPE REMOVAL
15	SUBMERSIBLE TRANSDUCER CABLE (50LF)
16	□16AWGx4 PUMP POWER CABLE (50LF)
17	E-Y SEALING FITTING
18	NEMA-4X/7 EXPLOSION-PROOF JUNCTION BOX WITH TERMINAL BLOCK
19	NEMA-4X STAINLESS-STEEL DISCONNECT-STYLE PUMP CONTROL PANEL, MAIN CIRCUIT-BREAKER WITH NEMA-4X FLANGE OPERATOR, NEMA-RATED FVNR MOTOR STARTER WITH MANUAL RESET OVERLOADS, ALLEN-BRADLEY MICROLOGIX PROGRAMMABLE LOGIC CONTROLLER WITH ETHERNET COMMUNICATION, FIBER/ETHERNET CONVERTER, PRECISION DIGITAL LEVEL INDICATOR, H/O/A SELECTOR SWITCH, INTRINSICALLY SAFE BARRIERS, CONTROL RELAYS, TERMINAL BLOCKS, ETC. AS REQUIRED
20	HDPE BLIND FLANGE WITH STAINLESS-STEEL NUTS □ BOLTS



D S7 LOCK-ABLE CAP FOR CLEANOUTS
SCALE: 3" □1□0"



B S7 END-OF-LINE CLEANOUT
SCALE: 3/8" □1□0"



C S7 IN-LINE CLEANOUT
SCALE: 3/8" □1□0"

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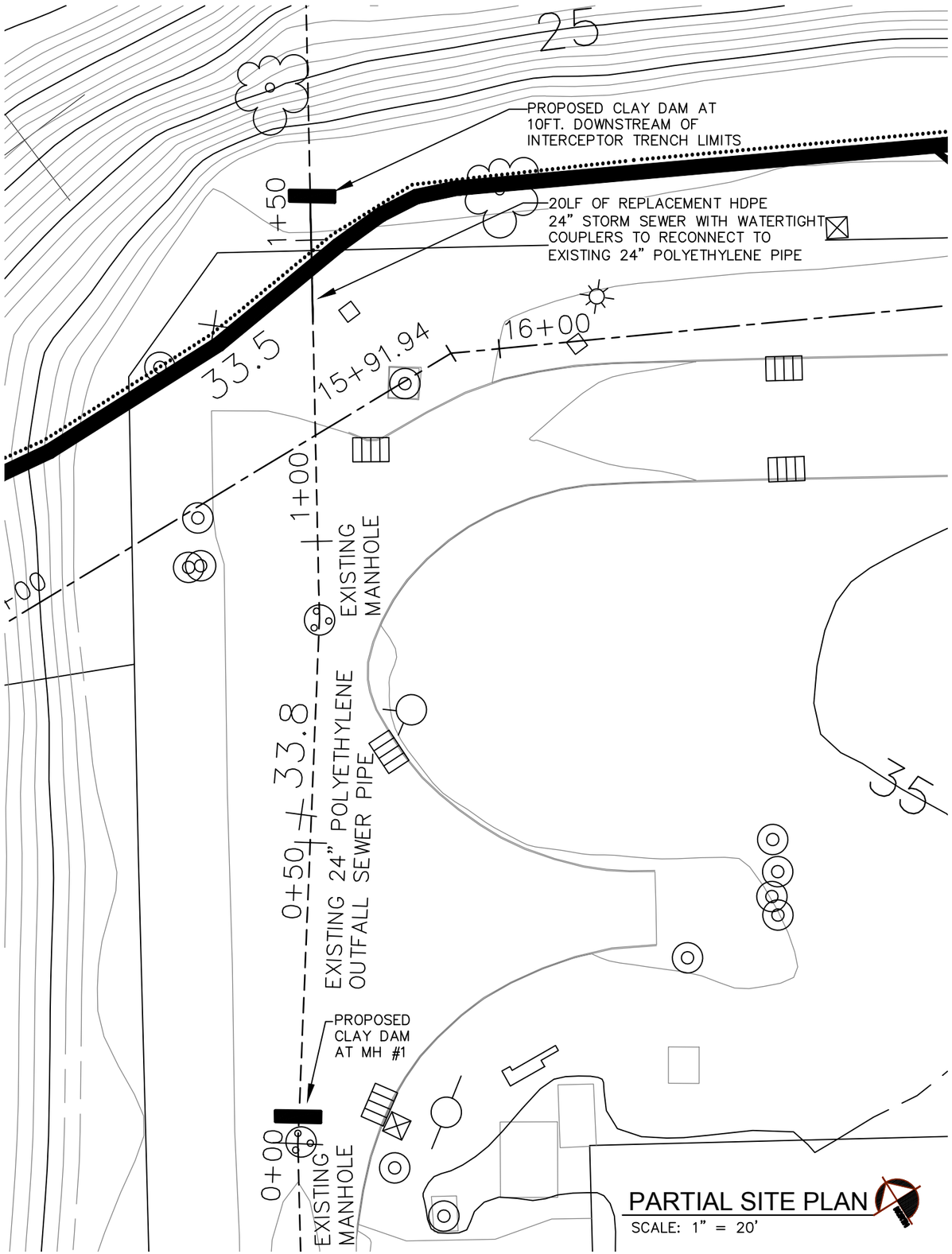
FILE NAME: SITE PLAN
DATE: REV.0 4.6.11
DRAWN BY: EMP
CHECKED BY: MWG

CLIENT: SEVENSON ENVIR. SERVICES
PROJECT: GASCO SITE - INTERCEPTOR TRENCH

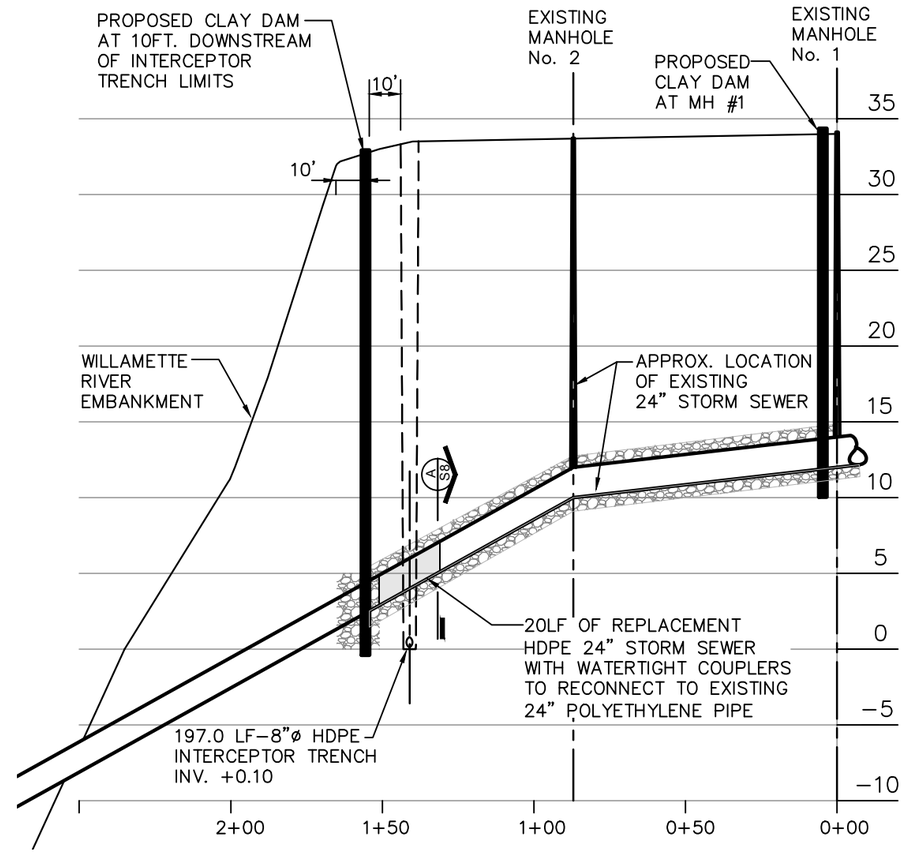
TITLE: DETAIL SHEET

DWG : S7



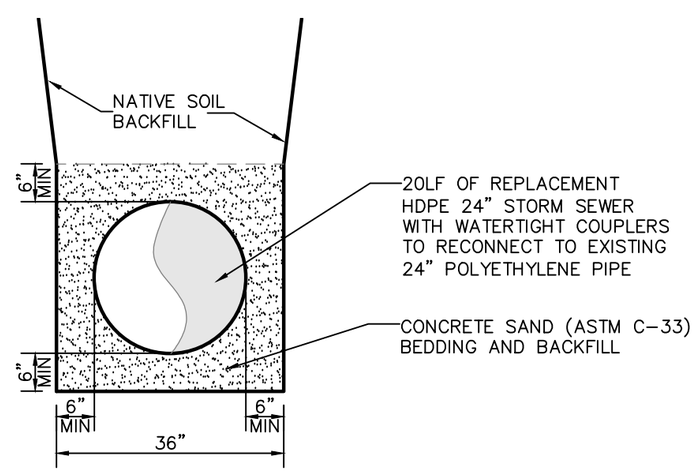
PARTIAL SITE PLAN

SCALE: 1" = 20'



PROFILE ALONG 24" STORM SEWER ALIGNMENT

SCALE: 1" = 50' (HORIZ.)
1"= 10' (VERTICAL)



REPLACEMENT OUTFALL 24" STORM SEWER DETAIL

A S8 SCALE: 1/2" = 1'-0"

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PROJECT: GASCO SITE - INTERCEPTOR TRENCH

TITLE: EXISTING 24" STORM SEWER OUTFALL TO RIVER

DWG : S8

DIVISION 1 GENERAL REQUIREMENTS

SECTION 01010 - SUMMARY OF THE WORK

PART I - GENERAL

A. Furnish all labor, materials, equipment and incidentals necessary to construct the interceptor sewer, as shown on these drawings(S1 thru S10). Specifically, the work includes, but is not limited to following:

1. Establishing and maintaining line and grade control.
2. Preconstruction survey of all existing above and below grade facilities.
3. Protection and/or removal - replacement of existing works along interceptor alignment.
4. Temporary excavation support with Bio-Polymer or an approved equivalent fliud.
5. Furnish and install all materials and equipment.
6. Commissioning and testing of interceptor and equipment.
7. Disposal of excess excavated material, as mandated by regulatory authority.
8. Preparation of record drawings.

B. The interceptor trench and appurtenances are designed to be fully operational and functional when installed. It is solely the contractors responsibility to determine the construction procedures, equipment and sequences and ensure the completed functionality of the system resulting from construction.

SECTION 01040 - COORDINATION

PART I - GENERAL

A. Drawing Revisions: It shall be the Contractor's responsibility to verify that construction proceeds in accordance with the latest revision of design drawings.

B. Coordination Drawings: Prepare field coordination drawings where work by separate entities requires off-site fabrication of products and materials which must accurately interface. Coordination drawings shall indicate how work shown by separate shop drawings will interface, and shall indicate sequence for installation.

SECTION 01060 - REGULATORY REQUIREMENTS

PART 1 - GENERAL

A. Working from lines and levels established by the contract documents, establish and maintain bench marks and other dependable markers. Establish bench marks and markers to set lines and levels for work at each level of construction and elsewhere as needed to properly locate each element of the project. Calculate and measure required dimensions as shown within recognized tolerances. Drawings shall not be scaled to determine dimensions.

B. Record and maintain a set of construction drawings on site to document details of construction that differ from the design. Also, contractor shall perform detailed survey to document the location of existing structures and new and existing utilities.

C. Construction shall conform to the latest edition of the Oregon State Building Code requirements.

D. Intentionally left Blank.

E. Where specifically indicated, the Geotechnical Engineer, the Owners Testing Agency or the special inspector, shall verify adequacy of all subgrades, fills and backfills before placement of fills, footings, piers, slabs, or other construction dependent upon them.

F. Coordinate all work with the contract drawings, site development drawings, electrical drawings, architectural drawings, and the latest manufacturer's drawings. Notify Glynn Geotechnical Engineering (referred to as the Engineer) in writing of conflicts prior to construction. Resolution by Engineer will be given in writing.

G. Contractor is responsible for means, methods, procedures and safety associated with performance of the work.

H. Contractor shall verify all dimensions on the job. Verification of existing dimensions and conditions shall be done prior to preparation of shop drawings.

I. Intentionally left Blank.

J. Typical details apply to all drawings and shall be used except where otherwise shown or noted.

K. All work shall be performed in accordance with local practice in a workman like manner.

L. Provide attachment and connection devices and methods for securing the work. Secure work true to line and level, and within recognized industry tolerances.

SECTION 01400 - QUALITY CONTROL

PART 1 - SUMMARY OF WORK

A. Testing and inspection shall conform to the latest edition of the Oregon State Building Code.

B. Special inspection if required shall be identified by the local building officials or code enforcment office.

C. Intentionally left Blank.

D. Manufacturer's Instructions: Where installations include manufactured products, comply with the manufacturers applicable instructions and recommendations for installation, to the extent that these instructions and recommendations are more explicit or more stringent than requirements indicated in the contract documents.

E. Conflicting Requirements: Where compliance with two or more standards is specified, and where these standards establish different or conflicting requirements for minimum quantities or quality levels, the most stringent requirement will be enforced, unless the contract documents specifically indicate otherwise. Refer to Engineer for a written decision regarding requirements that are different, but apparently equal, and uncertainties as to which quality level is more stringent, before proceeding.

F. All building materials shall be new products. All building materials shall be installed per manufacturer's specifications, for the intended use. Any questions regarding installation, strength, factor of safety, maintenance, or similar concern shall be brought to the engineers attention in writing. Resolution will be documented by engineer in writing.

G. Inspection and Tests: Required inspection and testing services are intended to assist in the determination of probable compliance of the work with requirements specified or indicated. These required services do not relieve the Contractor of responsibility for compliance with these requirements or for compliance with requirements of the contract documents. Inspections, tests and related actions specified in this section are not intended to limit the Contractor's own quality control procedures which facilitate overall compliance with requirements of the contract documents.

H. Retest Responsibility: Where results of required inspections, tests or similar services prove unsatisfactory and do not indicate compliance of related work with the requirements of the contract documents, retests are the responsibility of the Contractor, regardless of whether or not the original test was the Contractor's responsibility. Retesting the work revised or replaced by the Contractor is the Contractor's responsibility, where required tests were performed on original work.

I. Responsibility for Associated Services: The Contractor is required to cooperate with the independent agencies performing required inspections, tests and similar services. Provide such auxiliary services as are reasonably requested. Notify the testing agency sufficiently in advance of operations to permit assignment of personnel. These auxiliary services include but are not necessarily limited to the following:

1. Providing access to the work.
2. Taking samples or assistance with taking samples.
3. Delivery of samples to test laboratories.
4. Security and protection of samples and test equipment at the project site.

J. Coordination: The Contractor and each independent agency engaged to perform inspections, tests and similar services for the project shall coordinate the sequence of their activities so as to accommodate required services with a minimum of delay in the progress of the work. In addition, Contractor and each independent testing agency shall coordinate their work so as to avoid the necessity of removing or replacing work to accommodate inspections and tests. The Contractor is responsible for scheduling times for inspections, tests, taking of samples and similar activities.

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GGE PROJ. # 05-1043D
FILE NAME: SITE PLAN
DATE: REV.0 4.6.11
DRAWN BY: EMP
CHECKED BY: MWG

CLIENT: SEVENSON ENVIR. SERVICES
PROJECT: GASCO SITE - INTERCEPTOR TRENCH

TITLE: SPECIFICATIONS AND NOTES

DWG : S9

DIVISION 2 SITEWORK

SECTION 02200 - EARTHWORK

PART I - GENERAL

1.01 SUMMARY OF WORK

A. Extent of earthwork is indicated on drawings and includes, but is not limited to the following:

1. Site clearing.
2. Excavation and trench stability using specialized fluid (Bio-Polymer).
3. Disposal of excess soil.
4. Maintenance of existing buildings, utilities and other structures.
5. Gravel backfill.
6. Interceptor underdrain pipe, clean out piping and pump riser.
7. PVC sheeting.
8. Clay barriers.
9. Removal, replacement as shown, and full time bypass pumping of all existing outfall sewers, including but not limited to the "Siltronic" storm sewer outfall.
10. Locate, establish and monitor settlement markers on all structures within 50 feet of the interceptor trench alignment.

B. Codes and Standards: Perform excavation work in compliance with applicable requirements of governing authorities having jurisdiction.

1.02 SUBMITTALS

A. Submit the following to Engineer:

1. Procedure for full time bypass pumping of outfall sewers.
2. Plan of settlement markers and details of monitoring program.
3. Product information for excavation support fluid, including detailed procedures for installation, maintenance and monitoring of qualities.
4. Experience records and qualifications of inspectors for excavation support plan.
5. Grain size report on granular backfill and concrete sand.
6. Shop drawings for all piping, cleanouts, and pump risers.
7. Material specification sheet for filter fabric, HDPE, and PVC sheeting.
8. Laboratory test data for clay barrier soil.

PART 2 - PRODUCTS

2.01 PRODUCT INFORMATION

A. Definitions:

1. Concrete Sand - ASTM C-33.
2. Barrier Clay - Unified classification CL, CH or other soil material with maximum permeability of 1.0E-007 cm/sec.
3. Piping - High density polyethlene (HDPE).
4. Sheet piling - "Shoreline" CL-9900 PVC.
5. Filter Fabric - non woven polypropelene identified as separation / filtration fabric by the Geosynthetics Fabric Assoc.
6. Stone bedding and backfill - Clean "pea-stone" size stone, natural or crushed, meeting gradations of AASHTO No. 57.
7. Topsoil - natural organic soil having a minimum 4% organic content.

PART 3 - EXECUTION

3.01 EXCAVATION

A. Excavation is Unclassified, and includes excavation to line and grade, regardless of character of materials.

B. Locate all existing below grade utilities. Provide utilities with positive protection against damage due to all construction activities and potential future settlement.

C. Excavation shall proceed through soil fill to native soil barrier layer. If encountered soil conditions are not as shown on the design drawings, contact Engineer for further action.

D. Shore, brace or otherwise support excavation to permit installation of interceptor system. Provide additional or specialized support system where required due to existing structures or overhead facilities.

E. Provide sediment and erosion control practices as mandated by the regulatory agencies.

F. Establish requirements for excavation safety to comply with OSHA, local codes and authorities having jurisdiction and neighboring infrastructure.

G. Install facilities as shown on design drawings. Connections shall be capable of resisting stress / force of installation handling. Locate components in general arrangement as on design drawings.

I. Place bedding and backfill stone in a loose condition and consolidate by means of flooding with water. Discontinue flooding when consolidation has been established based on visual clues.

J. Overlap filter fabric a minimum of 24" and join by sewing or tying.

3.02 QUALITY CONTROL

A. Provide manufacturers data sheets for all materials incorporated into the project.

B. Provide daily QA / QC reports of construction activities.

C. Provide final record drawings of installation.

D. Flush all cleanouts and televise all collection piping to demonstrate integity of completed system.

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PROJECT: GASCO SITE - INTERCEPTOR TRENCH

TITLE: SPECIFICATIONS AND NOTES

DWG : S10

APPENDIX K
WELL CONSTRUCTION AND DEVELOPMENT PLAN

APPENDIX K

WELL CONSTRUCTION AND DEVELOPMENT PLAN

GROUNDWATER SOURCE CONTROL

DRAFT FINAL DESIGN REPORT

NW NATURAL GASCO SITE

Prepared for

NW Natural

Prepared by

Anchor QEA, LLC

April 2011

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1 INTRODUCTION

This *Well Construction and Development Plan* has been prepared as Appendix K to the *Groundwater Source Control Draft Final Design Report* for the NW Natural Gasco Site (Site) in Portland, Oregon. Extraction wells, observation wells, and piezometers will be drilled and installed. Prior to installation of each well or piezometer, a borehole will be drilled using Sonic drilling techniques. The drilling contractor will obtain Oregon Start Cards for each well or piezometer. Each location will be checked for underground and above-ground utilities prior to the start of drilling. For sites where the location of underground utilities is uncertain, a NW Natural representative will pre-approve the drilling locations. The well construction and development work will be done under the direction of an Oregon Registered Geologist. During drilling activities, continuous cores will be obtained from the deepest boring at each location. The cores will then be photographed and a geologic log will be created in the field to assist in selection of the appropriate screen interval. Step-down drilling techniques will be used in areas of where non-aqueous phase liquid (NAPL) is present as shown on Figure 2-3b of the Draft Final Design Report. In those locations, the casing will be advanced a minimum of 5 feet below the expected depth of NAPL and a bentonite plug will be placed in the bottom of the borehole. The bentonite chips will be allowed to hydrate and the contaminated water will be removed from the borehole immediately after the upper casing is seated in the bentonite plug, and just before the secondary casing is placed downhole.

2 WELL DESIGN

2.1 Extraction Well Design

The extraction wells will be constructed of 6-inch diameter steel flush threaded casing with 15 to 20 feet of stainless steel wire-wrapped screen with 0.035-inch slots and a 5-foot bottom sump. The stainless steel screens will be ordered in 5- and 10-foot lengths to provide flexibility in design of the extraction well screen depth at each location. Upon completion of drilling activities, the well screen and casing will be placed in the borehole to the desired depth. A filter pack consisting of 10 to 20 Colorado silica sand will be installed in the annulus from the total depth of the borehole to approximately 2 feet above the top of the screened interval. After placement of the filter pack, the well screen will be surged to allow proper settlement and prevent bridging of filter pack material. If the level of the filter pack drops during surging, more filter pack material will be added to maintain a thickness of approximately 2 feet above the top of the screened interval. A filter pack seal of at least 3 feet thickness consisting of 3/8-

inch bentonite chips, coated chips, or fine sand will then be installed in the annulus on top of the filter pack. If heavy sheen or NAPL is present, fine graded sand will be used as a filter pack seal. A bentonite grout annular seal mixed to a weight of at least 9.5 pounds per gallon will be pumped in the remaining annulus via tremie pipe from the top of the bentonite seal until grout returns are observed at the surface, ensuring a complete grout column. If NAPL is present, an organoclay mix will be used instead of the bentonite grout seal and a NAPL funnel will be installed at the base of the screen. If a NAPL funnel is required, it should be noted that we will rely on collapse of the native formation in the annular space below the NAPL funnel to fill the void as placement of sand or seal material will not be possible below the funnel. A well monument and concrete surface seal will then be installed at the ground surface.

2.2 Observation Well Design

A surficial fill water bearing zone (WBZ) observation well will also be installed adjacent to the pumping wells. Construction of the surficial fill observation wells will follow the design of the monitoring wells described below.

2.3 Monitoring Well Design

Monitoring wells will be installed between extraction wells to monitor water level drawdown effects at various depths in the Alluvium WBZ due to pumping. The monitoring wells will be constructed of 2-inch diameter PVC casing with stainless steel wire-wrapped screen with 0.020-inch slots and a 3-foot bottom sump. Upon completion of drilling activities, the well screen and casing will be placed in the borehole to the desired depth. Other than as described above in this section, monitoring well installation will follow the same procedures as described in Section 2.1, "Extraction Well Design."

2.4 Piezometer Design

Piezometers will be installed in the river sediments on the shoreline downgradient of some of the extraction wells. The purpose of the piezometers will be to measure groundwater levels in the river sediments during testing of the shoreline extraction wells and during full-scale operation of the system. The piezometers at the base of the riprap slope will be drilled with a track mounted sonic drill rig or, if river levels are high enough, from a barge. The piezometers will consist of 2-inch diameter PVC casing with 5 feet of 0.020-inch slotted screen with a pre-packed sand filter pack and a 3-foot sump. Piezometer installation will follow the installation

procedures as described above. The piezometers installed on the shoreline will be completed with locking above-ground pipe casings, surrounded by protective casing monuments. As with the previously installed PZ5 cluster, monuments will be installed to extend to approximately 16 feet, City of Portland datum.

3 WELL DEVELOPMENT

Following installation, the wells and piezometers will be developed to clean the wells of drilling materials and remove fine materials from the annular sand pack, thereby developing the sand pack and increasing communication with the aquifer.

Monitoring wells, observation wells, and piezometers will be surged for at least 10 minutes with a device equipped with a surge-block in order to move water in and out of the well screen to loosen and flush out sediment from the well screen and from the filter sand pack. The well will then be pumped until at least 10 casing volumes of water have been removed, water quality parameters (pH, specific conductivity, and temperature) have stabilized to +/-10% of the previous reading, and sediment is removed from the well.

Extraction wells will undergo a more rigorous development process to obtain the best practical condition of the annular sand pack. The development of the extraction wells will be completed by the driller while the rig is still in location on the borehole. The drilling contractor will select the development method, but the well screens will be surged and pumped until the water is clear and colorless. In some instances, clear and colorless conditions will not be possible. If this is the case, development will continue until turbidity stabilizes at the best practical condition and field water quality parameters are stable. This may take up to 24 hours of development activities per extraction well.

4 EQUIPMENT DECONTAMINATION AND INVESTIGATION DERIVED WASTE PROTOCOLS

Between borehole locations, all drilling and downhole sampling equipment will be decontaminated at a prepared location on site. The drilling equipment will be decontaminated by steam cleaning or a hot water pressure wash.

Residual soils, groundwater, and decontamination fluids (commonly referred to as investigation-derived waste [IDW]) will be handled as specified in this section. Generally,

material generated during this scope of work will be contained, identified, and characterized. Holding containers will be labeled with their contents, the date of collection, and the origin of the material. The holding containers will be secured and stored in a designated IDW storage area on the site until their contents have been characterized.

After the work is complete and analytical results are received, residual soils and liquids will be evaluated for disposal method consistent with Oregon Department of Environmental Quality (DEQ) regulations and procedures currently in place and being used by NW Natural and Siltronic.

4.1 Soil Cuttings

Soil cuttings originating from the soil borings will be contained in 55-gallon drums or lined drop boxes, which will be stored in the designated IDW storage area. Each storage container will be labeled to include the source of the soil.

4.2 Groundwater

Water generated during well development and sampling will be contained in 55-gallon drums or temporarily transferred to the on-site liquid holding container. The liquids will be treated using the on-site carbon filtration system and discharged to the publicly owned treatment works (POTW) under the existing industrial wastewater discharge permit. The only exception to this would be if the water contains chlorinated solvents from the Siltronic site. In that case, the groundwater may not be treated in the on-site carbon unit, and other treatment/disposal options will be evaluated for approval by DEQ. Groundwater from the Siltronic site will be stored in separate containers from the groundwater sourced from the Gasco site.

4.3 Decontamination Water

Water generated by equipment decontamination will be properly contained during decontamination activities. Decontamination water will be transferred to the liquid storage containers and treated/disposed as described in the previous section for groundwater.

APPENDIX L
AQUA GARD WELL TREATMENT INFORMATION

AQUA GARD®

well maintenance technology

The AQUA GARD® permanent in-well device significantly improves well maintenance

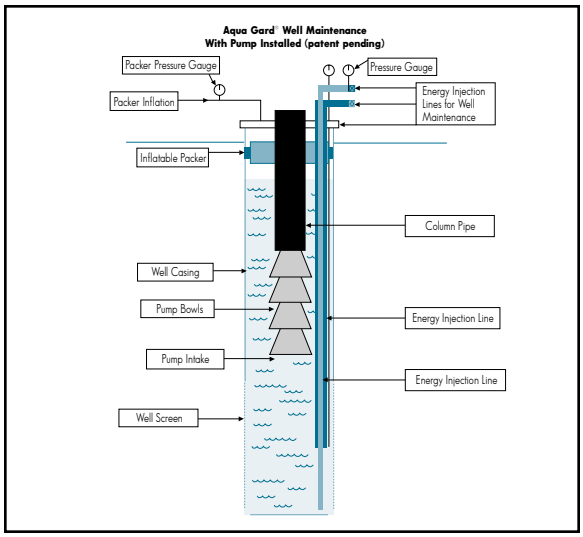
by applying increased energy to more completely remove deposits from wells. The AQUA GARD® system utilizes the permanent placement of energy injection equipment in the well, to efficiently clean well surfaces without pulling the pump.

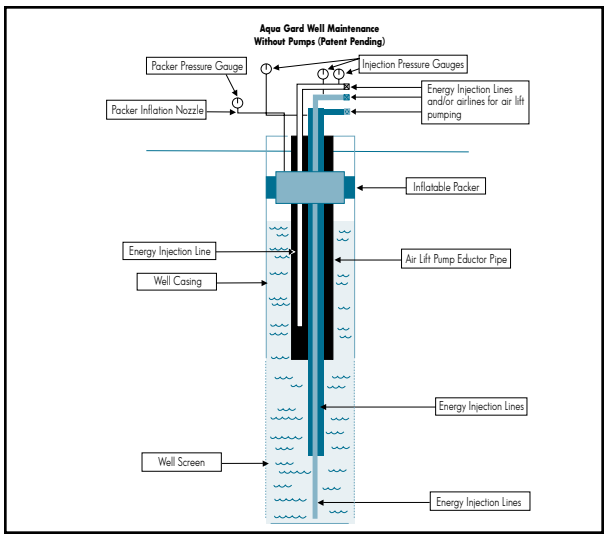
Many wells experience loss of production and water quality problems as a normal process of aging.

The causes of lost capacity and water quality problems are normally categorized into physical, mineral and biological. Often the causes of problems within wells is a combination of bacteria growing in biofilms and filtering minerals from the water as it passes over the surface. Within this biologically accumulated material, fines from the formation (clay, silt, and fine sand) can also become trapped.

Delayed or insufficient rehabilitation treatment can cause build-up or incomplete cleaning of wells.

The amount of deposited material can be very extensive and complete removal of the deposits will most likely be difficult if well treatment is





delayed. Some well rehabilitation treatments are often performed with the pumps in place to reduce the cost, although removing a well's pumping equipment during rehabilitation will allow more energy into the well and the surrounding aquifer. Consequently, the lower portion of many wells is not effectively cleaned due to insufficient velocity achieved to "flush" deposits from the well.

In order to remove deposits from surfaces, we need to deliver more effective energy into the well and aquifer.

This required energy consists of energy of disruption, energy of detachment, energy of dissolution, energy of mobilization and energy of fluidization. Shock chlorination of wells has been used widely in the past in an attempt to maintain a well's performance. However, chlorine as an oxidizing agent does not have the capability of dissolving minerals that are most often associated with biological slime.

Carbon Dioxide possesses the energy to more completely remove deposits from surfaces in the well and further into the surrounding formation.

AQUA GARD® cleans wells more economically and effectively.

The permanent placement of energy injection equipment in the well allows the energy necessary

to remove deposits from the surfaces to be introduced and mobilized in the well without the cost of pulling the pump. The AQUA GARD® system is patent pending and utilizes gaseous and liquid carbon dioxide, providing one of the best methods to deliver energy into every part of the well and the surrounding formation. With a packer and injection lines already in place, Aqua Gard performs the cleaning process without having to pull the pump.

Periodic cleaning can be performed on a scheduled interval to keep the well surfaces clean. The cost of this periodic cleaning can be significantly reduced with the injection equipment already in place. The cleaning is often performed using only carbon dioxide, offering the advantage of not having to neutralize or dispose of chemicals. The use of chemical energy can be added if necessary to remove severe biomass and associated minerals.

Barrier wells and injection wells not equipped with pumps can also benefit from an AquaGard® installation.

There are many barrier wells or injection wells that currently are operated in an injection mode. They do not have internal pumps to backflush their surfaces. Periodically pumping an injection well will extend the time between cleanings, by removing some of the deposited material from surfaces.

Once the material has been detached from the surfaces it must be removed from the bottom part of the well and the surrounding formation. This can best be achieved with the simultaneous pumping and occasional fluidization of the sediments and deposits. This cleans the surfaces more completely and can maintain the original pore volume that exists around wells more effectively. Maintaining the pore volume and keeping surfaces clean increases the timeframe between rehabilitations.

THE BENEFITS OF AQUA GARD®

- Improved Well Performance
- Lower Cost for Well Maintenance
- No need to pull the pump
- Keeping the surfaces clean
- Less “unsafe” bacterial results
- Minimizes the effects of “Iron Related Bacteria”
- Increases the life of a well
- Maintains the Pore Volume of the Well and Aquifer
- Maintains Well Production
- Provides for scheduled preventative well maintenance
- Can be completely automated

If you are experiencing any or all of the following problems, Aqua Gard® may be your long-term solution

- Well experiences lost capacity quickly and/or frequently
- Well has water quality problems
- New wells in areas where deposition of material is known to occur
- Well has periodic “unsafe” bacterial results

AQUA GARD® APPLICATIONS

- Water Supply Wells
- Horizontal Wells
- Collector Wells
- Barrier Injection Wells
- Remediation Wells

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http://www.subsurfacetech.com

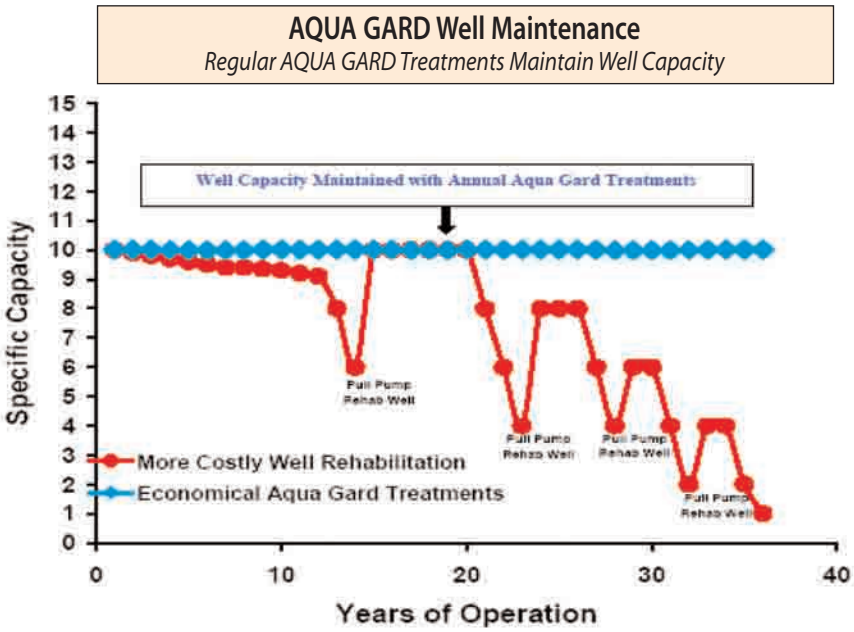
Well Maintenance Technology (patented)

The AQUA GARD® permanent in-well device significantly improves well maintenance

AQUA GARD® Well Maintenance Systems include the permanent placement of energy injection equipment into the well to allow the well to be cleaned effectively, maintaining quantity and quality, without having to remove the pumping or injection equipment. AQUA GARD provides a "proactive rather than reactive cleaning, and has proved to be more effective and much more economical for the client.

Many wells experience loss of production and water quality problems as a normal process of aging.

When your well is equipped with an AQUA GARD system, energy can be delivered into the well for removal of mineral and biological deposits, before they become hardened making them much easier to remove. Subsurface Technologies use of carbon dioxide applied on many thousands of wells over decades has proven to be the most effective method of injecting energy and rehabilitating wells and continues to be the energy of choice, because of its effectiveness and environmental friendliness. The scheduled periodic cleaning service is performed usually in one to two days, reducing down time and cost while ensuring that the well surfaces are kept clean for improved water quality and increased flow capacity.



Well Maintenance Technology (patented)

The Benefits of AQUA GARD®

- ✓ Improved Well Performance
- ✓ Lower Cost for Well Maintenance
- ✓ No need to pull the pump
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- ✓ Increases the life of a well
- ✓ Maintains the Pore Volume of the Well and Aquifer
- ✓ Maintains Well Production
- ✓ Provides for scheduled preventative well maintenance
- ✓ Can be completely automated

If you are experiencing any or all of the following problems, AQUA GARD may be your long-term solution

Well experiences lost capacity quickly and/or frequently

Well has water quality problems

New wells in areas where deposition of material is known to occur

Well has periodic "unsafe" bacterial results

AQUA GARD Applications

Water Supply Wells

Horizontal Wells

Collector Wells

Barrier Injection Wells

Remediation Wells

CASE STUDIES

A 9 well industrial site in the northeast, required rehabilitation every 6 months to restore lost capacity due to very high levels of biological activity, producing extremely poor water quality and rendering the wells un-potable. In 2001 AQUA GARD was installed on 5 of the 9 wells and serviced quarterly, producing increased yield, along with sustained higher pumping levels & efficiencies. Plant demand was then fully met by the 5 wells that were equipped with AQUA GARD, with greatly reduced maintenance and energy costs during the following 3 year period as shown in the cost benefit analysis below.

Taconic Farms	36 Month Period pre AQUA GARD	36 Month period post AQUA GARD	
Item	**10/98 to 10/01**	**10/01 to 10/04**	**Savings**
Well Rehabilitation		$ 9,200.00	
Aqua Gard Installation	$ 2,595.00		
Per Well Cleaning Cost	$ 2,520.00	$ 6,000.00	
Water Treatment Cost During Cycle	$ 65,600.00	$ 13,600.00	
Energy Cost During 3 Year Term			
Supplemental Water			

In November of 2004, AQUA GARD was installed on 1 of a 5 well potable water supply system. The well was completed to 540' and produced 160 GPM with a pumping level of 259'. Almost immediately well yield and efficiency began a steady decline. Within 6 months the well had lost 35% of its yield and 37% of its efficiency. The well was cleaned and AQUA GARD installed. Based on the historical performance the well would have required cleaning at 6 month intervals to minimize lost yield and reduced efficiency. The following represents the cost benefit to the installation of an AQUA GARD preventative maintenance system.

Forest, PA (5) well site	Without Aqua Gard	With Aqua Gard	Savings
Well Rehabilitation	$ 19,000.00	$ 19,000.00	
Aqua Gard Installation		$ 7,000.00	
Service Events During 3 Year Cycle	5.00	11.00	
Cost per service	$ 19,000.00	$ 3,400.00	
Energy cost			
Supplemental water cost			
Total per well cost for 36 months	$ 114,000.00	$ 63,400.00	$ 50,600.00
Cost per site during 3 year term	$ 570,000.00	$ 317,000.00	$ 253,000.00

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APPENDIX M
TARGOST DNAPL BORING PROCEDURES

1 INTRODUCTION

In comments to the *Groundwater Source Control Interim Design Report* (IDR; Anchor QEA 2009; presented in Appendix A of this *Groundwater Source Control Final Design Report* [FDR]), Oregon Department of Environmental Quality (DEQ) commented that operation of the extraction wells could potentially mobilize and spread dense non-aqueous phase liquid (DNAPL) and that potential expansion of the distribution of DNAPL is a significant factor for source control measures planning and design. As described in Section 3.2.2.2.1 of this FDR, the number, depth, and locations of Segment 1 extraction wells were redesigned to minimize the potential for DNAPL mobilization. Mobile DNAPL is expected to migrate into shallow Segment 1 extraction wells that are inadvertently screened in mobile DNAPL. However, the reduced horizontal and vertical gradients that will result from the currently proposed extraction well network are not expected to mobilize DNAPL beyond a distance of a few feet from each extraction well.

To further address DEQ's concerns, a DNAPL monitoring component has been added to the system performance monitoring program. The DNAPL monitoring program consists of three main elements:

- TarGOST sampling
- Monitoring and recovery of DNAPL that enters wells
- Monitoring of DNAPL that enters the treatment system oil-water separators

These elements are described in detail in Section 3.2.2.5.3 of this FDR. This appendix presents the methodologies to be followed during the TarGOST sampling activities. Per the approach outlined in Section 3.2.2.5.3 of this FDR, if DNAPL is detected in a TarGOST boring in a DNAPL monitoring area during monitoring activities, a second TarGOST boring will be advanced to confirm the TarGOST results. If DNAPL is detected in the confirmation TarGOST boring, a soil core sample will be collected adjacent to the TarGOST boring at the depth where DNAPL was detected. The following sections describe the methodologies to be followed during the TarGOST sampling activities and consist of protocols for:

- Field documentation
- TarGOST screening
- Soil sample collection and analysis
- Field equipment decontamination
- Horizontal position and vertical control

- Soil boring abandonment
- Investigation derived waste.

The Health and Safety Plan (HASP) presented in Appendix P of this FDR specifies safety protocols to be followed during these activities.

2 FIELD DOCUMENTATION

A record of field activities will be maintained in a field log book or on daily log forms. On-site activities, including health and safety entries and field observations, will be documented. Entries will be made in indelible ink.

Logs and field notes of core and boring samples will be maintained as samples are collected and correlated to the sampling location map. The following information will be included in this log:

- Date and time of collection of sample
- Names of field supervisor and person(s) collecting and logging in the sample
- Observations made during sample collection
- Sample station number
- Length and depth intervals of each boring section

3 TARGOST SCREENING

As described in Section 3.2.1.6 of this FDR, Hahn Associates, Inc. (HAI), conducted TarGOST investigations on behalf of NW Natural in 2007 and 2008. The TarGOST exploration technology uses a cone penetrometer drill tool equipped with a detector that is pushed to selected subsurface sampling depths. The detector measures the fluorescent signature and magnitude to identify the presence of various petroleum compounds. The device was specifically calibrated to respond to DNAPL tar and oil at the Site by conducting test borings at locations where the DNAPL occurrence was known from previous investigations. The technology is reliable for the detection of the presence of tar and oil but cannot differentiate between tar and oil or determine if the material is mobile. The cone penetrometer measures the change in earth resistance as it is pushed into the ground, and the magnitude of resistance is correlated to soil types, such as sand, silt, and clay. Thus, the penetrometer logs are used to determine soil type.

TarGOST borings will be used to screen for the presence or absence of DNAPL in the DNAPL monitoring areas generally following the methods described in the DEQ- approved *Final*

Remedial Investigation Work Plan, Historical Manufactured Gas Plan Activities, Siltronic Corporation Property, 7200 NW Frond Avenue, Portland, Oregon (HAI 2007) and the *Remedial Investigation Data Summary Report, Historical Manufactured Gas Plan Activities, Siltronic Corporation Property, 7200 NW Front Avenue, Portland, Oregon* (RI Data Summary Report) (HAI 2011). These methods are briefly described below.

TarGOST borings will be installed using direct push methods. Real-time TarGOST data (as a percent emitter) will be collected and observed on a laptop computer display during boring installation. All borings will be advanced to depth of approximately 150 feet below ground surface (bgs) or to refusal. If it is not possible to advance the TarGOST apparatus through the fill, a pre-drilled hole will be prepared using a hollow-stem auger or direct push equipment and cased with polyvinyl chloride (PVC). TarGOST data cannot be obtained from a cased borehole. Logs will be prepared to document the TarGOST results.

4 SOIL SAMPLE COLLECTION AND ANALYSIS

As described in Section 1, if DNAPL is detected in a confirmation TarGOST boring, a soil core sample will be collected adjacent to the TarGOST boring at the depth where DNAPL was detected. The soil sample will be collected using direct push methods and submitted to the laboratory to confirm the presence of DNAPL and to assess the mobility of the DNAPL.

These methods were used previously at the Site during the Supplemental Remedial Investigation activities described in the RI Data Summary Report. The soil sample collection and analysis procedures will generally follow the DEQ-approved approach for these activities described in the *Supplemental Remedial Investigation Field Sampling Activities, DNAPL Characterization, Siltronic Corporation Property, 7200 NW Front Avenue, Portland, Oregon* technical memorandum submitted by Rob Ede, R.G., of HAI to DEQ on January 16, 2009. The following subsections describe the protocols to be followed during the soil sample collection and analysis activities.

4.1 Soil Sample Collection

Borings will be advanced by a truck-mounted or track-mounted direct push (i.e., Geoprobe™ or similar) rig. Continuous soil samples will be obtained by closed-piston sampler. Coring will start at the ground surface with a 5-foot-long, 1.5-inch inside-diameter (ID) core sampler. The piston tip will be loosened and the sampler will be advanced into the ground, thereby coring the soil inside the sampler's disposable, single-use plastic liner. The sampler will then be

withdrawn to retrieve the liner and the soil sample. The liner will be cut to remove the soil sample or capped for laboratory analysis as described below.

A new liner will be placed inside the core sampler, and the core sampler with the piston tip locked will be advanced to the top of the next sample interval. The piston tip will then be released and the core sampler will be advanced to obtain the next sample. This process will be repeated until refusal or the specific depth (i.e., the depth where DNAPL was detected by the TarGOST boring) is reached.

Soil cores will be collected in 5-foot intervals. The 5-foot interval corresponding to the depth interval where DNAPL was detected in the TarGOST boring will be processed for transfer to the analytical laboratory as follows:

- The core section will be brought to the surface, immediately placed in the horizontal position, and the plastic liner removed from the core barrel.
- The bottom of the plastic liner will be capped, and the core placed in the vertical position with the bottom of the core down.
- Excess (empty) liner will be trimmed from the top and the top of the remaining core liner will be capped.
- The liner will be returned to the horizontal position and the core recovery will be measured to the nearest tenth of a foot.
- The core will likely require further cutting in order to reduce lengths to approximately 18-inch sections that will fit into coolers for shipping. Further cutting will be conducted with the core in the horizontal position, with new ends immediately capped and labeled. Plastic film may be placed under the cap if needed to prevent core movement within the sleeve.
- Core subsections will be labeled in permanent ink with the boring identification number and depth interval. Core subsections will be labeled sequentially from top to bottom with letters starting at the top (shallowest) subsection.
- Core saturations and structural integrity will be preserved by wrapping each core section with three layers of plastic film and placing them horizontally in a cooler containing dry ice. Care will be taken to ensure that the core sections are not in direct contact with the dry ice.

Cores collected each day will be shipped frozen to the analytical laboratory by overnight courier under chain-of-custody procedures as follows:

- The shipping containers will be clearly labeled with sufficient information (name of project, time and date container was sealed, person sealing the container, and consultant's office name and address) to enable positive identification.
- A sealed envelope containing chain-of-custody forms will be enclosed in a plastic bag and taped to the inside lid of the cooler.
- The cooler lids will be secured by wrapping the coolers in strapping tape.
- Signed and dated chain-of-custody seals will be placed on all coolers prior to shipping.
- Each cooler or container containing the sediment and soil samples for analysis will be shipped by courier daily.

Upon transfer of sample possession to the analytical laboratory, the persons transferring custody of the sample container will sign the chain-of-custody form. Upon receipt of samples at the laboratory, the shipping container seal will be broken, and the receiver will record the temperature and condition of the samples and cross-check the sample inventory with the chain-of-custody form. Chain-of-custody forms will be used internally in the lab to track sample handling and final disposition.

4.2 Laboratory Analysis

All soil cores submitted to the analytical laboratory will be maintained in a frozen state. The cores will be photographed under white and ultraviolet (UV) light to determine soil type, structure, and the presence and distribution of DNAPL occurrence (the DNAPL will fluoresce under UV light). The photographs will be inspected to determine the depth interval with the greatest apparent DNAPL occurrence in each core. This interval will be further analyzed as follows:

- Grain size analysis using American Society of Testing and Materials (ASTM) methods D422/D4464M
- Pore fluid saturation testing (percent water saturation, percent non-aqueous phase liquid [NAPL] saturation, total porosity, grain density, dry bulk density, and initial moisture content) using ASTM methods D2216/API RP40
- Free product mobility/residual saturation testing using ASTM method D425M

5 FIELD EQUIPMENT DECONTAMINATION

To prevent sample cross-contamination, sampling and processing equipment in contact with the environmental samples will undergo the following decontamination procedures prior to

and between collection activities. Between samples, all sampling equipment that will come in contact with the sample media, except single-use materials (e.g., piston core liners) will be decontaminated prior to use by the following procedure:

- Rinse with potable water and wash with scrub brush until free of soil.
- Wash with phosphate-free detergent (e.g., Alconox®).
- Visually inspect the sampler and repeat the scrub and rinse step, if necessary. If scrubbing and rinsing with Alconox® is insufficient to remove visually observable tar/oil-related contamination on sampling equipment, the equipment will be scrubbed and rinsed using hexane (or similar type solution) until visual signs of contamination are absent.
- Rinse with distilled or deionized water three times.

6 HORIZONTAL POSITIONING AND VERTICAL CONTROL

The horizontal position of TarGOST and soil boring location will be determined using a handheld global positioning system (GPS) unit and recorded in field documentation. Depths associated with the TarGOST and soil boring activities will be recorded in field documentation as depth bgs. The location will be surveyed following completion of TarGOST and soil boring activities. Vertical elevation coordinates will be relative to the City of Portland (COP) datum and horizontal coordinates will be relative to the North American Datum (NAD) 83 High Accuracy Reference Network (HARN), Oregon State Plane, North Zone. Coordinates will be in international feet.

7 SOIL BORING ABANDONMENT

Soil borings will be abandoned using organoclay/bentonite grout slurry. The slurry will be placed from the bottom of the borehole to the ground surface via tremie tube methodology. The discharge end of the tremie tube shall be submerged in the grout to avoid breaking the seal while filling the borehole. The grout slurry will consist of a bentonite/organoclay blend, consisting of approximately nine parts Wyoming sodium bentonite and one part organoclay by volume, mixed to a 20% solids content. The resulting mud weight of the 20% solids solution will be approximately 9.5 to 9.7 pounds per gallon. The mud weight of each batch of grout that is mixed will be weighed and recorded to verify appropriate solids content is achieved. The use of granular bentonite across the portion of the borehole within the vadose zone is an acceptable alternative to the placement of the grout slurry across this zone.

8 INVESTIGATION DERIVED WASTE

Investigation derived waste (IDW), including soil cuttings, fluids used for decontamination of sampling equipment, and disposable wastes (e.g., gloves, paper towels, foil, etc.) will be placed into appropriate containers and staged on-site for disposal.

Soil remaining following collection and processing will be placed into sealable containers (55-gallon open top drums). Disposable wastes will be placed into two heavy duty plastic bags (i.e., double-bagged). Solid waste will be disposed off-site at an appropriate Resource Conservation and Recovery Act- (RCRA-) permitted solid waste disposal facility.

Per the current *IDW Management Plan* (HAI 2008) for the Gasco site, soil IDW will be characterized by collecting and analyzing one 5-part composite sample per drop box and one composite sample per every five to ten 55-gallon drums. Samples will be tested for the following analyte lists:

- Free liquids by Paint Filter Test
- Volatile organic compounds (VOCs) by U.S. Environmental Protection Agency (EPA) method 8260
- Diesel- and oil-range hydrocarbons by NW-TPH-Dx
- Gasoline-range hydrocarbons by NW-TPH-Gx
- RCRA metals (total) by EPA Method 6010/7000
- Total cyanide by EPA Method 335.4
- Polycyclic aromatic hydrocarbons (PAHs) by 8270C SIM

Soil IDW will be screened to determine whether the waste is characteristically hazardous. If soil IDW contains detectable concentrations of F002-related constituents, testing results will be screened against F002 Threshold Screening Values, DEQ's most current risk-based concentrations (RBCs) for human health occupational exposure pathway for F002-related constituents in order to determine whether the waste will need to be handled as an F002-listed RCRA waste. *The IDW Management Plan (*HAI 2008) identifies the following chemicals as F002-related constituents:

- Trichloroethene
- cis-1,2 Dichloroethene
- Trans-1,2-Dichlorethene
- 1-1 Dichloroethene

- Vinyl Chloride

If detectable concentrations of F002-related constituents are present, NW Natural will prepare a letter of intent to dispose IDW which will be submitted to DEQ for review. The request to DEQ will include laboratory testing results, screening results, and the proposed final disposition of the waste. Upon DEQ approval of the proposed final waste disposition, a waste profile will be submitted to the selected disposal facility requesting acceptance of the waste for the disposal. Upon acceptance by the disposal facility, waste will be transported from the site to the facility by a selected licensed contractor.

IDW that does not contain detectable concentrations of F002-related constituents will be managed consistent with DEQ's April 8, 2010 letter to Mr. Robert J. Wyatt of NW Natural with the subject line *Managing Soil Investigation Derived Waste Impacted by Manufactured Gas Plant Waste Properties Owned by NW Natural and Siltronic Corporation, Portland, Oregon, ECSI Nos. 84 and 183*. For IDW in which F002-related constituents are not detected, NW Natural will prepare and submit a letter directly to Waste Management requesting acceptance of the waste for disposal at a selected facility. DEQ will be copied on the letter which will include testing results, screening results, and the final disposition of the waste. Upon acceptance of the waste for disposal at the selected Waste Management facility, waste will be transported to the facility by a licensed contractor.

The decontamination fluids and other water generated during the investigation will be treated by the on-site treatment system.

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APPENDIX N
GROUNDWATER TREATMENT SYSTEM PILOT PLANT REPORT

NW Natural Gas Company

NW Natural and Siltronic
Wastewater Treatment Pilot Plant Report

December 2009

Sevenson Environmental Services, Inc.

NW Natural/Siltronic
Wastewater Treatment Pilot Plant Report
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Executive Summary

The NW Natural and Siltronic wastewater treatment pilot plant operated for approximately 5 weeks, from late July 7 through the end of August 2009. The pilot plant was conducted in accordance with a plan submitted and approved by DEQ. The pilot discharge standards were also promulgated by DEQ.

Two separate process flow trains were utilized: one for NW Natural wells and one for Siltronic wells. These processes were kept separate because of concern for comingling the Siltronic F002-listed waste with the unlisted NW Natural waste. The NW Natural pilot included processes designed to oxidize and remove iron and manganese, cyanide, volatile organics and semi-volatile organics. The Siltronic pilot also included processes to handle these pollutants, but had an additional Advanced Oxidation Process (AOP) to destroy the chlorinated solvents that cause the Siltronic waste to be listed as hazardous.

The results of the NW Natural pilot demonstrated its effectiveness: all discharge limitations for organic compounds were met in all NW Natural samples. All free cyanide values met the discharge limitations. One iron exceedance was found, three manganese exceedances, and one small copper exceedance occurred over the 5-week period. Sevenson believes that these exceedances can be addressed through duplication of chemical feed points and that the overall process will be even more stable when run continuously.

With the exception of one iron exceedance, the results of the Siltronic pilot showed all parameters (organics, free cyanide, and heavy metals) met the discharge standards. The tests also showed that the listed components of the Siltronic wastewater were reduced below the Threshold Values, making the wastewater “unlisted” with regard to the F002 RCRA waste code. As with the NW Natural exceedances, Sebvenson believes that the single iron exceedance will be addressed with duplicate chemical addition points and will be unlikely to re-occur given a more stable, continuous operation.

Sludge from the pilot processes were characterized. The major finding was that chlorinated organics in the sludge from Siltronic were significantly below the F002 Threshold Values for Soil, meaning that the Siltronic sludge could be combined, processed and disposed with NW Natural sludge, a much more cost-effective option than separate sludge-handling facilities and disposal as a hazardous waste.

In addition to the on-site pilot work, a separate air-stripping study was conducted at Sevenson's Wastestream Laboratories in Buffalo, NY to determine if air stripping would accomplish the required treatment levels at lower cost. The results of the air stripping tests showed that volatile organic compounds were effectively removed in both wastewater streams. In addition, the chlorinated organic compounds of concern in the Siltronic wastewater also appeared to have been reduced below F002 Threshold Values, though Wastestream's detection limits were too high to make an absolute determination of compliance.

As a result of the pilot plant work and the air stripping studies, Sevenson has developed a process flow scheme and has begun sizing the individual unit processes. These processes have been detailed in the Interim Design Report (IDR) submitted to Oregon DEQ on November 6, 2009. The general process approach has been to utilize the processes that have the best potential for meeting DEQ's requirements at the lowest life-cycle cost to NW Natural and Siltronic. As such, air stripping has been incorporated into both processes to reduce the level of volatile organics and chlorinated organics as early in the process as possible.

Following air stripping, the wastewater from Siltronic will be pumped in a dual-contained pipeline to the NW Natural site for blending with the NW Natural wastewater. A backup chemical oxidation system will be provided, if the F002 constituents have not been reduced below the threshold values after the air stripping process.

The combined wastewater will receive a coagulant and flocculant prior to separation in a settling tank. Heavy metals and iron and manganese will be removed. Following settling, an oxidant (either hydrogen peroxide or sodium hypochlorite will be added to the

wastewater for cyanide destruction in a designated reactor. Following pH adjustment into the neutral range, the wastewater will be pumped through bag filters to remove additional solids and then to granular activated carbon vessels for additional organics removal. Finally, prior to discharge to the Willamette River, the flow will be pumped through a 1-micron bag filter rack to catch any carbon particles and adsorbed organics that may escape.

Sludge from the plant, including both NW Natural and Siltronic sludge, will be thickened and dewatered, and disposed of off-site in an approved facility.

Pilot Plant Overview

In anticipation of the large-scale cleanup of the NW Natural and Siltronic sites, a wastewater treatment pilot plant was to be performed to refine the processes to be used, as well as to optimize the operations to meet the regulatory requirements for the cleanup while constructing and operating the most cost-effective system.

Oregon DEQ Effluent Requirements

After discussions with the Oregon Department of Environmental Quality (DEQ) concerning the cleanup of the Northwest Natural and Siltronic properties, the DEQ promulgated preliminary discharge limitations to be followed both during the pilot plant operations, and during the following full-scale operations.

DEQ specifically stated that the final full-scale operating discharge limitations may change following a risk-based assessment of the parameters achieved by the pilot process.

Discharge Limitations for NW Natural/Siltronic Discharge

Table 1 is a summary of discharge limitations summarized from the March 31, 2009 memorandum from the Oregon DEQ.

Table 1: Discharge Limitations for NW Natural/Gasco Site

Discharge Limitations		
Parameter	**Monthly Average**	**Daily Maximum**
Benzene	0.66 (µg/L)	1.1 (µg/L)
Benzo(a)Anthracene	Not to exceed EPA Method 625 Quantitation Limit of 1 µg/L	
Benzo(a)Pyrene	Not to exceed EPA Method 625 Quantitation Limit of 1 µg/L	
Benzo(b)Flouranthene	Not to exceed EPA Method 625 Quantitation Limit of 1 µg/L	
Benzo(k)Flouranthene	Not to exceed EPA Method 625 Quantitation Limit of 1 µg/L	
Copper	Not to exceed EPA Method 200.8 Quantitation Limit of 10 µg/L	17.7 (µg/L)
Chromium VI	Not to exceed EPA Method 218.6 Quantitation Limit of 10 µg/L	16 (µg/L)
Chrysene	Not to exceed EPA Method 625 Quantitation Limit of 1 µg/L	
Free Cyanide	Not to exceed ASTM Method 4282-95 Quantitation Limit of 10 µg/L	
Dibenzo(a,h)Anthracene	Not to exceed EPA Method 625 Quantitation Limit of 1 µg/L	
Indeno(1,2,3-Cd)Pyrene	Not to exceed EPA Method 625 Quantitation Limit of 1 µg/L	
Iron (Dissolved)	300.0 (µg/L)	520 (µg/L)
Manganese (Dissolved)	50.0 (µg/L)	86.6 (µg/L)
Mercury	Not to exceed EPA Method 245.7 Quantitation Limit of 0.01 µg/L	
Pentachlorophenol	Not to exceed EPA Method 625 Quantitation Limit of 2 µg/L	
pH	6.5 S.U.	8.5 S.U.
Temperature	7-day Avg. of the Daily Maximums Not to Exceed 68 °F	

Table 2 is the Oregon DEQ's monitoring requirements for the pilot plant and subsequent facilities. Besides the required permit tests, Sevenson performed other tests on influent and process flows as required to control and monitor process performance.

Sevenson collected samples and conducted the analyses for the following reasons:

- To satisfy the discharge reporting requirements of the regulatory agency.
- To form a rational basis for controlling the pilot treatment processes.
- To define the operational efficiency of the pilot plants.
- To develop a historical record of the conditions under which the plant has been operated, as an aid to the design of the full-scale plant.

Table 2 shows the Oregon DEQ's monitoring schedule that was used for both pilot plant operations. Besides the required tests, Sevenson performed other tests on internal process flows as required to control and monitor process performance, as shown in Tables 3 and 4 for NW Natural and Siltronic, respectively.

Sampling and Analysis Plan

General

This Sampling and Analysis Plan covers the pilot wastewater treatment plants at both the NW Natural and Siltronic sites and their effluent discharges. All samples taken were grab samples.

Influent and effluent samples were taken in accordance with the March 31, 2009 "Discharge Limitations and Monitoring Requirements for the NW Natural/Gasco Site" from Oregon Department of Environmental Quality (DEQ).

The NW Natural pilot treatment facilities were designed to remove:

- Iron and manganese;
- Cyanide
- Heavy metals

- Volatile and semi-volatile organic compounds, particularly polyaromatic hydrocarbons

The Siltronic pilot treatment facilities were designed to remove:

- Iron and manganese;
- Cyanide
- Heavy metals
- Volatile and semi-volatile organic compounds, particularly polyaromatic hydrocarbons, and
- Chlorinated solvents, particularly vinyl chloride.

Effluent Flow Routing and Monitoring

All flow from the NW Natural pilot wastewater treatment plant was discharged to the local POTW. The effluent flow rate was instantaneously measured and totalized. All flow from the Siltronic pilot plant was initially stored in an 18,000-gallon storage tank before being pumped and ultimately discharged to the NW Natural pilot plant.

Sample Locations

Both plants utilized influent equalization tanks and a common effluent storage tank. Grab samples were taken from these tanks. In addition, process samples were obtained from individual processes to facilitate the design of the individual processes.

Monitoring Program

In addition to those parameters shown in Tables 3 and 4, sludges or sludge cakes generated were tested for total solids and other pollutants. Also, all treatment chemicals used were tracked throughout the pilot test period for final design purposes.

Table 2: Discharge Limitations for NW Natural/Gasco Site

Minimum Monitoring			
Parameter	Minimum Frequency		Sample Type
	During Pilot Study	All Other Periods	
Volume Discharged	Daily, when discharging	Daily, when discharging	Metering
Temperature	Daily, when discharging	Daily, when discharging	Recorder
Bioassay Testing	-	Annual	Grab
Outfall Pipe	-	Annual	Inspection
pH	Weekly, when discharging	Monthly, when discharging	Grab
Hardness	Weekly, when discharging	Monthly, when discharging	Grab
Free Cyanide	Weekly, when discharging	Monthly, when discharging	Grab
Total Cyanide	Weekly, when discharging	Monthly, when discharging	Grab
Available Cyanide	Weekly, when discharging	Monthly, when discharging	Grab
Weak-acid Dissociable Cyanide	Weekly, when discharging	Monthly, when discharging	Grab
PAHs			
Acenaphthylene	Weekly, when discharging	Monthly, when discharging	Grab
Acenaphthene	Weekly, when discharging	Monthly, when discharging	Grab
Anthracene	Weekly, when discharging	Monthly, when discharging	Grab
Benzo(a)Anthracene	Weekly, when discharging	Monthly, when discharging	Grab
Benzo(a)Pyrene	Weekly, when discharging	Monthly, when discharging	Grab
Benzo(b)Flouranthene	Weekly, when discharging	Monthly, when discharging	Grab
Benzo(k)Flouranthene	Weekly, when discharging	Monthly, when discharging	Grab
Carbazole	Weekly, when discharging	Monthly, when discharging	Grab
Chrysene	Weekly, when discharging	Monthly, when discharging	Grab
Dibenzo(a,h)Anthracene	Weekly, when discharging	Monthly, when discharging	Grab
Dibenzofuran	Weekly, when discharging	Monthly, when discharging	Grab
Flouranthene	Weekly, when discharging	Monthly, when discharging	Grab
Flourene	Weekly, when discharging	Monthly, when discharging	Grab
Indeno(1,2,3-Cd) Pyrene	Weekly, when discharging	Monthly, when discharging	Grab
2-Methlynaphthalene	Weekly, when discharging	Monthly, when discharging	Grab
Naphthalene	Weekly, when discharging	Monthly, when discharging	Grab
Pyrene	Weekly, when discharging	Monthly, when discharging	Grab
Metals			
Arsenic (organic)	Weekly, when discharging	Monthly, when discharging	Grab
Arsenic (inorganic)	Weekly, when discharging	Monthly, when discharging	Grab
Cadmium	Weekly, when discharging	Monthly, when discharging	Grab
Chromium III	Weekly, when discharging	Monthly, when discharging	Grab
Chromium VI	Weekly, when discharging	Monthly, when discharging	Grab
Copper	Weekly, when discharging	Monthly, when discharging	Grab
Iron (dissolved)	Weekly, when discharging	Monthly, when discharging	Grab
Iron (total)	Weekly, when discharging	Monthly, when discharging	Grab
Lead	Weekly, when discharging	Monthly, when discharging	Grab
Manganese (dissolved)	Weekly, when discharging	Monthly, when discharging	Grab
Mercury	Weekly, when discharging	Monthly, when discharging	Grab
Nickel	Weekly, when discharging	Monthly, when discharging	Grab
Selenium	Weekly, when discharging	Monthly, when discharging	Grab
Silver	Weekly, when discharging	Monthly, when discharging	Grab
Zinc	Weekly, when discharging	Monthly, when discharging	Grab

Table 2 (Cont'd): Oregon DEQ Monitoring Requirements for NW Natural Site

Minimum Monitoring (Continued)			
Parameter	Minimum Frequency		Sample Type
	During Pilot Study	All Other Periods	
VOCs			
Acetone	Weekly, when discharging	Monthly, when discharging	Grab
Benzene	Weekly, when discharging	Monthly, when discharging	Grab
2-Butanone	Weekly, when discharging	Monthly, when discharging	Grab
1,1-dichloroethene	Weekly, when discharging	Monthly, when discharging	Grab
cis-1,2-dichloroethene	Weekly, when discharging	Monthly, when discharging	Grab
Ethylbenzene	Weekly, when discharging	Monthly, when discharging	Grab
Tetrachloroethene	Weekly, when discharging	Monthly, when discharging	Grab
Toluene	Weekly, when discharging	Monthly, when discharging	Grab
Trans-1,2-dichloroethene	Weekly, when discharging	Monthly, when discharging	Grab
Trichloroethene	Weekly, when discharging	Monthly, when discharging	Grab
Vinyl chloride	Weekly, when discharging	Monthly, when discharging	Grab
Xylene	Weekly, when discharging	Monthly, when discharging	Grab
Phenols			
2-Chlorophenol	Weekly, when discharging	Monthly, when discharging	Grab
2,4-Dichlorophenol	Weekly, when discharging	Monthly, when discharging	Grab
2,4-Dimethylphenol	Weekly, when discharging	Monthly, when discharging	Grab
2-methyl-4,6-Dinitrophenol	Weekly, when discharging	Monthly, when discharging	Grab
2-methylphenol	Weekly, when discharging	Monthly, when discharging	Grab
2-nitrophenol	Weekly, when discharging	Monthly, when discharging	Grab
4-nitrophenol	Weekly, when discharging	Monthly, when discharging	Grab
2,4,5-Trichlorophenol	Weekly, when discharging	Monthly, when discharging	Grab
2,4,6-Trichlorophenol	Weekly, when discharging	Monthly, when discharging	Grab
Pentachlorophenol	Weekly, when discharging	Monthly, when discharging	Grab
Phenol	Weekly, when discharging	Monthly, when discharging	Grab

Notes:

1. After receiving and reviewing the discharge data from several months of monitoring, the Department may make the determination that the monitoring of certain parameters will no longer be necessary, should continue, or assigning discharge limitations is warranted.
2. The quantitation limits specified in the November 2007 DEQ memorandum pertaining to water quality quantitation limits must be addressed for each applicable parameter.

Table 3: Process Monitoring Sampling Schedule—NW Natural[1]

Parameter	Influent	Clarifier Effluent	Bag Filter Effluent	Carbon Midpoint	Carbon Effluent	Final Effluent
Flow	D					D
pH	D	D	D			D
Oxidation-reduction potential (ORP)		D				D
Temperature[2]	D					D
Oil & Grease	W					W
Total suspended solids	D		D			D
Total & dissolved iron	D		D			D
Total & dissolved manganese	D		D			D
Total, amenable, WAD & free cyanide	D		D			D
Heavy metals incl mercury	D		D			D
Total hardness	W		W			W
Total organic carbon	D		D	D	D	D
Volatile organic compounds	D			D	D	D
Semi-volatile compounds	D			D	D	D
Methyl mercury	W					W

SAMPLING LEGEND
D—Daily
W--Weekly

[1] All samples grab samples, except pH, ORP, & temperature
[2] Temperature continuously recorded

Table 4: Process Monitoring Sampling Schedule—Siltronic[3]

Parameter	Influent	Clarifier Effluent	Advanced Oxidation Process Effluent to NW Natural Plant
Flow	D		D
pH	D	D	D
Oxidation-reduction potential (ORP)		D	
Temperature[4]	D	D	D
Oil & Grease	W		W
Total suspended solids	D		D
Total dissolved solids	D	D	
Total & dissolved iron	D		D
Total & dissolved manganese	D		D
Total, amenable, WAD & free cyanide	D		D
Heavy metals incl mercury	D		D
Total hardness	W		W
Total calcium, as CaCO3	D	D	
Total alkalinity, as CaCO3	D	D	
Total organic carbon	D		D
Volatile organic compounds	D		D
Semi-volatile compounds	D		D
Methyl mercury	W		W

SAMPLING LEGEND
D—Daily
W--Weekly

[3] All samples grab samples, except pH, ORP & temperature
[4] Temperature continuously recorded

Sample Collection and Handling

All samples collected for off-site laboratory analysis were stored in ice and preserved in accordance with the requirements of the particular analytical method. All samples were transported by courier on the day they were collected for analysis at a local analytical laboratory. One exception was the analysis for free cyanide using ASTM Method 4282-95 which was performed in a limited number of laboratories and was sent away for special testing. Proper preservation was used for these samples.

Sample Analytical Methods and Mean Reporting Limits

The analytical laboratory, Apex Labs of Tigard, Oregon was selected to perform the chemical analyses. A major consideration in the Apex selection was the ability of the laboratory to analyze for the required parameters down to the Method Reporting Limit (MRL) as specified by Oregon DEQ in Table 1.

Pilot Plant Process Design

NW Natural and Siltronic Site Plant Components

The pilot treatment process is largely designed to remove iron and manganese, cyanide, heavy metals, VOCs and SVOCs. The plant was situated inside a secondary containment area containing crushed stone over a 40-mil liner, with berms around the entire site to contain wastewater, residual, or chemical spills. The facility was operated under a site-specific Health and Safety Plan (HASP). The site-specific HASP addressed spill prevention and countermeasures to be taken and emergency contacts in the event of a spill.

The NW Natural pilot plant was designed to operate at a flow rate of 50 gpm. The Siltronic plant (15 gpm) was blended into the NW Natural facilities prior to the GAC facilities, though the facilities were not operated at the same time. Discharge was to the existing POTW connection.

All backwash water was recirculated to the influent equalization tanks for re-treatment. All plant residuals (bag filters, sedimentation tank solids, and spent carbon) were properly disposed of to a permitted facility.

The Wastewater Pilot Plant Testing Plan (Sevenson, April, 2009) was provided to DEQ on May 4, 2009. DEQ provided a preliminary comment letter on May 13 and Sevenson prepared a May 21 response letter addressing DEQ's comments. The approach and sizing data contained in this Pilot Test Report are based upon prior treatability studies that established the processes as effective in cost-effectively meeting Oregon DEQ's discharge standards. The 5-week pilot plant test was run from late July through the end of August 2009.

Sevenson has included its pilot plant treatment plant design and materials balance in Attachment A. The process flow drawings for the pilot plant showing the sampling locations are included in Attachment B.

An overall process flow diagram for the pilot plant is shown on Figure 1 and described further in this section.

NW Natural and Siltronic Pilot Wells Location

The NW Natural Pilot Plant drew separately from the MW-1-55 and PW-1 wells on the NW Natural Site, and two wells from the Siltronic site, as shown on Figure 2.

NW Natural Influent Equalization Tanks

Two equalization tanks were provided, each with a capacity of 21,000 gallons. Wells MW-1-55 and PW-1 each discharged into a separate 21,000-gallon equalization tank. In the pilot plant, the tanks were used to store the day's "run" rather than to provide any significant equalization benefits.

Clarifier Feed Pumps

Two 50-gpm clarifier feed pumps were used to pump (VFD) adjustable speed controls to allow for pumping different flow ratios from each well to the plant.

Recirculation Loops and In- Line Aeration

Two in-line aerators (eductors) were installed (one on each tank) on the recirculation lines from the clarifier feed pump to each of the Influent Equalization Tanks. The eductors will draw air into the recirculation line to assist in iron and manganese oxidation.

Sodium Hydroxide Feed Pumps

Two sodium hydroxide feed pumps, pH meters and controllers were installed on the Clarifier Feed Pump discharge lines to increase the influent pH to between 9.5 and 10.0 in the recycle loop and in the flow to the clarifier. The rates of iron and manganese oxidation are both greatly accelerated at the higher pH value.

Figure 1: NW Natural Pilot Plant Overall Process Flow

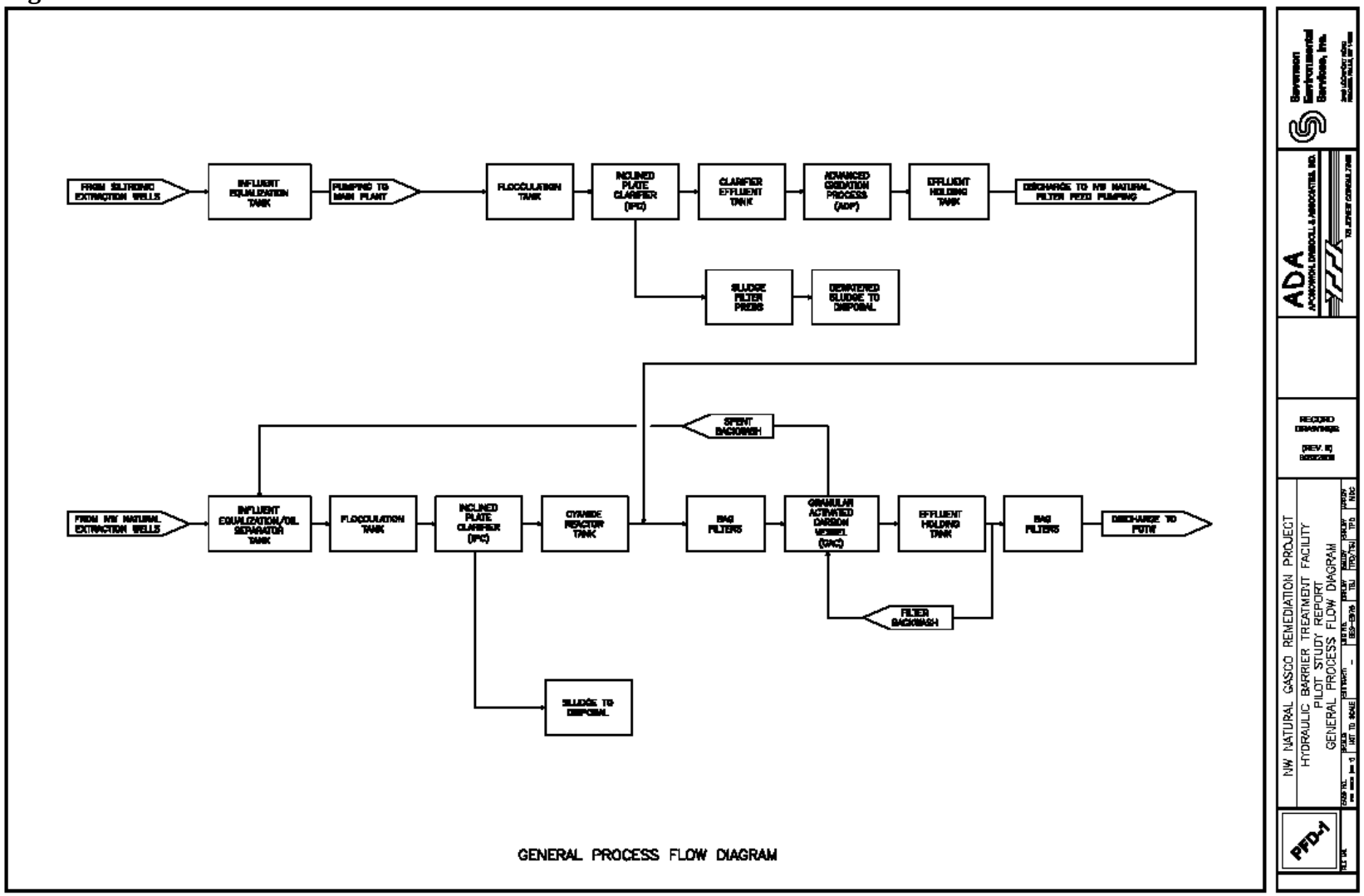
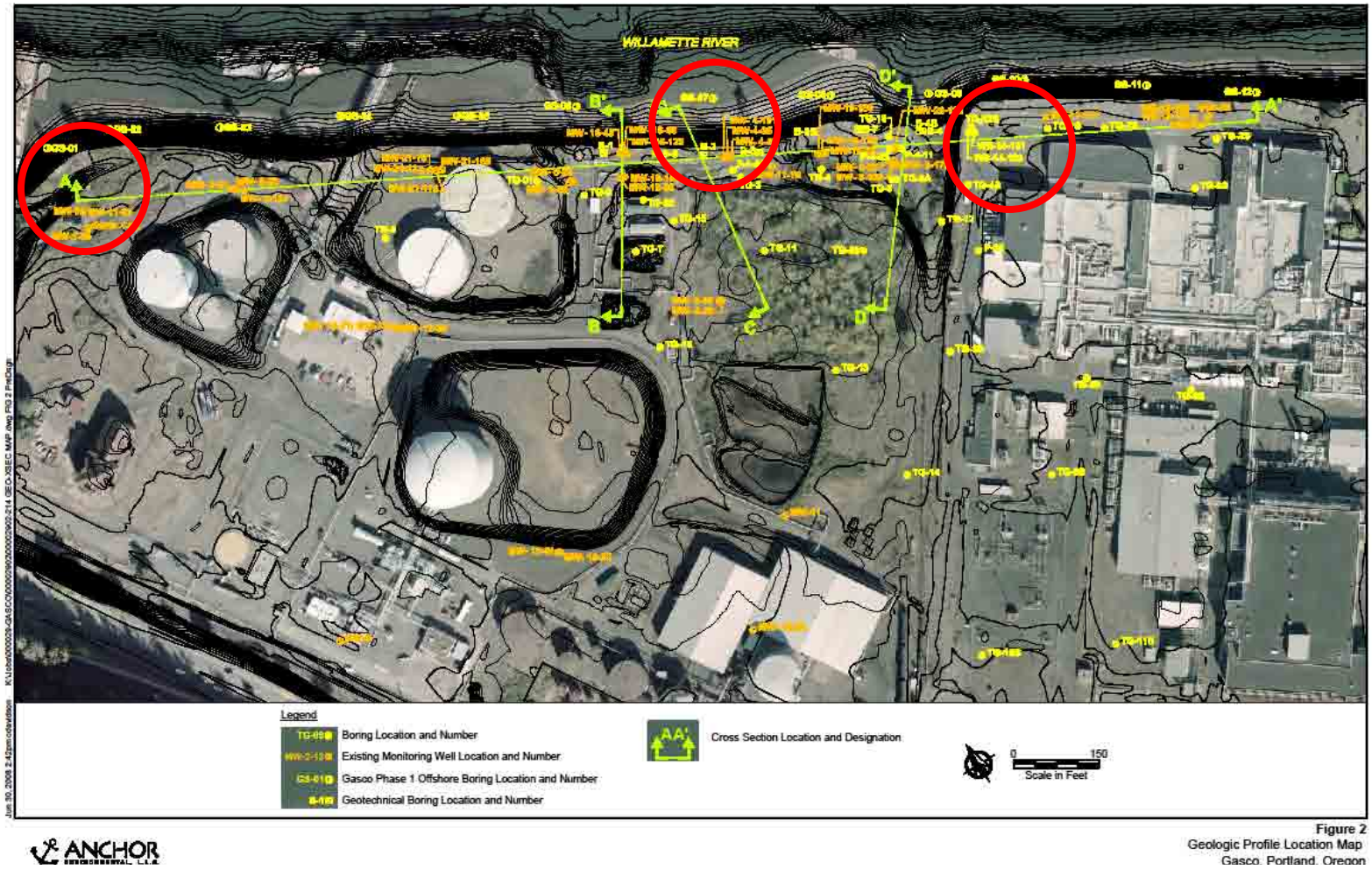


Figure 2: Location of NW Natural and Siltronic Wells for Pilot Plant



Polymer Addition

One polymer addition system was installed to feed polymer to the wastewater prior to introduction into the downstream inclined-plate clarifier to facilitate settling. The polymer was mixed in-line with a 2-inch static mixer, and manually paced.

Inclined-Plate Clarifier (IPC)

A single inclined-plate clarifier (IPC) received the flow from the equalization tanks to remove the oxidized iron and manganese. In addition, heavy metals were removed via iron co-precipitation in the clarifier.

Settled sludge was removed via a single air-operated diaphragm pump. The pump discharged to a tank for storage and ultimate dewatering. The resulting filter cake was stored in a proper container within the containment area and properly disposed of.

Hydrogen Peroxide Feed System

A hydrogen peroxide feed pump, ORP meter and controller was installed on the cyanide destruct reactor to destroy cyanide as described below. A 50% hydrogen peroxide solution was used.

Cyanide Destruct Reactor

A 6,000-gallon reactor tanks was used for cyanide destruction using the alkaline oxidation process. The alkaline oxidation process uses hydrogen peroxide (H_2O_2) and caustic (NaOH) to break the cyanide bond at high pH in two steps.

In the first step, cyanide (CN-) oxidized to cyanate (CNO-) as shown below:

$$CN^- + H_2O_2 \rightarrow CNO^- + H_2O$$

In the second step, cyanate is further oxidized to carbon dioxide and nitrogen gas, as shown below:

$$2CNO^- + 2H_2O_2 \rightarrow 2CO_2 \uparrow + N_2 \uparrow + 2H_2O$$

Both of these reactions will occur in the reactor tank. The addition of hydrogen peroxide (a strong oxidizer) is made ahead of the destruct tank. The hydrogen peroxide feed rate

was automatically controlled by Oxidation-Reduction Potential (ORP), measured in millivolts by a probe in the effluent tank. Adding the hydrogen peroxide raises ORP in the wastewater. An ORP controller will control the addition of the hydrogen peroxide to between +200-250 millivolts.

The tank was sized for a minimum detention time of 100 minutes, based upon the results in the treatability tests, and including both flows (from NW Natural wells and Siltronic wells).

Sulfuric Acid Feed System

A sulfuric acid feed pump, a pH meter and a controller were installed on the effluent pipe from the cyanide destruct tank to reduce the wastewater pH to approximately 8.5. The acid was injected upstream of a 2-inch in-line static mixer.

Filter Feed Pump

Following the cyanide reactor tank was a 50-gpm electric centrifugal pump. The pump was manually controlled, using the level downstream of the weirs in the cyanide destruct effluent tank. The Filter Feed Pump pumped the flow through the bag filters, and the granular activated carbon (GAC) vessels, before discharging into the effluent /backwash storage tank.

Primary Bag Filters

Two pressure bag filters in series were provided to remove remaining particulates from the wastewater prior to the GAC units. The bag filters were set up to operate in series to filter iron and other solids prior to introduction into the GAC vessels. Each bag filter has a capacity of 100 gpm.

The upstream and downstream filters were fitted with 10-micron and 5-micron bags, respectively. The vessels were fitted with inlet and outlet pressure indicators. When the selected pressure differential is reached, the operator changed filter bags before putting the train back on line.

Granular Activated Carbon Vessels

The waste stream then flows through three, 4-foot diameter Granular Activated Carbon (GAC) vessels, piped in parallel, with differential pressure measured across each vessel. The GAC units were intended to remove volatile organics and semi-volatile organics in the effluent from the filter units. One thousand, three hundred pounds of carbon was loaded into each vessel, for an overall total of 3,900 pounds of carbon.

The GAC filters were provided with backwashing. Spent backwash water was returned to the influent equalization tanks for re-processing through the plant.

Effluent/Backwash Storage Tanks

After the GAC vessels, the treated wastewater was discharged into one of two 21,000-gallon effluent/backwash storage tank. Each tank served as a "batch holding tank" during the pilot operation, and was utilized as clean water holding tank for backwash water. Each tank held a day's "run" until the results were received from the analytical laboratory, establishing that the process was working as intended.

Effluent/Backwash Pump

An electric centrifugal pump was provided, with a capacity of 150 gpm, to allow for a suitable backwash rate for the GAC vessels. The pumps wasl also be sized to discharge to the approved discharge point to the POTW.

Flow Meter Rate/Totalizer

All treated wastewater discharged from the plant passed through a 2-inch flow meter. Discharge flow rates and totalized volumes will be recorded by the SCADA system.

Effluent Bag Filters

A final filtration step used two bag filters arranged in parallel. The filters were intended to remove any carbon fines and adsorbed organics escaping the GAC vessels prior to the discharge to the POTW. The bag filters were equipped with 1.0-micron bags and were each sized for 100 gpm, and fitted with inlet and outlet pressure indicators. The bags were changed at an appropriate pressure differential.

Siltronic Site Pilot Plant Components

The proposed treatment process is largely designed to remove iron and manganese, cyanide, heavy metals, and chlorinated solvents including vinyl chloride. With the exception of the influent equalization tank and influent pump, the Siltronic Plant was situated inside the secondary containment area for the NW Natural plant. The Siltronic containment area contained crushed stone over a 40-mil liner, with berms around the site to contain wastewater, residual, or chemical spills.

The Siltronic groundwater-treatment facility on the NW Natural site was operated under Sevenson's Health and Safety Plan (HASP). The site-specific HASP addressed spill prevention and countermeasures to be taken and emergency contacts in the event of a spill.

The Siltronic equalization tank and pump were located approximately 500 feet away, from the NW Natural treatment plant on the NW Natural site. All piping between the influent tank, pumps and treatment process was dual-contained. The dual-contained piping was pitched toward lowest point on the line, to capture any leakage. No leakage was observed during the pilot plant operation.

The Siltronic plant was designed to operate at an average daily flow rate of 15 gpm on a continuous basis. The remote Siltronic Equalization Tank had caustic addition and recirculation aeration systems similar to the NW Natural components. Again, the purpose of these units was to oxidize iron and manganese before downstream settling and an advanced oxidation process.

The flow was pumped to a separate inclined-plate clarifier to remove iron, manganese, and other heavy metals. The clarified effluent was pumped to an advanced oxidation process (AOP), using hydrogen peroxide and ultraviolet light to destroy chlorinated solvents such as vinyl chloride, as well as cyanide.

Treated effluent from the advanced oxidation process was blended into the NW Natural plant into the effluent tank in the cyanide destruct tanks for further treatment (bag filtration, activated carbon, and final bag filtration) prior to discharge to the POTW.

All plant residuals (principally sedimentation tank solids) were analyzed to determine if the waste must be treated as a listed F002 waste (it was nonhazardous) and was properly disposed of to a permitted facility. Prior to disposal, the residuals were stored in a closed container located within the containment zone.

Sevenson has included its wastewater treatment plant design and materials balance for the Siltronic site in Attachment A. The pilot plant process flow diagram for the plant is included in Attachment B.

Siltronic Influent Equalization Tank

Waters from the Siltronic well(s) will be pumped into a single 21,000-gallon frac tank. The tank was air-tight, with a vapor-phase carbon system on top of the tank to handle off-gases (volatile organic compounds and air) that may be released from the tank.

The tank was designed to permit settling of DNAPL and flotation of LNAPL. The accumulated solids and floatables in the tanks were periodically removed as required using a trash pump. Plant influent characteristics were sampled from this tank.

Clarifier Feed Pump

One 30-gpm clarifier feed pump was provided. The pump was oversized to provide the capability to “loop” the flow through an in-line aerator to facilitate iron removal prior to sedimentation.

Sodium Hydroxide Feed Pump

A sodium hydroxide feed pump, pH meters and controllers were installed on the Clarifier Feed Pump discharge lines to increase the influent pH to between 9.5 and 10.0 in the recycle loop and in the flow to the clarifier. The rates of iron and manganese oxidation are both greatly accelerated at the higher pH value.

Recirculation Loop and In- Line Aeration

An in-line aerator was installed on the recirculation lines from the clarifier feed pump to the Influent Equalization Tank. The aerator was used to draw air into the recirculation line to assist in iron and manganese oxidation.

Polymer Addition

A polymer addition system was installed to feed polymer to the wastewater prior to introduction into the downstream inclined-plate clarifier to facilitate settling. The system was located at the NW Natural pilot plant site. The polymer was mixed in line with a 1-inch static mixer, and manually paced.

Inclined-Plate Clarifier (IPC)

A separate Siltronic inclined-plate clarifier (IPC), located at the NW Natural Site, received the pumped flow from the Siltronic influent equalization tank to remove the oxidized iron, manganese, and other heavy metals. Settled sludge was removed and pumped to a separate storage tank at the NW Natural site for further processing.

IPC Effluent Tank

A 2,500-gallon effluent tank was positioned at the outlet of the IPC to receive the flow by gravity. This tank served as the pump tank for the advanced oxidation feed pump.

Advanced Oxidation Feed Pump

A 15-gpm electric centrifugal pump followed the IPC effluent tank. The pump was manually controlled, using the level in the Siltronic IPC Effluent Tank.

The Advanced Oxidation Feed Pump pumped the wastewater flow through the advanced oxidation process, before discharging into the effluent holding tank for analysis and further treatment.

Advanced Oxidation Process (AOP)

The advanced oxidation process (AOP) utilizes a combination of hydrogen peroxide and ultraviolet light to destroy the chlorinated organic solvents and cyanide in the Siltronic wastewater.

A hydrogen peroxide feed pump, oxidation-reduction potential (ORP) indicator and controller delivered 50% hydrogen peroxide solution to an in-line static mixer to thoroughly mix the wastewater and hydrogen peroxide. The wastewater-hydrogen-peroxide mixture then passed through an ultraviolet light reactor to destroy the chlorinated solvents and cyanide.

Effluent Storage Tank

After the AOP, the treated wastewater was discharged into a single 2,500-gallon storage tank. This tank served as a "batch holding tank" before introducing the flow into the NW Natural Plant.

Siltronic Effluent Pump

A 15-gpm electric centrifugal pump was used to pump the effluent from the storage tank to the NW Natural Plant bag filter process.

Further Siltronic Treatment

Following the AOP process, the Siltronic effluent was pumped to the NW Natural bag filters for removal of most solids, then to the NW Natural GAC vessels, and then to the NW Natural Holding Tanks, before final bag filtration and discharge to the POTW.

Pilot Plant Operation

Pilot Plant Process Operation

The pilot plant was operated on a daily basis for most of the weekdays during the last week of July and throughout August 2009. Normal operating hours were from 9 AM-3 PM, which allowed for setup in the morning and cleanup/shutdown in the afternoon.

The plant was operated on a continuous basis, using the selected set of wells for the day. All effluent from the plant was stored at the end of a day in an Effluent Storage Tank. Grab samples were taken from the tank and sent to APEX Labs of Tigard, Oregon for rush analyses. Samples were held pending an acceptable analyses that met the pretreatment requirements of the Portland POTW. Once the lab results confirmed that the samples were compliant with the pretreatment requirements, the operators were directed to empty that day's batch to the sewer connection.

All Siltronic runs were performed without NW Natural wastewater to isolate and evaluate the Siltronic treatment scheme.

Pilot Plant Sampling and Analyses

All pilot plant sampling was performed in compliance with the Sevenson Sampling and Analysis Plan. Daily influent and effluent samples were taken while operating, as well as internal process samples to establish individual process performance. All samples were grab samples, taken as close to the time of laboratory sample pickup as possible. APEX Laboratory provided coolers, ice, and the preservative chemicals used when sampling, to ensure the integrity of the analyses performed by them.

Pilot Plant Residuals Handling and Disposal

All residuals from both the NW Natural and Siltronic treatment plants: settled solids, GAC media, and spent bag filters, were found to be nonhazardous and were properly disposed of.

Final Site Decontamination and Disposal of Chemicals and Residuals

All site personnel working at the treatment plant had required OSHA training and certification for management of potentially hazardous chemicals and waste materials. The minimum training for onsite personnel is described in the Sevenson HASP.

All chemicals were stored within the containment area to contain any chemical spills from operation or chemical delivery. Sumps were located within the containment area to collect chemical and process spills and pump to the influent equalization tanks. No significant spills or leakage occurred during the pilot test period.

Two separate decon areas: one for F002 contamination and one for non-F002 contamination, were provided within the lined, bermed area to permit decontamination of equipment, vehicles, etc.

Air Stripping Bench-Scale Studies

Purpose

In addition to the on-site pilot plant, additional air stripping studies were performed on the Siltronic well water at Sevenson's certified laboratory, Wastestream Laboratory, in Buffalo, NY. These studies were conducted within the same time frame as the on-site studies.

The goals of the additional air stripping studies were to determine:

1. If observed levels of chlorinated solvents found in the Siltronic wells could be stripped to comply with DEQ's Contained-In Determination Threshold Values for Liquids (as summarized in Hahn & Associates, Inc. letter to Dana Bayuk on February 26, 2008.
2. To determine if the levels of chlorinated solvents in the wastewater could be removed to an extent that any subsequent sludge generated by precipitation processes for heavy metals would also pass the DEQ's Contained-In Determination Threshold Values for Soils.

Set-Up and Procedure

A detailed procedure is contained in Attachment C, and summarized in this section. Six separate runs were performed on Siltronic wastewater. The collected wastewater was properly chilled and expedited to the Wastestream Laboratory.

The sample was characterized initially to establish baseline values for organic solvents, other VOCs, and iron and manganese. Six separate samples were set up for the testing, based upon pH differences and different air stripping parameters as shown in Table 5.

Two pH levels, 9.5 and 10.0, were tested to determine if iron and manganese removals were affected. Three different aeration periods: 30 minutes, 60 minutes and 90 minutes, were tested at each pH level to determine the amount of air required to achieve both optimal stripping performance while achieving a high level of iron and manganese oxidation and removal.

Table 5: Summary of Air Stripping Runs

Run	Nominal pH[5]	Aeration Time, Mins	Air: Water Ratio
1	10.0	30	10: 1
2	9.5	30	10: 1
3	10.0	60	20: 1
4	9.5	60	20: 1
5	10.0	90	30: 1
6	9.5	90	30: 1

[5] Actual pH varied slightly, as shown in the results

Pilot Plant and Bench-Scale Results

The results of the pilot plant and air stripping testing are summarized in this section. Complete results of the pilot plant and air stripping tests are included in Attachment D through H.

The NW Natural and Siltronic results are most easily understood in combination with the pilot plant process drawings in Attachment B. These drawings show the location of the sampling points within the process flow train.

The NW Natural pilot plant results are tabulated in two ways:

1. By *process performance* through the entire plant on a given date. These tabulations are most useful in evaluating the performance of individual unit processes on a given day, and therefore which processes are likely to achieve the desired treatment and discharge goals. These data are included in Attachment D for the NW Natural flows and in Attachment F for Siltronic flows.
2. By *sample point* for the entire pilot plant operating period. The sampling point tabulations are most useful in predicting influent and effluent concentrations for the full-scale design. These data are included in Attachment E for the NW Natural flows and Attachment G for the Siltronic flows.

NW Natural Results

A summary of the results of the NW Natural well testing is shown in Table 6. Because a number of the data points were analyzed to be below the mean detection limit, an average value of the constituents was not statistically meaningful. Therefore, the daily minimum and maximum values for each constituent are shown for the entire pilot testing period. The influent values shown are from individual wells MW-1 and PW-1, while the effluent value is shown for their common effluent.

PW-1 Characteristics

The PW-1 well parameters, summarized in Table 7, show the following general characteristics:

- Alkaline pH values ranging from 9.8—10.4
- Higher total cyanide values than either MW-1 or the Siltronic wells
- High levels of naphthalene (up to 9,760 ug/L) and methylnaphthalene (up to 1,070 ug/L)
- Low levels of remaining semi-volatile organics including polyaromatic hydrocarbons
- High levels of dissolved iron and manganese
- High levels of benzene, ethylbenzene, toluene, and xylene

MW-1 Characteristics

The MW-1 well parameters, summarized in Table 7, show the following general characteristics:

- Alkaline pH values ranging from 7.72—10.5
- High levels of total suspended solids (up to 3,530 mg/L)
- Lower total cyanide values than PW-1, similar to the Siltronic wells
- Low levels (mostly below detection limits) of semi-volatile organics including polyaromatic hydrocarbons
- Highest levels of dissolved iron and manganese
- Low levels (mostly below detection limits) of VOCs including benzene, ethylbenzene, toluene, and xylene

Table 6: NW Natural Influent--Effluent Results[6]

		PW-1 INFLUENT		MW-1 INFLUENT		NW NATURAL EFFLUENT	
NW Natural Pilot Results	Units	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
pH	pH Units	9.82	10.4	7.72	10.5	7.14	8.23
pH Temperature	pH Units	14	24	13.7	24.8	15.9	31.8
Total Dissolved Solids	mg/L	893	1270	982	3490	518	1720
Total Suspended Solids	mg/L	7	143	5	3530	<5.00	<5.00
Total Organic Carbon	mg/L	23.8 [1] [1]	33.5	3.74	14.6	<2.00	7.97
Total Iron	mg/L					<100 [4] [9]	338 [6] [9]
Total Manganese	mg/L					9.44 [5] [9]	171 [6] [9]
CYANIDE							
Cyanide, Total	mg/L	0.546	1.08	0.299	0.585	0.0200 [1] [2] [1] [6]	0.712
Cyanide, WAD	mg/L	0.0819	0.121	0.0498	0.0765	0.0101	0.0738
Cyanide, Amenable	mg/L	<0.0150	0.174	<0.00500	<0.0300	<0.00500	<0.0100
CATC, chlorinated	mg/L	0.372	1.13	0.429	0.739	0.0193	0.739
Cyanide, Free	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100
CATC, total	mg/L	0.546	1.08	0.299	0.585	0.0200 [2] [6]	0.712
Available Cyanide	mg/L	0.0033	0.0088	0.0033	0.0088	<0.0020	<0.0020
SEMI-VOLATILE ORGANICS							
Acenaphthylene	ug/L	116 [3]	264 [6]	<0.0755 [3]	<0.152	<0.0769 [3]	0.169 [5]
Acenaphthene	ug/L	244 [11]	374 [6]	<0.0755 [3]	<0.152	<0.0762 [5]	<0.0816 [11]
Anthracene	ug/L	21.1 [6]	96.4 [6]	<0.0755 [3]	<0.152	<0.0769 [3]	0.0863 [5]
Benz(a)anthracene	ug/L	4.12 [6]	<93.0 [3]	<0.0755 [3]	<0.152	0.625 [5]	0.0893 [6]
Benzo(a)pyrene	ug/L	5.98 [6]	119 [3]	<0.0755 [3]	<0.152	<0.0784	1.84 [5]
Benzo(b)fluoranthene	ug/L	<15.2 [3]	<93.0 [3]	<0.0755 [3]	<0.152	<0.0769 [3]	<0.0816 [11]
Benzo(k)fluoranthene	ug/L	<15.2 [3]	<93.0 [3]	<0.0755 [3]	<0.152	<0.0769 [3]	<0.0816 [11]
Benzo(b+k)fluoranthene(s)	ug/L	7.99 [6] [19] [6]	143 [3] [15] [6]			<0.157 [6] [16] [10]	2.22 [5] [15] [10]
Benzo(g,h,i)perylene	ug/L	3.59 [6]	<93.0 [3]	<0.0755 [3]	<0.152	<0.0769 [3]	1.74 [5]
Carbazole	ug/L	114 [3]	184 [6]	<0.0755 [3]	0.0988 [3]	<0.0762 [5]	<0.0816 [9]
Chrysene	ug/L	4.49 [6]	96.4 [3]	<0.0755 [3]	<0.152	<0.0769 [3]	<0.0816 [11]
Dibenz(a,h)anthracene	ug/L	<1.90 [6]	<93.0 [3]	<0.0755 [3]	<0.152	<0.0769 [3]	0.171 [5]
Dibenzofuran	ug/L	20.1 [3]	<93.0 [3]	<0.0755 [3]	<0.152	<0.0762 [5]	<0.0816 [9]
Fluoranthene	ug/L	32.6 [6]	299 [3]	<0.0755 [3]	0.159	<0.0769 [3]	0.660 [5]
Fluorene	ug/L	100 [11]	180 [6]	<0.0755 [3]	<0.152	<0.0762 [5]	<0.0816 [9]
Indeno(1,2,3-cd)pyrene	ug/L	2.27 [6] [8] [5]	<93.0 [3]	<0.0755 [3]	<0.152	<0.0769 [3]	1.57 [5]
2-Methylnaphthalene	ug/L	36.7 [3]	1070 [6]	<0.0755 [3]	0.675	<0.0769 [3]	0.104 [9] [11] [6]
Naphthalene	ug/L	21.7 [3]	9760 [3] [6] [3]	<0.0779 [3]	3.62	<0.0762 [5]	955 [2] [9] [11] [4] [6]
Phenanthrene	ug/L	230 [6]	717 [6]	<0.0755 [3]	0.439	<0.0769 [3]	0.317 [5]
Pyrene	ug/L	34.2 [3]	364 [3]	<0.0755 [3]	0.169	<0.0769 [3]	0.980 [5]
2-Chlorophenol	ug/L	<23.8 [6]	<1160 [3]	<0.943 [3]	<1.90	<0.952 [5]	<1.02 [11]
2,4-Dichlorophenol	ug/L	<23.8 [6]	<1160 [3]	<0.943 [3]	<1.90	<0.952 [5]	<1.02 [11]
2,4-Dimethylphenol	ug/L	<23.8 [6]	<1160 [3]	<0.943 [3]	<1.90	<0.952 [5]	<1.02 [11]
4,6-Dinitro-2-methylphenol	ug/L	<23.8 [6]	<1160 [3]	<0.943 [3]	<1.90	<0.952 [5]	<1.02 [11]
2-Methylphenol	ug/L	<23.8 [6]	<1160 [3]	<0.943 [3]	<1.90	<0.952 [5]	<1.02 [11]
2-Nitrophenol	ug/L	<23.8 [6]	<1160 [3]	<0.943 [3]	<1.90	<0.952 [5]	<1.02 [11]
4-Nitrophenol	ug/L	<23.8 [6]	<1160 [3]	<0.943 [3]	<1.90	<3.81 [5]	<1.02 [11]
2,4,5-Trichlorophenol	ug/L	<23.8 [6]	<1160 [3]	<0.943 [3]	<1.90	<0.952 [5]	<1.02 [11]
2,4,6-Trichlorophenol	ug/L	<23.8 [6]	<1160 [3]	<0.943 [3]	<1.90	<0.952 [5]	<1.02 [11]
Pentachlorophenol (PCP)	ug/L	<23.8 [6]	<1160 [3]	<0.943 [3]	<1.90	<0.952 [5]	<1.02 [11]
Phenol	ug/L	<23.8 [6]	<1160 [3]	<0.943 [3]	<1.90	<0.952 [5]	5.84
METALS							
Hexavalent Chromium	mg/L	<0.0100	<0.0200	<0.0100	<0.0500 [17] [9]	<0.0100	<0.0400 [20] [12]
Silver	ug/L	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Arsenic	ug/L					2.67 [1] [6]	30.5
Cadmium	ug/L	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Chromium	ug/L	<1.00	1.41	<1.00	5.66	<1.00	2.2
Copper	ug/L	<5.00	<5.00	<5.00	7.99	<5.00	17.9
Iron	ug/L	1050	15600	682	925000	168	1990
Mercury	ug/L	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	0.0176
Manganese	ug/L	265	1720	126	32300	11.5	175
Nickel	ug/L	<1.00	<1.00	<1.00	16.6	2.57	31.5
Lead	ug/L	<1.00	<1.00	<1.00	<1.00	<1.00	7.66
Selenium	ug/L	<1.00	1.49	1.13	3.02 [1] [5]	1.86	5.6
Zinc	ug/L	20.6	126	<4.00	26.3	6.26	30.7
Calcium	ug/L	2410	18000	63700	1390000	6950	21700
Chromium	ug/L	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Hardness (Calc by 6020)	mg CaCO3/L	178	260	404	6920	133	360
Magnesium	ug/L	40400	45800	49200	838000	24200	76600
Trivalent Chromium	ug/L	1.41	<21.0	<1.00	<101	<1.00	<41.0
VOLATILE ORGANICS							
Acetone	ug/L	<400	<2000	<20.0	<20.0	<20.0	<200 [11] [12] [11]
Benzene	ug/L	3620	7200	<0.250 [22]	<0.500 [18] [10]	<0.250	<2.50 [12]
2-Butanone (MEK)	ug/L	<200	<1000	<10.0	17.9	<10.0	<100 [11] [12] [11]
1,1-Dichloroethene	ug/L	<10.0	<50.0	<0.500	<0.500	<5.00 [12]	<5.00 [12]
cis-1,2-Dichloroethene	ug/L	<10.0	<50.0	<0.500	<0.500	<5.00 [12]	<5.00 [12]
trans-1,2-Dichloroethene	ug/L	<10.0	<50.0	<0.500	<0.500	<5.00 [12]	<5.00 [12]
Ethylbenzene	ug/L	42	868	<0.500	<0.500	<5.00 [12]	<5.00 [12]
Tetrachloroethene (PCE)	ug/L	<10.0	<50.0	<0.500	<0.500	<5.00 [12]	<5.00 [12]
Toluene	ug/L	64.8	200	<0.500	<0.500	<5.00 [12]	<5.00 [12]
Trichloroethene (TCE)	ug/L	<10.0	<50.0	<0.500	<0.500	<5.00 [12]	<5.00 [12]
Vinyl chloride	ug/L	<10.0	<50.0	<0.500	<0.500	<5.00 [12]	<5.00 [12]
m,p-Xylene	ug/L	196	463	<1.00	<1.00	<1.00	<10.0 [12]
o-Xylene	ug/L	125	242	<0.500	0.54	<0.500	<5.00 [12]

[6] Footnotes for results found in individual data in Attachment E.

NW Natural Effluent Characteristics and Results

The NW Natural process flow train included equalization, oxidation, chemical addition, settling, cyanide destruction, filtration, granular activated carbon, and final filtration. This process flow train was focused on iron and manganese removal, heavy metals removal, cyanide removal, and volatile and semi-volatile organics removal.

The NW Natural pilot plant effluent characteristics, shown in Table 6, showed compliance with the Oregon DEQ parameters in Table 2 on virtually all samples taken. Only a one iron value (out of 11 samples) exceeded the requirements of Table 2. Three manganese values exceeded Table 2. One copper sample was 0.2 ug/L above the daily maximum requirement.

All other parameters were within the limits in Table 2, or were below the laboratory detection limit for the sample.

Siltronic Results

Siltronic influent and effluent parameters are summarized in Table 7. Again, because a number of the data points were analyzed to be below the mean detection limit, an average value of the constituents was not statistically meaningful. Therefore, the daily minimum and maximum values for each constituent are shown for the entire pilot testing period. The influent values shown are from Siltronic wells. The effluent values shown are downstream of the granular activated carbon columns at sampling point NW 9S.

Siltronic Characteristics

The Siltronic well parameters, summarized in Table 7, show the following general characteristics:

- Slightly alkaline pH values ranging from 7.31—7.60
- Lower total cyanide values than PW-1, similar to MW-1 well
- Low levels (mostly below detection limits) of semi-volatile organics including polyaromatic hydrocarbons

Table 7: Siltronic Influent--Effluent Results[7]

Siltronic Pilot Summary		Siltronic Influent		Siltronic Effluent	
Parameters	Units	Min	Max	Min	Max
pH	pH Units	9.53	10.2	7.31	7.6
pH Temperature	pH Units	16.4	23.7	16	22
Total Dissolved Solids	mg/L	608	744	718	1060
Total Suspended Solids	mg/L	5	56	<5.00	16
Total Organic Carbon	mg/L	<2.00	8.34	<2.00	3.72
Iron	ug/L			<100 [5] [4]	<100 [5] [4]
Manganese	ug/L			25.6 [6] [4]	46.3 [4] [4]
CYANIDE					
Cyanide, Total	mg/L	0.283	0.463	0.0226	0.152
Cyanide, WAD	mg/L	0.0438	0.0878	0.0079	0.0288
Cyanide, Amenable	mg/L	<0.00500	0.0351	<0.00500	0.0146
CATC, chlorinated	mg/L	0.392	0.428	0.026	0.137
Cyanide, Free	mg/L	<0.0100	0.0206	<0.0100	<0.0100
CATC, total	mg/L	0.283	0.463	0.0226	0.152
Available Cyanide	mg/L	<0.0020	0.0059	<0.0020	<0.0020
SEMI-VOLATILE ORGANICS					
Acenaphthylene	ug/L	<0.0792 [6]	<1.86 [4]	<0.0762 [4]	<0.0816 [3]
Acenaphthene	ug/L	0.603 [1] [4]	1.92 [2]	<0.0762 [4]	<0.0816 [3]
Anthracene	ug/L	<0.0755 [3]	<1.86 [5] [15]	<0.0762 [4]	<0.0816 [3]
Benz(a)anthracene	ug/L	<0.0755 [3]	<1.86 [5] [15]	<0.0762 [4]	<0.0816 [3]
Benzo(a)pyrene	ug/L	<0.0755 [3]	<2.14 [5] [14] [15] [8]	<0.0762 [4]	<0.0816 [3]
Benzo(b)fluoranthene	ug/L	<0.0755 [3]	<1.86 [4]	<0.0762 [4]	<0.0816 [3]
Benzo(k)fluoranthene	ug/L	<0.0755 [3]	<1.86 [4]	<0.0762 [4]	<0.0816 [3]
Benzo(g,h,i)perylene	ug/L	<0.0755 [3]	<1.86 [4]	<0.0762 [4]	<0.0816 [3]
Carbazole	ug/L	0.831 [6]	3.24 [4]	<0.0762 [4]	<0.0816 [3]
Chrysene	ug/L	<0.0755 [3]	<1.86 [4]	<0.0762 [4]	<0.0816 [3]
Dibenz(a,h)anthracene	ug/L	<0.0755 [3]	<1.86 [4]	<0.0762 [4]	<0.0816 [3]
Dibenzofuran	ug/L	<0.0755 [3]	<1.86 [4]	<0.0762 [4]	<0.0816 [3]
Fluoranthene	ug/L	<0.0755 [3]	<1.86 [4]	<0.0762 [4]	<0.0816 [3]
Fluorene	ug/L	<0.0755 [3]	<1.86 [4]	<0.0762 [4]	<0.0816 [3]
Indeno(1,2,3-cd)pyrene	ug/L	<0.0755 [3]	<1.86 [4]	<0.0762 [4]	<0.0816 [3]
2-Methylnaphthalene	ug/L	<0.0755 [3]	6.63 [2]	<0.0762 [4]	<0.0816 [3]
Naphthalene	ug/L	0.0902 [3]	141 [2]	<0.0816 [3]	0.172 [2] [4] [1]
Phenanthrene	ug/L	<0.0755 [3]	2.22 [4]	<0.0762 [4]	<0.0816 [3]
Pyrene	ug/L	<0.0755 [3]	<1.86 [4]	<0.0762 [4]	<0.0816 [3]
2-Chlorophenol	ug/L	<0.943 [3]	<23.3 [4]	<0.952 [4]	<1.02 [3]
2,4-Dichlorophenol	ug/L	<0.943 [3]	<23.3 [4]	<0.952 [4]	<1.02 [3]
2,4-Dimethylphenol	ug/L	<0.943 [3]	<23.3 [4]	<0.952 [4]	<1.02 [3]
4,6-Dinitro-2-methylphenol	ug/L	<0.943 [3]	<23.3 [4]	<0.952 [4]	<1.02 [3]
2-Methylphenol	ug/L	<0.943 [3]	<23.3 [4]	<0.952 [4]	<1.02 [3]
2-Nitrophenol	ug/L	<0.943 [3]	<23.3 [4]	<0.952 [4]	<1.02 [3]
4-Nitrophenol	ug/L	<0.943 [3]	<23.3 [4]	<0.952 [4]	<4.08 [3]
2,4,5-Trichlorophenol	ug/L	<0.943 [3]	<23.3 [4]	<0.952 [4]	<1.02 [3]
2,4,6-Trichlorophenol	ug/L	<0.943 [3]	<23.3 [4]	<0.952 [4]	<1.02 [3]
Pentachlorophenol (PCP)	ug/L	<0.943 [3]	<23.3 [4]	<0.952 [4]	<1.02 [3]
Phenol	ug/L	<0.943 [3]	<23.3 [4]	<0.952 [4]	<1.02 [3]
METALS					
Hexavalent Chromium	mg/L	<0.0100	<0.0200 [8] [19] [6] [8]	<0.0100	<0.0100
Silver	ug/L	<1.00	<1.00	<1.00	<1.00
Arsenic	ug/L	2.94	5.03 [1] [3]	3.73	5.99
Cadmium	ug/L	<1.00	<1.00	<1.00	<1.00
Chromium	ug/L	<1.00	<1.00	<1.00	<1.00
Copper	ug/L	<5.00	7.07	<5.00	<5.00
Iron	ug/L	775	5300	378	644
Mercury	ug/L	<0.0100	<0.0100	<0.0100	0.0136
Manganese	ug/L	178	359	45.9	75.9
Nickel	ug/L	1	1.77	2.66	4.81
Lead	ug/L	<1.00	6.32	<1.00	<1.00
Selenium	ug/L	2.99	5.51	2.1	2.73
Zinc	ug/L	<4.00	12.4	4.92	5.4
Calcium	ug/L	2000	6720	3230	5830
Chromium	ug/L	<1.00	<1.00		
Hardness (Calc by 6020)	mg $CaCO_3$/L	134	160	131	150
Magnesium	ug/L	29700	36200	29900	32800
Trivalent Chromium	ug/L	<11.0	<101	<11.0	<11.0
VOLATILE ORGANICS					
Acetone	ug/L	<40.0	<400 [19]	<20.0 [15]	<20.0 [15]
Benzene	ug/L	4.04 [17]	29.2	<0.250	<0.250
2-Butanone (MEK)	ug/L	<20.0	<200 [19]	<10.0	<10.0
1,1-Dichloroethene	ug/L	2.78	<10.0 [19]	<0.500	<0.500
cis-1,2-Dichloroethene	ug/L	206 [17]	950	<0.500	<0.500
trans-1,2-Dichloroethene	ug/L	1.54 [17]	13.4	<0.500	<0.500
Ethylbenzene	ug/L	<1.00 [17]	10.2	<0.500	<0.500
Tetrachloroethene (PCE)	ug/L	<1.00	<10.0 [19]	<0.500	<0.500
Toluene	ug/L	3.08	<10.0 [19]	<0.500	<0.500
Trichloroethene (TCE)	ug/L	1.18	87.9	<0.500	<0.500
Vinyl chloride	ug/L	3.12 [17]	98.2	<0.500	<0.500
m,p-Xylene	ug/L	<10.0	98.2	<1.00 [15]	<1.00 [15]
o-Xylene	ug/L	<1.00 [17]	11.2 [19]	<0.500 [15]	<0.500 [15]

[7] Footnotes for results found in individual data in Attachment G.

- Moderate levels of dissolved iron and manganese
- High levels of VOCs including vinyl chloride, trichloroethene (TCE), and cis 1,2 dichloroethene. Other chlorinated organics (trans 1,2 dichloroethene and 1,1 dichloroethene) were detected in the wells, but were below the Contained-In Determination Threshold Values for Liquids as will be discussed later in this section
- Moderate levels of benzene, ethylbenzene, toluene, and xylene.

Siltronic Effluent Characteristics and Results

The Siltronic process flow train included equalization, oxidation, chemical addition, settling, the advanced oxidation process (AOP) using hydrogen peroxide and ultraviolet light, filtration, granular activated carbon, and final filtration. This process flow train was focused on iron and manganese removal, heavy metals removal, cyanide removal, and volatile and semi-volatile organics removal, with a particular focus on chlorinated organics removal ahead of the common NW Natural downstream processes

The Siltronic pilot plant effluent characteristics, shown in Table 7, showed compliance with the Oregon DEQ parameters in Table 2 on virtually all samples taken. Only a one iron value (out of 3 final effluent samples) exceeded the requirements of Table 2. All other parameters were within the limits in Table 2, or were below the laboratory detection limit for the sample.

With particular regard to the chlorinated organics, Table 8 compares the maximum influent values and effluent values to the Oregon DEQ accepted criteria for threshold F002 hazardous waste listing. From the table it can be surmised that the Siltronic processes readily reduced the chlorinated organic values to well below the F002 threshold values.

Table 8: Comparison of Siltronic Influent and Effluent F002 Constituents to F002 Threshold Values

F002 Constituent	Maximum Influent, ug/L	Maximum Pilot Effluent, ug/L	F002 Threshold Value, ug/L
Trichlorethene (TCE)	**87.9**	**< 0.500**	**5**
Cis 1,2 Dichloroethene (cis 1,2 DCE)	**950**	**< 0.500**	**70**
Trans 1,2 Dichloroethene (tran 1,2 DCE)	**13.4**	**< 0.500**	**100**
1,1 Dichloroethene (1,1 DCE)	**< 10.0**	**< 0.500**	**7**
Vinyl chloride (VC)	**98.2**	**< 0.500**	**2**

Bench-Scale Air Stripping Results

The purpose of the air stripping studies was to determine if standard air stripping could provide similar chlorinated organic results as the AOP process, but at significantly lower capital and operating costs. One additional concern with the AOP flow train tested during the pilot was that there were upstream processes (equalization and settling) that would produce residuals (sludge) that might also be an F002-listed waste. This sludge would then have to be handled separately from the unlisted NW Natural sludge, with attendent higher capital and operating costs.

As envisioned, the air stripping process would be located upstream of all processes to strip the volatile chlorinated organics ahead of all downstream processes. In addition to the Siltronic chlorinated organics, air stripping was evaluated for NW Natural wastewater to oxidize the reduced forms of iron and manganese, and to strip volatile organics such as benzene, toluene, and xylene. Partial stripping of the semi-volatile naphthalene was also evaluated. Air stripping of these compounds would reduce downstream costs of oxidizing chemicals and activated carbon.

NW Natural Air Stripping Results

The results of the air stripping tests are found in Attachment H.

The results of six separate air stripping runs for the MW-1 wells showed little impact on volatile organics, as there is little or no volatile organic compounds found in the well. While iron was consistently removed below the Table 2 standards, manganese was still somewhat above the standards indicating additional processes may be required for manganese.

With regard to PW-1, the air stripping results showed close compliance for iron and manganese. Attachment H shows that volatile organic compounds, particularly benzene, ethylbenzene, toluene, and xylene were readily removed by air stripping.

Semi-volatile removals were fair as expected, though the major concern, naphthalene showed removals ranging from 28% up to 78%.

Siltronic Air Stripping Results

The Siltronic results, also in Attachment H, show removals of iron and manganese consistently below the DEQ requirements of Table 2. Semi-volatile removal was again fair, with some removals (naphthalene) in excess of 50%.

Table 9 summarizes the results of air stripping of chlorinated organics, and compares the results to the F002 values. Unlike the prior analyses that compared the maximum effluent value obtained, the minimum value obtained was used because each run was performed using different parameters. The best results then would serve as the basis for full-scale design. In this case, Run 5 (pH =10; air: water ratio =30:1) was used for the comparison.

Pilot Plant Sludge Results

Sludge was generated during the pilot plant operation from two sources: from accumulated solids in the influent equalization tanks and from the settled solids from the inclined-plate clarifiers in both the NW Natural and Siltronic process flow trains.

Table 9: Comparison of Air Stripping Results to F002 Threshold Values[8]

F002 Constituent	Maximum Influent, ug/L	Run 5 Pilot Effluent, ug/L	F002 Threshold Value, ug/L
Trichlorethene (TCE)	**56**	**< 5**	**5**
Cis 1,2 Dichloroethene (cis 1,2 DCE)	**739**	**< 5**	**70**
Trans 1,2 Dichloroethene (tran 1,2 DCE)	**< 5**	**< 5**	**100**
1,1 Dichloroethene (1,1 DCE)	**< 5**	**< 5**	**7**
Vinyl chloride (VC)	**166**	**< 10**	**2**

[8] Wastestream Laboratories mean detection limits indicated as <

As the sludge generated during the pilot studies was not sufficient to warrant mechanical dewatering in a filter press, the sludge was removed from the vessels and allowed to air dry within the containment pad prior to disposal.

Sludge data was taken to determine the extent to which organic compounds and heavy metals were accumulating in the sludge, and the possibility that the sludge might be determined to be hazardous.

Tables 10 and 11 show the sludge analysis from the NW Natural and Siltronic pilot operation, respectively. Table 12 is a comparison of the observed levels of chlorinated organics in the Siltronic sludge to the Contained-In Threshold Values for Soils.

Table 10: NW Natural Sludge Characteristics

	09/10/09	08/20/09	Units	Min	Max
	NW-10 Sludge	NW-10 Sludge			
Cyanide, Total		<10.2 [18] [4]	mg/kg		
% Solids	13.4	30.9	% by Weight	13.4	30.9
Aroclor 1016	<92.8 [3]		ug/kg	<92.8 [3]	<92.8 [3]
Aroclor 1221	<92.8 [3]		ug/kg	<92.8 [3]	<92.8 [3]
Aroclor 1232	<92.8 [3]		ug/kg	<92.8 [3]	<92.8 [3]
Aroclor 1242	<92.8 [3]		ug/kg	<92.8 [3]	<92.8 [3]
Aroclor 1248	<92.8 [3]		ug/kg	<92.8 [3]	<92.8 [3]
Aroclor 1254	<92.8 [3]		ug/kg	<92.8 [3]	<92.8 [3]
Aroclor 1260	<92.8 [3]		ug/kg	<92.8 [3]	<92.8 [3]
Silver	<0.100		mg/L	<0.100	<0.100
Arsenic	<0.100		mg/L	<0.100	<0.100
Barium	<1.25		mg/L	<1.25	<1.25
Cadmium	<0.0500		mg/L	<0.0500	<0.0500
Chromium	<0.100		mg/L	<0.100	<0.100
Mercury	<0.00400		mg/L	<0.00400	<0.00400
Lead	<0.0500		mg/L	<0.0500	<0.0500
Selenium	<0.0500		mg/L	<0.0500	<0.0500
Silver		<3.56	mg/kg	<3.56	<3.56
Arsenic		7.9	mg/kg	7.9	7.9
Barium		167	mg/kg	167	167
Cadmium		<3.56	mg/kg	<3.56	<3.56
Mercury		<0.285	mg/kg	<0.285	<0.285
Lead		30.7	mg/kg	30.7	30.7
Selenium		<3.56	mg/kg	<3.56	<3.56
Acetone	<81300 [8] [10] [11] [3]		ug/kg	<81300 [8] [10] [11] [3]	<81300 [8] [10] [11] [3]
Benzene	67600 [10] [11]		ug/kg	67600 [10] [11]	67600 [10] [11]
Bromobenzene	<2030 [10] [11]		ug/kg	<2030 [10] [11]	<2030 [10] [11]
Bromochloromethane	<2030 [10] [11]		ug/kg	<2030 [10] [11]	<2030 [10] [11]
Bromodichloromethane	<2030 [10] [11]		ug/kg	<2030 [10] [11]	<2030 [10] [11]
Bromoform	<4060 [10] [11]		ug/kg	<4060 [10] [11]	<4060 [10] [11]
Bromomethane	<40600 [10] [11]		ug/kg	<40600 [10] [11]	<40600 [10] [11]
2-Butanone (MEK)	<40600 [8] [10] [11] [3]		ug/kg	<40600 [8] [10] [11] [3]	<40600 [8] [10] [11] [3]
n-Butylbenzene	8410 [10] [11]		ug/kg	8410 [10] [11]	8410 [10] [11]
sec-Butylbenzene	<4060 [10] [11]		ug/kg	<4060 [10] [11]	<4060 [10] [11]
tert-Butylbenzene	<4060 [10] [11]		ug/kg	<4060 [10] [11]	<4060 [10] [11]
Carbon tetrachloride	<8130 [10] [11]		ug/kg	<8130 [10] [11]	<8130 [10] [11]
Chlorobenzene	<2030 [10] [11]		ug/kg	<2030 [10] [11]	<2030 [10] [11]
Chloroethane	<40600 [10] [11]		ug/kg	<40600 [10] [11]	<40600 [10] [11]
Chloroform	<20300 [10] [11]		ug/kg	<20300 [10] [11]	<20300 [10] [11]
Chloromethane	<20300 [10] [11]		ug/kg	<20300 [10] [11]	<20300 [10] [11]
2-Chlorotoluene	<2030 [10] [11]		ug/kg	<2030 [10] [11]	<2030 [10] [11]
4-Chlorotoluene	<4060 [10] [11]		ug/kg	<4060 [10] [11]	<4060 [10] [11]
1,2-Dibromo-3-chloropropane	<8130 [10] [11]		ug/kg	<8130 [10] [11]	<8130 [10] [11]
Dibromochloromethane	<8130 [10] [11]		ug/kg	<8130 [10] [11]	<8130 [10] [11]
1,2-Dibromoethane (EDB)	<2030 [10] [11]		ug/kg	<2030 [10] [11]	<2030 [10] [11]
Dibromomethane	<4060 [10] [11]		ug/kg	<4060 [10] [11]	<4060 [10] [11]
1,2-Dichlorobenzene	<2030 [10] [11]		ug/kg	<2030 [10] [11]	<2030 [10] [11]
1,3-Dichlorobenzene	<2030 [10] [11]		ug/kg	<2030 [10] [11]	<2030 [10] [11]
1,4-Dichlorobenzene	<4060 [10] [11]		ug/kg	<4060 [10] [11]	<4060 [10] [11]
Dichlorodifluoromethane	<8130 [10] [11]		ug/kg	<8130 [10] [11]	<8130 [10] [11]
1,1-Dichloroethane	<2030 [10] [11]		ug/kg	<2030 [10] [11]	<2030 [10] [11]
1,2-Dichloroethane (EDC)	<2030 [10] [11]		ug/kg	<2030 [10] [11]	<2030 [10] [11]
1,1-Dichloroethene	<2030 [10] [11]		ug/kg	<2030 [10] [11]	<2030 [10] [11]
cis-1,2-Dichloroethene	<2030 [10] [11]		ug/kg	<2030 [10] [11]	<2030 [10] [11]
trans-1,2-Dichloroethene	<4060 [10] [11]		ug/kg	<4060 [10] [11]	<4060 [10] [11]
1,2-Dichloropropane	<2030 [10] [11]		ug/kg	<2030 [10] [11]	<2030 [10] [11]
1,3-Dichloropropane	<2030 [10] [11]		ug/kg	<2030 [10] [11]	<2030 [10] [11]
2,2-Dichloropropane	<4060 [10] [11]		ug/kg	<4060 [10] [11]	<4060 [10] [11]
1,1-Dichloropropene	<4060 [10] [11]		ug/kg	<4060 [10] [11]	<4060 [10] [11]
cis-1,3-Dichloropropene	<8130 [10] [11]		ug/kg	<8130 [10] [11]	<8130 [10] [11]
trans-1,3-Dichloropropene	<8130 [10] [11]		ug/kg	<8130 [10] [11]	<8130 [10] [11]
Ethylbenzene	192000 [10] [11]		ug/kg	192000 [10] [11]	192000 [10] [11]
Hexachlorobutadiene	<20300 [10] [11]		ug/kg	<20300 [10] [11]	<20300 [10] [11]
2-Hexanone	<40600 [10] [11]		ug/kg	<40600 [10] [11]	<40600 [10] [11]
Isopropylbenzene	10800 [10] [11]		ug/kg	10800 [10] [11]	10800 [10] [11]
4-Isopropyltoluene	6090 [10] [11]		ug/kg	6090 [10] [11]	6090 [10] [11]
4-Methyl-2-pentanone (MiBK)	<40600 [10] [11]		ug/kg	<40600 [10] [11]	<40600 [10] [11]
Methyl tert-butyl ether (MTBE)	<4060 [10] [11]		ug/kg	<4060 [10] [11]	<4060 [10] [11]
Methylene chloride	<20300 [8] [10] [11] [3]		ug/kg	<20300 [8] [10] [11] [3]	<20300 [8] [10] [11] [3]
Naphthalene	12000000 [10] [11]		ug/kg	12000000 [10] [11]	12000000 [10] [11]
n-Propylbenzene	6180 [10] [11]		ug/kg	6180 [10] [11]	6180 [10] [11]
Styrene	<8130 [10] [11]		ug/kg	<8130 [10] [11]	<8130 [10] [11]
1,1,1,2-Tetrachloroethane	<4060 [10] [11]		ug/kg	<4060 [10] [11]	<4060 [10] [11]
1,1,2,2-Tetrachloroethane	<4060 [10] [11]		ug/kg	<4060 [10] [11]	<4060 [10] [11]
Tetrachloroethene (PCE)	<4060 [10] [11]		ug/kg	<4060 [10] [11]	<4060 [10] [11]
Toluene	11100 [10] [11]		ug/kg	11100 [10] [11]	11100 [10] [11]
1,2,3-Trichlorobenzene	<8130 [10] [11]		ug/kg	<8130 [10] [11]	<8130 [10] [11]
1,2,4-Trichlorobenzene	<8130 [10] [11]		ug/kg	<8130 [10] [11]	<8130 [10] [11]
1,1,1-Trichloroethane	<4060 [10] [11]		ug/kg	<4060 [10] [11]	<4060 [10] [11]
1,1,2-Trichloroethane	<4060 [10] [11]		ug/kg	<4060 [10] [11]	<4060 [10] [11]
Trichloroethene (TCE)	<2030 [10] [11]		ug/kg	<2030 [10] [11]	<2030 [10] [11]
Trichlorofluoromethane	<8130 [10] [11]		ug/kg	<8130 [10] [11]	<8130 [10] [11]
1,2,3-Trichloropropane	<4060 [10] [11]		ug/kg	<4060 [10] [11]	<4060 [10] [11]
1,2,4-Trimethylbenzene	200000 [10] [11]		ug/kg	200000 [10] [11]	200000 [10] [11]
1,3,5-Trimethylbenzene	66200 [10] [11]		ug/kg	66200 [10] [11]	66200 [10] [11]
Vinyl chloride	<2030 [10] [11]		ug/kg	<2030 [10] [11]	<2030 [10] [11]
m,p-Xylene	145000 [10] [11]		ug/kg	145000 [10] [11]	145000 [10] [11]
o-Xylene	71500 [10] [11]		ug/kg	71500 [10] [11]	71500 [10] [11]
Acetone	<81300 [8] [10] [11] [3]	<83100 [19]	ug/kg	<83100 [19]	<83100 [19]
Benzene	67600 [10] [11]	1330 [19]	ug/kg	1330 [19]	67600 [10] [11]
2-Butanone (MEK)	<40600 [8] [10] [11] [3]	<41500 [19]	ug/kg	<40600 [8] [10] [11] [3]	<41500 [19]
1,1-Dichloroethene	<2030 [10] [11]	<2080 [19]	ug/kg	<2030 [10] [11]	<2080 [19]
cis-1,2-Dichloroethene	<2030 [10] [11]	<2080 [19]	ug/kg	<2030 [10] [11]	<2080 [19]
trans-1,2-Dichloroethene	<4060 [10] [11]	<4150 [19]	ug/kg	<4060 [10] [11]	<4150 [19]
Ethylbenzene	192000 [10] [11]	6890 [19]	ug/kg	6890 [19]	192000 [10] [11]
Tetrachloroethene (PCE)	<4060 [10] [11]	<4150 [19]	ug/kg	<4060 [10] [11]	<4150 [19]
Toluene	11100 [10] [11]	<8310 [19]	ug/kg	<8310 [19]	11100 [10] [11]
Trichloroethene (TCE)	<2030 [10] [11]	<2080 [19]	ug/kg	<2030 [10] [11]	<2080 [19]
Vinyl chloride	<2030 [10] [11]	<2080 [19]	ug/kg	<2030 [10] [11]	<2080 [19]
m,p-Xylene	145000 [10] [11]	11500 [19]	ug/kg	11500 [19]	145000 [10] [11]
o-Xylene	71500 [10] [11]	5730 [19]	ug/kg	5730 [19]	71500 [10] [11]

Table 11: Siltronic Sludge Characteristics

	08/27/09	Units
% Solids	16.5	% by Weight
Silver	<5.98	mg/kg
Arsenic	10.9	mg/kg
Barium	262	mg/kg
Cadmium	<5.98	mg/kg
Chromium	<12.0	mg/kg
Mercury	<0.478	mg/kg
Lead	<5.98	mg/kg
Selenium	<5.98	mg/kg
Acetone	<10500 [9]	ug/kg
Benzene	<131 [9]	ug/kg
2-Butanone (MEK)	<5240 [9]	ug/kg
1,1-Dichloroethene	<262 [9]	ug/kg
cis-1,2-Dichloroethene	587 [9]	ug/kg
trans-1,2-Dichloroethene	<524 [9]	ug/kg
Ethylbenzene	<262 [9]	ug/kg
Tetrachloroethene (PCE)	<524 [9]	ug/kg
Toluene	<1050 [9]	ug/kg
Trichloroethene (TCE)	<262 [9]	ug/kg
Vinyl chloride	<262 [9]	ug/kg
m,p-Xylene	<524 [9]	ug/kg
o-Xylene	<262 [9]	ug/kg

Table 12: Comparison of Siltronic Sludge Values to F002 Threshold Values

F002 Constituent	**Siltronic Sludge ug/kg**	**F002 Threshold Value for Soils, ug/kg**
Trichlorethene (TCE)	**< 262**	**3,400**
Cis 1,2 Dichloroethene (cis 1,2 DCE)	**587**	**4,900,000**
Trans 1,2 Dichloroethene (tran 1,2 DCE)	**< 524**	**8,900,000**
1,1 Dichloroethene (1,1 DCE)	**< 262**	**26,000,000**
Vinyl chloride (VC)	**< 262**	**3,900**

From the data in Table 12, it is clear that the Siltronic sludge parameters are orders of magnitude below the F002 Threshold Values and would therefore be acceptable to be combined with the NW Natural sludge for common processing and disposal.

Implications of Pilot Plant Results for Full-Scale Plant

As a result of the pilot plant work and the air stripping studies, Sevenson has put together a process flow scheme and has begun sizing the individual unit processes. These processes have been detailed in the Interim Design Report (IDR) submitted to Oregon DEQ on November 6, 2009.

The general process approach has been to utilize the processes that have the best potential for meeting DEQ's requirements at the lowest life-cycle cost to NW Natural and Siltronic. As such, air stripping has been incorporated into both processes to reduce the level of volatile organics and chlorinated organics as early in the process as possible.

Following air stripping, the wastewater from Siltronic will be pumped in a dual-contained pipeline to the NW Natural site for blending with the NW Natural wastewater. As indicated a backup chemical oxidation system will be provided if the F002 constituents have not been reduced below the threshold values after the air stripping process.

The combined wastewater will receive a coagulant and flocculant prior to separation in a settling tank. Heavy metals and iron and manganese will be removed. Following settling, an oxidant (either hydrogen peroxide or sodium hypochlorite will be added to the wastewater for cyanide destruction in a designated reactor.

Following pH adjustment into the neutral range, the wastewater will be pumped through bag filters to remove additional solids and then to granular activated carbon vessels for additional organics removal. Finally, prior to discharge to the Willamette River, the flow will be pumped through a 1-micron bag filter rack to catch any carbon particles and adsorbed organics that may escape.

Sludge from the plant, including both NW Natural and Siltronic sludge, will be thickened and dewatered, and disposed of off-site in an approved facility.

Attachment A: Pilot Plant Design Data

23-Nov-09		
NW NATURAL GROUNDWATER PILOT PLANT PROCESS DESIGN		
PRELIMINARY DESIGN DATA --50 GPM		**COMMENTS/ASSUMPTIONS**
INFLUENT CHARACTERISTICS--WASTEWATER		
DESIGN AVERAGE FLOW, GPD	18,000	6-Hour Days
, GPM	50	
AVERAGE TOTAL ORGANIC CARBON, LBS/DAY	6.0	@ 40 mg/L
TOTAL SUSPENDED SOLIDS, LBS/DAY	3.0	@ 20 mg/L
TOTAL CYANIDE, LBS/DAY	0.2	@ 1.5 mg/L
TOTAL IRON, LBS/DAY	12	@ 80 mg/L
TOTAL MANGANESE, LBS/DAY	0.2	@ 1 mg/L
REQUIRED EFFLUENT CHARACTERISTICS		
TOC, MG/L	0.05	Assumed
, LBS/DAY	0.01	
, % REMOVAL	99.9%	
VOCs, MG/L	0.02	Approximate (individual values checked)
, LBS/DAY	0.003	
SVOCs, MG/L	0.03	
, LBS/DAY	0.005	Approximate (individual values checked)
TSS, MG/L	0.04	Assumed
, LBS/DAY	0.01	
, % REMOVAL	99.8%	
FREE CYANIDE, MG/L	0.01	DEQ
, LBS/DAY	0.0180	
, % REMOVAL	92.0%	
DISSOLVED IRON, MG/L	0.3	DEQ
, LBS/DAY	0.0	
, % REMOVAL	99.6%	
DISSOLVED MANGANESE, MG/L	0.05	DEQ
, LBS/DAY	0.01	
, % REMOVAL	95.0%	
INFLUENT EQUALIZATION TANKS		Closed tanks with level control
TYPE	FRAC	
NO OF UNITS INSTALLED	2	
UNIT VOLUME, GALS	21,000	
VOLUME, GALS	42,000	
DETENTION TIME, DAYS	4.7	
REACTOR FEED PUMPS		Controlled off reactor level
TYPE	CENTRIFUGAL	
NO OF UNITS	2	
UNIT CAPACITY, GPM	100	
TDH, FT	20	
UNIT HP	3	with VFD

MAZZEI EDUCTORS--FE AERATION IN RECIRC		
STOICHIOMETRIC FACTOR IRON	0.1432	
STOICHIOMETRIC FACTOR MANGANESE	0.2912	
ASSUMED INFLUENT OXYGEN, mg/L	0	
DESIRED RESIDUAL OXYGEN, mg/L	5	
OXYGEN REQUIRED, mg/l	17	
INFLUENT FLOW METERS		
TYPE	MAGNETIC	Tied to VFDs
NUMBER	2	
SIZE, INCHES	2	
CAUSTIC FEED PUMPS		pH Adjustment as required
TYPE	Diaphragm	
CONTROL	pH	
NUMBER OF UNITS	1	
PROJECTED USAGE, GALS/DAY	18	Treatability using 25%
PROJECTED USAGE, LBS/DAY	234	
, GALS/HOUR	3.0	6 hr days
UNIT CAPACITY, GALS/HR	0-4	
STORAGE PROVIDED, GALS	260	Totes
STORAGE PROVIDED, DAYS	14.4	
HYDROGEN PEROXIDE FEED PUMPS		CYANIDE OXIDATION
TYPE	Diaphragm	pH = 10.2
CONTROL	Paced off ORP	ORP = 650 mv
NUMBER OF UNITS	1	
PROJECTED USAGE, GALS/DAY	7	Treatability & Estimate
PROJECTED USAGE, LBS/DAY	72	Estimate
, GALS/HOUR	1.2	
UNIT CAPACITY, GALS/HOUR	0-8	
STORAGE PROVIDED, GALS	260	Totes
STORAGE PROVIDED, DAYS	36.1	
CYANIDE REACTOR		
DESIRED DETENTION TIME, MINS	120	Oxidation to Cyanate
NUMBER OF UNITS	1	
LENGTH, FT	20	
WIDTH, FT	6	
DEPTH	6	
VOLUME, CU FT	720	
VOLUME, GALS	5,386	
DETENTION TIME, MINS	108	
SULFURIC ACID FEED PUMPS		pH Adjustment 8-8.5
TYPE	Diaphragm	
CONTROL	Paced off pH	
NUMBER OF UNITS	1	
PROJECTED USAGE @ 28 mg/L, LBS/DAY	6	Estimate
, GALS/HOUR	0.08	
, GALS/DAY	0.6	
UNIT CAPACITY, GALS/HOUR	0-2	
STORAGE PROVIDED, GALS	20	Drum
STORAGE PROVIDED, DAYS	31.9	

IN-LINE MIXER		
NUMBER	1	
TYPE	IN LINE STATIC	
SIZE, INCHES	2	
INCLINED-PLATE CLARIFIER		
TYPE	INCLINED PLATE	
NUMBER	1	
DIMENSIONS, FT		
LENGTH	8	
WIDTH	4	
HEIGHT	8	
PROJECTED SETTLING AREA, SQ FT	250	
LOADING RATE, GPM/SQ FT	0.20	
SOLIDS PRODUCTION		
INFLUENT SOILIDS	2	@ 75% Removal of Influent
CHEMICAL SOLIDS	36	@ 3 X Influent Iron
TOTAL SOLIDS, LBS/DAY	38	
, CONCENTRATION @	3%	
, LBS/DAY	1,276	
, GALS/DAY	150	
, GALS/MIN @ 10 MINS/HR	0.6	
IPC EFFLUENT TANK		
TYPE	Polypropylene	
NO OF UNITS INSTALLED	1	
VOLUME, GALS	2,500	
DETENTION TIME, MINS	50.0	
SLUDGE PUMP		
TYPE	DIAPHRAGM	
NUMBER	1	
CAPACITY, GPM	15	Sandpiper S05 Al
REQUIRED AIR, CFM	14	
AIR COMPRESSOR		
TYPE		
CAPACITY, CFM	25	
PRESSURE, PSI	125	
SLUDGE THICKENER/STORAGE		
NO OF UNITS	1	
UNIT VOLUME, GALS	2,500	
TOTAL VOLUME, GALS	2,500	
SLUDGE FEED, GALS/DAY	150	
STORAGE CAPACITY, DAYS	16.7	
THICKENED SLUDGE, LBS/DAY	34	@ 90% Solids capture
THICKENED SLUDGE, 2 x INFLUENT	6%	
THICKENED SLUDGE, GALS	67	
RECIRCULATED OVERFLOW, GALS/DAY	83	

ANIONIC POLYMER FEED PUMP		Settling Aid
TYPE	Diaphragm	
CONTROL	Manual Stroke	
NUMBER OF UNITS	1	
PROJECTED USAGE @ 8.6 LBS/GAL, LBS/DAY	0.8	@ 5 mg/L
PROJECTED USAGE @ 8.6 LBS/GAL, GALS/DAY	0.1	20-Gallon Carboy
, GALS/HOUR	0.01	
UNIT CAPACITY, GALS/HR	0-1	
DILUTION WATER @ 0.25%, GALS/DAY	36	
, GALS/HOUR	3	
FILTER/GAC FEED PUMPS		
TYPE	CENTRIFUGAL	
NO OF UNITS	1	
UNIT CAPACITY, GPM	75	
TDH, FT	100	
UNIT HP	25.0	
BAG FILTERS		Metals/solids removal
NO OF UNITS	2	In series
BAG MEDIA, MICRONS	10-->5	
GRANULAR ACTIVATED CARBON VESSELS		Organics Removal
DESIGN PARAMETERS		
CONTACT TIME, MINS	15	
LOADING RATE, GPM/SQ FT	4	
NO OF UNITS	3	In Parallel
UNIT DIAMETER, FT	4	
UNIT HEIGHT, FT	10	
CARBON DEPTH, FT	3.5	
UNIT AREA, SQ FT	13	
TOTAL AREA, SQ FT	38	
EFFECTIVE UNIT VOLUME, CU FT	44	
TOTAL EFFECTIVE VOLUME, CU FT	132	
HYDRAULIC LOADING, GPM/SQ FT	4.0	
LBS CARBON/UNIT @ 30 LBS/CU FT	1,319	
TOTAL AVAILABLE CARBON, LBS	3,956	
EMPTY BED CONTACT TIME , MINS	19.7	
TOTAL ORGANICS TO CARBON UNITS, LBS/DAY	4.5	25% Removal across oxidation/sedimentation
% TOTAL ORGANICS REMOVAL	99%	
EFFLUENT ORGANICS, LBS/DAY	0.05	
, mg/L	0.30	
UTILIZATION RATE, LBS TOCr/LB CARBON	0.10	
UTILIZATION RATE, LBS/CARBON/DAY	45	
, LBS/YEAR	16,274	
ESTIMATED BREAKTHROUGH LEAD COLUMN, DAYS	30	
TOTAL BED LIFE, DAYS	89	

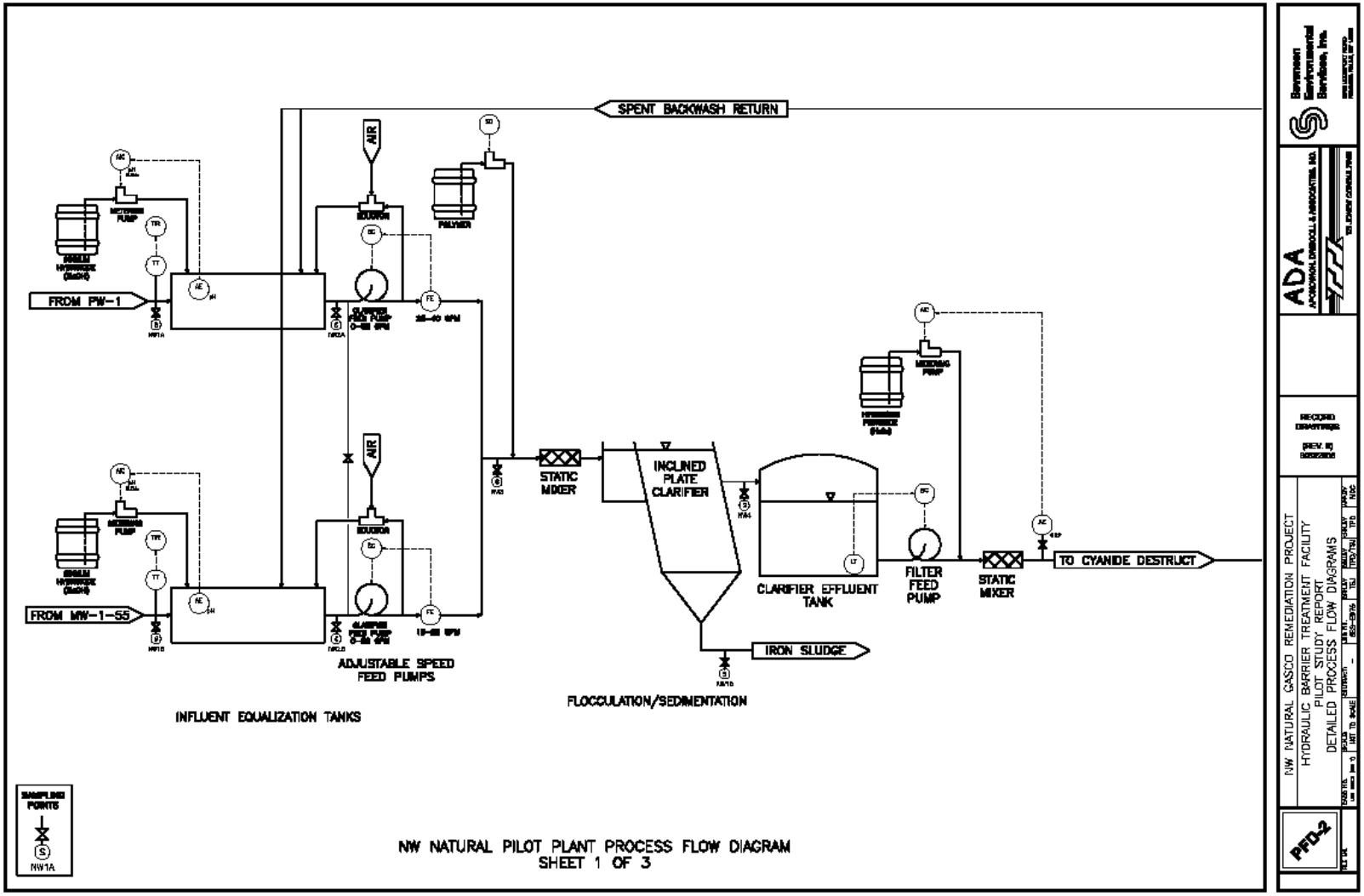
EFFLUENT HOLDING TANK		
TYPE	FRAC TANK	
NO OF UNITS INSTALLED	2	
VOLUME, GALS	20,000	
DETENTION TIME, HRS	17.8	
EFFLUENT/GAC BACKWASH PUMPS		
TYPE	CENTRIFUGAL	
NO OF UNITS INSTALLED	2	
UNIT CAPACITY, GPM	151	Backwash Rate = 12 gpm/sq ft
TDH, FT	60	
UNIT BHP	10	
BAG FILTERS		Carbon fines removal removal
NO OF UNITS	1	
BAG MEDIA, MICRONS	0.5	
EFFLUENT FLOW METER		
TYPE	MAGNETIC	
SIZE, INCHES	2	

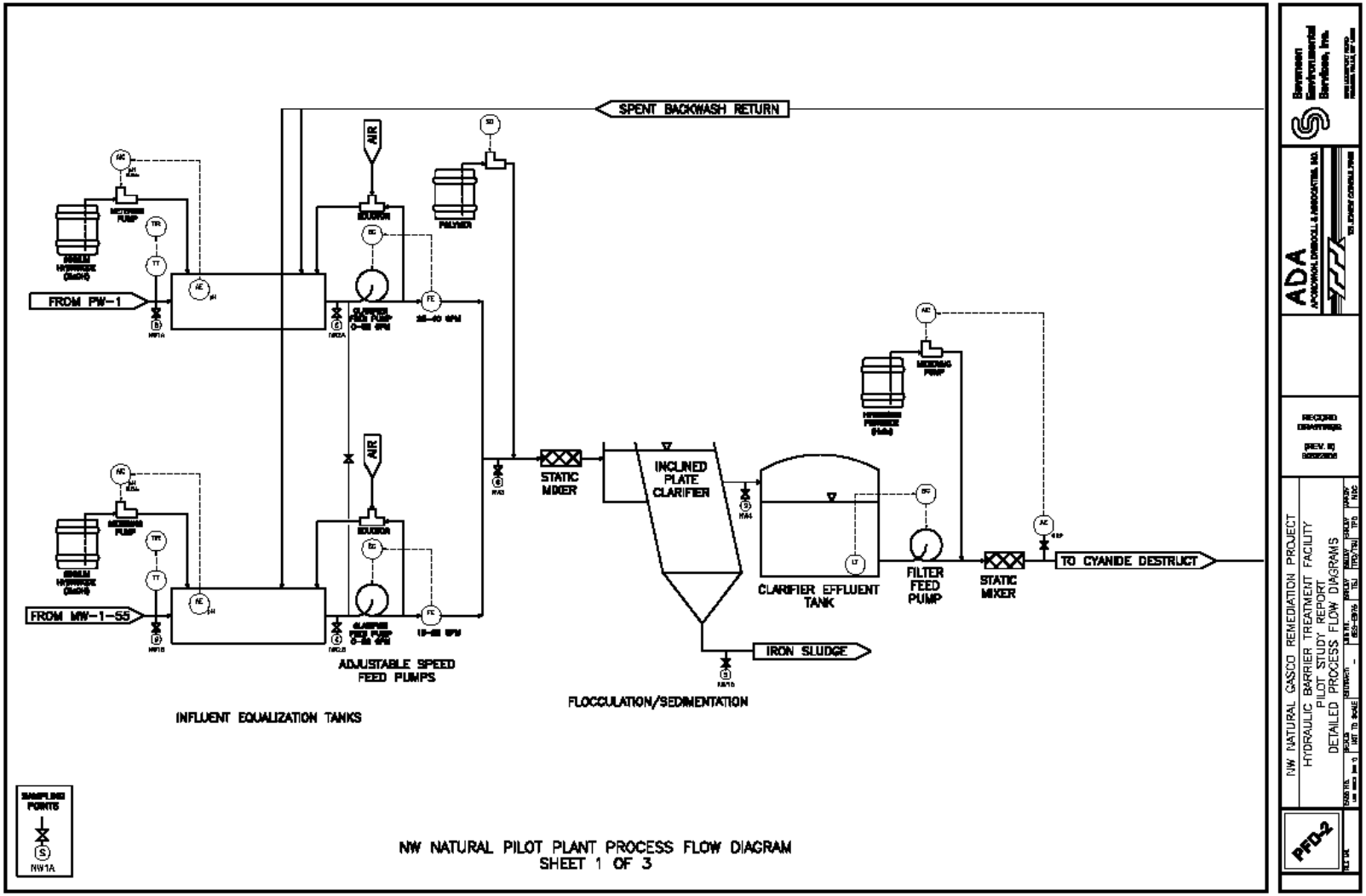
SILTRONICS GROUNDWATER PILOT PLANT PROCESS DESIGN		
PRELIMINARY DESIGN DATA --15 GPM		**COMMENTS/ASSUMPTIONS**
INFLUENT CHARACTERISTICS--WASTEWATER		
DESIGN AVERAGE FLOW, GPD	5,400	6-Hour Days
, GPM	15	
AVERAGE TOTAL ORGANIC CARBON, LBS/DAY	1.1	@ 25 mg/L
TOTAL SUSPENDED SOLIDS, LBS/DAY	0.9	@ 20 mg/L
TOTAL CYANIDE, LBS/DAY	0.02	@ 0.5 mg/L
TOTAL IRON, LBS/DAY	2.25	@ 50 mg/L
TOTAL MANGANESE, LBS/DAY	0.05	@ 1 mg/L
REQUIRED EFFLUENT CHARACTERISTICS		
TOC, MG/L	0.05	Assumed
, LBS/DAY	0.00	
, % REMOVAL	99.8%	
TSS, MG/L	0.04	Assumed
, LBS/DAY	0.00	
, % REMOVAL	99.8%	
TOTAL CYANIDE, MG/L	0.0014	DEQ
, LBS/DAY	0.0025	
, % REMOVAL	88.8%	
TOTAL IRON, MG/L	0.3	DEQ
, LBS/DAY	0.01	
, % REMOVAL	99.4%	
TOTAL MANGANESE, MG/L	0.05	DEQ
, LBS/DAY	0.002	
, % REMOVAL	95.0%	
INFLUENT EQUALIZATION TANK		Closed tanks with level control
TYPE	FRAC	
NO OF UNITS INSTALLED	1	
UNIT VOLUME, GALS	21,000	
VOLUME, GALS	21,000	
DETENTION TIME, DAYS	3.9	
REACTOR FEED PUMP		Controlled off reactor level
TYPE	CENTRIFUGAL	
NO OF UNITS	1	
UNIT CAPACITY, GPM	30	with 100% recycle
TDH, FT	20	
UNIT HP	0.5	with VFD

MAZZEI EDUCTORS--FE AERATION IN RECIRC		
STOICHIOMETRIC FACTOR IRON	0.1432	
STOICHIOMETRIC FACTOR MANGANESE	0.2912	
ASSUMED INFLUENT OXYGEN, mg/L	0	
DESIRED RESIDUAL OXYGEN, mg/L	5	
OXYGEN REQUIRED, mg/l	12	
INFLUENT FLOW METER		
TYPE	MAGNETIC	Tied to VFD
NUMBER	1	
SIZE, INCHES	1	
CAUSTIC FEED PUMP		pH Adjustment as required
TYPE	Diaphragm	
CONTROL	pH	
NUMBER OF UNITS	1	
PROJECTED USAGE, GALS/DAY	5	Treatability using 25%
PROJECTED USAGE, LBS/DAY	70	
, GALS/HOUR	0.9	6 hr days
UNIT CAPACITY, GALS/HR	0-2	
STORAGE PROVIDED, GALS	260	Tote
STORAGE PROVIDED, DAYS	48.1	
IN-LINE MIXER		
NUMBER	1	
TYPE	IN LINE STATIC	
SIZE, INCHES	1	
INCLINED-PLATE CLARIFIER		
TYPE	INCLINED PLATE	
NUMBER	1	
DIMENSIONS, FT		
LENGTH	8	
WIDTH	4	
HEIGHT	8	
PROJECTED SETTLING AREA, SQ FT	80	
LOADING RATE, GPM/SQ FT	0.19	
SOLIDS PRODUCTION		
INFLUENT SOILIDS	1	@ 75% Removal of Influent
CHEMICAL SOLIDS	7	@ 3 X Influent Iron
TOTAL SOLIDS, LBS/DAY	8	
, CONCENTRATION @	3%	
, LBS/DAY	255	
, GALS/DAY	30	
, GALS/MIN @ 10 MINS/HR	0.1	
IPC EFFLUENT TANK		
TYPE	Polypropylene	
NO OF UNITS INSTALLED	1	
VOLUME, GALS	2,500	
DETENTION TIME, MINS	0.5	

HYDROGEN PEROXIDE FEED PUMP		CYANIDE OXIDATION
TYPE	Diaphragm	
CONTROL	Paced off ORP	ORP = 650 mv
NUMBER OF UNITS	1	
PROJECTED USAGE, GALS/DAY	2.2	Treatability & Estimate
PROJECTED USAGE, LBS/DAY	22	Estimate
, GALS/HOUR	0.4	
UNIT CAPACITY, GALS/HOUR	0-8	
TOTAL CAPACITY, GALS/HOUR	0-16	
STORAGE PROVIDED, GALS	260	Totes
STORAGE PROVIDED, DAYS	120.4	
IN-LINE MIXER		
NUMBER	1	
TYPE	IN LINE STATIC	
SIZE, INCHES	1	
ADVANCED OXIDATION FEED PUMP		Controlled off reactor level
TYPE	CENTRIFUGAL	
NO OF UNITS	1	
UNIT CAPACITY, GPM	15	
TDH, FT	20	
UNIT HP	0.5	with VFD
ADVANCED OXIDATION REACTOR		Ultraviolet Lights
DESIRED DETENTION TIME, MINS	30	Oxidation of halogenated organics
NUMBER OF UNITS	1	
LENGTH, FT	6	
WIDTH, FT	6	
DEPTH	6	
VOLUME, CU FT	216	
VOLUME, GALS	1,616	
DETENTION TIME, MINS	108	
EFFLUENT HOLDING TANK		
TYPE	FRAC TANK	
NO OF UNITS INSTALLED	1	
VOLUME, GALS	18,000	
DETENTION TIME, HRS	26.7	
EFFLUENT PUMP		
TYPE	CENTRIFUGAL	
NO OF UNITS INSTALLED	1	
UNIT CAPACITY, GPM	25	
TDH, FT	50	
UNIT BHP	0.5	
EFFLUENT FLOW METER		
TYPE	MAGNETIC	
SIZE, INCHES	1	

Attachment B: Pilot Plant Process Diagrams


SPENT BACKWASH RETURN
AIR
EDUCTOR
POLYMER
FROM PW-1
FROM MW-1-S5
ADJUSTABLE SPEED FEED PUMPS
INFLUENT EQUALIZATION TANKS
STATIC MIXER
INCLINED PLATE CLARIFIER
FLOCCULATION/SEDIMENTATION
IRON SLUDGE
CLARIFIER EFFLUENT TANK
FILTER FEED PUMP
STATIC MIXER
TO CYANIDE DESTRUCT
SAMPLING POINTS
NW NATURAL PILOT PLANT PROCESS FLOW DIAGRAM
SHEET 1 OF 3
ADA
NW NATURAL GASCO REMEDIATION PROJECT
HYDRAULIC BARRIER TREATMENT FACILITY
PILOT STUDY REPORT
DETAILED PROCESS FLOW DIAGRAMS
PFD-2


SPENT BACKWASH RETURN
AIR
AIR
FROM PW-1
FROM MW-1-55
STATIC MIXER
INCLINED PLATE CLARIFIER
CLARIFIER EFFLUENT TANK
FILTER FEED PUMP
STATIC MIXER
TO CYANIDE DESTRUCT
IRON SLUDGE
ADJUSTABLE SPEED FEED PUMPS
INFLUENT EQUALIZATION TANKS
FLOCCULATION/SEDIMENTATION
SAMPLING POINTS
NW1A
NW NATURAL PILOT PLANT PROCESS FLOW DIAGRAM
SHEET 1 OF 3
ADA
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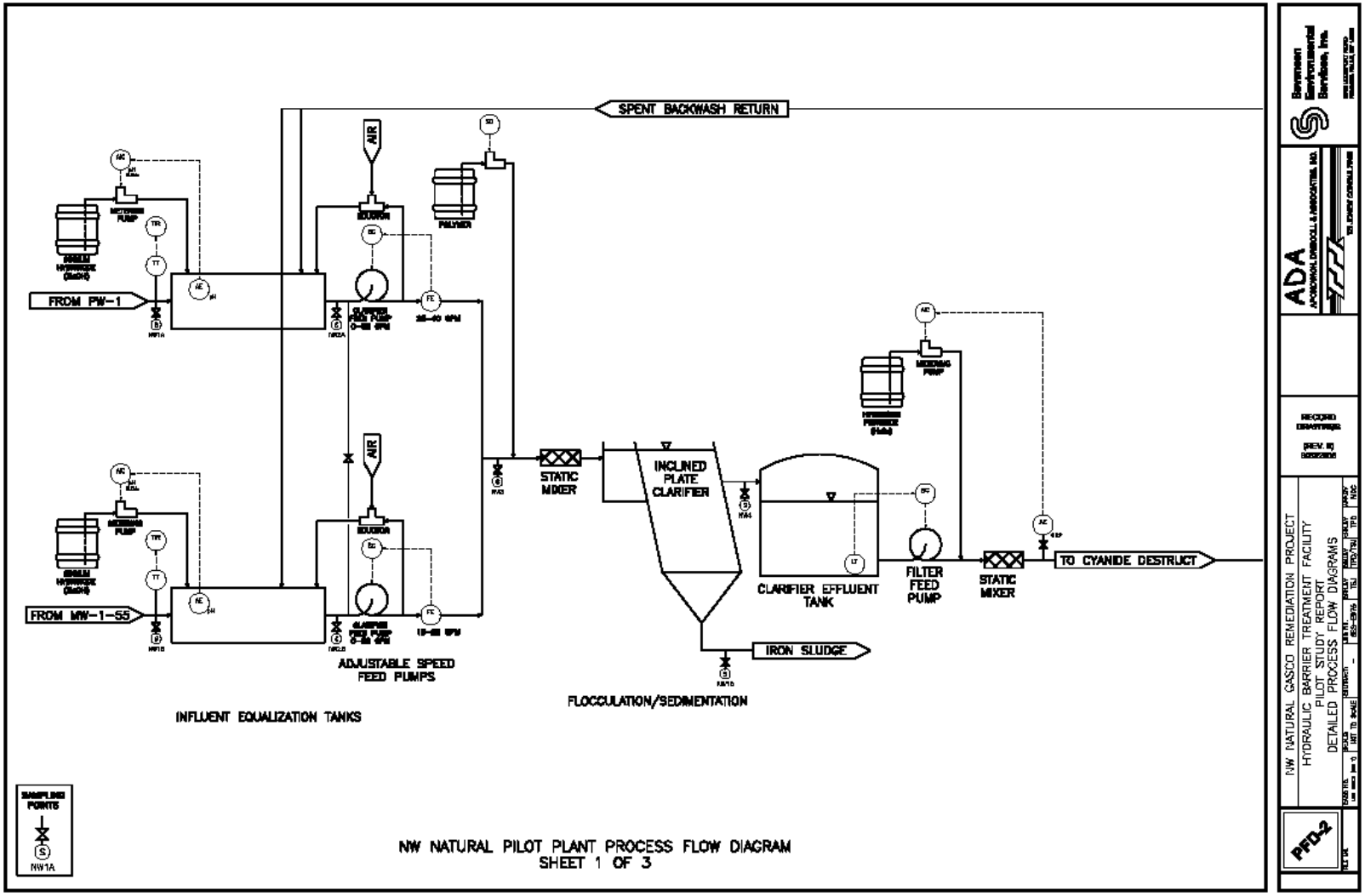
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Attachment C: Bench-Scale Air Stripping Procedure

Siltronics Air Stripping Pilot Procedure

Run 1

1.8L of Sitronics water were continuously mixed. The initial pH (6.72) was recorded. 1.5mL Sodium hydroxide (NaOH) was added to raise the pH to **10.07.** Once the pH was near 10.0 the sample was aerated at 600mL/min for **30** minutes. After the aeration period, 15ppm AE 843 was added to floc and settle the solids. The sample was then filtered through a 1um filter and bottled for Fe, Mn, VOC, SVOC and cyanide analyses.

Run 1	
Initial Sample	**9H25009-01**
Sample/Addition	**pH**
1.8L - Initial	6.72
+ 1.5mL NaOH	10.07
Aerate 30 minutes	--
+ 15ppm AE843	--
Filter through 1mm filter	**--**
Sample taken	**9H25009-05**

Run 2

1.8L of Siltronics water were continuously mixed. The initial pH (6.78) was recorded. 1.0mL Sodium hydroxide (NaOH) was added to raise the pH to **9.53**. Once the pH was above 9.5 the sample was aerated at 600mL/min for **30** minutes. After the aeration period, 15ppm AE 843 was added to floc and settle the solids. The sample was then filtered through a 1um filter and bottled for Fe, Mn, VOC, SVOC and cyanide analyses.

Run 2	
Initial Sample	**9H25009-01**
Sample/Addition	**pH**
1.8L - Initial	6.78
+ 1.0mL NaOH	9.53
Aerate 30 minutes	--
+ 15ppm AE843	--
Filter through 1mm filter	**--**
Sample taken	**9H25015-01**

Run 3

1.8L of Siltronics water were continuously mixed. The initial pH (6.41) was recorded. 1.5mL Sodium hydroxide (NaOH) was added to raise the pH to **10.04**. Once the pH was near 10.0 the sample was aerated at 600mL/min for **60** minutes. After the aeration period, 15ppm AE 843 was added to filter and bottled for Fe, Mn, VOC, SVOC and cyanide analyses.

Run 3	
Initial Sample	**9H25009-01**
Sample/Addition	**pH**
1.8L - Initial	6.41
+ 1.5mL NaOH	10.07
Aerate 60 minutes	--
+ 15ppm AE843	--
Filter through 1mm filter	**--**
Sample taken	**9H25009-02**

Run 4

1.8L of Siltronics water were continuously mixed. The initial pH (6.82) was recorded. 1.0mL Sodium hydroxide (NaOH) was added to raise the pH to **9.52**. Once the pH was near 9.5 the sample was aerated at 600mL/min for **60** minutes. After the aeration period, 15ppm AE 843 was added to floc and settle the solids. The sample was then filtered through a 1um filter and bottled for Fe, Mn, VOC, SVOC and cyanide analyses.

Run 4	
Initial Sample	**9H25009-01**
Sample/Addition	**pH**
1.8L - Initial	6.82
+ 1.0mL NaOH	9.52
Aerate 60 minutes	--
+ 15ppm AE843	--
Filter through 1mm filter	--
Sample taken	**9H25015-02**

Run 5

1.8L of Siltronics water were continuously mixed. The initial pH (6.75) was recorded. 1.5mL Sodium hydroxide (NaOH) was added to raise the pH to **10.02** Once the pH was near 10.0 the sample was aerated at 600mL/min for **90** minutes. After the aeration period, 15ppm AE 843 was added to floc and settle the solids. The sample was then filtered through a 1um filter and bottled for Fe, Mn, VOC, SVOC and cyanide analyses.

Run 5	
Initial Sample	**9H25009-01**
Sample/Addition	**pH**
1.8L - Initial	6.75
+ 1.5mL NaOH	10.02
Aerate 90 minutes	--
+ 15ppm AE843	--
Filter through 1mm filter	--
Sample taken	**9H25009-03**

Run 6

1.8L of Siltronics water were continuously mixed. The initial pH (6.71) was recorded. 1.0mL Sodium hydroxide (NaOH) was added to raise the pH to **9.50**. Once the pH was above 9.5 the sample was aerated at 600mL/min for **90** minutes. After the aeration period, 15ppm AE 843 was added to floc and settle the solids. The sample was then filtered through a 1um filter and bottled for Fe, Mn, VOC, SVOC and cyanide analyses.

Run 6	
Initial Sample	**9H25009-01**
Sample/Addition	**pH**
1.8L - Initial	6.71
+ 2.0mL NaOH	9.50
Aerate 90 minutes	--
+ 15ppm AE843	--
Filter through 1mm filter	--
Sample taken	**9H25009-04**

Attachment D: NW Natural Pilot Results—Through Process by Date

7/23/2009	Units	NW-1A	NW-2A	NW-1B	NW-2B	NW-3	NW-4	NW-5	NW-6	NW-7	NW-8	NW-9
		PW-1 Influent	PW-1 Eq Eff	MW-1 Influent	MW-1 Eq Eff	Combined IPC Inf	IPC Effluent	Cyanide Destruct Eff	Bag Filter Eff	GAC Midpoint	GAC Eff	Eff Storage Tank
pH	pH Units	6.73		6.17								
pH Temperature	pH Units	14.2		13.3								
Total Dissolved Solids	mg/L	553		3080	10							
Total Suspended Solids	mg/L	39		184	13.7							
Total Organic Carbon	mg/L	31.6		7.82	982							
Total Iron	ug/L				90							
Total Manganese	ug/L				6.75							
CYANIDE												
Cyanide, Total	mg/L	1.11		0.408	0.401							
Cyanide, WAD	mg/L	0.136		0.0559	0.0641							
Cyanide, Amenable	mg/L	<0.0500		0.0887	<0.00500							
CATC, chlorinated	mg/L	1.08		0.32	0.436							
Cyanide, Free	mg/L	<0.0100		<0.0100	<0.0100							
CATC, total	mg/L	1.11		0.408	0.401							
SEMI-VOLATILE ORGANICS												
Acenaphthylene	ug/L	125 [4] [5] [5]		0.0993	0.117							
Acenaphthene	ug/L	193 [4] [5] [5]		0.162	0.281							
Anthracene	ug/L	45.2 [4]		<0.0777	<0.0777							
Benz(a)anthracene	ug/L	23.7 [4] [6] [7]		<0.0777	<0.0777							
Benzo(a)pyrene	ug/L	29.0 [4]		0.0832	<0.0777							
Benzo(b)fluoranthene(s)	ug/L			0.088	<0.0777							
Benzo(k)fluoranthene(s)	ug/L			<0.0777	<0.0777							
Benzo(b+k)fluoranthene(s)	ug/L	32.5 [4] [16] [9]										
Benzo(g,h,i)perylene	ug/L	23.8 [4]		0.0943	0.129							
Carbazole	ug/L	184 [4] [5] [5]		0.0857	<0.0777							
Chrysene	ug/L	26.0 [4]		<0.0777	<0.0777							
Dibenz(a,h)anthracene	ug/L	2.50 [4]		<0.0777	<0.0777							
Dibenzofuran	ug/L	21.5 [4]		<0.0777	<0.0777							
Fluoranthene	ug/L	90.7 [4]		0.199	0.159							
Fluorene	ug/L	61.9 [4] [5] [5]		0.166	0.132							
Indeno(1,2,3-cd)pyrene	ug/L	20.7 [4]		<0.0777	<0.0777							
2-Methylnaphthalene	ug/L	595 [1] [3] [4] [1] [3]		0.153	0.675							
Naphthalene	ug/L	8000 [1] [3] [4] [1] [3]		0.676	3.62							
Phenanthrene	ug/L	220 [4] [5] [5]		0.589	0.439							
Pyrene	ug/L	103 [4] [5] [5]		0.223	0.169							
2-Chlorophenol	ug/L	<3.92 [4]		<0.971	<0.971							
2,4-Dichlorophenol	ug/L	<3920 [4]		<0.971	<0.971							
2,4-Dimethylphenol	ug/L	<3920 [4]		<0.971	<0.971							
4,6-Dinitro-2-methylphenol	ug/L	<3.92 [4]		<0.971	<0.971							
2-Methylphenol	ug/L	<3.92 [4]		<0.971	<0.971							
2-Nitrophenol	ug/L	<3920 [4] [15] [8]		<0.971	<0.971							
4-Nitrophenol	ug/L	<3.92 [4]		<0.971	<0.971							
2,4,5-Trichlorophenol	ug/L	<3.92 [4]		<0.971	<0.971							
2,4,6-Trichlorophenol	ug/L	<3.92 [4]		<0.971	<0.971							
Pentachlorophenol (PCP)	ug/L	<3.92 [4]		<0.971	<0.971							
Phenol	ug/L	5.38 [4]		<0.971	<0.971							
METALS												
Hexavalent Chromium	mg/L	<0.0100		0.0112	<0.0100 [6] [7]							
Silver	ug/L	<1.00		<1.00	<1.00							
Arsenic	ug/L	3.92		1.11								
Cadmium	ug/L	<1.00		<1.00	<1.00							
Chromium	ug/L	5.48		<1.00	<1.00							
Copper	ug/L	<5.00		21.5	<5.00							
Dissolved Iron	ug/L	27800		218000	6490							
Mercury	ug/L	<0.0100		<0.0100	<0.0100							
Dissolved Manganese	ug/L	3100		6790	282							
Nickel	ug/L	3.03		9.04	1.97							
Lead	ug/L	5.52		17.4	<1.00							
Selenium	ug/L	1.61		2.06	2.52							
Zinc	ug/L	441		34.9	<4.00							
Calcium	ug/L	78300		318000	163000							
Chromium	ug/L											
Hardness (Calc by 6020)	mg CaCO3/L	412		1620	1200							
Magnesium	ug/L	52700		202000	193000							
Trivalent Chromium	ug/L	<11.0		<11.0	<11.0							
VOLATILE ORGANICS												
Acetone	ug/L	<10000		<20.0	<20.0							
Benzene	ug/L	7540		<0.250	<0.250							
2-Butanone (MEK)	ug/L	<5000		<10.0	17.9							
1,1-Dichloroethene	ug/L	<250		<0.500	<0.500							
cis-1,2-Dichloroethene	ug/L	<250		<0.500	<0.500							
trans-1,2-Dichloroethene	ug/L	<250		<0.500	<0.500							
Ethylbenzene	ug/L	620		<0.500	<0.500							
Tetrachloroethene (PCE)	ug/L	<250		<0.500	<0.500							
Toluene	ug/L	<250		<0.500	<0.500							
Trichloroethene (TCE)	ug/L	<250		<0.500	<0.500							
Vinyl chloride	ug/L	<250		<0.500	<0.500							
m,p-Xylene	ug/L	<500		<1.00	<1.00							
o-Xylene	ug/L	<250		<0.500	<0.500							

7/29/2009	Units	NW-1A	NW-2A	NW-1B	NW-2B	NW-3	NW-4	NW-5	NW-6	NW-7	NW-8	NW-9
		PW-1 Influent	PW-1 Eq Eff	MW-1 Influent	MW-1 Eq Eff	Combined IPC Inf	IPC Effluent	Cyanide Destruct Eff	Bag Filter Eff	GAC Midpoint	GAC Eff	Eff Storage Tank
pH	pH Units	6.73										8.23
pH Temperature	pH Units	14.2										31.8
Total Dissolved Solids	mg/L	553										518
Total Suspended Solids	mg/L	39										<5.00
Total Organic Carbon	mg/L	31.6										2.95
Total Iron	ug/L											<100 [4] [9]
Total Manganese	ug/L											43.0 [4] [9]
CYANIDE												
Cyanide, Total	mg/L	1.11										0.0200 [1] [2] [1] [6]
Cyanide, WAD	mg/L	0.136										0.0101
Cyanide, Amenable	mg/L	<0.0500										<0.00500
CATC, chlorinated	mg/L	1.08										0.0193
Cyanide, Free	mg/L	<0.0100										<0.0100
CATC, total	mg/L	1.11										0.0200 [2] [6]
SEMI-VOLATILE ORGANICS												
Acenaphthylene	ug/L	125 [4] [5] [5]										<0.0784
Acenaphthene	ug/L	193 [4] [5] [5]										<0.0784
Anthracene	ug/L	45.2 [4]										<0.0784
Benz(a)anthracene	ug/L	23.7 [4] [6] [7]										<0.0784
Benzo(a)pyrene	ug/L	29.0 [4]										<0.0784
Benzo(b)fluoranthene(s)	ug/L											<0.0784
Benzo(k)fluoranthene(s)	ug/L											<0.0784
Benzo(b+k)fluoranthene(s)	ug/L	32.5 [4] [16] [9]										
Benzo(g,h,i)perylene	ug/L	23.8 [4]										<0.0784
Carbazole	ug/L	184 [4] [5] [5]										<0.0784
Chrysene	ug/L	26.0 [4]										<0.0784
Dibenz(a,h)anthracene	ug/L	2.50 [4]										<0.0784
Dibenzofuran	ug/L	21.5 [4]										<0.0784
Fluoranthene	ug/L	90.7 [4]										0.0794
Fluorene	ug/L	61.9 [4] [5] [5]										<0.0784
Indeno(1,2,3-cd)pyrene	ug/L	20.7 [4]										<0.0784
2-Methylnaphthalene	ug/L	595 [1] [3] [4] [1] [3]										<0.0784
Naphthalene	ug/L	8000 [1] [3] [4] [1] [3]										<0.0784
Phenanthrene	ug/L	220 [4] [5] [5]										<0.0784
Pyrene	ug/L	103 [4] [5] [5]										<0.0784
2-Chlorophenol	ug/L	<3.92 [4]										<0.980
2,4-Dichlorophenol	ug/L	<3920 [4]										<0.980
2,4-Dimethylphenol	ug/L	<3920 [4]										<0.980
4,6-Dinitro-2-methylphenol	ug/L	<3.92 [4]										<0.980
2-Methylphenol	ug/L	<3.92 [4]										<0.980
2-Nitrophenol	ug/L	<3920 [4] [15] [8]										<0.980
4-Nitrophenol	ug/L	<3.92 [4]										<0.980
2,4,5-Trichlorophenol	ug/L	<3.92 [4]										<0.980
2,4,6-Trichlorophenol	ug/L	<3.92 [4]										<0.980
Pentachlorophenol (PCP)	ug/L	<3.92 [4]										<0.980
Phenol	ug/L	5.38 [4]										5.84
METALS												
Hexavalent Chromium	mg/L	<0.0100										<0.0100
Silver	ug/L	<1.00										<1.00
Arsenic	ug/L	3.92										30.5
Cadmium	ug/L	<1.00										<1.00
Chromium	ug/L	5.48										2.2
Copper	ug/L	<5.00										17.9
Dissolved Iron	ug/L	27800										1990
Mercury	ug/L	<0.0100										0.0176
Dissolved Manganese	ug/L	3100										47.1
Nickel	ug/L	3.03										31.5
Lead	ug/L	5.52										4.34
Selenium	ug/L	1.61										1.9
Zinc	ug/L	441										30.7
Calcium	ug/L	78300										13300
Chromium	ug/L											
Hardness (Calc by 6020)	mg CaCO3/L	412										133
Magnesium	ug/L	52700										24200
Trivalent Chromium	ug/L	<11.0										<11.0
VOLATILE ORGANICS												
Acetone	ug/L	<10000										<200 [11] [12] [11]
Benzene	ug/L	7540										<2.50 [12]
2-Butanone (MEK)	ug/L	<5000										<100 [11] [12] [11]
1,1-Dichloroethene	ug/L	<250										<5.00 [12]
cis-1,2-Dichloroethene	ug/L	<250										<5.00 [12]
trans-1,2-Dichloroethene	ug/L	<250										<5.00 [12]
Ethylbenzene	ug/L	620										<5.00 [12]
Tetrachloroethene (PCE)	ug/L	<250										<5.00 [12]
Toluene	ug/L	<250										<5.00 [12]
Trichloroethene (TCE)	ug/L	<250										<5.00 [12]
Vinyl chloride	ug/L	<250										<5.00 [12]
m,p-Xylene	ug/L	<500										<10.0 [12]
o-Xylene	ug/L	<250										<5.00 [12]

8/3/2009	Units	NW-1A	NW-2A	NW-1B	NW-2B	NW-3	NW-4	NW-5	NW-6	NW-7	NW-8	NW-9
		PW-1 Influent	PW-1 Eq Eff	MW-1 Influent	MW-1 Eq Eff	Combined IPC Inf	IPC Effluent	Cyanide Destruct Eff	Bag Filter Eff	GAC Midpoint	GAC Eff	Eff Storage Tank
pH	pH Units	6.53	10.1	6.09	7.72							7.91
pH Temperature	pH Units	20.3	20.8	20.7	21.5							20.6
Total Dissolved Solids	mg/L	548	893	2760	3170							1500
Total Suspended Solids	mg/L	68	7	107	42				<5.00			<5.00
Total Organic Carbon	mg/L	26	23.8 [1] [1]	6.34 [1] [1]	4.75 [1] [1]			22.5 [1] [1]	23.4 [1] [1]	<2.00	3.41	2.82 [1] [2]
Total Iron	ug/L					8500	910		2880 [13] [6]			157 [13] [9]
Total Manganese	ug/L					537	76.3		578 [13] [6]			100 [13] [9]
CYANIDE												
Cyanide, Total	mg/L	1.09	1.08	0.368	0.399			0.723	0.703			0.0929
Cyanide, WAD	mg/L	0.114	0.121	0.0583	0.0654			0.104	0.124			0.0165
Cyanide, Amenable	mg/L	<0.0500	<0.0500	0.169	<0.00500			<0.0100	<0.0100			<0.00500
CATC, chlorinated	mg/L	1.06	1.13	0.2	0.429			0.837	0.804			0.1
Cyanide, Free	mg/L	<0.0100	<0.0100	<0.0100	<0.0100			<0.0100	<0.0100			<0.0100
CATC, total	mg/L	1.09	1.08	0.368	0.399			0.723	0.703			0.0929
SEMI-VOLATILE ORGANICS												
Acenaphthylene	ug/L	396	169 [11]	<1.95	<0.152			59.8 [11]	106 [11]	<0.0777	0.392 [11]	<0.0816 [11]
Acenaphthene	ug/L	529	244 [11]	<1.95	<0.152			77.3 [11]	146 [11]	<0.0777	0.404 [11]	<0.0816 [11]
Anthracene	ug/L	99.8	27.2 [11]	<1.95	<0.152			<38.5 [11]	10.7 [11]	<0.0777	<0.377 [11]	<0.0816 [11]
Benz(a)anthracene	ug/L	50.5 [14] [7]	<19.2 [11]	<1.95	<0.152			<38.5 [11]	<3.81 [11]	<0.0777	<0.377 [11]	<0.0816 [11]
Benzo(a)pyrene	ug/L	68.3	<24.0 [11] [28] [7]	<1.95	<0.152			<38.5 [11]	<4.76 [11] [28] [8]	<0.0971 [28] [8]	<0.377 [11]	<0.102 [11] [28] [12]
Benzo(b)fluoranthene(s)	ug/L	83.9 [24] [9]	<19.2 [11]	<1.95	<0.152			<38.5 [11]	<3.81 [11]		<0.377 [11]	<0.0816 [11]
Benzo(k)fluoranthene(s)	ug/L		<19.2 [11]	<1.95	<0.152			<38.5 [11]	<3.81 [11]		<0.377 [11]	<0.0816 [11]
Benzo(b+k)fluoranthene(s)	ug/L	57								<0.155 [24] [6]		
Benzo(g,h,i)perylene	ug/L	378	<19.2 [11]	<1.95	<0.152			<38.5 [11]	<3.81 [11]	<0.0777	<0.377 [11]	<0.0816 [11]
Carbazole	ug/L	58.8	131 [11]	<1.95	<0.152			63.9 [11]	82.0 [11]	<0.0777	0.425 [11]	<0.0816 [11]
Chrysene	ug/L	<9.52	<19.2 [11]	<1.95	<0.152			<38.5 [11]	<3.81 [11]	<0.0777	<0.377 [11]	<0.0816 [11]
Dibenz(a,h)anthracene	ug/L	45.1	<19.2 [11]	<1.95	<0.152			<38.5 [11]	<3.81 [11]	<0.0777	<0.377 [11]	<0.0816 [11]
Dibenzofuran	ug/L	208	20.8 [11]	<1.95	<0.152			<38.5 [11]	13.0 [11]	<0.0777	<0.377 [11]	<0.0816 [11]
Fluoranthene	ug/L	237	35.8 [11]	<1.95	<0.152			<38.5 [11]	13.6 [11]	0.0806	<0.377 [11]	<0.0816 [11]
Fluorene	ug/L	45.5	100 [11]	<1.95	<0.152			<38.5 [11]	60.6 [11]	<0.0777	<0.377 [11]	<0.0816 [11]
Indeno(1,2,3-cd)pyrene	ug/L	1260	<19.2 [11]	<1.95	<0.152			<38.5 [11]	<3.81 [11]	<0.0777	<0.377 [11]	<0.0816 [11]
2-Methylnaphthalene	ug/L	14200 [9] [1]	629 [9] [11] [3]	5.67	<0.152			189 [9] [11] [3]	409 [9] [11] [4]	<0.0777	1.11 [9] [11] [3]	0.104 [9] [11] [6]
Naphthalene	ug/L	808	4200 [9] [11] [3]	56.0 [9] [7]	349 [3] [9] [4] [5]			1550 [9] [11] [3]	3140 [9] [11] [4]	0.143 [3] [9] [3] [4]	8.73 [2] [9] [11] [1] [3]	0.955 [2] [9] [11] [4] [6]
Phenanthrene	ug/L	242	251 [11]	<1.95	<0.152			72.2 [11]	129 [11]	<0.0777	<0.377 [11]	<0.0816 [11]
Pyrene	ug/L	<119	36.4 [11]	<1.95	0.156			<38.5 [11]	13.5 [11]	0.0927	<0.377 [11]	<0.0816 [11]
2-Chlorophenol	ug/L	<119	<240 [11]	<24.4	<1.90			<481 [11]	<47.6 [11]	<0.971	<4.72 [11]	<1.02 [11]
2,4-Dichlorophenol	ug/L	<119	<240 [11]	<24.4	<1.90			<481 [11]	<47.6 [11]	<0.971	<4.72 [11]	<1.02 [11]
2,4-Dimethylphenol	ug/L	<119	<240 [11]	<24.4	<1.90			<481 [11]	<47.6 [11]	<0.971	<4.72 [11]	<1.02 [11]
4,6-Dinitro-2-methylphenol	ug/L	<119	<240 [11]	<24.4	<1.90			<481 [11]	<47.6 [11]	<0.971	<4.72 [11]	<1.02 [11]
2-Methylphenol	ug/L	<119	<240 [11]	<24.4	<1.90			<481 [11]	<47.6 [11]	<0.971	<4.72 [11]	<1.02 [11]
2-Nitrophenol	ug/L	<119	<240 [11]	<24.4	<1.90			<481 [11]	<47.6 [11]	<0.971	<4.72 [11]	<1.02 [11]
4-Nitrophenol	ug/L	<119	<240 [11]	<24.4	<1.90			<481 [11]	<47.6 [11]	<0.971	<4.72 [11]	<1.02 [11]
2,4,5-Trichlorophenol	ug/L	<119	<240 [11]	<24.4	<1.90			<481 [11]	<47.6 [11]	<0.971	<4.72 [11]	<1.02 [11]
2,4,6-Trichlorophenol	ug/L	<119	<240 [11]	<24.4	<1.90			<481 [11]	<47.6 [11]	<0.971	<4.72 [11]	<1.02 [11]
Pentachlorophenol (PCP)	ug/L	<119	<240 [11]	<24.4	<1.90			<481 [11]	<47.6 [11]	<0.971	<4.72 [11]	<1.02 [11]
Phenol	ug/L		<240 [11]	<24.4	<1.90			<481 [11]	65.9 [11]	<0.971	<4.72 [11]	<1.02 [11]
METALS												
Hexavalent Chromium	mg/L											
Silver	ug/L	<1.00	<1.00	<1.00	<1.00				<1.00			<1.00
Arsenic	ug/L	4.46		<1.00		1.6	1.38	2.09	1.7		6.07	7.48
Cadmium	ug/L	<1.00	<1.00	<1.00	<1.00				<1.00			<1.00
Chromium	ug/L	1.66	1.41	<1.00	<1.00				1.17			<1.00
Copper	ug/L	<5.00	<5.00	5.82	<5.00				39.8			<5.00
Dissolved Iron	ug/L	32400	1050	176000	22200	344 [13] [2]	294 [13] [2]		648			168
Mercury	ug/L	<0.0100	<0.0100	<0.0100	<0.0100				0.108			<0.0100
Dissolved Manganese	ug/L	3150	265	6180	786	14.6 [13] [2]	7.28 [13] [2]		51.6			98.3
Nickel	ug/L	<1.00	<1.00	3.42	1.38				7.09			8.42
Lead	ug/L	<1.00	<1.00	4.37	<1.00				18.1			1.82
Selenium	ug/L	<1.00	1.03	1.09	1.13				2.21			1.86
Zinc	ug/L	492	20.6	9.26	4.87				341			6.66
Calcium	ug/L	77700	4450	294000	138000							21700
Chromium	ug/L											
Hardness (Calc by 6020)	mg CaCO3/L	396	200	1450	1020				345			360
Magnesium	ug/L	48900	45800	173000	164000							74300
Trivalent Chromium	ug/L	1.66	1.41	<1.00	<1.00				1.17			<1.00
VOLATILE ORGANICS												
Acetone	ug/L	<4000 [32]	<400	<20.0 [4] [33]	<20.0			<200	<200	<20.0	<20.0	<20.0
Benzene	ug/L	7820 [32]	4570	<0.250 [4] [33]	<0.250			1880	1760	<0.250	<0.250	<0.250
2-Butanone (MEK)	ug/L	<2000 [32]	<200	<10.0 [4] [33]	<10.0			<100	<100	<10.0	<10.0	<10.0
1,1-Dichloroethene	ug/L	<100 [32]	<10.0	<0.500 [4] [33]	<0.500			<5.00	<5.00	<0.500	<0.500	<0.500
cis-1,2-Dichloroethene	ug/L	<100 [32]	<10.0	<0.500 [4] [33]	<0.500			<5.00	<5.00	<0.500	<0.500	<0.500
trans-1,2-Dichloroethene	ug/L	<100 [32]	<10.0	<0.500 [4] [33]	<0.500			<5.00	<5.00	<0.500	<0.500	<0.500
Ethylbenzene	ug/L	752 [32]	101	<0.500 [4] [33]	<0.500			44.5	40.7	<0.500	<0.500	<0.500
Tetrachloroethene (PCE)	ug/L	<100 [32]	<10.0	<0.500 [4] [33]	<0.500			<5.00	<5.00	<0.500	<0.500	<0.500
Toluene	ug/L	152 [32]	64.8	<0.500 [4] [33]	<0.500			22	22.2	<0.500	<0.500	<0.500
Trichloroethene (TCE)	ug/L	<100 [32]	<10.0	<0.500 [4] [33]	<0.500			<5.00	<5.00	<0.500	<0.500	<0.500
Vinyl chloride	ug/L	<100 [32]	<10.0	<0.500 [4] [33]	<0.500			<5.00	<5.00	<0.500	<0.500	<0.500
m,p-Xylene	ug/L	364 [32]	227	<1.00 [4] [33]	<1.00			50.7	56.1	<1.00	<1.00	<1.00
o-Xylene	ug/L	200 [32]	148	<0.500 [4] [33]	<0.500			41.6	42.9	<0.500	<0.500	<0.500

8/7/2009	Units	NW-1A	NW-2A	NW-1B	NW-2B	NW-3	NW-4	NW-5	NW-6	NW-7	NW-8	NW-9
		PW-1 Influent	PW-1 Eq Eff	MW-1 Influent	MW-1 Eq Eff	Combined IPC Inf	IPC Effluent	Cyanide Destruct Eff	Bag Filter Eff	GAC Midpoint	GAC Eff	Eff Storage Tank
pH	pH Units	6.74	9.99	6.32	10.1							7.74
pH Temperature	pH Units	16.9	14	18.7	15.7							15.9
Total Dissolved Solids	mg/L	573	1040	3000	2920							1590
Total Suspended Solids	mg/L	58	10	63	64				<5.00			<5.00
Total Organic Carbon	mg/L	21.8	29.9	4.07	6.48			24.3	21.5	2.14	<2.00	<2.00
Total Iron	ug/L					4940	3660		442 [4] [6]			125 [4] [9]
Total Manganese	ug/L					375	284		169 [4] [6]			63.5 [4] [9]
CYANIDE												
Cyanide, Total	mg/L	0.926	0.546	0.257	0.299			0.458	0.611			0.135
Cyanide, WAD	mg/L	0.125	0.132	0.111	0.0711			0.0777	0.0827			0.0244
Cyanide, Amenable	mg/L	<0.0250	0.174	<0.0500	<0.00500			<0.0100	<0.0100			<0.00500
CATC, chlorinated	mg/L	0.933	0.372	1.09	0.438			0.904	0.858			0.153
Cyanide, Free	mg/L	<0.0100	<0.0100	<0.0100	<0.0100			<0.0100	0.0102			<0.0100
CATC, total	mg/L	0.926	0.546	0.257	0.299			0.458	0.611			0.135
Available Cyanide	mg/L	0.011	0.0033	0.0083	0.0061			0.023	0.029			<0.0020
SEMI-VOLATILE ORGANICS												
Acenaphthylene	ug/L	<381 [3]	116 [3]	<1.90 [3]	<0.0779 [3]			79.4 [3]	84.3 [3]	0.103 [3]	<0.756 [3] [15]	<0.0800 [3]
Acenaphthene	ug/L	404 [3]	248 [3]	<1.90 [3]	<0.0779 [3]			155 [3]	156 [3]	0.137 [3]	<0.756 [3] [15]	<0.0800 [3]
Anthracene	ug/L	<381 [3]	30.5 [3]	<1.90 [3]	<0.0779 [3]			<38.5 [3]	<39.6 [3]	<0.0760 [3]	<0.756 [3] [15]	<0.0800 [3]
Benz(a)anthracene	ug/L	<381 [3]	<15.2 [3]	<1.90 [3]	<0.0779 [3]			<38.5 [3]	<39.6 [3]	<0.0760 [3]	<0.756 [3] [15]	<0.0800 [3]
Benzo(a)pyrene	ug/L	724 [3]	<15.2 [3]	<2.14 [3] [14] [14]	<0.0876 [3] [14] [8]			<38.5 [3]	<39.6 [3]	<0.114 [3] [14] [8]	<0.756 [3] [15]	<0.100 [3] [14] [12]
Benzo(b)fluoranthene(s)	ug/L		<15.2 [3]	<1.90 [3]	<0.0779 [3]			<38.5 [3]	<39.6 [3]	<0.0760 [3]	<0.756 [3] [15]	<0.0800 [3]
Benzo(k)fluoranthene(s)	ug/L		<15.2 [3]	<1.90 [3]	<0.0779 [3]			<38.5 [3]	<39.6 [3]	<0.0760 [3]	<0.756 [3] [15]	<0.0800 [3]
Benzo(b+k)fluoranthene(s)	ug/L	<762 [3] [12] [9]										
Benzo(g,h,i)perylene	ug/L	397 [3]	<15.2 [3]	<1.90 [3]	<0.0779 [3]			<38.5 [3]	<39.6 [3]	<0.0760 [3]	<0.756 [3] [15]	<0.0800 [3]
Carbazole	ug/L	<381 [3]	129 [3]	<1.90 [3]	0.0988 [3]			106 [3]	112 [3]	0.107 [3]	<0.756 [3] [15]	<0.0800 [3]
Chrysene	ug/L	<381 [3]	<15.2 [3]	<1.90 [3]	<0.0779 [3]			<38.5 [3]	<39.6 [3]	<0.0760 [3]	<0.756 [3] [15]	<0.0800 [3]
Dibenz(a,h)anthracene	ug/L	<381 [3]	<15.2 [3]	<1.90 [3]	<0.0779 [3]			<38.5 [3]	<39.6 [3]	<0.0760 [3]	<0.756 [3] [15]	<0.0800 [3]
Dibenzofuran	ug/L	<381 [3]	20.1 [3]	<1.90 [3]	<0.0779 [3]			<38.5 [3]	<39.6 [3]	<0.0760 [3]	<0.756 [3] [15]	<0.0800 [3]
Fluoranthene	ug/L	838 [3]	33.4 [3]	<1.90 [3]	<0.0779 [3]			<38.5 [3]	<39.6 [3]	0.196 [3]	<0.756 [3] [15]	0.127 [3]
Fluorene	ug/L	<381 [3]	107 [3]	<1.90 [3]	<0.0779 [3]			66.4 [3]	68.9 [3]	<0.0760 [3]	<0.756 [3] [15]	<0.0800 [3]
Indeno(1,2,3-cd)pyrene	ug/L	<381 [3]	<15.2 [3]	<1.90 [3]	<0.0779 [3]			<38.5 [3]	<39.6 [3]	<0.0760 [3]	<0.756 [3] [15]	<0.0800 [3]
2-Methylnaphthalene	ug/L	742 [3]	36.7 [3]	<1.90 [3]	<0.0779 [3]			74.4 [3]	60.4 [3]	0.114 [3]	<0.756 [3] [15]	<0.0800 [3]
Naphthalene	ug/L	6280 [3]	21.7 [3]	4.59 [3]	<0.0779 [3]			440 [3]	303 [3]	0.765 [3]	<0.756 [3] [15]	0.201 [3]
Phenanthrene	ug/L	1450 [3]	259 [3]	<1.90 [3]	<0.0779 [3]			154 [3]	148 [3]	0.250 [3]	<0.756 [3] [15]	0.121 [3]
Pyrene	ug/L	947 [3]	34.2 [3]	<1.90 [3]	<0.0779 [3]			<38.5 [3]	<39.6 [3]	0.237 [3]	<0.756 [3] [15]	0.148 [3]
2-Chlorophenol	ug/L	<4760 [3]	<190 [3]	<23.8 [3]	<0.974 [3]			<481 [3]	<495 [3]	<0.951 [3]	<9.45 [3] [15]	<1.00 [3]
2,4-Dichlorophenol	ug/L	<4760 [3]	<190 [3]	<23.8 [3]	<0.974 [3]			<481 [3]	<495 [3]	<0.951 [3]	<9.45 [3] [15]	<1.00 [3]
2,4-Dimethylphenol	ug/L	<4760 [3]	<190 [3]	<23.8 [3]	<0.974 [3]			<481 [3]	<495 [3]	<0.951 [3]	<9.45 [3] [15]	<1.00 [3]
4,6-Dinitro-2-methylphenol	ug/L	<4760 [3]	<190 [3]	<23.8 [3]	<0.974 [3]			<481 [3]	<495 [3]	<0.951 [3]	<9.45 [3] [15]	<1.00 [3]
2-Methylphenol	ug/L	<4760 [3]	<190 [3]	<23.8 [3]	<0.974 [3]			<481 [3]	<495 [3]	<0.951 [3]	<9.45 [3] [15]	<1.00 [3]
2-Nitrophenol	ug/L	<4760 [3]	<190 [3]	<23.8 [3]	<0.974 [3]			<481 [3]	<495 [3]	<0.951 [3]	<9.45 [3] [15]	<1.00 [3]
4-Nitrophenol	ug/L	<4760 [3]	<190 [3]	<23.8 [3]	<0.974 [3]			<481 [3]	<495 [3]	<0.951 [3]	<9.45 [3] [15]	<1.00 [3]
2,4,5-Trichlorophenol	ug/L	<4760 [3]	<190 [3]	<23.8 [3]	<0.974 [3]			<481 [3]	<495 [3]	<0.951 [3]	<9.45 [3] [15]	<1.00 [3]
2,4,6-Trichlorophenol	ug/L	<4760 [3]	<190 [3]	<23.8 [3]	<0.974 [3]			<481 [3]	<495 [3]	<0.951 [3]	<9.45 [3] [15]	<1.00 [3]
Pentachlorophenol (PCP)	ug/L	<4760 [3]	<190 [3]	<23.8 [3]	<0.974 [3]			<481 [3]	<495 [3]	<0.951 [3]	<9.45 [3] [15]	<1.00 [3]
Phenol	ug/L	<4760 [3]	<190 [3]	<23.8 [3]	<0.974 [3]			<481 [3]	<495 [3]	<0.951 [3]	<9.45 [3] [15]	<1.00 [3]
METALS												
Hexavalent Chromium	mg/L	<0.0200	<0.0200		<0.0200				<0.0200			<0.0200
Silver	ug/L	<1.00	<1.00		<1.00				<1.00			<1.00
Arsenic	ug/L	5.11	<1.00	1.09			1.76	2.63	1.63		3.81	3.87
Cadmium	ug/L	<1.00	1.02	<1.00	<1.00				<1.00			<1.00
Chromium	ug/L	2.18	<5.00	<1.00	<1.00				<1.00			<1.00
Copper	ug/L	<5.00	4640	5.87	<5.00				33.3			<5.00
Dissolved Iron	ug/L	33800	<0.0100	182000	6270		347 [4] [2]		724			222
Mercury	ug/L	<0.0100	444	<0.0100	<0.0100				0.117 [1] [2]			<0.0100
Dissolved Manganese	ug/L	3320	<1.00	6360	268		20.7 [4] [2]		112			68
Nickel	ug/L	2.33	<1.00	2.81	<1.00				1.49			7.63
Lead	ug/L	3.69	1.32	1.52	<1.00				14.7			<1.00
Selenium	ug/L	1.27	54.2	1	1.31				1.89			2.19
Zinc	ug/L	1210	3700	5.83	<4.00				160			8.18
Calcium	ug/L	76000		296000	67600							14200
Chromium	ug/L		198									
Hardness (Calc by 6020)	mg CaCO3/L	391	45900	1490	854							351
Magnesium	ug/L	49000	<21.0	181000	166000							76600
Trivalent Chromium	ug/L	<21.0		<101	<21.0				<21.0			<21.0
VOLATILE ORGANICS												
Acetone	ug/L	<2000	<1000	<20.0	<20.0			<400	<200		<20.0	<20.0
Benzene	ug/L	9100	4150	0.31	<0.250			1740	1700		<0.250	<0.250
2-Butanone (MEK)	ug/L	<1000	<500	<10.0	<10.0			<200	<100		<10.0	<10.0
1,1-Dichloroethene	ug/L	<50.0	<25.0	<0.500	<0.500			<10.0	<5.00		<0.500	<0.500
cis-1,2-Dichloroethene	ug/L	<50.0	<25.0	<0.500	<0.500			<10.0	<5.00		<0.500	<0.500
trans-1,2-Dichloroethene	ug/L	<50.0	<25.0	<0.500	<0.500			<10.0	<5.00		<0.500	<0.500
Ethylbenzene	ug/L	988	118	<0.500	<0.500			42	49.2		<0.500	<0.500
Tetrachloroethene (PCE)	ug/L	<50.0	<25.0	<0.500	<0.500			<10.0	<5.00		<0.500	<0.500
Toluene	ug/L	367	84	<0.500	<0.500			27.2	31.6		<0.500	<0.500
Trichloroethene (TCE)	ug/L	<50.0	<25.0	<0.500	<0.500			<10.0	<5.00		<0.500	<0.500
Vinyl chloride	ug/L	<50.0	<25.0	<0.500	<0.500			<10.0	<5.00		<0.500	<0.500
m,p-Xylene	ug/L	474	196	<1.00	<1.00			35.4	74.8		<1.00	<1.00
o-Xylene	ug/L	229	125	<0.500	<0.500			35.2	55.5		<0.500	<0.500

8/11/2009	Units	NW-1A	NW-2A	NW-1B	NW-2B	NW-3	NW-4	NW-5	NW-6	NW-7	NW-8	NW-9
		PW-1 Influent	PW-1 Eq Eff	MW-1 Influent	MW-1 Eq Eff	Combined IPC Inf	IPC Effluent	Cyanide Destruct Eff	Bag Filter Eff	GAC Midpoint	GAC Eff	Eff Storage Tank
pH	pH Units	6.79		6.26								7.6
pH Temperature	pH Units	20.1		20.6								20.2
Total Dissolved Solids	mg/L	493		3310								1540
Total Suspended Solids	mg/L	37		67					<5.00			<5.00
Total Organic Carbon	mg/L	49.6		6.81					24.6			<2.00
Total Iron	ug/L								467 [7] [6]			162 [7] [9]
Total Manganese	ug/L								123 [7] [6]			118 [7] [9]
CYANIDE												
Cyanide, Total	mg/L	0.892		0.47					0.709			0.133
Cyanide, WAD	mg/L	0.0722		0.0591					0.0161			0.0689
Cyanide, Amenable	mg/L	<0.0250		<0.00500					<0.0100			<0.00500
CATC, chlorinated	mg/L	0.938		0.467					0.808			0.142
Cyanide, Free	mg/L	<0.0100		<0.0100					<0.0100			<0.0100
CATC, total	mg/L	0.892		0.47					0.709			0.133
SEMI-VOLATILE ORGANICS												
Acenaphthylene	ug/L	413 [6]		0.347 [6]					52.3 [6]			<0.0808 [6]
Acenaphthene	ug/L	658 [6]		1.51 [6] [8] [10]					104 [6]			<0.0808 [6]
Anthracene	ug/L	455 [6]		0.128 [6]					<18.6 [6]			<0.0808 [6]
Benz(a)anthracene	ug/L	503 [6]		<0.0755 [6]					<18.6 [6]			<0.0808 [6]
Benzo(a)pyrene	ug/L	894 [6]		0.106 [6]					<23.3 [6] [17] [8]			0.104 [6]
Benzo(b)fluoranthene(s)	ug/L			<0.151 [6] [16] [11]					<18.6 [6]			
Benzo(k)fluoranthene(s)	ug/L			<0.151 [6] [16] [11]					<18.6 [6]			
Benzo(b+k)fluoranthene(s)	ug/L	1080 [6] [16] [9]										0.164 [6] [16] [10]
Benzo(g,h,i)perylene	ug/L	621 [6]		<0.0755 [6]					<18.6 [6]			0.107 [6]
Carbazole	ug/L	385 [6]		0.170 [6]					73.2 [6]			<0.0808 [6]
Chrysene	ug/L	605 [6]		<0.0755 [6]					<18.6 [6]			<0.0808 [6]
Dibenz(a,h)anthracene	ug/L	<372 [6]		<0.0755 [6]					<18.6 [6]			<0.0808 [6]
Dibenzofuran	ug/L	<372 [6]		<0.0755 [6]					<18.6 [6]			<0.0808 [6]
Fluoranthene	ug/L	1690 [6]		0.214 [6]					27.4 [6]			0.104 [6]
Fluorene	ug/L	397 [6]		0.317 [6]					44.0 [6]			<0.0808 [6]
Indeno(1,2,3-cd)pyrene	ug/L	<372 [6]		<0.0755 [6]					<18.6 [6]			<0.0808 [6]
2-Methylnaphthalene	ug/L	928 [6]		1.25 [6]					166 [6]			<0.0808 [6]
Naphthalene	ug/L	5520 [3] [6] [1]		5.15 [3] [6] [7]					1500 [3] [6] [4]			0.0809 [3] [6] [6]
Phenanthrene	ug/L	3130 [6]		1.01 [6]					123 [6]			<0.0808 [6]
Pyrene	ug/L	1990 [6]		0.223 [6]					29.1 [6]			0.125 [6]
2-Chlorophenol	ug/L	<4650 [6]		<0.943 [6]					<233 [6]			<1.01 [6]
2,4-Dichlorophenol	ug/L	<4650 [6]		<0.943 [6]					<233 [6]			<1.01 [6]
2,4-Dimethylphenol	ug/L	<4650 [6]		<0.943 [6]					<233 [6]			<1.01 [6]
4,6-Dinitro-2-methylphenol	ug/L	<4650 [6]		<0.943 [6]					<233 [6]			<1.01 [6]
2-Methylphenol	ug/L	<4650 [6]		<0.943 [6]					<233 [6]			<1.01 [6]
2-Nitrophenol	ug/L	<4650 [6]		<0.943 [6]					<233 [6]			<1.01 [6]
4-Nitrophenol	ug/L	<4650 [6]		<0.943 [6]					<233 [6]			<1.01 [6]
2,4,5-Trichlorophenol	ug/L	<4650 [6]		<0.943 [6]					<233 [6]			<1.01 [6]
2,4,6-Trichlorophenol	ug/L	<4650 [6]		<0.943 [6]					<233 [6]			<1.01 [6]
Pentachlorophenol (PCP)	ug/L	<4650 [6]		<0.943 [6]					<233 [6]			<1.01 [6]
Phenol	ug/L	<4650 [6]		<0.943 [6]					<233 [6]			<1.01 [6]
METALS												
Hexavalent Chromium	mg/L	<0.0100		0.0436					<0.0100			<0.0100
Silver	ug/L	<1.00		<1.00					<1.00			<1.00
Arsenic	ug/L	4.48		1.53					1.87			3.83
Cadmium	ug/L	<1.00		<1.00					<1.00			<1.00
Chromium	ug/L	1.04		<1.00					<1.00			<1.00
Copper	ug/L	<5.00		5.22					14			8.62
Dissolved Iron	ug/L	29600		216000					591			234
Mercury	ug/L	<0.0100		<0.0100					0.0798			<0.0100
Dissolved Manganese	ug/L	3080		7280					131			121
Nickel	ug/L	1.36		3.12					1.17			11.7
Lead	ug/L	<1.00		<1.00					3.79			2.27
Selenium	ug/L	1.41		1.19					2.27			2.93
Zinc	ug/L	339		8.26					60.7			17.9
Calcium	ug/L	64800		310000								18000
Chromium	ug/L											
Hardness (Calc by 6020)	mg CaCO3/L	343		1610								352
Magnesium	ug/L	44100		202000								74600
Trivalent Chromium	ug/L	<11.0		<11.0					<11.0			<11.0
VOLATILE ORGANICS												
Acetone	ug/L	<2000		<20.0					<400			<20.0
Benzene	ug/L	9060		<0.250 [22]					1650			<0.250
2-Butanone (MEK)	ug/L	<1000		<10.0					<200			<10.0
1,1-Dichloroethene	ug/L	<50.0		<0.500					<10.0			<0.500
cis-1,2-Dichloroethene	ug/L	<50.0		<0.500					<10.0			<0.500
trans-1,2-Dichloroethene	ug/L	<50.0		<0.500					<10.0			<0.500
Ethylbenzene	ug/L	798		<0.500					125			<0.500
Tetrachloroethene (PCE)	ug/L	<50.0		<0.500					<10.0			<0.500
Toluene	ug/L	317		<0.500					37.2			<0.500
Trichloroethene (TCE)	ug/L	<50.0		<0.500					<10.0			<0.500
Vinyl chloride	ug/L	<50.0		<0.500					<10.0			<0.500
m,p-Xylene	ug/L	360		<1.00					78.6			<1.00
o-Xylene	ug/L	195		<0.500					52			<0.500

8/12/2009	Units	NW-1A PW-1 Influent	NW-2A PW-1 Eq Eff	NW-1B MW-1 Influent	NW-2B MW-1 Eq Eff	NW-3 Combined IPC Inf	NW-4 IPC Effluent	NW-5 Cyanide Destruct Eff	NW-6 Bag Filter Eff	NW-7 GAC Midpoint	NW-8 GAC Eff	NW-9 Eff Storage Tank
pH	pH Units	6.54	10.1	6.17	10.4							7.58
pH Temperature	pH Units	20.2	19.8	21.3	19.8							16.3
Total Dissolved Solids	mg/L	529	1020	3340	2900							1600
Total Suspended Solids	mg/L	102	84	140	91				<5.00			<5.00
Total Organic Carbon	mg/L	29.9	31.6	7.33	5			13.2	20.9	2.5	2.8	2.09
Total Iron	ug/L					9930	3960		413 [10] [6]			158 [10] [9]
Total Manganese	ug/L					814	346		110 [10] [6]			64.9 [10] [9]
CYANIDE												
Cyanide, Total	mg/L	0.586	0.81	0.377	0.322			0.457	0.706			0.183
Cyanide, WAD	mg/L	0.067	0.0868	0.06	0.0703			0.0503	0.0585			0.0175
Cyanide, Amenable	mg/L	<0.0100	<0.0500	<0.0100	<0.00500			<0.0100	<0.0100			<0.00500
CATC, chlorinated	mg/L	0.847	0.998	0.586	0.462			0.807	0.876			0.226
Cyanide, Free	mg/L	<0.0100	<0.0100	<0.0100	<0.0100			<0.0100	<0.0100			<0.0100
CATC, total	mg/L	0.586	0.81	0.377	0.322			0.457	0.706			0.183
Available Cyanide	mg/L	0.0060	0.0060	0.0051	0.0045			0.019	0.033			<0.0020
SEMI-VOLATILE ORGANICS												
Acenaphthylene	ug/L	1580 [6]	264 [6]	0.0954 [6]	<0.0777 [6]			40.3 [6]	73.1 [9]	0.0876 [6]	<0.0762 [9]	<0.0816 [9]
Acenaphthene	ug/L	2730 [6]	374 [6]	1.35 [6] [16] [14]	0.874 [6] [17] [8]			137 [6]	107 [9]	<0.0800 [6]	<0.0762 [9]	<0.0816 [9]
Anthracene	ug/L	1470 [6]	96.4 [6]	<0.0833 [6]	<0.0777 [6]			<18.6 [6]	<18.6 [9]	0.119 [6]	<0.0762 [9]	<0.0816 [9]
Benz(a)anthracene	ug/L	1300 [6]	74.7 [6]	<0.0833 [6]	<0.0777 [6]			<18.6 [6]	<18.6 [9]	0.592 [6]	0.156 [9]	<0.0816 [9]
Benzo(a)pyrene	ug/L	1720 [6]	109 [6]	0.110 [6] [16] [14]	<0.0777 [6]			28.8 [6]	<21.4 [9] [18] [8]	0.890 [6]	0.255 [9]	0.171 [9]
Benzo(b)fluoranthene(s)	ug/L			<0.0833 [6]	<0.0777 [6]				<18.6 [9]			
Benzo(k)fluoranthene(s)	ug/L			<0.0833 [6]	<0.0777 [6]				<18.6 [9]			
Benzo(b+k)fluoranthene(s)	ug/L	2200 [6] [15] [9]	133 [6] [16] [6]					<37.2 [6] [16] [6]		1.18 [6] [16] [6]	0.386 [9] [17] [5]	
Benzo(g,h,i)perylene	ug/L	1160 [6]	71.7 [6]	<0.0833 [6]	<0.0777 [6]			<18.6 [6]	<18.6 [9]	0.670 [6]	0.249 [9]	0.123 [9]
Carbazole	ug/L	636 [6]	184 [6]	<0.0833 [6]	<0.0777 [6]			94.6 [6]	97.5 [9]	<0.0800 [6]	<0.0762 [9]	<0.0816 [9]
Chrysene	ug/L	1370 [6]	94.7 [6]	<0.0833 [6]	<0.0777 [6]			<18.6 [6]	<18.6 [9]	0.647 [6]	0.152 [9]	<0.0816 [9]
Dibenz(a,h)anthracene	ug/L	<372 [6]	<18.6 [6]	<0.0833 [6]	<0.0777 [6]			<18.6 [6]	<18.6 [9]	<0.0800 [6]	<0.0762 [9]	<0.0816 [9]
Dibenzofuran	ug/L	<372 [6]	35.0 [6]	<0.0833 [6]	<0.0777 [6]			<18.6 [6]	<18.6 [9]	<0.0800 [6]	<0.0762 [9]	<0.0816 [9]
Fluoranthene	ug/L	4270 [6]	269 [6]	0.167 [6]	<0.0777 [6]			54.8 [6]	30.8 [9]	1.13 [6]	0.210 [9]	0.111 [9]
Fluorene	ug/L	1640 [6]	180 [6]	0.120 [6]	<0.0777 [6]			67.7 [6]	47.1 [9]	<0.0800 [6]	<0.0762 [9]	<0.0816 [9]
Indeno(1,2,3-cd)pyrene	ug/L	952 [6]	58.6 [6]	<0.0833 [6]	<0.0777 [6]			<18.6 [6]	<18.6 [9]	0.473 [6]	0.178 [9]	0.0818 [9]
2-Methylnaphthalene	ug/L	6110 [6]	1070 [6]	0.283 [6]	<0.0777 [6]			365 [6]	297 [9]	<0.0800 [6]	<0.0762 [9]	<0.0816 [9]
Naphthalene	ug/L	31100 [4] [6] [1]	9760 [3] [6] [3]	0.654 [4] [6] [7]	0.358 [3] [6] [5]			3460 [3] [6] [3]	2980 [5] [9] [4]	0.142 [3] [6] [4]	0.123 [5] [9] [3]	<0.0816 [8] [9] [7]
Phenanthrene	ug/L	9510 [6]	717 [6]	0.521 [6]	<0.0777 [6]			203 [6]	120 [9]	0.617 [6]	0.0921 [9]	<0.0816 [9]
Pyrene	ug/L	5190 [6]	323 [6]	0.180 [6]	<0.0777 [6]			60.9 [6]	33.2 [9]	1.63 [6]	0.296 [9]	0.138 [9]
2-Chlorophenol	ug/L	<4650 [6]	<233 [6]	<1.04 [6]	<0.971 [6]			<233 [6]	<233 [9]	<1.00 [6]	<0.952 [9]	<1.02 [9]
2,4-Dichlorophenol	ug/L	<4650 [6]	<233 [6]	<1.04 [6]	<0.971 [6]			<233 [6]	<233 [9]	<1.00 [6]	<0.952 [9]	<1.02 [9]
2,4-Dimethylphenol	ug/L	<4650 [6]	<233 [6]	<1.04 [6]	<0.971 [6]			<233 [6]	<233 [9]	<1.00 [6]	<0.952 [9]	<1.02 [9]
4,6-Dinitro-2-methylphenol	ug/L	<4650 [6]	<233 [6]	<1.04 [6]	<0.971 [6]			<233 [6]	<233 [9]	<1.00 [6]	<0.952 [9]	<1.02 [9]
2-Methylphenol	ug/L	<4650 [6]	<233 [6]	<1.04 [6]	<0.971 [6]			<233 [6]	<233 [9]	<1.00 [6]	<0.952 [9]	<1.02 [9]
2-Nitrophenol	ug/L	<4650 [6]	<233 [6]	<1.04 [6]	<0.971 [6]			<233 [6]	<233 [9]	<1.00 [6]	<0.952 [9]	<1.02 [9]
4-Nitrophenol	ug/L	<4650 [6]	<233 [6]	<1.04 [6]	<0.971 [6]			<233 [6]	<233 [9]	<1.00 [6]	<0.952 [9]	<1.02 [9]
2,4,5-Trichlorophenol	ug/L	<4650 [6]	<233 [6]	<1.04 [6]	<0.971 [6]			<233 [6]	<233 [9]	<1.00 [6]	<0.952 [9]	<1.02 [9]
2,4,6-Trichlorophenol	ug/L	<4650 [6]	<233 [6]	<1.04 [6]	<0.971 [6]			<233 [6]	<233 [9]	<1.00 [6]	<0.952 [9]	<1.02 [9]
Pentachlorophenol (PCP)	ug/L	<4650 [6]	<233 [6]	<1.04 [6]	<0.971 [6]			<233 [6]	<233 [9]	<1.00 [6]	<0.952 [9]	<1.02 [9]
Phenol	ug/L	<4650 [6]	<233 [6]	<1.04 [6]	<0.971 [6]			<233 [6]	<233 [9]	<1.00 [6]	<0.952 [9]	<1.02 [9]
METALS												
Hexavalent Chromium	mg/L	<0.0100	<0.0100	0.130 [2] [3]	<0.100 [17] [8]				<0.0100			<0.0100
Silver	ug/L	<1.00	<1.00	<1.00	<1.00				<1.00			<1.00
Arsenic	ug/L	4.57		1.37		2.63	2.12	2.18	1.92		3.52	4.02
Cadmium	ug/L	<1.00	<1.00	<1.00	<1.00				<1.00			<1.00
Chromium	ug/L	1.38	1.36	<1.00	<1.00				1.02			<1.00
Copper	ug/L	<5.00	<5.00	<5.00	<5.00				36.5			6.14
Dissolved Iron	ug/L	29600	10800	222000	6770	369 [7] [2]	353 [10] [2]		701			255
Mercury	ug/L	<0.0100	<0.0100	<0.0100	<0.0100				0.253 [2] [3]			0.0130 [2] [3]
Dissolved Manganese	ug/L	2860	1070	7470	227	21.7 [7] [2]	24.3 [10] [2]		118			66.1
Nickel	ug/L	1.26	<1.00	2.9	1.07				3.1			9.68
Lead	ug/L	<1.00	<1.00	2.46	<1.00				7.19			2.7
Selenium	ug/L	1.09	1.02	1.14	1.32				1.76			3.01
Zinc	ug/L	151	96.2	113	<4.00				150			21
Calcium	ug/L	64400	18000	326000	72100							13000
Chromium	ug/L											
Hardness (Calc by 6020)	mg CaCO3/L	345	218	1660	819							342
Magnesium	ug/L	44700	42100	206000	155000							75100
Trivalent Chromium	ug/L	<11.0	<11.0	<11.0	<101				<11.0			<11.0
VOLATILE ORGANICS												
Acetone	ug/L	<2000	<1000	<20.0	<20.0 [22]			<400	<400	<20.0	<20.0	<20.0
Benzene	ug/L	8690	5250	<0.250	<0.250 [22]			2690	2460	<0.250	<0.250	<0.250
2-Butanone (MEK)	ug/L	<1000	<500	<10.0	<10.0 [22]			<200	<200	<10.0	<10.0	<10.0
1,1-Dichloroethene	ug/L	<50.0	<25.0	<0.500	<0.500 [22]			<10.0	<10.0	<0.500	<0.500	<0.500
cis-1,2-Dichloroethene	ug/L	<50.0	<25.0	<0.500	<0.500 [22]			<10.0	<10.0	<0.500	<0.500	<0.500
trans-1,2-Dichloroethene	ug/L	<50.0	<25.0	<0.500	<0.500 [22]			<10.0	<10.0	<0.500	<0.500	<0.500
Ethylbenzene	ug/L	1220	622	<0.500	<0.500 [22]			286	252	<0.500	<0.500	<0.500
Tetrachloroethene (PCE)	ug/L	<50.0	<25.0	<0.500	<0.500 [22]			<10.0	<10.0	<0.500	<0.500	<0.500
Toluene	ug/L	248	160	<0.500	<0.500 [22]			77.4	66	<0.500	<0.500	<0.500
Trichloroethene (TCE)	ug/L	<50.0	<25.0	<0.500	<0.500 [22]			<10.0	<10.0	<0.500	<0.500	<0.500
Vinyl chloride	ug/L	<50.0	<25.0	<0.500	<0.500 [22]			<10.0	<10.0	<0.500	<0.500	<0.500
m,p-Xylene	ug/L	596	426	<1.00	<1.00 [22]			180	157	<1.00	<1.00	<1.00
o-Xylene	ug/L	306	218	<0.500	<0.500 [22]			106	93.8	<0.500	<0.500	<0.500

8/18/2009	Units	NW-1A PW-1 Influent	NW-2A PW-1 Eq Eff	NW-1B MW-1 Influent	NW-2B MW-1 Eq Eff	NW-3 Combined IPC Inf	NW-4 IPC Effluent	NW-5 Cyanide Destruct Eff	NW-6 Bag Filter Eff	NW-7 GAC Midpoint	NW-8 GAC Eff	NW-9 Eff Storage Tank
pH	pH Units	6.57	9.82	6.08	10							7.62
pH Temperature	pH Units	14.8	17.2	17.5	17.3							16.2
Total Dissolved Solids	mg/L	514	996	4460	2810							1490
Total Suspended Solids	mg/L	82	27	86	5				<5.00			<5.00
Total Organic Carbon	mg/L	29.8	30.9	7.59	6.04			21.5	18.9	3.34	3.77	3.85
Total Iron	ug/L					110000	5070		411 [7] [6]			171 [7] [9]
Total Manganese	ug/L					9750	427		223 [7] [6]			53.1 [7] [9]
CYANIDE												
Cyanide, Total	mg/L	1.22	1.08	0.679	0.415			0.804	0.807			0.26
Cyanide, WAD	mg/L	0.0972	0.0916	0.0845	0.0687			0.0825	0.083			0.0238
Cyanide, Amenable	mg/L	<0.0500	0.089	0.0304	<0.00500			0.131	0.138			<0.00500
CATC, chlorinated	mg/L	1.27	0.987	0.649	0.489			0.673	0.668			0.259
Cyanide, Free	mg/L	<0.0100	<0.0100	<0.0100	<0.0100			<0.0100	<0.0100			<0.0100
CATC, total	mg/L	1.22	1.08	0.679	0.415			0.804	0.807			0.26
SEMI-VOLATILE ORGANICS												
Acenaphthylene	ug/L	736 [6]	130 [6]	<0.0784 [6]	<0.0755 [6]			<19.0 [6]	35.4 [6]	<0.0777 [6]	<0.0784 [6]	<0.0800 [6]
Acenaphthene	ug/L	1170 [6]	248 [6]	<0.0784 [6]	<0.0755 [6]			60.1 [6]	101 [6]	<0.0777 [6]	<0.0784 [6]	<0.0800 [6]
Anthracene	ug/L	642 [6]	21.1 [6]	<0.0784 [6]	<0.0755 [6]			<19.0 [6]	<18.6 [6]	<0.0777 [6]	<0.0784 [6]	<0.0800 [6]
Benz(a)anthracene	ug/L	634 [6]	4.12 [6]	<0.0784 [6]	<0.0755 [6]			<19.0 [6]	<18.6 [6]	0.137 [6]	0.0932 [6]	0.0893 [6]
Benzo(a)pyrene	ug/L	1070 [6]	5.98 [6]	<0.0980 [6] [20] [14]	<0.0755 [6]			<21.4 [6] [20] [7]	<18.6 [6]	0.233 [6]	0.168 [6]	0.133 [6]
Benzo(b)fluoranthene(s)	ug/L			<0.0882 [6] [20] [14]	<0.0755 [6]			<19.0 [6]	<18.6 [6]			
Benzo(k)fluoranthene(s)	ug/L			<0.0784 [6]	<0.0755 [6]			<19.0 [6]	<18.6 [6]			
Benzo(b+k)fluoranthene(s)	ug/L	1240 [6] [19] [9]	7.99 [6] [19] [6]						0.280 [6] [19] [6]	28 [6] [19] [5]	17 [6] [19] [10]	
Benzo(g,h,i)perylene	ug/L	602 [6]	3.59 [6]	<0.0784 [6]	<0.0755 [6]			<19.0 [6]	<18.6 [6]	0.135 [6]	0.112 [6]	0.110 [6]
Carbazole	ug/L	498 [6]	151 [6]	<0.0784 [6]	<0.0755 [6]			19.4 [6]	88.3 [6]	<0.0777 [6]	<0.0784 [6]	<0.0800 [6]
Chrysene	ug/L	588 [6]	4.49 [6]	<0.0784 [6]	<0.0755 [6]			<19.0 [6]	<18.6 [6]	0.130 [6]	0.0835 [6]	<0.0800 [6]
Dibenz(a,h)anthracene	ug/L	<381 [6]	<1.90 [6]	<0.0784 [6]	<0.0755 [6]			<19.0 [6]	<18.6 [6]	<0.0777 [6]	<0.0784 [6]	<0.0800 [6]
Dibenzofuran	ug/L	<381 [6]	22.9 [6]	<0.0784 [6]	<0.0755 [6]			<19.0 [6]	<18.6 [6]	<0.0777 [6]	<0.0784 [6]	<0.0800 [6]
Fluoranthene	ug/L	1900 [6]	32.6 [6]	0.184 [6]	<0.0755 [6]			29.3 [6]	25.2 [6]	0.300 [6]	0.210 [6]	0.191 [6]
Fluorene	ug/L	710 [6]	105 [6]	<0.0784 [6]	<0.0755 [6]			68.9 [6]	49.0 [6]	<0.0777 [6]	<0.0784 [6]	<0.0800 [6]
Indeno(1,2,3-cd)pyrene	ug/L	419 [6]	2.27 [6] [8] [5]	<0.0784 [6]	<0.0755 [6]			<19.0 [6]	<18.6 [6]	0.0905 [6]	<0.0784 [6]	<0.0800 [6]
2-Methylnaphthalene	ug/L	2600 [6]	534 [6]	<0.0784 [6]	<0.0755 [6]			272 [6]	226 [6]	<0.0777 [6]	<0.0784 [6]	<0.0800 [6]
Naphthalene	ug/L	15900 [4] [6] [1]	3450 [4] [6] [3]	0.302 [3] [4] [6] [4] [7]	[3] [4] [6] [3] [5]			2210 [4] [6] [3]	720 [4] [6] [4]	[4] [6] [2] [4]	[4] [6] [2] [3]	[4] [6] [5] [6]
Phenanthrene	ug/L	4030 [6]	230 [6]	0.438 [6]	<0.0755 [6]			126 [6]	119 [6]	0.263 [6]	0.155 [6]	0.118 [6]
Pyrene	ug/L	2290 [6]	36.3 [6]	0.188 [6]	<0.0755 [6]			27.9 [6]	24.9 [6]	0.402 [6]	0.276 [6]	0.247 [6]
2-Chlorophenol	ug/L	<4760 [6]	<23.8 [6]	<0.980 [6]	<0.943 [6]			<238 [6]	<233 [6]	<0.971 [6]	<0.980 [6]	<1.00 [6]
2,4-Dichlorophenol	ug/L	<4760 [6]	<23.8 [6]	<0.980 [6]	<0.943 [6]			<238 [6]	<233 [6]	<0.971 [6]	<0.980 [6]	<1.00 [6]
2,4-Dimethylphenol	ug/L	<4760 [6]	<23.8 [6]	<0.980 [6]	<0.943 [6]			<238 [6]	<233 [6]	<0.971 [6]	<0.980 [6]	<1.00 [6]
4,6-Dinitro-2-methylphenol	ug/L	<4760 [6]	<23.8 [6]	<0.980 [6]	<0.943 [6]			<238 [6]	<233 [6]	<0.971 [6]	<0.980 [6]	<1.00 [6]
2-Methylphenol	ug/L	<4760 [6]	<23.8 [6]	<0.980 [6]	<0.943 [6]			<238 [6]	<233 [6]	<0.971 [6]	<0.980 [6]	<1.00 [6]
2-Nitrophenol	ug/L	<4760 [6]	<23.8 [6]	<0.980 [6]	<0.943 [6]			<238 [6]	<233 [6]	<0.971 [6]	<0.980 [6]	<1.00 [6]
4-Nitrophenol	ug/L	<4760 [6]	<23.8 [6]	<0.980 [6]	<0.943 [6]			<238 [6]	<233 [6]	<0.971 [6]	<0.980 [6]	<1.00 [6]
2,4,5-Trichlorophenol	ug/L	<4760 [6]	<23.8 [6]	<0.980 [6]	<0.943 [6]			<238 [6]	<233 [6]	<0.971 [6]	<0.980 [6]	<1.00 [6]
2,4,6-Trichlorophenol	ug/L	<4760 [6]	<23.8 [6]	<0.980 [6]	<0.943 [6]			<238 [6]	<233 [6]	<0.971 [6]	<0.980 [6]	<1.00 [6]
Pentachlorophenol (PCP)	ug/L	<4760 [6]	<23.8 [6]	<0.980 [6]	<0.943 [6]			<238 [6]	<233 [6]	<0.971 [6]	<0.980 [6]	<1.00 [6]
Phenol	ug/L	<4760 [6]	52.4 [6]	<0.980 [6]	<0.943 [6]			<238 [6]	<233 [6]	<0.971 [6]	<0.980 [6]	<1.00 [6]
METALS												
Hexavalent Chromium	mg/L	<0.0100	<0.0200 [20] [7]	0.204	<0.0400 [20] [8]				<0.0400 [20] [8]			<0.0400 [20] [12]
Silver	ug/L	<1.00	<1.00	<1.00	<1.00				<1.00			<1.00
Arsenic	ug/L	4.56	<1.00	1.71	<1.00	9.72	2.24	2.67	1.31		4.12	3.82
Cadmium	ug/L	<1.00	1.18	<1.00	<1.00				<1.00			<1.00
Chromium	ug/L	2.34	<5.00	<1.00	<5.00				<1.00			<1.00
Copper	ug/L	<5.00	7590	<5.00	682				21.4			19.6
Dissolved Iron	ug/L	34000	<0.0100	268000	<0.0100	366 [7] [2]	354 [7] [2]		860			464
Mercury	ug/L	<0.0100	675	<0.0100	6.62				0.0969			<0.0100
Dissolved Manganese	ug/L	3160	<1.00	9360	<1.00	105 [7] [2]	42.9 [7] [2]		330			62.2
Nickel	ug/L	1.57	<1.00	3.47	<1.00				3.76			9.98
Lead	ug/L	<1.00	<1.00	<1.00	1.22				6.61			7.66
Selenium	ug/L	<1.00	65.2	1.86	<4.00				1.54			2.02
Zinc	ug/L	301	2410	15.4	63700				156			30.6
Calcium	ug/L	74100		431000								10200
Chromium	ug/L											
Hardness (Calc by 6020)	mg CaCO3/L	384	178	2170	771							313
Magnesium	ug/L	48300	41800	266000	149000							69900
Trivalent Chromium	ug/L	<11.0	<21.0	<41.0	<41.0				<41.0			<41.0
VOLATILE ORGANICS												
Acetone	ug/L	<2000	<1000	<20.0	<20.0			<400	<400	<20.0	<20.0	<20.0
Benzene	ug/L	9070	3620	<0.500 [22] [16]	<0.250			1610	1340	0.500 [22] [9]	<0.250	<0.250
2-Butanone (MEK)	ug/L	<1000	<500	<10.0	<10.0			<200	<200	<10.0	<10.0	<10.0
1,1-Dichloroethene	ug/L	<50.0	<25.0	<0.500	<0.500			<10.0	<10.0	<0.500	<0.500	<0.500
cis-1,2-Dichloroethene	ug/L	<50.0	<25.0	<0.500	<0.500			<10.0	<10.0	<0.500	<0.500	<0.500
trans-1,2-Dichloroethene	ug/L	<50.0	<25.0	<0.500	<0.500			<10.0	<10.0	<0.500	<0.500	<0.500
Ethylbenzene	ug/L	1090	42	<0.500	<0.500			60.6	47.6	<0.500	<0.500	<0.500
Tetrachloroethene (PCE)	ug/L	<50.0	<25.0	<0.500	<0.500			<10.0	<10.0	<0.500	<0.500	<0.500
Toluene	ug/L	290	102	<0.500	<0.500			39.4	30	<0.500	<0.500	<0.500
Trichloroethene (TCE)	ug/L	<50.0	<25.0	<0.500	<0.500			<10.0	<10.0	<0.500	<0.500	<0.500
Vinyl chloride	ug/L	<50.0	<25.0	<0.500	<0.500			<10.0	<10.0	<0.500	<0.500	<0.500
m,p-Xylene	ug/L	561	256	<1.00	<1.00			74.8	57	<1.00	<1.00	<1.00
o-Xylene	ug/L	282	150	<0.500	<0.500			51.6	39.6	<0.500	<0.500	<0.500

8/19/2009	Units	NW-1A PW-1 Influent	NW-2A PW-1 Eq Eff	NW-1B MW-1 Influent	NW-2B MW-1 Eq Eff	NW-3 Combined IPC Inf	NW-4 IPC Effluent	NW-5 Cyanide Destruct Eff	NW-6 Bag Filter Eff	NW-7 GAC Midpoint	NW-8 GAC Eff	NW-9 Eff Storage Tank
pH	pH Units	6.55	9.83	6.08	10.1							7.65
pH Temperature	pH Units	24.9	24	24.8	23.7							23.9
Total Dissolved Solids	mg/L	551	977	4080	3070							1600
Total Suspended Solids	mg/L	65	143	101	52				<5.00			<5.00
Total Organic Carbon	mg/L	27.1	28	<2.00	6.09			26.3	20.3	8.15	7.1	6.83
Total Iron	ug/L	4330				11800	2360		418 [4] [6]			
Total Manganese	ug/L	2810				1210	251		104 [4] [6]			
CYANIDE												
Cyanide, Total	mg/L	1.05	0.979	0.493	0.387			0.709	0.773			0.333
Cyanide, WAD	mg/L	0.0723	0.0819	0.0634	0.0636			0.0693	0.0671			0.0738
Cyanide, Amenable	mg/L	0.0392	0.0342	<0.0100	<0.00500			0.0951	0.0482			<0.00500
CATC, chlorinated	mg/L	1.01	0.944	0.544	0.435			0.614	0.725			0.347
Cyanide, Free	mg/L	<0.0100	<0.0100	<0.0100	<0.0100			<0.0100	<0.0100			<0.0100
CATC, total	mg/L	1.05	0.979	0.493	0.387			0.709	0.773			0.333
SEMI-VOLATILE ORGANICS												
Acenaphthylene	ug/L	<190 [3]	228 [3]	<0.0777 [3]	<0.0769 [3]			<19.0 [3]	67.2 [3]	<0.0777 [3]	<0.762 [3] [17]	<0.0800 [3]
Acenaphthene	ug/L	284 [3]	349 [3]	<0.0777 [3]	<0.0769 [3]			120 [3]	118 [3]	<0.0777 [3]	<0.762 [3] [17]	<0.0800 [3]
Anthracene	ug/L	<190 [3]	89.0 [3]	<0.0777 [3]	<0.0769 [3]			<19.0 [3]	<19.0 [3]	<0.0777 [3]	<0.762 [3] [17]	<0.0800 [3]
Benz(a)anthracene	ug/L	250 [3]	78.2 [3]	<0.0777 [3]	<0.0769 [3]			<19.0 [3]	<19.0 [3]	0.0975 [3]	<0.762 [3] [17]	<0.0800 [3]
Benzo(a)pyrene	ug/L	361 [3]	119 [3]	0.0874 [3] [16] [14]	<0.0769 [3]			<21.9 [3] [16] [7]	<19.0 [3]	0.167 [3]	<0.762 [3] [17]	0.14 [3] [16] [12]
Benzo(b)fluoranthene(s)	ug/L			<0.0777 [3]	<0.0769 [3]			<19.0 [3]	<19.0 [3]		<0.762 [3] [17]	<0.0800 [3]
Benzo(k)fluoranthene(s)	ug/L			<0.0777 [3]	<0.0769 [3]			<19.0 [3]	<19.0 [3]		<0.762 [3] [17]	<0.0800 [3]
Benzo(b+k)fluoranthene(s)	ug/L	406 [3] [15] [9]	143 [3] [15] [6]							0.205 [3] [15] [6]		
Benzo(g,h,i)perylene	ug/L	<190 [3]	64.9 [3]	<0.0777 [3]	<0.0769 [3]			<19.0 [3]	<19.0 [3]	<0.0777 [3]	<0.762 [3] [17]	<0.0800 [3]
Carbazole	ug/L	<190 [3]	150 [3]	<0.0777 [3]	<0.0769 [3]			53.9 [3]	82.0 [3]	<0.0777 [3]	<0.762 [3] [17]	<0.0800 [3]
Chrysene	ug/L	<190 [3]	96.4 [3]	<0.0777 [3]	<0.0769 [3]			<19.0 [3]	<19.0 [3]	0.0897 [3]	<0.762 [3] [17]	<0.0800 [3]
Dibenz(a,h)anthracene	ug/L	<190 [3]	<38.1 [3]	<0.0777 [3]	<0.0769 [3]			<19.0 [3]	<19.0 [3]	<0.0777 [3]	<0.762 [3] [17]	<0.0800 [3]
Dibenzofuran	ug/L	<190 [3]	<38.1 [3]	<0.0777 [3]	<0.0769 [3]			<19.0 [3]	<19.0 [3]	<0.0777 [3]	<0.762 [3] [17]	<0.0800 [3]
Fluoranthene	ug/L	602 [3]	299 [3]	<0.0777 [3]	<0.0769 [3]			26.3 [3]	<19.0 [3]	0.215 [3]	<0.762 [3] [17]	<0.0800 [3]
Fluorene	ug/L	<190 [3]	171 [3]	<0.0777 [3]	<0.0769 [3]			60.0 [3]	50.4 [3]	<0.0777 [3]	<0.762 [3] [17]	<0.0800 [3]
Indeno(1,2,3-cd)pyrene	ug/L	<190 [3]	66.1 [3]	<0.0777 [3]	<0.0769 [3]			<19.0 [3]	<19.0 [3]	<0.0777 [3]	<0.762 [3] [17]	<0.0800 [3]
2-Methylnaphthalene	ug/L	538 [3]	963 [3]	<0.0777 [3]	0.0811 [3]			387 [3]	327 [3]	<0.0777 [3]	<0.762 [3] [17]	<0.0800 [3]
Naphthalene	ug/L	4360 [1] [3] [1]	8690 [1] [3] [3]	0.271 [1] [3] [7]	0.408 [1] [3] [5]			3940 [1] [3] [3]	4400 [1] [3] [4]	0.157 [1] [3] [4]	<0.762 [3] [17]	0.0837 [1] [3] [6]
Phenanthrene	ug/L	1130 [3]	706 [3]	0.0892 [3]	<0.0769 [3]			138 [3]	123 [3]	0.156 [3]	<0.762 [3] [17]	<0.0800 [3]
Pyrene	ug/L	745 [3]	364 [3]	<0.0777 [3]	<0.0769 [3]			29.8 [3]	<19.0 [3]	0.291 [3]	<0.762 [3] [17]	<0.0800 [3]
2-Chlorophenol	ug/L	<2380 [3]	<476 [3]	<0.971 [3]	<0.962 [3]			<238 [3]	<238 [3]	<0.971 [3]	<9.52 [3] [17]	<1.00 [3]
2,4-Dichlorophenol	ug/L	<2380 [3]	<476 [3]	<0.971 [3]	<0.962 [3]			<238 [3]	<238 [3]	<0.971 [3]	<9.52 [3] [17]	<1.00 [3]
2,4-Dimethylphenol	ug/L	<2380 [3]	<476 [3]	<0.971 [3]	<0.962 [3]			<238 [3]	<238 [3]	<0.971 [3]	<9.52 [3] [17]	<1.00 [3]
4,6-Dinitro-2-methylphenol	ug/L	<2380 [3]	<476 [3]	<0.971 [3]	<0.962 [3]			<238 [3]	<238 [3]	<0.971 [3]	<9.52 [3] [17]	<1.00 [3]
2-Methylphenol	ug/L	<2380 [3]	<476 [3]	<0.971 [3]	<0.962 [3]			<238 [3]	<238 [3]	<0.971 [3]	<9.52 [3] [17]	<1.00 [3]
2-Nitrophenol	ug/L	<2380 [3]	<476 [3]	<0.971 [3]	<0.962 [3]			<238 [3]	<238 [3]	<0.971 [3]	<9.52 [3] [17]	<1.00 [3]
4-Nitrophenol	ug/L	<2380 [3]	<476 [3]	<0.971 [3]	<0.962 [3]			<238 [3]	<238 [3]	<0.971 [3]	<9.52 [3] [17]	<1.00 [3]
2,4,5-Trichlorophenol	ug/L	<2380 [3]	<476 [3]	<0.971 [3]	<0.962 [3]			<238 [3]	<238 [3]	<0.971 [3]	<9.52 [3] [17]	<1.00 [3]
2,4,6-Trichlorophenol	ug/L	<2380 [3]	<476 [3]	<0.971 [3]	<0.962 [3]			<238 [3]	<238 [3]	<0.971 [3]	<9.52 [3] [17]	<1.00 [3]
Pentachlorophenol (PCP)	ug/L	<2380 [3]	<476 [3]	<0.971 [3]	<0.962 [3]			<238 [3]	<238 [3]	<0.971 [3]	<9.52 [3] [17]	<1.00 [3]
Phenol	ug/L	<2380 [3]	<476 [3]	<0.971 [3]	<0.962 [3]			<238 [3]	<238 [3]	<0.971 [3]	<9.52 [3] [17]	<1.00 [3]
METALS												
Hexavalent Chromium	mg/L	<0.0100	<0.0100	<0.0500 [17] [15]	<0.0500 [17] [9]				<0.0100			<0.0100
Silver	ug/L	<1.00	<1.00	<1.00	<1.00				<1.00			<1.00
Arsenic	ug/L	4.22 [1] [1]		1.41 [1] [7]		2.27 [1] [1]	1.82 [1] [1]	2.46	2.10 [1] [4]		2.86	2.92 [1] [6]
Cadmium	ug/L	<1.00	<1.00	<1.00	<1.00				<1.00			<1.00
Chromium	ug/L	1.22	<1.00	<1.00	<1.00				1.29			<1.00
Copper	ug/L	<5.00	<5.00	<5.00	<5.00				11.9			<5.00
Dissolved Iron	ug/L	30800	15600	238000	3960	372 [4] [2]	356 [4] [2]		627			283
Mercury	ug/L	<0.0100	<0.0100	<0.0100	<0.0100				0.0676			<0.0100
Dissolved Manganese	ug/L	2790	1720	8120	126	56.1 [4] [2]	46.3 [4] [2]		108			65.5
Nickel	ug/L	1.41	<1.00	3.3	1.1				<1.00			4.57
Lead	ug/L	<1.00	<1.00	<1.00	<1.00				6.86			<1.00
Selenium	ug/L	<1.00	<1.00	1.31	1.6				2.14			2.19
Zinc	ug/L	1500	126	13.3	<4.00				45.1			9.02
Calcium	ug/L	74400	31200	398000	72400							14100
Chromium	ug/L											
Hardness (Calc by 6020)	mg CaCO3/L	376	260	1960	722							313
Magnesium	ug/L	46200	44200	234000	131000							67500
Trivalent Chromium	ug/L	<11.0	<11.0	<51.0	<51.0				<11.0			<11.0
VOLATILE ORGANICS												
Acetone	ug/L	<2000	<1000	<20.0	<20.0			<400	<400	<20.0	<20.0	<20.0
Benzene	ug/L	8390	5590	<0.500 [18] [16]	<0.500 [18] [10]			2380	2410	<0.550 [18] [9]	<0.250	<0.250
2-Butanone (MEK)	ug/L	<1000	<500	<10.0	<10.0			<200	<200	<10.0	<10.0	<10.0
1,1-Dichloroethene	ug/L	<50.0	<25.0	<0.500	<0.500			<10.0	<10.0	<0.500	<0.500	<0.500
cis-1,2-Dichloroethene	ug/L	<50.0	<25.0	<0.500	<0.500			<10.0	<10.0	<0.500	<0.500	<0.500
trans-1,2-Dichloroethene	ug/L	<50.0	<25.0	<0.500	<0.500			<10.0	<10.0	<0.500	<0.500	<0.500
Ethylbenzene	ug/L	827	613	<0.500	<0.500			229	240	<0.500	<0.500	<0.500
Tetrachloroethene (PCE)	ug/L	<50.0	<25.0	<0.500	<0.500			<10.0	<10.0	<0.500	<0.500	<0.500
Toluene	ug/L	235	136	<0.500	<0.500			59	61.4	<0.500	<0.500	<0.500
Trichloroethene (TCE)	ug/L	<50.0	<25.0	<0.500	<0.500			<10.0	<10.0	<0.500	<0.500	<0.500
Vinyl chloride	ug/L	<50.0	<25.0	<0.500	<0.500			<10.0	<10.0	<0.500	<0.500	<0.500
m,p-Xylene	ug/L	378	330	<1.00	<1.00			123	143	<1.00	<1.00	<1.00
o-Xylene	ug/L	194	179	<0.500	<0.500			78.2	90.2	<0.500	<0.500	<0.500

8/21/2009	Units	NW-1A PW-1 Influent	NW-2A PW-1 Eq Eff	NW-1B MW-1 Influent	NW-2B MW-1 Eq Eff	NW-3 Combined IPC Inf	NW-4 IPC Effluent	NW-5 Cyanide Destruct Eff	NW-6 Bag Filter Eff	NW-7 GAC Midpoint	NW-8 GAC Eff	NW-9 Eff Storage Tank
pH	pH Units	6.72	10.1	6.2	10.5							7.84
pH Temperature	pH Units	27.6	23.2	27.5	24.8							23.6
Total Dissolved Solids	mg/L	505	1040	4100	3140							1610
Total Suspended Solids	mg/L	79	72	122	184				6			<5.00
Total Organic Carbon	mg/L	26.3	25.5	2.21	6.24		31.0 [2] [2]		17.5	2.82	<2.00	<2.00
Total Iron	ug/L					12900	2980		427 [7] [6]			337 [7] [9]
Total Manganese	ug/L					972	233		62.2 [7] [6]			42.7 [7] [9]
CYANIDE												
Cyanide, Total	mg/L	0.873	0.873	0.587	0.412			0.686	0.716			0.558
Cyanide, WAD	mg/L	0.0607	0.0988	0.0619	0.0592			0.0663	0.0532			0.0392
Cyanide, Amenable	mg/L	<0.0150	<0.0150	<0.0100	<0.00500			<0.0200	<0.0100			<0.0100
CATC, chlorinated	mg/L	0.939	0.956	0.589	0.472			1.65	0.789			0.589
Cyanide, Free	mg/L	<0.0100	<0.0100	<0.0100	<0.0100			<0.0100	<0.0100			<0.0100
CATC, total	mg/L	0.873	0.873	0.587	0.412			0.686	0.716			0.558
Available Cyanide	mg/L	0.0030	0.0037	0.012	0.0041			0.0056	0.0051			<0.0020
SEMI-VOLATILE ORGANICS												
Acenaphthylene	ug/L	<372 [6]	198 [6]	<0.0755 [6]	<0.0769 [6]			37.6 [6]	69.8 [6]	<0.0777 [6]	<0.0748 [6]	<0.0784 [6]
Acenaphthene	ug/L	538 [6]	267 [6]	<0.0755 [6]	<0.0769 [6]			131 [6]	123 [6]	<0.0777 [6]	<0.0748 [6]	<0.0784 [6]
Anthracene	ug/L	<372 [6]	61.6 [6]	<0.0755 [6]	<0.0769 [6]			<18.6 [6]	<18.6 [6]	<0.0777 [6]	<0.0748 [6]	<0.0784 [6]
Benz(a)anthracene	ug/L	<372 [6]	45.3 [6]	<0.0755 [6]	<0.0769 [6]			<18.6 [6]	<18.6 [6]	0.114 [6]	<0.0748 [6]	<0.0784 [6]
Benzo(a)pyrene	ug/L	686 [6]	73.9 [6]	<0.0755 [6]	<0.0808 [6] [18] [8]			<22.3 [6] [18] [7]	24.2 [6]	0.201 [6]	0.148 [6]	0.117 [6]
Benzo(b)fluoranthene(s)	ug/L			<0.0755 [6]	<0.0769 [6]			<18.6 [6]	20.4 [6]			
Benzo(k)fluoranthene(s)	ug/L			<0.0755 [6]	<0.0769 [6]			<18.6 [6]	<18.6 [6]			
Benzo(b+k)fluoranthene(s)	ug/L	<744 [6] [16] [9]	81.3 [6] [16] [6]							0.247 [6] [16] [6]	0.185 [6] [16] [5]	<0.157 [6] [16] [10]
Benzo(g,h,i)perylene	ug/L	389 [6]	45.6 [6]	<0.0755 [6]	<0.0769 [6]			<18.6 [6]	<18.6 [6]	0.153 [6]	0.123 [6]	0.0913 [6]
Carbazole	ug/L	<372 [6]	157 [6]	<0.0755 [6]	<0.0769 [6]			83.6 [6]	94.0 [6]	<0.0777 [6]	<0.0748 [6]	<0.0784 [6]
Chrysene	ug/L	<372 [6]	45.6 [6]	<0.0755 [6]	<0.0769 [6]			<18.6 [6]	<18.6 [6]	0.106 [6]	<0.0748 [6]	<0.0784 [6]
Dibenz(a,h)anthracene	ug/L	<372 [6]	<18.6 [6]	<0.0755 [6]	<0.0769 [6]			<18.6 [6]	<18.6 [6]	<0.0777 [6]	<0.0748 [6]	<0.0784 [6]
Dibenzofuran	ug/L	<372 [6]	25.8 [6]	<0.0755 [6]	<0.0769 [6]			<18.6 [6]	<18.6 [6]	<0.0777 [6]	<0.0748 [6]	<0.0784 [6]
Fluoranthene	ug/L	979 [6]	182 [6]	<0.0755 [6]	<0.0769 [6]			26.2 [6]	22.9 [6]	0.273 [6]	0.0996 [6]	<0.0784 [6]
Fluorene	ug/L	<372 [6]	135 [6]	<0.0755 [6]	<0.0769 [6]			63.4 [6]	57.1 [6]	<0.0777 [6]	<0.0748 [6]	<0.0784 [6]
Indeno(1,2,3-cd)pyrene	ug/L	<372 [6]	35.1 [6]	<0.0755 [6]	<0.0769 [6]			<18.6 [6]	<18.6 [6]	0.113 [6]	0.0831 [6]	<0.0784 [6]
2-Methylnaphthalene	ug/L	1020 [6]	835 [6]	<0.0755 [6]	0.0973 [6]			397 [6]	366 [6]	<0.0777 [6]	<0.0748 [6]	<0.0784 [6]
Naphthalene	ug/L	8640 [3] [4] [6] [1] [2]	8050 [3] [6] [3]	[1] [3] [6] [2] [7]	0.577 [1] [3] [6] [2] [5]			4100 [3] [4] [6] [3] [4]	3850 [3] [6] [4]	0.199 [3] [6] [4]	<0.0748 [6]	0.0986 [3] [6] [6]
Phenanthrene	ug/L	1900 [6]	450 [6]	<0.0755 [6]	<0.0769 [6]			144 [6]	125 [6]	0.167 [6]	<0.0748 [6]	<0.0784 [6]
Pyrene	ug/L	1160 [6]	222 [6]	<0.0755 [6]	<0.0769 [6]			29.1 [6]	23.6 [6] [17] [7]	0.395 [6] [17] [7]	0.138 [6] [17] [7]	<0.0784 [6]
2-Chlorophenol	ug/L	<4650 [6]	<233 [6]	<0.943 [6]	<0.962 [6]			<233 [6]	<233 [6]	<0.971 [6]	<0.935 [6]	<0.980 [6]
2,4-Dichlorophenol	ug/L	<4650 [6]	<233 [6]	<0.943 [6]	<0.962 [6]			<233 [6]	<233 [6]	<0.971 [6]	<0.935 [6]	<0.980 [6]
2,4-Dimethylphenol	ug/L	<4650 [6]	<233 [6]	<0.943 [6]	<0.962 [6]			<233 [6]	<233 [6]	<0.971 [6]	<0.935 [6]	<0.980 [6]
4,6-Dinitro-2-methylphenol	ug/L	<4650 [6]	<233 [6]	<0.943 [6]	<0.962 [6]			<233 [6]	<233 [6]	<0.971 [6]	<0.935 [6]	<0.980 [6]
2-Methylphenol	ug/L	<4650 [6]	<233 [6]	<0.943 [6]	<0.962 [6]			<233 [6]	<233 [6]	<0.971 [6]	<0.935 [6]	<0.980 [6]
2-Nitrophenol	ug/L	<4650 [6]	<233 [6]	<0.943 [6]	<0.962 [6]			<233 [6]	<233 [6]	<0.971 [6]	<0.935 [6]	<0.980 [6]
4-Nitrophenol	ug/L	<4650 [6]	<233 [6]	<0.943 [6]	<0.962 [6]			<233 [6]	<233 [6]	<0.971 [6]	<0.935 [6]	<0.980 [6]
2,4,5-Trichlorophenol	ug/L	<4650 [6]	<233 [6]	<0.943 [6]	<0.962 [6]			<233 [6]	<233 [6]	<0.971 [6]	<0.935 [6]	<0.980 [6]
2,4,6-Trichlorophenol	ug/L	<4650 [6]	<233 [6]	<0.943 [6]	<0.962 [6]			<233 [6]	<233 [6]	<0.971 [6]	<0.935 [6]	<0.980 [6]
Pentachlorophenol (PCP)	ug/L	<4650 [6]	<233 [6]	<0.943 [6]	<0.962 [6]			<233 [6]	<233 [6]	<0.971 [6]	<0.935 [6]	<0.980 [6]
Phenol	ug/L	<4650 [6]	<233 [6]	<0.943 [6]	<0.962 [6]			<233 [6]	<233 [6]	<0.971 [6]	<0.935 [6]	<0.980 [6]
METALS												
Hexavalent Chromium	mg/L	<0.0100	<0.0100	<0.0100	<0.0100				<0.0100			<0.0100
Silver	ug/L	<1.00	<1.00	<1.00	<1.00				<1.00			<1.00
Arsenic	ug/L	5.13 [3] [1]		1.34 [3] [7]		2.64 [3] [1]	1.66 [3] [1]	2.53	2.40 [3] [4]		2.96	3.32 [3] [6]
Cadmium	ug/L	<1.00	<1.00	<1.00	<1.00				<1.00			<1.00
Chromium	ug/L	2.38	1.23	<1.00	<1.00				<1.00			<1.00
Copper	ug/L	<5.00	<5.00	<5.00	<5.00				7.13			10.1
Dissolved Iron	ug/L	31400	14800	243000	7500	368 [7] [2]	368 [7] [2]		887			761
Mercury	ug/L	<0.0100	<0.0100	<0.0100	<0.0100				0.073			<0.0100
Dissolved Manganese	ug/L	2940	1260	8180	276	11.1 [7] [2]	21.7 [7] [2]		83.8			55
Nickel	ug/L	2.92	<1.00	3.24	1.12				<1.00			7.92
Lead	ug/L	1.51	<1.00	<1.00	<1.00				3.76			1.93
Selenium	ug/L	<1.00	<1.00	1.02	<1.00				3.23			5.3
Zinc	ug/L	98.8	50.5	8.3	<4.00				10.6			17.3
Calcium	ug/L	67900	13200	377000	81700							9300
Chromium	ug/L											
Hardness (Calc by 6020)	mg CaCO3/L	346	207	1890	442							181
Magnesium	ug/L	42900	42200	230000	57800							38300
Trivalent Chromium	ug/L	<11.0	<11.0	<11.0	<11.0				<11.0			<11.0
VOLATILE ORGANICS												
Acetone	ug/L	<2000 [22]	<1000	<20.0	<20.0			<400	<400	<20.0	<20.0	<20.0
Benzene	ug/L	7880 [22]	7200	<0.250	<0.250			3150	2990	<0.500 [19] [9]	<0.250	<0.250
2-Butanone (MEK)	ug/L	<1000 [22]	<500	<10.0	<10.0			<200	<200	<10.0	<10.0	<10.0
1,1-Dichloroethene	ug/L	<50.0 [22]	<25.0	<0.500	<0.500			<10.0	<10.0	<0.500	<0.500	<0.500
cis-1,2-Dichloroethene	ug/L	<50.0 [22]	<25.0	<0.500	<0.500			<10.0	<10.0	<0.500	<0.500	<0.500
trans-1,2-Dichloroethene	ug/L	<50.0 [22]	<25.0	<0.500	<0.500			<10.0	<10.0	<0.500	<0.500	<0.500
Ethylbenzene	ug/L	808 [22]	868	<0.500	<0.500			342	318	<0.500	<0.500	<0.500
Tetrachloroethene (PCE)	ug/L	<50.0 [22]	<25.0	<0.500	<0.500			<10.0	<10.0	<0.500	<0.500	<0.500
Toluene	ug/L	224 [22]	200	<0.500	<0.500			79.2	77.2	<0.500	<0.500	<0.500
Trichloroethene (TCE)	ug/L	<50.0 [22]	<25.0	<0.500	<0.500			<10.0	<10.0	<0.500	<0.500	<0.500
Vinyl chloride	ug/L	<50.0 [22]	<25.0	<0.500	<0.500			<10.0	<10.0	<0.500	<0.500	<0.500
m,p-Xylene	ug/L	374 [22]	463	<1.00	<1.00			181	178	<1.00	<1.00	<1.00
o-Xylene	ug/L	190 [22]	242	<0.500	<0.500			103	103	<0.500	<0.500	<0.500

8/25/2009	Units	NW-1A	NW-2A	NW-1B	NW-2B	NW-3	NW-4	NW-5	NW-6	NW-7	NW-8	NW-9
		PW-1 Influent	PW-1 Eq Eff	MW-1 Influent	MW-1 Eq Eff	Combined IPC Inf	IPC Effluent	Cyanide Destruct Eff	Bag Filter Eff	GAC Midpoint	GAC Eff	Eff Storage Tank
pH	pH Units	6.73	10.4	6.16	9.65							7.89
pH Temperature	pH Units	21.4	20.3	20.8	21.3							21.3
Total Dissolved Solids	mg/L	577	1190	5030	3180							1720
Total Suspended Solids	mg/L	63	74	74	55				<5.00			<5.00
Total Organic Carbon	mg/L	30	33.5	8.67	3.74			22.8	21.1	2.04	3.07	2.03
Total Iron	ug/L					11400	2060		419 [4] [6]			337 [4] [9]
Total Manganese	ug/L					869	154		165 [4] [6]			63.9 [4] [9]
CYANIDE												
Cyanide, Total	mg/L	0.941	0.97	0.704	0.434			0.705	0.718			0.627
Cyanide, WAD	mg/L	0.0805	0.0924	0.0801	0.0765			0.0989	0.0755			0.0463
Cyanide, Amenable	mg/L	<0.0200	0.0755	0.0537	<0.0100			<0.0100	<0.0100			<0.0100
CATC, chlorinated	mg/L	1.12	0.894	0.65	0.449			0.773	0.785			0.668
Cyanide, Free	mg/L	<0.0100	<0.0100	<0.0100	<0.0100			<0.0100	<0.0100			<0.0100
CATC, total	mg/L	0.0941	0.97	0.704	0.434			0.705	0.718			0.627
Available Cyanide	mg/L	0.0066	0.0088	0.0093	0.0082			0.0088	0.0089			<0.0020
SEMI-VOLATILE ORGANICS												
Acenaphthylene	ug/L	<186 [3]	164 [3]	<0.0755 [3]	<0.0755 [3]			46.1 [3]	104 [3]	<0.0816 [3]	<0.0777 [3]	<0.0769 [3]
Acenaphthene	ug/L	<186 [3]	247 [3]	1.42 [3] [12] [14]	0.755 [3] [12] [8]			102 [3]	142 [3]	<0.0816 [3]	<0.0777 [3]	<0.0769 [3]
Anthracene	ug/L	<186 [3]	<93.0 [3]	<0.0755 [3]	<0.0755 [3]			<18.6 [3]	<18.6 [3]	<0.0816 [3]	<0.0777 [3]	<0.0769 [3]
Benz(a)anthracene	ug/L	<186 [3]	<93.0 [3]	<0.0755 [3]	<0.0755 [3]			<18.6 [3]	<18.6 [3]	<0.0816 [3]	<0.0777 [3]	<0.0769 [3]
Benzo(a)pyrene	ug/L	<209 [3] [12] [10]	<100 [3] [12] [7]	<0.0755 [3]	<0.0755 [3]			<18.6 [3]	<18.6 [3]	357 [3] [12] [8]	0.0995 [3]	55 [3] [12] [12]
Benzo(b)fluoranthene(s)	ug/L		<93.0 [3]	<0.0755 [3]	<0.0755 [3]			<18.6 [3]	<18.6 [3]	<0.0816 [3]	352 [3] [11] [6]	<0.0769 [3]
Benzo(k)fluoranthene(s)	ug/L		<93.0 [3]	<0.0755 [3]	<0.0755 [3]			<18.6 [3]	<18.6 [3]	<0.0816 [3]	777 [3] [11] [6]	<0.0769 [3]
Benzo(b+k)fluoranthene(s)	ug/L	<186 [3]										
Benzo(g,h,i)perylene	ug/L	<186 [3]	<93.0 [3]	<0.0755 [3]	<0.0755 [3]			<18.6 [3]	<18.6 [3]	<0.0816 [3]	<0.0777 [3]	<0.0769 [3]
Carbazole	ug/L	<186 [3]	114 [3]	<0.0755 [3]	<0.0755 [3]			82.9 [3]	81.7 [3]	<0.0816 [3]	<0.0777 [3]	<0.0769 [3]
Chrysene	ug/L	<186 [3]	<93.0 [3]	<0.0755 [3]	<0.0755 [3]			<18.6 [3]	<18.6 [3]	<0.0816 [3]	<0.0777 [3]	<0.0769 [3]
Dibenz(a,h)anthracene	ug/L	<186 [3]	<93.0 [3]	<0.0755 [3]	<0.0755 [3]			<18.6 [3]	<18.6 [3]	<0.0816 [3]	<0.0777 [3]	<0.0769 [3]
Dibenzofuran	ug/L	<186 [3]	<93.0 [3]	<0.0755 [3]	<0.0755 [3]			<18.6 [3]	<18.6 [3]	<0.0816 [3]	<0.0777 [3]	<0.0769 [3]
Fluoranthene	ug/L	<186 [3]	<93.0 [3]	<0.0755 [3]	<0.0755 [3]			<18.6 [3]	<18.6 [3]	<0.0816 [3]	<0.0777 [3]	<0.0769 [3]
Fluorene	ug/L	<186 [3]	107 [3]	<0.0755 [3]	<0.0755 [3]			48.4 [3]	57.4 [3]	<0.0816 [3]	<0.0777 [3]	<0.0769 [3]
Indeno(1,2,3-cd)pyrene	ug/L	<186 [3]	<93.0 [3]	<0.0755 [3]	<0.0755 [3]			<18.6 [3]	<18.6 [3]	<0.0816 [3]	<0.0777 [3]	<0.0769 [3]
2-Methylnaphthalene	ug/L	441 [3]	750 [3]	<0.0755 [3]	<0.0755 [3]			274 [3]	423 [3]	<0.0816 [3]	<0.0777 [3]	<0.0769 [3]
Naphthalene	ug/L	5880 [3]	7540 [3]	0.450 [3]	0.312 [3]			2620 [3]	4120 [3]	0.215 [3]	0.158 [3]	0.0795 [3]
Phenanthrene	ug/L	322 [3]	311 [3]	<0.0755 [3]	<0.0755 [3]			115 [3]	111 [3]	<0.0816 [3]	<0.0777 [3]	<0.0769 [3]
Pyrene	ug/L	<186 [3]	104 [3]	<0.0755 [3]	<0.0755 [3]			19.2 [3]	<18.6 [3]	<0.0816 [3]	0.0952 [3]	<0.0769 [3]
2-Chlorophenol	ug/L	<2330 [3]	<1160 [3]	<0.943 [3]	<0.943 [3]			<233 [3]	<233 [3]	<1.02 [3]	<0.971 [3]	<0.962 [3]
2,4-Dichlorophenol	ug/L	<2330 [3]	<1160 [3]	<0.943 [3]	<0.943 [3]			<233 [3]	<233 [3]	<1.02 [3]	<0.971 [3]	<0.962 [3]
2,4-Dimethylphenol	ug/L	<2330 [3]	<1160 [3]	<0.943 [3]	<0.943 [3]			<233 [3]	<233 [3]	<1.02 [3]	<0.971 [3]	<0.962 [3]
4,6-Dinitro-2-methylphenol	ug/L	<2330 [3]	<1160 [3]	<0.943 [3]	<0.943 [3]			<233 [3]	<233 [3]	<1.02 [3]	<0.971 [3]	<0.962 [3]
2-Methylphenol	ug/L	<2330 [3]	<1160 [3]	<0.943 [3]	<0.943 [3]			<233 [3]	<233 [3]	<1.02 [3]	<0.971 [3]	<0.962 [3]
2-Nitrophenol	ug/L	<2330 [3]	<1160 [3]	<0.943 [3]	<0.943 [3]			<233 [3]	<233 [3]	<1.02 [3]	<0.971 [3]	<0.962 [3]
4-Nitrophenol	ug/L	<2330 [3]	<1160 [3]	6.42 [3] [12] [14]	<0.943 [3]			<233 [3]	<233 [3]	<1.02 [3]	<0.971 [3]	<0.962 [3]
2,4,5-Trichlorophenol	ug/L	<2330 [3]	<1160 [3]	<0.943 [3]	<0.943 [3]			<233 [3]	<233 [3]	<1.02 [3]	<0.971 [3]	<0.962 [3]
2,4,6-Trichlorophenol	ug/L	<2330 [3]	<1160 [3]	<0.943 [3]	<0.943 [3]			<233 [3]	<233 [3]	<1.02 [3]	<0.971 [3]	<0.962 [3]
Pentachlorophenol (PCP)	ug/L	<2330 [3]	<1160 [3]	<0.943 [3]	<0.943 [3]			<233 [3]	<233 [3]	<1.02 [3]	<0.971 [3]	<0.962 [3]
Phenol	ug/L	<2330 [3]	<1160 [3]	<0.943 [3]	<0.943 [3]			<233 [3]	<233 [3]	<1.02 [3]	<0.971 [3]	<0.962 [3]
METALS												
Hexavalent Chromium	mg/L	<0.0100	<0.0100	<0.0100	<0.0100				<0.0100			<0.0100
Silver	ug/L	<1.00	<1.00	<1.00	<1.00				<1.00			<1.00
Arsenic	ug/L	5.03 [1] [1]		1.14 [1] [7]		2.26 [1] [1]	1.74 [1] [1]	2.57	1.50 [1] [4]		2.37	2.67 [1] [6]
Cadmium	ug/L	<1.00	<1.00	<1.00	<1.00				<1.00			<1.00
Chromium	ug/L	1.37 [1] [1]	<1.00	<1.00	<1.00				<1.00			<1.00
Copper	ug/L	<5.00	<5.00	<5.00	<5.00				15.6			<5.00
Dissolved Iron	ug/L	34000	13100	266000	6900	339 [4] [2]	337 [4] [2]		443			409
Mercury	ug/L	<0.0100	<0.0100	<0.0100	<0.0100				0.0192			<0.0100
Dissolved Manganese	ug/L	3110	1150	10000	225	12.2 [4] [2]	13.3 [4] [2]		201			67
Nickel	ug/L	1.7	<1.00	4.16	1.06				1.39			3.09
Lead	ug/L	<1.00	<1.00	<1.00	<1.00				3.48			<1.00
Selenium	ug/L	1.36 [1] [1]	<1.00	1.67 [1] [7]	3.02 [1] [5]				1.96 [1] [4]			3.94 [1] [6]
Zinc	ug/L	892	56.1	21.4	<4.00				116			6.5
Calcium	ug/L	74500	10500	482000	80700							15300
Chromium	ug/L	1.37 [1] [1]	<1.00	<1.00	<1.00				<1.00			<1.00
Hardness (Calc by 6020)	mg CaCO3/L	384	202	2430	404							234
Magnesium	ug/L	48000	42600	298000	49200							47600
Trivalent Chromium	ug/L	<11.0	<11.0	<11.0	<11.0				<11.0			<11.0
VOLATILE ORGANICS												
Acetone	ug/L	<2000	<2000	<20.0	<20.0			<1000		<20.0	<20.0	<20.0
Benzene	ug/L	8730	6590	<0.250	<0.250			2850		<0.250	<0.250	<0.250
2-Butanone (MEK)	ug/L	<1000	<1000	<10.0	<10.0			<500		<10.0	<10.0	<10.0
1,1-Dichloroethene	ug/L	<50.0	<50.0	<0.500	<0.500			<25.0		<0.500	<0.500	<0.500
cis-1,2-Dichloroethene	ug/L	<50.0	<50.0	<0.500	<0.500			<25.0		<0.500	<0.500	<0.500
trans-1,2-Dichloroethene	ug/L	<50.0	<50.0	<0.500	<0.500			<25.0		<0.500	<0.500	<0.500
Ethylbenzene	ug/L	733	602	<0.500	<0.500			234		<0.500	<0.500	<0.500
Tetrachloroethene (PCE)	ug/L	<50.0	<50.0	<0.500	<0.500			<25.0		<0.500	<0.500	<0.500
Toluene	ug/L	179	152	<0.500	<0.500			65.5		<0.500	<0.500	<0.500
Trichloroethene (TCE)	ug/L	<50.0	<50.0	<0.500	<0.500			<25.0		<0.500	<0.500	<0.500
Vinyl chloride	ug/L	<50.0	<50.0	<0.500	<0.500			<25.0		<0.500	<0.500	<0.500
m,p-Xylene	ug/L	285	330	<1.00	<1.00			132		<1.00	<1.00	<1.00
o-Xylene	ug/L	162	190	<0.500	<0.500			77.5		<0.500	<0.500	<0.500

08/26/09	Units	NW-1A	NW-2A	NW-1B	NW-2B	NW-3	NW-4	NW-5	NW-6	NW-7	NW-8	NW-9
		PW-1 Influent	PW-1 Eq Eff	MW-1 Influent	MW-1 Eq Eff	Combined IPC Inf	IPC Effluent	Cyanide Destruct Eff	Bag Filter Eff	GAC Midpoint	GAC Eff	Eff Storage Tank
pH	pH Units	6.65	10.2	6.08	9.92							7.95
pH Temperature	pH Units	20.7	20.7	21.5	21							21.8
Total Dissolved Solids	mg/L	537	1270	4780	3490							1360
Total Suspended Solids	mg/L	49	43	86	3530				5			<5.00
Total Organic Carbon	mg/L	25	28	4.69	14.6			30.8	29	<2.00	<2.00	3.97
Total Iron	ug/L					344000	1260					279 [5] [9]
Total Manganese	ug/L					11900	50.2					9.44 [5] [9]
CYANIDE												
Cyanide, Total	mg/L	1.04	0.977	0.702	0.585			0.708	0.763			0.554
Cyanide, WAD	mg/L	0.1	0.094	0.0874	0.0498			0.0789	0.0801			0.0441
Cyanide, Amenable	mg/L	<0.0200	<0.0200	<0.0100	<0.0300			<0.0100	<0.0100			<0.0100
CATC, chlorinated	mg/L	1.07	0.961	0.725	0.739			0.806	0.854			0.584
Cyanide, Free	mg/L	<0.0100	<0.0100	<0.0100	<0.0100			<0.0100	<0.0100			<0.0100
CATC, total	mg/L	1.04	0.977	0.702	0.585			0.708	0.763			0.554
SEMI-VOLATILE ORGANICS												
Acenaphthylene	ug/L	88.4 [4]	179 [4]	<0.0748 [4]	<0.100 [4]			<18.6 [4]	52.2 [4]	<0.0777 [4]	<0.0769 [4]	<0.0792 [4]
Acenaphthene	ug/L	171 [4]	257 [4]	1.12 [4] [17] [14]	<0.100 [4]			85.7 [4]	126 [4]	<0.0777 [4]	<0.0769 [4]	<0.0792 [4]
Anthracene	ug/L	71.4 [4]	<37.2 [4]	<0.0748 [4]	<0.100 [4]			<18.6 [4]	<18.6 [4]	<0.0777 [4]	<0.0769 [4]	<0.0792 [4]
Benz(a)anthracene	ug/L	69.2 [4]	<37.2 [4]	<0.0748 [4]	<0.100 [4]			<18.6 [4]	<18.6 [4]	<0.0777 [4]	<0.0769 [4]	<0.0792 [4]
Benzo(a)pyrene	ug/L	88.4 [4]	46.3 [4]	<0.0748 [4]	<0.100 [4]			<18.6 [4]	<18.6 [4]	0.0926 [4]	308 [4] [17] [8]	32 [4] [17] [12]
Benzo(b)fluoranthene(s)	ug/L			<0.0748 [4]	<0.100 [4]			<18.6 [4]	<18.6 [4]		<0.0769 [4]	<0.0792 [4]
Benzo(k)fluoranthene(s)	ug/L			<0.0748 [4]	<0.100 [4]			<18.6 [4]	<18.6 [4]		<0.0769 [4]	<0.0792 [4]
Benzo(b+k)fluoranthene(s)	ug/L	84.6 [4] [15] [9]							<0.155 [4] [15] [6]			
Benzo(g,h,i)perylene	ug/L	49.0 [4]		<0.0748 [4]	<0.100 [4]			<18.6 [4]	<18.6 [4]	<0.0777 [4]	<0.0769 [4]	<0.0792 [4]
Carbazole	ug/L	55.1 [4]	<74.4 [4] [15] [6]	<0.0748 [4]	<0.100 [4]			36.9 [4]	79.6 [4]	<0.0777 [4]	<0.0769 [4]	<0.0792 [4]
Chrysene	ug/L	69.4 [4]	<37.2 [4]	<0.0748 [4]	<0.100 [4]			<18.6 [4]	<18.6 [4]	<0.0777 [4]	<0.0769 [4]	<0.0792 [4]
Dibenz(a,h)anthracene	ug/L	<37.2 [4]	129 [4]	<0.0748 [4]	<0.100 [4]			<18.6 [4]	<18.6 [4]	<0.0777 [4]	<0.0769 [4]	<0.0792 [4]
Dibenzofuran	ug/L	<37.2 [4]	<37.2 [4]	<0.0748 [4]	<0.100 [4]			<18.6 [4]	<18.6 [4]	<0.0777 [4]	<0.0769 [4]	<0.0792 [4]
Fluoranthene	ug/L	254 [4]	<37.2 [4]	<0.0748 [4]	<0.100 [4]			<18.6 [4]	<18.6 [4]	0.106 [4]	<0.0769 [4]	<0.0792 [4]
Fluorene	ug/L	99.6 [4]	<37.2 [4]	<0.0748 [4]	<0.100 [4]			48.6 [4]	55.1 [4]	<0.0777 [4]	<0.0769 [4]	<0.0792 [4]
Indeno(1,2,3-cd)pyrene	ug/L	55.9 [4]	70.1 [4]	<0.0748 [4]	<0.100 [4]			<18.6 [4]	<18.6 [4]	<0.0777 [4]	<0.0769 [4]	<0.0792 [4]
2-Methylnaphthalene	ug/L	334 [4]	109 [4]	<0.0748 [4]	<0.100 [4]			325 [4]	385 [4]	<0.0777 [4]	<0.0769 [4]	<0.0792 [4]
Naphthalene	ug/L	3030 [4]	<37.2 [4]	0.214 [4]	0.484 [4]			3350 [4]	3890 [4]	0.327 [4]	0.142 [4]	<0.0792 [4]
Phenanthrene	ug/L	540 [4]	823 [4]	<0.0748 [4]	<0.100 [4]			97.6 [4]	116 [4]	0.0848 [4]	<0.0769 [4]	<0.0792 [4]
Pyrene	ug/L	307 [4]	7770 [4]	<0.0748 [4]	<0.100 [4]			<18.6 [4]	<18.6 [4]	0.148 [4]	<0.0769 [4]	<0.0792 [4]
2-Chlorophenol	ug/L	<465 [4]	278 [4]	<0.935 [4]	<1.25 [4]			<233 [4]	<233 [4]	<0.971 [4]	<0.962 [4]	<0.990 [4]
2,4-Dichlorophenol	ug/L	<465 [4]	82.5 [4]	<0.935 [4]	<1.25 [4]			<233 [4]	<233 [4]	<0.971 [4]	<0.962 [4]	<0.990 [4]
2,4-Dimethylphenol	ug/L	<465 [4]	<465 [4]	<0.935 [4]	<1.25 [4]			<233 [4]	<233 [4]	<0.971 [4]	<0.962 [4]	<0.990 [4]
4,6-Dinitro-2-methylphenol	ug/L	<465 [4]	<465 [4]	<0.935 [4]	<1.25 [4]			<233 [4]	<233 [4]	<0.971 [4]	<0.962 [4]	<0.990 [4]
2-Methylphenol	ug/L	<465 [4]	<465 [4]	<0.935 [4]	<1.25 [4]			<233 [4]	<233 [4]	<0.971 [4]	<0.962 [4]	<0.990 [4]
2-Nitrophenol	ug/L	<465 [4]	<465 [4]	<0.935 [4]	<1.25 [4]			<233 [4]	<233 [4]	<0.971 [4]	<0.962 [4]	<0.990 [4]
4-Nitrophenol	ug/L	<465 [4]	<465 [4]	<0.935 [4]	<1.25 [4]			<233 [4]	<233 [4]	<0.971 [4]	<0.962 [4]	<0.990 [4]
2,4,5-Trichlorophenol	ug/L	<465 [4]	<465 [4]	<0.935 [4]	<1.25 [4]			<233 [4]	<233 [4]	<0.971 [4]	<0.962 [4]	<0.990 [4]
2,4,6-Trichlorophenol	ug/L	<465 [4]	<465 [4]	<0.935 [4]	<1.25 [4]			<233 [4]	<233 [4]	<0.971 [4]	<0.962 [4]	<0.990 [4]
Pentachlorophenol (PCP)	ug/L	<465 [4]	<465 [4]	<0.935 [4]	<1.25 [4]			<233 [4]	<233 [4]	<0.971 [4]	<0.962 [4]	<0.990 [4]
Phenol	ug/L	<465 [4]	<465 [4]	<0.935 [4]	<1.25 [4]			<233 [4]	<233 [4]	<0.971 [4]	<0.962 [4]	<0.990 [4]
METALS												
Hexavalent Chromium	mg/L	0.0626	<0.0100 [1] [2]	<0.0100	<0.0100				<0.0100			<0.0100
Silver	ug/L	<1.00	<1.00	<1.00	<1.00				<1.00			<1.00
Arsenic	ug/L	4.49	<1.00	1.2		4.21	1.41	2.03 [2] [3]	2.09		2.34 [2] [3]	2.79
Cadmium	ug/L	<1.00	1.17	<1.00	<1.00				<1.00			<1.00
Chromium	ug/L	1.9		<1.00	5.66				<1.00			<1.00
Copper	ug/L	<5.00	<5.00	18.5	7.99				<5.00			<5.00
Dissolved Iron	ug/L	32900	6780	263000	925000	323 [5] [2]	298 [5] [2]		904			432
Mercury	ug/L	<0.0100	<0.0100	<0.0100	<0.0100				<0.0100			<0.0100
Dissolved Manganese	ug/L	2990	624	9920	32300	1.94 [5] [2]	2.79 [5] [2]		53.7			11.5
Nickel	ug/L	2	<1.00	5.86	16.6				<1.00			2.57
Lead	ug/L	<1.00	<1.00	1.01	<1.00				<1.00			<1.00
Selenium	ug/L	1.74	1.49	2.24	2.64				2.64			4.5
Zinc	ug/L	156	20.9	19.1	26.3				8.62			9.11
Calcium	ug/L	68900	11000	470000	1390000							8540
Chromium	ug/L											
Hardness (Calc by 6020)	mg CaCO3/L	354	194	2380	6920							204
Magnesium	ug/L	44100	40400	293000	838000							44500
Trivalent Chromium	ug/L	<11.0	<11.0	<11.0	<11.0				<11.0			<11.0
VOLATILE ORGANICS												
Acetone	ug/L	<2000	<2000	<20.0				<1000	<1000	<20.0	<20.0	<20.0
Benzene	ug/L	8080	6150	<0.250				2100	3300	1.12	<0.250	<0.250
2-Butanone (MEK)	ug/L	<1000	<1000	<10.0				<500	<500	<10.0	<10.0	<10.0
1,1-Dichloroethene	ug/L	<50.0	<50.0	<0.500				<25.0	<25.0	<0.500	<0.500	<0.500
cis-1,2-Dichloroethene	ug/L	<50.0	<50.0	<0.500				<25.0	<25.0	<0.500	<0.500	<0.500
trans-1,2-Dichloroethene	ug/L	<50.0	<50.0	<0.500				<25.0	<25.0	<0.500	<0.500	<0.500
Ethylbenzene	ug/L	888	669	<0.500				186	330	<0.500	<0.500	<0.500
Tetrachloroethene (PCE)	ug/L	<50.0	<50.0	<0.500				<25.0	<25.0	<0.500	<0.500	<0.500
Toluene	ug/L	235	159	<0.500				47	80.5	<0.500	<0.500	<0.500
Trichloroethene (TCE)	ug/L	<50.0	<50.0	<0.500				<25.0	<25.0	<0.500	<0.500	<0.500
Vinyl chloride	ug/L	<50.0	<50.0	<0.500				<25.0	<25.0	<0.500	<0.500	<0.500
m,p-Xylene	ug/L	380	372	<1.00				91	178	<1.00	<1.00	<1.00
o-Xylene	ug/L	194	187	<0.500				56	110	<0.500	<0.500	<0.500

Attachment E: NW Natural Pilot Plant Results—By Sample Point

PW-1 Influent	08/26/09	08/25/09	08/21/09	08/19/09	08/18/09	08/12/09	08/11/09	08/07/09	08/03/09	07/23/09	Units	Min	Max
pH	6.65	6.73	6.72	6.55	6.57	6.54	6.79	6.74	6.53	6.73	pH Units	6.53	6.79
pH Temperature	20.7	21.4	27.6	24.9	14.8	20.2	20.1	16.9	20.3	14.2	pH Units	14.2	27.6
Total Dissolved Solids	537	577	505	551	514	529	493	573	548	553	mg/L	493	577
Total Suspended Solids	49	63	79	65	82	102	37	58	68	39	mg/L	37	102
Total Organic Carbon	25	30	26.3	27.1	29.8	29.9	49.6	21.8	26	31.6	mg/L	21.8	49.6
Total Iron				4330							ug/L		
Total Manganese				2810							ug/L		
CYANIDE													
Cyanide, Total	1.04	0.941	0.873	1.05	1.22	0.586	0.892	0.926	1.09	1.11	mg/L	0.586	1.22
Cyanide, WAD	0.1	0.0805	0.0607	0.0723	0.0972	0.067	0.0722	0.125	0.114	0.136	mg/L	0.0607	0.136
Cyanide, Amenable	<0.0200	<0.0200	<0.0150	0.0392	<0.0500	<0.0100	<0.0250	<0.0250	<0.0500	<0.0500	mg/L	<0.0100	<0.0500
CATC, chlorinated	1.07	1.12	0.939	1.01	1.27	0.847	0.938	0.933	1.06	1.08	mg/L	0.847	1.27
Cyanide, Free	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	mg/L	<0.0100	<0.0100
CATC, total	1.04	0.0941	0.873	1.05	1.22	0.586	0.892	0.926	1.09	1.11	mg/L	0.586	1.22
Available Cyanide		0.0030	0.0066			0.0060		0.0110			mg/L	0.0030	0.0110
SEMI-VOLATILE ORGANICS													
Acenaphthylene	88.4 [4]	<186 [3]	<372 [6]	<190 [3]	736 [6]	1580 [6]	413 [6]	<381 [3]	396	125 [4] [5] [5]	ug/L	88.4 [4]	1580 [6]
Acenaphthene	171 [4]	<186 [3]	538 [6]	284 [3]	1170 [6]	2730 [6]	658 [6]	404 [3]	529	193 [4] [5] [5]	ug/L	171 [4]	2730 [6]
Anthracene	71.4 [4]	<186 [3]	<372 [6]	<190 [3]	642 [6]	1470 [6]	455 [6]	<381 [3]	99.8	45.2 [4]	ug/L	45.2 [4]	1470 [6]
Benz(a)anthracene	69.2 [4]	<186 [3]	<372 [6]	250 [3]	634 [6]	1300 [6]	503 [6]	<381 [3]	50.5 [14] [7]	23.7 [4] [6] [7]	ug/L	23.7 [4] [6] [7]	1300 [6]
Benzo(a)pyrene	88.4 [4]	<209 [3] [12] [10]	686 [6]	361 [3]	1070 [6]	1720 [6]	894 [6]	724 [3]	68.3	29.0 [4]	ug/L	29.0 [4]	1720 [6]
Benzo(b+k)fluoranthene(s)	84.6 [4] [15] [9]	<186 [3]	<744 [6] [16] [9]	406 [3] [15] [9]	1240 [6] [19] [9]	2200 [6] [15] [9]	1080 [6] [16] [9]	<762 [3] [12] [9]	83.9 [24] [9]	32.5 [4] [16] [9]	ug/L	32.5 [4] [16] [9]	2200 [6] [15] [9]
Benzo(g,h,i)perylene	49.0 [4]	<186 [3]	389 [6]	<190 [3]	602 [6]	1160 [6]	621 [6]	397 [3]	57	23.8 [4]	ug/L	23.8 [4]	1160 [6]
Carbazole	55.1 [4]	<186 [3]	<372 [6]	<190 [3]	498 [6]	636 [6]	385 [6]	<381 [3]	378	184 [4] [5] [5]	ug/L	55.1 [4]	636 [6]
Chrysene	69.4 [4]	<186 [3]	<372 [6]	<190 [3]	588 [6]	1370 [6]	605 [6]	<381 [3]	58.8	26.0 [4]	ug/L	26.0 [4]	1370 [6]
Dibenz(a,h)anthracene	<37.2 [4]	<186 [3]	<372 [6]	<190 [3]	<381 [6]	<372 [6]	<372 [6]	<381 [3]	<9.52	2.50 [4]	ug/L	2.50 [4]	<381 [6]
Dibenzofuran	<37.2 [4]	<186 [3]	<372 [6]	<190 [3]	<381 [6]	<372 [6]	<372 [6]	<381 [3]	45.1	21.5 [4]	ug/L	21.5 [4]	<381 [3]
Fluoranthene	254 [4]	<186 [3]	979 [6]	602 [3]	1900 [6]	4270 [6]	1690 [6]	838 [3]	208	90.7 [4]	ug/L	90.7 [4]	4270 [6]
Fluorene	99.6 [4]	<186 [3]	<372 [6]	<190 [3]	710 [6]	1640 [6]	397 [6]	<381 [3]	237	61.9 [4] [5] [5]	ug/L	61.9 [4] [5] [5]	1640 [6]
Indeno(1,2,3-cd)pyrene	55.9 [4]	<186 [3]	<372 [6]	<190 [3]	419 [6]	952 [6]	<372 [6]	<381 [3]	45.5	20.7 [4]	ug/L	20.7 [4]	952 [6]
2-Methylnaphthalene	334 [4]	441 [3]	1020 [6]	538 [3]	2600 [6]	6110 [6]	928 [6]	742 [3]	1260	595 [1] [3] [4] [1] [3]	ug/L	334 [4]	6110 [6]
Naphthalene	3030 [4]	5880 [3]	8640 [3] [4] [6] [1] [2]	4360 [1] [3] [1]	15900 [4] [6] [1]	31100 [4] [6] [1]	5520 [3] [6] [1]	6280 [3]	14200 [9] [1]	8000 [1] [3] [4] [1] [3]	ug/L	3030 [4]	31100 [4] [6] [1]
Phenanthrene	540 [4]	322 [3]	1900 [6]	1130 [3]	4030 [6]	9510 [6]	3130 [6]	1450 [3]	808	220 [4] [5] [5]	ug/L	220 [4] [5] [5]	9510 [6]
Pyrene	307 [4]	<186 [3]	1160 [6]	745 [3]	2290 [6]	5190 [6]	1990 [6]	947 [3]	242	103 [4] [5] [5]	ug/L	103 [4] [5] [5]	5190 [6]
2-Chlorophenol	<465 [4]	<2330 [3]	<4650 [6]	<2380 [3]	<4760 [6]	<4650 [6]	<4650 [6]	<4760 [3]	<119	<3.92 [4]	ug/L	<3.92 [4]	<4760 [6]
2,4-Dichlorophenol	<465 [4]	<2330 [3]	<4650 [6]	<2380 [3]	<4760 [6]	<4650 [6]	<4650 [6]	<4760 [3]	<119	<3920 [4]	ug/L	<119	<4760 [3]
2,4-Dimethylphenol	<465 [4]	<2330 [3]	<4650 [6]	<2380 [3]	<4760 [6]	<4650 [6]	<4650 [6]	<4760 [3]	<119	<3920 [4]	ug/L	<119	<4760 [3]
4,6-Dinitro-2-methylphenol	<465 [4]	<2330 [3]	<4650 [6]	<2380 [3]	<4760 [6]	<4650 [6]	<4650 [6]	<4760 [3]	<119	<3.92 [4]	ug/L	<3.92 [4]	<4760 [3]
2-Methylphenol	<465 [4]	<2330 [3]	<4650 [6]	<2380 [3]	<4760 [6]	<4650 [6]	<4650 [6]	<4760 [3]	<119	<3.92 [4]	ug/L	<3.92 [4]	<4760 [3]
2-Nitrophenol	<465 [4]	<2330 [3]	<4650 [6]	<2380 [3]	<4760 [6]	<4650 [6]	<4650 [6]	<4760 [3]	<119	<3920 [4] [15] [8]	ug/L	<119	<4760 [3]
4-Nitrophenol	<465 [4]	<2330 [3]	<4650 [6]	<2380 [3]	<4760 [6]	<4650 [6]	<4650 [6]	<4760 [3]	<119	<3.92 [4]	ug/L	<3.92 [4]	<4760 [3]
2,4,5-Trichlorophenol	<465 [4]	<2330 [3]	<4650 [6]	<2380 [3]	<4760 [6]	<4650 [6]	<4650 [6]	<4760 [3]	<119	<3.92 [4]	ug/L	<3.92 [4]	<4760 [3]
2,4,6-Trichlorophenol	<465 [4]	<2330 [3]	<4650 [6]	<2380 [3]	<4760 [6]	<4650 [6]	<4650 [6]	<4760 [3]	<119	<3.92 [4]	ug/L	<3.92 [4]	<4760 [3]
Pentachlorophenol (PCP)	<465 [4]	<2330 [3]	<4650 [6]	<2380 [3]	<4760 [6]	<4650 [6]	<4650 [6]	<4760 [3]	<119	<3.92 [4]	ug/L	<3.92 [4]	<4760 [3]
Phenol	<465 [4]	<2330 [3]	<4650 [6]	<2380 [3]	<4760 [6]	<4650 [6]	<4650 [6]	<4760 [3]	<119	5.38 [4]	ug/L	5.38 [4]	<4760 [3]
METALS													
Hexavalent Chromium	0.0626	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0200		<0.0100	mg/L	<0.0100	0.0626
Silver	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Arsenic	4.49	5.03 [1] [1]	5.13 [3] [1]	4.22 [1] [1]	4.56	4.57	4.48	5.11	4.46	3.92	ug/L	3.92	5.13 [3] [1]
Cadmium	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Chromium	1.9	1.37 [1] [1]	2.38	1.22	2.34	1.38	1.04	2.18	1.66	5.48	ug/L	1.04	5.48
Copper	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	ug/L	<5.00	<5.00
Dissolved Iron	32900	34000	31400	30800	34000	29600	29600	33800	32400	27800	ug/L	27800	34000
Mercury	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	ug/L	<0.0100	<0.0100
Dissolved Manganese	2990	3110	2940	2790	3160	2860	3080	3320	3150	3100	ug/L	2790	3320
Nickel	2	1.7	2.92	1.41	1.57	1.26	1.36	2.33	<1.00	3.03	ug/L	<1.00	3.03
Lead	<1.00	<1.00	1.51	<1.00	<1.00	<1.00	<1.00	3.69	<1.00	5.52	ug/L	<1.00	5.52
Selenium	1.74	1.36 [1] [1]	<1.00	<1.00	<1.00	1.09	1.41	1.27	<1.00	1.61	ug/L	<1.00	1.74
Zinc	156	892	98.8	1500	301	151	339	1210	492	441	ug/L	98.8	1500
Calcium	68900	74500	67900	74400	74100	64400	64800	76000	77700	78300	ug/L	64400	78300
Chromium		1.37 [1] [1]									ug/L	1.37 [1] [1]	1.37 [1] [1]
Hardness (Calc by 6020)	354	384	346	376	384	345	343	391	396	412	mg CaCO3/L	343	412
Magnesium	44100	48000	42900	46200	48300	44700	44100	49000	48900	52700	ug/L	42900	52700
Trivalent Chromium	<11.0	<11.0	<11.0	<11.0	<11.0	<11.0	<11.0	<21.0	1.66	<11.0	ug/L	1.66	<21.0
VOLATILE ORGANICS													
Acetone	<2000	<2000	<2000 [22]	<2000	<2000	<2000	<2000	<2000	<4000 [32]	<10000	ug/L	<2000	<10000
Benzene	8080	8730	7880 [22]	8390	9070	8690	9060	9100	7820 [32]	7540	ug/L	7540	9100
2-Butanone (MEK)	<1000	<1000	<1000 [22]	<1000	<1000	<1000	<1000	<1000	<2000 [32]	<5000	ug/L	<1000	<5000
1,1-Dichloroethene	<50.0	<50.0	<50.0 [22]	<50.0	<50.0	<50.0	<50.0	<50.0	<100 [32]	<250	ug/L	<50.0	<250
cis-1,2-Dichloroethene	<50.0	<50.0	<50.0 [22]	<50.0	<50.0	<50.0	<50.0	<50.0	<100 [32]	<250	ug/L	<50.0	<250
trans-1,2-Dichloroethene	<50.0	<50.0	<50.0 [22]	<50.0	<50.0	<50.0	<50.0	<50.0	<100 [32]	<250	ug/L	<50.0	<250
Ethylbenzene	888	733	808 [22]	827	1090	1220	798	988	752 [32]	620	ug/L	620	1220
Tetrachloroethene (PCE)	<50.0	<50.0	<50.0 [22]	<50.0	<50.0	<50.0	<50.0	<50.0	<100 [32]	<250	ug/L	<50.0	<250
Toluene	235	179	224 [22]	235	290	248	317	367	152 [32]	<250	ug/L	152 [32]	367
Trichloroethene (TCE)	<50.0	<50.0	<50.0 [22]	<50.0	<50.0	<50.0	<50.0	<50.0	<100 [32]	<250	ug/L	<50.0	<250
Vinyl chloride	<50.0	<50.0	<50.0 [22]	<50.0	<50.0	<50.0	<50.0	<50.0	<100 [32]	<250	ug/L	<50.0	<250
m,p-Xylene	380	285	374 [22]	378	561	596	360	474	364 [32]	<500	ug/L	285	596
o-Xylene	194	162	190 [22]	194	282	306	195	229	200 [32]	<250	ug/L	162	306

FootNumber	TextBody	Qualifier
1	Analyte detected in the associated extraction blank.	B
2	Analyte detected in the extraction blank at a level greater than the MRL. All associated samples contain the same analyte at a level that is greater than 10 times the method blank.	B-01
3	Analyte was detected in the associated extraction blank at a level greater than the MRL. The result for the analyte in this sample is greater than 5 times the result in the extraction blank.	B-04
4	Extract has undergone a GPC (Gel-Permeation Chromotography) cleanup per EPA 3640A.	C-05
5	Estimated Value. The result is above the calibration range of the instrument.	E
6	Estimated Result . Result detected below the lowest point of the calibration curve, but above the statistical MDL.	J
7	Due to matrix interference, this analyte cannot be accurately quantified. The reported result is estimated.	M-02
8	Recovery of Continuing Calibration Verification standard was above acceptable limits. Analyte was not detected in reported client samples, therefore Data Quality is not affected.	Q-25
9	Peak separation for Benzo(b) and Benzo(k)fluoranthenes does not meet method specified criteria. Reported result includes the combined area of the two isomers and should be considered the total of Benzo(b+k)Fluoranthenes.	Q-26
10	The Reporting Limit for this analyte has been raised to account for matrix interference.	R-01
11	Surrogate recovery for this sample is not available due to sample dilution required from high analyte concentration and/or matrix interference.	S-01
12	Surrogate recovery cannot be accurately quantified due to interference from coeluting organic compounds present in the sample extract.	S-02
13	Surrogate recovery is outside of established control limits due to a sample matrix effect.	S-04
14	Surrogate recovery cannot be accurately quantified due to sample dilution required from high analyte concentration and/or matrix interference.	S-05
15	Surrogate recovery is outside of established control limits.	S-06
16	Sample aliquot taken from VOA vial with headspace (air bubble greater than 6 mm diameter).	V-01

MW-1 Influent	08/26/09	08/25/09	08/21/09	08/19/09	08/18/09	08/12/09	08/11/09	08/07/09	08/03/09	07/23/09	Units	Min	Max
pH	6.08	6.16	6.2	6.08	6.08	6.17	6.26	6.32	6.09	6.17	pH Units	6.08	6.32
pH Temperature	21.5	20.8	27.5	24.8	17.5	21.3	20.6	18.7	20.7	13.3	pH Units	13.3	27.5
Total Dissolved Solids	4780	5030	4100	4080	4460	3340	3310	3000	2760	3080	mg/L	2760	5030
Total Suspended Solids	86	74	122	101	86	140	67	63	107	184	mg/L	63	184
Total Organic Carbon	4.69	8.67	2.21	<2.00	7.59	7.33	6.81	4.07	6.34 [1] [1]	7.82	mg/L	<2.00	8.67
CYANIDE													
Cyanide, Total	0.702	0.704	0.587	0.493	0.679	0.377	0.47	0.257	0.368	0.408	mg/L	0.257	0.704
Cyanide, WAD	0.0874	0.0801	0.0619	0.0634	0.0845	0.06	0.0591	0.111	0.0583	0.0559	mg/L	0.0591	0.111
Cyanide, Amenable	<0.0100	0.0537	<0.0100	<0.0100	0.0304	<0.0100	<0.00500	<0.0500	0.169	0.0887	mg/L	<0.00500	0.0887
CATC, chlorinated	0.725	0.65	0.589	0.544	0.649	0.586	0.467	1.09	0.2	0.32	mg/L	0.2	1.09
Cyanide, Free	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	mg/L	<0.0100	<0.0100
CATC, total	0.702	0.704	0.587	0.493	0.679	0.377	0.47	0.257	0.368	0.408	mg/L	0.257	0.704
Available Cyanide		0.0093	0.0120			0.0051		0.0083			mg/L	0.0051	0.0120
SEMI-VOLATILE ORGANICS													
Acenaphthylene	<0.0748 [4]	<0.0755 [3]	<0.0755 [6]	<0.0777 [3]	<0.0784 [6]	0.0954 [6]	0.347 [6]	<1.90 [3]	<1.95	0.0993	ug/L	<0.0755 [3]	<1.95
Acenaphthene	<1.12 [4] [17] [14]	<1.42 [3] [12] [14]	<0.0755 [6]	<0.0777 [3]	<0.0784 [6]	<1.35 [6] [16] [14]	1.51 [6] [8] [10]	<1.90 [3]	<1.95	0.162	ug/L	<0.0755 [6]	<1.95
Anthracene	<0.0748 [4]	<0.0755 [3]	<0.0755 [6]	<0.0777 [3]	<0.0784 [6]	<0.0833 [6]	0.128 [6]	<1.90 [3]	<1.95	<0.0777	ug/L	<0.0748 [4]	<1.95
Benz(a)anthracene	<0.0748 [4]	<0.0755 [3]	<0.0755 [6]	<0.0777 [3]	<0.0784 [6]	<0.0833 [6]	<0.0755 [6]	<1.90 [3]	<1.95	<0.0777	ug/L	<0.0748 [4]	<1.95
Benzo(a)pyrene	<0.0748 [4]	<0.0755 [3]	<0.0755 [6]	<0.0874 [3] [16] [14]	<0.0980 [6] [20] [14]	<0.110 [6] [16] [14]	0.106 [6]	<2.14 [3] [14] [14]	<1.95	0.0832	ug/L	<0.0748 [4]	<2.14 [3] [14] [14]
Benzo(b)fluoranthene	<0.0748 [4]	<0.0755 [3]	<0.0755 [6]	<0.0777 [3]	<0.0882 [6] [20] [14]	<0.0833 [6]	<0.151 [6] [16] [11]	<1.90 [3]	<1.95	0.088	ug/L	<0.0748 [4]	<1.95
Benzo(k)fluoranthene	<0.0748 [4]	<0.0755 [3]	<0.0755 [6]	<0.0777 [3]	<0.0784 [6]	<0.0833 [6]	<0.151 [6] [16] [11]	<1.90 [3]	<1.95	<0.0777	ug/L	<0.0748 [4]	<1.90 [3]
Benzo(g,h,i)perylene	<0.0748 [4]	<0.0755 [3]	<0.0755 [6]	<0.0777 [3]	<0.0784 [6]	<0.0833 [6]	<0.0755 [6]	<1.90 [3]	<1.95	0.0943	ug/L	<0.0748 [4]	<1.95
Carbazole	<0.0748 [4]	<0.0755 [3]	<0.0755 [6]	<0.0777 [3]	<0.0784 [6]	<0.0833 [6]	0.170 [6]	<1.90 [3]	<1.95	0.0857	ug/L	<0.0748 [4]	<1.95
Chrysene	<0.0748 [4]	<0.0755 [3]	<0.0755 [6]	<0.0777 [3]	<0.0784 [6]	<0.0833 [6]	<0.0755 [6]	<1.90 [3]	<1.95	<0.0777	ug/L	<0.0748 [4]	<1.95
Dibenz(a,h)anthracene	<0.0748 [4]	<0.0755 [3]	<0.0755 [6]	<0.0777 [3]	<0.0784 [6]	<0.0833 [6]	<0.0755 [6]	<1.90 [3]	<1.95	<0.0777	ug/L	<0.0748 [4]	<1.95
Dibenzofuran	<0.0748 [4]	<0.0755 [3]	<0.0755 [6]	<0.0777 [3]	<0.0784 [6]	<0.0833 [6]	<0.0755 [6]	<1.90 [3]	<1.95	<0.0777	ug/L	<0.0748 [4]	<1.95
Fluoranthene	<0.0748 [4]	<0.0755 [3]	<0.0755 [6]	<0.0777 [3]	0.184 [6]	0.167 [6]	0.214 [6]	<1.90 [3]	<1.95	0.199	ug/L	0.167 [6]	<1.95
Fluorene	<0.0748 [4]	<0.0755 [3]	<0.0755 [6]	<0.0777 [3]	<0.0784 [6]	0.120 [6]	0.317 [6]	<1.90 [3]	<1.95	0.166	ug/L	<0.0748 [4]	<1.95
Indeno(1,2,3-cd)pyrene	<0.0748 [4]	<0.0755 [3]	<0.0755 [6]	<0.0777 [3]	<0.0784 [6]	<0.0833 [6]	<0.0755 [6]	<1.90 [3]	<1.95	<0.0777	ug/L	<0.0748 [4]	<1.95
2-Methylnaphthalene	<0.0748 [4]	<0.0755 [3]	<0.0755 [6]	<0.0777 [3]	<0.0784 [6]	0.283 [6]	1.25 [6]	<1.90 [3]	5.67	0.153	ug/L	<0.0748 [4]	5.67
Naphthalene	0.214 [4]	0.450 [3]	0.331 [1] [3] [6] [2] [7]	0.271 [1] [3] [7]	0.302 [3] [4] [6] [4] [7]	0.654 [4] [6] [7]	5.15 [3] [6] [7]	4.59 [3]	56.0 [9] [7]	0.676	ug/L	0.214 [4]	56.0 [9] [7]
Phenanthrene	<0.0748 [4]	<0.0755 [3]	<0.0755 [6]	0.0892 [3]	0.438 [6]	0.521 [6]	1.01 [6]	<1.90 [3]	<1.95	0.589	ug/L	0.589	<1.95
Pyrene	<0.0748 [4]	<0.0755 [3]	<0.0755 [6]	<0.0777 [3]	0.188 [6]	0.180 [6]	0.223 [6]	<1.90 [3]	<1.95	0.223	ug/L	<0.0755 [3]	<1.95
2-Chlorophenol	<0.935 [4]	<0.943 [3]	<0.943 [6]	<0.971 [3]	<0.980 [6]	<1.04 [6]	<0.943 [6]	<23.8 [3]	<24.4	<0.971	ug/L	<0.943 [3]	<24.4
2,4-Dichlorophenol	<0.935 [4]	<0.943 [3]	<0.943 [6]	<0.971 [3]	<0.980 [6]	<1.04 [6]	<0.943 [6]	<23.8 [3]	<24.4	<0.971	ug/L	<0.935 [4]	<24.4
2,4-Dimethylphenol	<0.935 [4]	<0.943 [3]	<0.943 [6]	<0.971 [3]	<0.980 [6]	<1.04 [6]	<0.943 [6]	<23.8 [3]	<24.4	<0.971	ug/L	<0.935 [4]	<24.4
4,6-Dinitro-2-methylphenol	<0.935 [4]	<0.943 [3]	<0.943 [6]	<0.971 [3]	<0.980 [6]	<1.04 [6]	<0.943 [6]	<23.8 [3]	<24.4	<0.971	ug/L	<0.935 [4]	<24.4
2-Methylphenol	<0.935 [4]	<0.943 [3]	<0.943 [6]	<0.971 [3]	<0.980 [6]	<1.04 [6]	<0.943 [6]	<23.8 [3]	<24.4	<0.971	ug/L	<0.935 [4]	<24.4
2-Nitrophenol	<0.935 [4]	<0.943 [3]	<0.943 [6]	<0.971 [3]	<0.980 [6]	<1.04 [6]	<0.943 [6]	<23.8 [3]	<24.4	<0.971	ug/L	<0.935 [4]	<24.4
4-Nitrophenol	<0.935 [4]	<6.42 [3] [12] [14]	<0.943 [6]	<0.971 [3]	<0.980 [6]	<1.04 [6]	<0.943 [6]	<23.8 [3]	<24.4	<0.971	ug/L	<0.935 [4]	<24.4
2,4,5-Trichlorophenol	<0.935 [4]	<0.943 [3]	<0.943 [6]	<0.971 [3]	<0.980 [6]	<1.04 [6]	<0.943 [6]	<23.8 [3]	<24.4	<0.971	ug/L	<0.935 [4]	<24.4
2,4,6-Trichlorophenol	<0.935 [4]	<0.943 [3]	<0.943 [6]	<0.971 [3]	<0.980 [6]	<1.04 [6]	<0.943 [6]	<23.8 [3]	<24.4	<0.971	ug/L	<0.935 [4]	<24.4
Pentachlorophenol (PCP)	<0.935 [4]	<0.943 [3]	<0.943 [6]	<0.971 [3]	<0.980 [6]	<1.04 [6]	<0.943 [6]	<23.8 [3]	<24.4	<0.971	ug/L	<0.935 [4]	<24.4
Phenol	<0.935 [4]	<0.943 [3]	<0.943 [6]	<0.971 [3]	<0.980 [6]	<1.04 [6]	<0.943 [6]	<23.8 [3]	<24.4	<0.971	ug/L	<0.935 [4]	<24.4
METALS													
Hexavalent Chromium	<0.0100	<0.0100	<0.0100	<0.0500 [17] [15]	0.204	0.130 [2] [3]	0.0436	0.265		0.0112	mg/L	<0.0100	0.265
Silver	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Arsenic	1.2	1.14 [1] [7]	1.34 [3] [7]	1.41 [1] [7]	1.71	1.37	1.53	1.09	<1.00	1.11	ug/L	<1.00	1.71
Cadmium	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Chromium	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Copper	18.5	<5.00	<5.00	<5.00	<5.00	<5.00	5.22	5.87	5.82	21.5	ug/L	<5.00	21.5
Iron	263000	266000	243000	238000	268000	222000	216000	182000	176000	218000	ug/L	176000	268000
Mercury	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	ug/L	<0.0100	<0.0100
Manganese	9920	10000	8180	8120	9360	7470	7280	6360	6180	6790	ug/L	6180	10000
Nickel	5.86	4.16	3.24	3.3	3.47	2.9	3.12	2.81	3.42	9.04	ug/L	2.81	9.04
Lead	1.01	<1.00	<1.00	<1.00	<1.00	2.46	<1.00	1.52	4.37	17.4	ug/L	<1.00	17.4
Selenium	2.24	1.67 [1] [7]	1.02	1.31	1.86	1.14	1.19	1	1.09	2.06	ug/L	1	2.06
Zinc	19.1	21.4	8.3	13.3	15.4	113	8.26	5.83	9.26	34.9	ug/L	5.83	113
Calcium	470000	482000	377000	398000	431000	326000	310000	296000	294000	318000	ug/L	294000	482000
Chromium		<1.00									ug/L	<1.00	<1.00
Hardness (Calc by 6020)	2380	2430	1890	1960	2170	1660	1610	1490	1450	1620	mg CaCO3/L	1450	2430
Magnesium	293000	298000	230000	234000	266000	206000	202000	181000	173000	202000	ug/L	173000	298000
Trivalent Chromium	<11.0	<11.0	<11.0	<51.0	<41.0	<11.0	<11.0	<101	<1.00	<11.0	ug/L	<1.00	<101
VOLATILE ORGANICS													
Acetone	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0 [4] [33]	<20.0	ug/L	<20.0	<20.0
Benzene	<0.250	<0.250	<0.250	<0.500 [18] [16]	<0.500 [22] [16]	<0.250	<0.250 [22]	0.31	<0.250 [4] [33]	<0.250	ug/L	<0.250	<0.500 [22] [16]
2-Butanone (MEK)	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0 [4] [33]	<10.0	ug/L	<10.0	<10.0
1,1-Dichloroethene	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [4] [33]	<0.500	ug/L	<0.500	<0.500
cis-1,2-Dichloroethene	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [4] [33]	<0.500	ug/L	<0.500	<0.500
trans-1,2-Dichloroethene	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [4] [33]	<0.500	ug/L	<0.500	<0.500
Ethylbenzene	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [4] [33]	<0.500	ug/L	<0.500	<0.500
Tetrachloroethene (PCE)	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [4] [33]	<0.500	ug/L	<0.500	<0.500
Toluene	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [4] [33]	<0.500	ug/L	<0.500	<0.500
Trichloroethene (TCE)	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [4] [33]	<0.500	ug/L	<0.500	<0.500
Vinyl chloride	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [4] [33]	<0.500	ug/L	<0.500	<0.500
m,p-Xylene	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00 [4] [33]	<1.00	ug/L	<1.00	<1.00
o-Xylene	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [4] [33]	<0.500	ug/L	<0.500	<0.500

FootNumber	Qualifier	TextBody
1	A-01	Ending CCV fails at 89% (limit 90-110). Data possibly biased slightly low.
2	A-01	Naphthalene was detected in this sample is less than ten times the amount detected in the blank. Results may be biased high.
3	A-01a	Sample reanalyzed outside of hold time, intitial analysis failed to meet QC criteria.
4	A-01b	Naphthalene detected in sample is less then ten times the level detected in the method blank. Results may be biased high.
5	A-01c	Results from 3 voas are not consistent.
6	A-02	Result for 2-Butanone is much higher than the other two VOAs.
7	B	Analyte detected in the associated extraction blank.
8	C-05	Extract has undergone a GPC (Gel-Permeation Chromotography) cleanup per EPA 3640A.
9	E	Estimated Value. The result is above the calibration range of the instrument.
10	M-02	Due to matrix interference, this analyte cannot be accurately quantified. The reported result is estimated.
11	Q-26	Peak separation for Benzo(b) and Benzo(k)fluoranthenes does not meet method specified criteria. Reported result includes the combined area of the two isomers and should be considered the total of Benzo(b+k)Fluoranthenes.
12	Q-30	Recovery for Lab Control Spike (LCS) is below the lower control limit. Data may be biased low.
13	Q-32	Benz(a)Anthracene and Chrysene can not be resolved. Reported result includes the contribution from both analytes and contains a high bias.
14	R-01	The Reporting Limit for this analyte has been raised to account for matrix interference.
15	R-04	Reporting levels elevated due to dilution necessary for analysis.
16	R-06	Reporting level raised due to possible carryover from a previous sample.
17	S-04	Surrogate recovery is outside of established control limits due to a sample matrix effect.
18	S-07	Surrogate recovery above control limits. Related target analytes were not detected, or detected below reporting limits, therefore data quality is not affected.
19	X	See Case Narrative.

PW-1 Eq Efflent	08/26/09	08/25/09	08/21/09	08/19/09	08/18/09	08/12/09	08/07/09	08/03/09	Units	Min	Max
pH	10.2	10.4	10.1	9.83	9.82	10.1	9.99	10.1	pH Units	9.82	10.4
pH Temperature	20.7	20.3	23.2	24	17.2	19.8	14	20.8	pH Units	14	24
Total Dissolved Solids	1270	1190	1040	977	996	1020	1040	893	mg/L	893	1270
Total Suspended Solids	43	74	72	143	27	84	10	7	mg/L	7	143
Total Organic Carbon	28	33.5	25.5	28	30.9	31.6	29.9	23.8 [1] [1]	mg/L	23.8 [1] [1]	33.5
CYANIDE											
Cyanide, Total	0.977	0.97	0.873	0.979	1.08	0.81	0.546	1.08	mg/L	0.546	1.08
Cyanide, WAD	0.094	0.0924	0.0988	0.0819	0.0916	0.0868	0.132	0.121	mg/L	0.0819	0.121
Cyanide, Amenable	<0.0200	0.0755	<0.0150	0.0342	0.089	<0.0500	0.174	<0.0500	mg/L	<0.0150	0.174
CATC, chlorinated	0.961	0.894	0.956	0.944	0.987	0.998	0.372	1.13	mg/L	0.372	1.13
Cyanide, Free	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	mg/L	<0.0100	<0.0100
CATC, total	0.977	0.97	0.873	0.979	1.08	0.81	0.546	1.08	mg/L	0.546	1.08
Available Cyanide		0.0088	0.0037			0.0060	0.0033		mg/L	0.0033	0.0088
SEMI-VOLATILE ORGANICS											
Acenaphthylene	179 [4]	164 [3]	198 [6]	228 [3]	130 [6]	264 [6]	116 [3]	169 [11]	ug/L	116 [3]	264 [6]
Acenaphthene	257 [4]	247 [3]	267 [6]	349 [3]	248 [6]	374 [6]	248 [3]	244 [11]	ug/L	244 [11]	374 [6]
Anthracene	<37.2 [4]	<93.0 [3]	61.6 [6]	89.0 [3]	21.1 [6]	96.4 [6]	30.5 [3]	27.2 [11]	ug/L	21.1 [6]	96.4 [6]
Benz(a)anthracene	<37.2 [4]	<93.0 [3]	45.3 [6]	78.2 [3]	4.12 [6]	74.7 [6]	<15.2 [3]	<19.2 [11]	ug/L	4.12 [6]	<93.0 [3]
Benzo(a)pyrene	46.3 [4]	<100 [3] [12] [7]	73.9 [6]	119 [3]	5.98 [6]	109 [6]	<15.2 [3]	<24.0 [11] [28] [7]	ug/L	5.98 [6]	119 [3]
Benzo(b)fluoranthene		<93.0 [3]					<15.2 [3]	<19.2 [11]	ug/L	<15.2 [3]	<93.0 [3]
Benzo(k)fluoranthene		<93.0 [3]					<15.2 [3]	<19.2 [11]	ug/L	<15.2 [3]	<93.0 [3]
Benzo(b+k)fluoranthene(s)	<74.4 [4] [15] [6]		81.3 [6] [16] [6]	143 [3] [15] [6]	7.99 [6] [19] [6]	133 [6] [16] [6]			ug/L	7.99 [6] [19] [6]	143 [3] [15] [6]
Benzo(g,h,i)perylene	<37.2 [4]	<93.0 [3]	45.6 [6]	64.9 [3]	3.59 [6]	71.7 [6]	<15.2 [3]	<19.2 [11]	ug/L	3.59 [6]	<93.0 [3]
Carbazole	129 [4]	114 [3]	157 [6]	150 [3]	151 [6]	184 [6]	129 [3]	131 [11]	ug/L	114 [3]	184 [6]
Chrysene	<37.2 [4]	<93.0 [3]	45.6 [6]	96.4 [3]	4.49 [6]	94.7 [6]	<15.2 [3]	<19.2 [11]	ug/L	4.49 [6]	96.4 [3]
Dibenz(a,h)anthracene	<37.2 [4]	<93.0 [3]	<18.6 [6]	<38.1 [3]	<1.90 [6]	<18.6 [6]	<15.2 [3]	<19.2 [11]	ug/L	<1.90 [6]	<93.0 [3]
Dibenzofuran	<37.2 [4]	<93.0 [3]	25.8 [6]	<38.1 [3]	22.9 [6]	35.0 [6]	20.1 [3]	20.8 [11]	ug/L	20.1 [3]	<93.0 [3]
Fluoranthene	70.1 [4]	<93.0 [3]	182 [6]	299 [3]	32.6 [6]	269 [6]	33.4 [3]	35.8 [11]	ug/L	32.6 [6]	299 [3]
Fluorene	109 [4]	107 [3]	135 [6]	171 [3]	105 [6]	180 [6]	107 [3]	100 [11]	ug/L	100 [11]	180 [6]
Indeno(1,2,3-cd)pyrene	<37.2 [4]	<93.0 [3]	35.1 [6]	66.1 [3]	2.27 [6] [8] [5]	58.6 [6]	<15.2 [3]	<19.2 [11]	ug/L	2.27 [6] [8] [5]	<93.0 [3]
2-Methylnaphthalene	823 [4]	750 [3]	835 [6]	963 [3]	534 [6]	1070 [6]	36.7 [3]	629 [9] [11] [3]	ug/L	36.7 [3]	1070 [6]
Naphthalene	7770 [4]	7540 [3]	8050 [3] [6] [3]	8690 [1] [3] [3]	3450 [4] [6] [3]	9760 [3] [6] [3]	21.7 [3]	4200 [9] [11] [3]	ug/L	21.7 [3]	9760 [3] [6] [3]
Phenanthrene	278 [4]	311 [3]	450 [6]	706 [3]	230 [6]	717 [6]	259 [3]	251 [11]	ug/L	230 [6]	717 [6]
Pyrene	82.5 [4]	104 [3]	222 [6]	364 [3]	36.3 [6]	323 [6]	34.2 [3]	36.4 [11]	ug/L	34.2 [3]	364 [3]
2-Chlorophenol	<465 [4]	<1160 [3]	<233 [6]	<476 [3]	<23.8 [6]	<233 [6]	<190 [3]	<240 [11]	ug/L	<23.8 [6]	<1160 [3]
2,4-Dichlorophenol	<465 [4]	<1160 [3]	<233 [6]	<476 [3]	<23.8 [6]	<233 [6]	<190 [3]	<240 [11]	ug/L	<23.8 [6]	<1160 [3]
2,4-Dimethylphenol	<465 [4]	<1160 [3]	<233 [6]	<476 [3]	<23.8 [6]	<233 [6]	<190 [3]	<240 [11]	ug/L	<23.8 [6]	<1160 [3]
4,6-Dinitro-2-methylphenol	<465 [4]	<1160 [3]	<233 [6]	<476 [3]	<23.8 [6]	<233 [6]	<190 [3]	<240 [11]	ug/L	<23.8 [6]	<1160 [3]
2-Methylphenol	<465 [4]	<1160 [3]	<233 [6]	<476 [3]	<23.8 [6]	<233 [6]	<190 [3]	<240 [11]	ug/L	<23.8 [6]	<1160 [3]
2-Nitrophenol	<465 [4]	<1160 [3]	<233 [6]	<476 [3]	<23.8 [6]	<233 [6]	<190 [3]	<240 [11]	ug/L	<23.8 [6]	<1160 [3]
4-Nitrophenol	<465 [4]	<1160 [3]	<233 [6]	<476 [3]	<23.8 [6]	<233 [6]	<190 [3]	<240 [11]	ug/L	<23.8 [6]	<1160 [3]
2,4,5-Trichlorophenol	<465 [4]	<1160 [3]	<233 [6]	<476 [3]	<23.8 [6]	<233 [6]	<190 [3]	<240 [11]	ug/L	<23.8 [6]	<1160 [3]
2,4,6-Trichlorophenol	<465 [4]	<1160 [3]	<233 [6]	<476 [3]	<23.8 [6]	<233 [6]	<190 [3]	<240 [11]	ug/L	<23.8 [6]	<1160 [3]
Pentachlorophenol (PCP)	<465 [4]	<1160 [3]	<233 [6]	<476 [3]	<23.8 [6]	<233 [6]	<190 [3]	<240 [11]	ug/L	<23.8 [6]	<1160 [3]
Phenol	<465 [4]	<1160 [3]	<233 [6]	<476 [3]	52.4 [6]	<233 [6]	<190 [3]	<240 [11]	ug/L	<23.8 [6]	<1160 [3]
METALS											
Hexavalent Chromium	<0.0100 [1] [2]	<0.0100	<0.0100	<0.0100	<0.0200 [20] [7]	<0.0100	<0.0200		mg/L	<0.0100	<0.0200
Silver	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Cadmium	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Chromium	1.17	<1.00	1.23	<1.00	1.18	1.36	1.02	1.41	ug/L	<1.00	1.41
Copper	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	ug/L	<5.00	<5.00
Iron	6780	13100	14800	15600	7590	10800	4640	1050	ug/L	1050	15600
Mercury	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	ug/L	<0.0100	<0.0100
Manganese	624	1150	1260	1720	675	1070	444	265	ug/L	265	1720
Nickel	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Lead	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Selenium	1.49	<1.00	<1.00	<1.00	<1.00	1.02	1.32	1.03	ug/L	<1.00	1.49
Zinc	20.9	56.1	50.5	126	65.2	96.2	54.2	20.6	ug/L	20.6	126
Calcium	11000	10500	13200	31200	2410	18000	3700	4450	ug/L	2410	18000
Chromium		<1.00							ug/L	<1.00	<1.00
Hardness (Calc by 6020)	194	202	207	260	178	218	198	200	mg CaCO3/L	178	260
Magnesium	40400	42600	42200	44200	41800	42100	45900	45800	ug/L	40400	45800
Trivalent Chromium	<11.0	<11.0	<11.0	<11.0	<21.0	<11.0	<21.0	1.41	ug/L	1.41	<21.0
VOLATILE ORGANICS											
Acetone	<2000	<2000	<1000	<1000	<1000	<1000	<1000	<400	ug/L	<400	<2000
Benzene	6150	6590	7200	5590	3620	5250	4150	4570	ug/L	3620	7200
2-Butanone (MEK)	<1000	<1000	<500	<500	<500	<500	<500	<200	ug/L	<200	<1000
1,1-Dichloroethene	<50.0	<50.0	<25.0	<25.0	<25.0	<25.0	<25.0	<10.0	ug/L	<10.0	<50.0
cis-1,2-Dichloroethene	<50.0	<50.0	<25.0	<25.0	<25.0	<25.0	<25.0	<10.0	ug/L	<10.0	<50.0
trans-1,2-Dichloroethene	<50.0	<50.0	<25.0	<25.0	<25.0	<25.0	<25.0	<10.0	ug/L	<10.0	<50.0
Ethylbenzene	669	602	868	613	42	622	118	101	ug/L	42	868
Tetrachloroethene (PCE)	<50.0	<50.0	<25.0	<25.0	<25.0	<25.0	<25.0	<10.0	ug/L	<10.0	<50.0
Toluene	159	152	200	136	102	160	84	64.8	ug/L	64.8	200
Trichloroethene (TCE)	<50.0	<50.0	<25.0	<25.0	<25.0	<25.0	<25.0	<10.0	ug/L	<10.0	<50.0
Vinyl chloride	<50.0	<50.0	<25.0	<25.0	<25.0	<25.0	<25.0	<10.0	ug/L	<10.0	<50.0
m,p-Xylene	372	330	463	330	256	426	196	227	ug/L	196	463
o-Xylene	187	190	242	179	150	218	125	148	ug/L	125	242

FootNumber	Qualifier	TextBody
1	A-01	Ending CCV fails at 89% (limit 90-110). Data possibly biased slightly low.
2	A-01	Sample analyzed 5 min past EPA recommended hold time.
3	B	Analyte detected in the associated extraction blank.
4	C-05	Extract has undergone a GPC (Gel-Permeation Chromotography) cleanup per EPA 3640A.
5	M-02	Due to matrix interference, this analyte cannot be accurately quantified. The reported result is estimated.
6	Q-26	Peak separation for Benzo(b) and Benzo(k)fluoranthenes does not meet method specified criteria. Reported result includes the combined area of the two isomers and should be considered the
7	R-01	The Reporting Limit for this analyte has been raised to account for matrix interference.
8	S-04	Surrogate recovery is outside of established control limits due to a sample matrix effect.
9	S-05	Surrogate recovery cannot be accurately quantified due to sample dilution required from high analyte concentration and/or matrix interference.
10	S-06	Surrogate recovery is outside of established control limits.

	08/26/09	08/25/09	08/21/09	08/19/09	08/18/09	08/12/09	08/07/09	08/03/09	07/23/09	Units	Min	Max
MW-1 Eq Eff												
pH	9.92	9.65	10.5	10.1	10	10.4	10.1	7.72	10	pH Units	7.72	10.5
pH Temperature	21	21.3	24.8	23.7	17.3	19.8	15.7	21.5	13.7	pH Units	13.7	24.8
Total Dissolved Solids	3490	3180	3140	3070	2810	2900	2920	3170	982	mg/L	982	3490
Total Suspended Solids	3530	55	184	52	5	91	64	42	90	mg/L	5	3530
Total Organic Carbon	14.6	3.74	6.24	6.09	6.04	5	6.48	4.75 [1] [1]	6.75	mg/L	3.74	14.6
CYANIDE												
Cyanide, Total	0.585	0.434	0.412	0.387	0.415	0.322	0.299	0.399	0.401	mg/L	0.299	0.585
Cyanide, WAD	0.0498	0.0765	0.0592	0.0636	0.0687	0.0703	0.0711	0.0654	0.0641	mg/L	0.0498	0.0765
Cyanide, Amenable	<0.0300	<0.0100	<0.00500	<0.00500	<0.00500	<0.00500	<0.00500	<0.00500	<0.00500	mg/L	<0.00500	<0.0300
CATC, chlorinated	0.739	0.449	0.472	0.435	0.489	0.462	0.438	0.429	0.436	mg/L	0.429	0.739
Cyanide, Free	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	mg/L	<0.0100	<0.0100
CATC, total	0.585	0.434	0.412	0.387	0.415	0.322	0.299	0.399	0.401	mg/L	0.299	0.585
Available Cyanide		0.0093	0.0041			0.0045	0.0061			mg/L	0.0041	0.0093
SEMI-VOLATILE ORGANICS												
Acenaphthylene	<0.100 [4]	<0.0755 [3]	<0.0769 [6]	<0.0769 [3]	<0.0755 [6]	<0.0777 [6]	<0.0779 [3]	<0.152	0.117	ug/L	<0.0755 [3]	<0.152
Acenaphthene	<0.100 [4]	<0.755 [3] [12] [8]	<0.0769 [6]	<0.0769 [3]	<0.0755 [6]	<0.874 [6] [17] [8]	<0.0779 [3]	<0.152	0.281	ug/L	<0.0755 [3]	<0.152
Anthracene	<0.100 [4]	<0.0755 [3]	<0.0769 [6]	<0.0769 [3]	<0.0755 [6]	<0.0777 [6]	<0.0779 [3]	<0.152	<0.0777	ug/L	<0.0755 [3]	<0.152
Benz(a)anthracene	<0.100 [4]	<0.0755 [3]	<0.0769 [6]	<0.0769 [3]	<0.0755 [6]	<0.0777 [6]	<0.0779 [3]	<0.152	<0.0777	ug/L	<0.0755 [3]	<0.152
Benzo(a)pyrene	<0.100 [4]	<0.0755 [3]	<0.0808 [6] [18] [8]	<0.0769 [3]	<0.0755 [6]	<0.0777 [6]	<0.0876 [3] [14] [8]	<0.152	<0.0777	ug/L	<0.0755 [3]	<0.152
Benzo(b)fluoranthene	<0.100 [4]	<0.0755 [3]	<0.0769 [6]	<0.0769 [3]	<0.0755 [6]	<0.0777 [6]	<0.0779 [3]	<0.152	<0.0777	ug/L	<0.0755 [3]	<0.152
Benzo(k)fluoranthene	<0.100 [4]	<0.0755 [3]	<0.0769 [6]	<0.0769 [3]	<0.0755 [6]	<0.0777 [6]	<0.0779 [3]	<0.152	<0.0777	ug/L	<0.0755 [3]	<0.152
Benzo(g,h,i)perylene	<0.100 [4]	<0.0755 [3]	<0.0769 [6]	<0.0769 [3]	<0.0755 [6]	<0.0777 [6]	<0.0779 [3]	<0.152	0.129	ug/L	<0.0755 [3]	<0.152
Carbazole	<0.100 [4]	<0.0755 [3]	<0.0769 [6]	<0.0769 [3]	<0.0755 [6]	<0.0777 [6]	0.0988 [3]	<0.152	<0.0777	ug/L	<0.0755 [3]	0.0988 [3]
Chrysene	<0.100 [4]	<0.0755 [3]	<0.0769 [6]	<0.0769 [3]	<0.0755 [6]	<0.0777 [6]	<0.0779 [3]	<0.152	<0.0777	ug/L	<0.0755 [3]	<0.152
Dibenz(a,h)anthracene	<0.100 [4]	<0.0755 [3]	<0.0769 [6]	<0.0769 [3]	<0.0755 [6]	<0.0777 [6]	<0.0779 [3]	<0.152	<0.0777	ug/L	<0.0755 [3]	<0.152
Dibenzofuran	<0.100 [4]	<0.0755 [3]	<0.0769 [6]	<0.0769 [3]	<0.0755 [6]	<0.0777 [6]	<0.0779 [3]	<0.152	<0.0777	ug/L	<0.0755 [3]	<0.152
Fluoranthene	<0.100 [4]	<0.0755 [3]	<0.0769 [6]	<0.0769 [3]	<0.0755 [6]	<0.0777 [6]	<0.0779 [3]	<0.152	0.159	ug/L	<0.0755 [3]	0.159
Fluorene	<0.100 [4]	<0.0755 [3]	<0.0769 [6]	<0.0769 [3]	<0.0755 [6]	<0.0777 [6]	<0.0779 [3]	<0.152	0.132	ug/L	<0.0755 [3]	<0.152
Indeno(1,2,3-cd)pyrene	<0.100 [4]	<0.0755 [3]	<0.0769 [6]	<0.0769 [3]	<0.0755 [6]	<0.0777 [6]	<0.0779 [3]	<0.152	<0.0777	ug/L	<0.0755 [3]	<0.152
2-Methylnaphthalene	<0.100 [4]	<0.0755 [3]	0.0973 [6]	0.0811 [3]	<0.0755 [6]	<0.0777 [6]	<0.0779 [3]	<0.152	0.675	ug/L	<0.0755 [3]	0.675
Naphthalene	0.484 [4]	0.312 [3]	0.577 [1] [3] [6] [2] [5]	0.408 [1] [3] [5]	0.215 [3] [4] [6] [3] [5]	0.358 [3] [6] [5]	<0.0779 [3]	0.349 [3] [9] [4] [5]	3.62	ug/L	<0.0779 [3]	3.62
Phenanthrene	<0.100 [4]	<0.0755 [3]	<0.0769 [6]	<0.0769 [3]	<0.0755 [6]	<0.0777 [6]	<0.0779 [3]	<0.152	0.439	ug/L	<0.0755 [3]	0.439
Pyrene	<0.100 [4]	<0.0755 [3]	<0.0769 [6]	<0.0769 [3]	<0.0755 [6]	<0.0777 [6]	<0.0779 [3]	0.156	0.169	ug/L	<0.0755 [3]	0.169
2-Chlorophenol	<1.25 [4]	<0.943 [3]	<0.962 [6]	<0.962 [3]	<0.943 [6]	<0.971 [6]	<0.974 [3]	<1.90	<0.971	ug/L	<0.943 [3]	<1.90
2,4-Dichlorophenol	<1.25 [4]	<0.943 [3]	<0.962 [6]	<0.962 [3]	<0.943 [6]	<0.971 [6]	<0.974 [3]	<1.90	<0.971	ug/L	<0.943 [3]	<1.90
2,4-Dimethylphenol	<1.25 [4]	<0.943 [3]	<0.962 [6]	<0.962 [3]	<0.943 [6]	<0.971 [6]	<0.974 [3]	<1.90	<0.971	ug/L	<0.943 [3]	<1.90
4,6-Dinitro-2-methylphenol	<1.25 [4]	<0.943 [3]	<0.962 [6]	<0.962 [3]	<0.943 [6]	<0.971 [6]	<0.974 [3]	<1.90	<0.971	ug/L	<0.943 [3]	<1.90
2-Methylphenol	<1.25 [4]	<0.943 [3]	<0.962 [6]	<0.962 [3]	<0.943 [6]	<0.971 [6]	<0.974 [3]	<1.90	<0.971	ug/L	<0.943 [3]	<1.90
2-Nitrophenol	<1.25 [4]	<0.943 [3]	<0.962 [6]	<0.962 [3]	<0.943 [6]	<0.971 [6]	<0.974 [3]	<1.90	<0.971	ug/L	<0.943 [3]	<1.90
4-Nitrophenol	<1.25 [4]	<0.943 [3]	<0.962 [6]	<0.962 [3]	<0.943 [6]	<0.971 [6]	<0.974 [3]	<1.90	<0.971	ug/L	<0.943 [3]	<1.90
2,4,5-Trichlorophenol	<1.25 [4]	<0.943 [3]	<0.962 [6]	<0.962 [3]	<0.943 [6]	<0.971 [6]	<0.974 [3]	<1.90	<0.971	ug/L	<0.943 [3]	<1.90
2,4,6-Trichlorophenol	<1.25 [4]	<0.943 [3]	<0.962 [6]	<0.962 [3]	<0.943 [6]	<0.971 [6]	<0.974 [3]	<1.90	<0.971	ug/L	<0.943 [3]	<1.90
Pentachlorophenol (PCP)	<1.25 [4]	<0.943 [3]	<0.962 [6]	<0.962 [3]	<0.943 [6]	<0.971 [6]	<0.974 [3]	<1.90	<0.971	ug/L	<0.943 [3]	<1.90
Phenol	<1.25 [4]	<0.943 [3]	<0.962 [6]	<0.962 [3]	<0.943 [6]	<0.971 [6]	<0.974 [3]	<1.90	<0.971	ug/L	<0.943 [3]	<1.90
METALS												
Hexavalent Chromium	<0.0100	<0.0100	<0.0100	<0.0500 [17] [9]	<0.0400 [20] [8]	<0.100 [17] [8]	<0.0200		<0.0100 [6] [7]	mg/L	<0.0100	<0.0500 [17] [9]
Silver	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Cadmium	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Chromium	5.66	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	ug/L	<1.00	5.66
Copper	7.99	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	ug/L	<5.00	7.99
Iron	925000	6900	7500	3960	682	6770	6270	22200	6490	ug/L	682	925000
Mercury	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	ug/L	<0.0100	<0.0100
Manganese	32300	225	276	126	6.62	227	268	786	282	ug/L	126	32300
Nickel	16.6	1.06	1.12	1.1	<1.00	1.07	<1.00	1.38	1.97	ug/L	<1.00	16.6
Lead	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Selenium	2.64	3.02 [1] [5]	<1.00	1.6	1.22	1.32	1.31	1.13	2.52	ug/L	1.13	3.02 [1] [5]
Zinc	26.3	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	4.87	<4.00	ug/L	<4.00	26.3
Calcium	1390000	80700	81700	72400	63700	72100	67600	138000	163000	ug/L	63700	1390000
Chromium		<1.00								ug/L	<1.00	<1.00
Hardness (Calc by 6020)	6920	404	442	722	771	819	854	1020	1200	mg CaCO3/L	404	6920
Magnesium	838000	49200	57800	131000	149000	155000	166000	164000	193000	ug/L	49200	838000
Trivalent Chromium	<11.0	<11.0	<11.0	<51.0	<41.0	<101	<21.0	<1.00	<11.0	ug/L	<1.00	<101
VOLATILE ORGANICS												
Acetone	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0 [22]	<20.0	<20.0	<20.0	ug/L	<20.0	<20.0
Benzene	<0.250	<0.250	<0.250	<0.500 [18] [10]	<0.250	<0.250 [22]	<0.250	<0.250	<0.250	ug/L	<0.250 [22]	<0.500 [18] [10]
2-Butanone (MEK)	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0 [22]	<10.0	<10.0	17.9	ug/L	<10.0	17.9
1,1-Dichloroethene	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [22]	<0.500	<0.500	<0.500	ug/L	<0.500	<0.500
cis-1,2-Dichloroethene	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [22]	<0.500	<0.500	<0.500	ug/L	<0.500	<0.500
trans-1,2-Dichloroethene	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [22]	<0.500	<0.500	<0.500	ug/L	<0.500	<0.500
Ethylbenzene	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [22]	<0.500	<0.500	<0.500	ug/L	<0.500	<0.500
Tetrachloroethene (PCE)	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [22]	<0.500	<0.500	<0.500	ug/L	<0.500	<0.500
Toluene	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [22]	<0.500	<0.500	<0.500	ug/L	<0.500	<0.500
Trichloroethene (TCE)	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [22]	<0.500	<0.500	<0.500	ug/L	<0.500	<0.500
Vinyl chloride	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [22]	<0.500	<0.500	<0.500	ug/L	<0.500	<0.500
m,p-Xylene	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00 [22]	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
o-Xylene	0.54	<0.500	<0.500	<0.500	<0.500	<0.500 [22]	<0.500	<0.500	<0.500	ug/L	<0.500	0.54

FootNumber	Qualifier	TextBody
1	A-01	Ending CCV fails at 89% (limit 90-110). Data possibly biased slightly low.
2	A-01	Naphthalene was detected in this sample is less than ten times the amount detected in the blank. Results may be biased high.
3	A-01b	Naphthalene detected in sample is less then ten times the level detected in the method blank. Results may be biased high.
4	A-01b	Result less than 10 times the amount detected in the method blank. Results may be biased high.
5	B	Analyte detected in the associated extraction blank.
6	C-05	Extract has undergone a GPC (Gel-Permeation Chromotography) cleanup per EPA 3640A.
7	M-02	Due to matrix interference, this analyte cannot be accurately quantified. The reported result is estimated.
8	R-01	The Reporting Limit for this analyte has been raised to account for matrix interference.
9	R-04	Reporting levels elevated due to dilution necessary for analysis.
10	R-06	Reporting level raised due to possible carryover from a previous sample.
11	S-04	Surrogate recovery is outside of established control limits due to a sample matrix effect.
12	S-07	Surrogate recovery above control limits. Related target analytes were not detected, or detected below reporting limits, therefore data quality is not affected.
13	X	See Case Narrative.

Combined IPC Inf		08/26/09	08/25/09	08/21/09	08/19/09	08/18/09	08/12/09	08/07/09	08/03/09	Units	**Min**	**Max**
		NW-3	NW-3	NW-3	NW-3	NW-3	NW-3	NW-3	NW-3			
Dissolved Iron	ug/L	323 [5] [2]	339 [4] [2]	368 [7] [2]	372 [4] [2]	366 [7] [2]	369 [7] [2]	381 [4] [2]	344 [13] [2]	ug/L	323 [5] [2]	381 [4] [2]
Dissolved Manganese	ug/L	1.94 [5] [2]	12.2 [4] [2]	11.1 [7] [2]	56.1 [4] [2]	105 [7] [2]	21.7 [7] [2]	14.2 [4] [2]	14.6 [13] [2]	ug/L	1.94 [5] [2]	105 [7] [2]
Arsenic	ug/L	4.21	2.26 [1] [1]	2.64 [3] [1]	2.27 [1] [1]	9.72	2.63	1.88	1.6	ug/L	1.6	9.72
Iron	ug/L	344000	11400	12900	11800	110000	9930	4940	8500	ug/L	4940	344000
Manganese	ug/L	11900	869	972	1210	9750	814	375	537	ug/L	375	11900
FootNumber	Qualifier	TextBody										
1	B	Analyte detected in the associated extraction blank.										
2	FILT	Sample was lab filtered and acid preserved prior to analysis. See sample preparation section of report for date and time of filtration.										

	Units	08/26/09	08/25/09	08/21/09	08/19/09	08/18/09	08/12/09	08/07/09	08/03/09	Units	Min	Max
IPC Effluent												
Dissolved Iron	ug/L	298 [5] [2]	337 [4] [2]	368 [7] [2]	356 [4] [2]	354 [7] [2]	353 [10] [2]	347 [4] [2]	294 [13] [2]	ug/L	294 [13] [2]	368 [7] [2]
Dissolved Manganese	ug/L	2.79 [5] [2]	13.3 [4] [2]	21.7 [7] [2]	46.3 [4] [2]	42.9 [7] [2]	24.3 [10] [2]	20.7 [4] [2]	7.28 [13] [2]	ug/L	2.79 [5] [2]	46.3 [4] [2]
Arsenic	ug/L	1.41	1.74 [1] [1]	1.66 [3] [1]	1.82 [1] [1]	2.24	2.12	1.76	1.38	ug/L	1.38	2.24
Iron	ug/L	1260	2060	2980	2360	5070	3960	3660	910	ug/L	910	5070
Manganese	ug/L	50.2	154	233	251	427	346	284	76.3	ug/L	50.2	427
FootNumber	Qualifier	TextBody										
1	B	Analyte detected in the associated extraction blank.										
2	FILT	Sample was lab filtered and acid preserved prior to analysis. See sample preparation section of report for date and time of filtration.										

Cyanide Destruct Effluent	08/26/09	08/25/09	08/21/09	08/19/09	08/18/09	08/12/09	08/07/09	08/03/09	Units	Min	Max
Total Organic Carbon	30.8	22.8	31.0 [2] [2]	26.3	21.5	13.2	24.3	22.5 [1] [1]	mg/L	13.2	31.0 [2] [2]
CYANIDE											
Cyanide, Total	0.708	0.705	0.686	0.709	0.804	0.457	0.458	0.723	mg/L	0.457	0.804
Cyanide, WAD	0.0789	0.0989	0.0663	0.0693	0.0825	0.0503	0.0777	0.104	mg/L	0.0503	0.104
Cyanide, Amenable	<0.0100	<0.0100	<0.0200	0.0951	0.131	<0.0100	<0.0100	<0.0100	mg/L	<0.0100	0.131
CATC, chlorinated	0.806	0.773	1.65	0.614	0.673	0.807	0.904	0.837	mg/L	0.614	1.65
Cyanide, Free	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	mg/L	<0.0100	<0.0100
CATC, total	0.708	0.705	0.686	0.709	0.804	0.457	0.458	0.723	mg/L	0.457	0.804
Available Cyanide		0.0088	0.0056			0.0190	0.0230		mg/L	0.0056	0.0230
SEMI-VOLATILE ORGANICS											
Acenaphthylene	<18.6 [4]	46.1 [3]	37.6 [6]	<19.0 [3]	<19.0 [6]	40.3 [6]	79.4 [3]	59.8 [11]	ug/L	<18.6 [4]	79.4 [3]
Acenaphthene	85.7 [4]	102 [3]	131 [6]	120 [3]	60.1 [6]	137 [6]	155 [3]	77.3 [11]	ug/L	60.1 [6]	155 [3]
Anthracene	<18.6 [4]	<18.6 [3]	<18.6 [6]	<19.0 [3]	<19.0 [6]	<18.6 [6]	<38.5 [3]	<38.5 [11]	ug/L	<18.6 [6]	<38.5 [11]
Benz(a)anthracene	<18.6 [4]	<18.6 [3]	<18.6 [6]	<19.0 [3]	<19.0 [6]	<18.6 [6]	<38.5 [3]	<38.5 [11]	ug/L	<18.6 [6]	<38.5 [11]
Benzo(a)pyrene	<18.6 [4]	<18.6 [3]	<22.3 [6] [18] [7]	<21.9 [3] [16] [7]	<21.4 [6] [20] [7]	28.8 [6]	<38.5 [3]	<38.5 [11]	ug/L	<18.6 [6]	<38.5 [11]
Benzo(b)fluoranthene	<18.6 [4]	<18.6 [3]	<18.6 [6]	<19.0 [3]	<19.0 [6]		<38.5 [3]	<38.5 [11]	ug/L	<18.6 [6]	<38.5 [11]
Benzo(k)fluoranthene	<18.6 [4]	<18.6 [3]	<18.6 [6]	<19.0 [3]	<19.0 [6]		<38.5 [3]	<38.5 [11]	ug/L	<18.6 [6]	<38.5 [11]
Benzo(b+k)fluoranthene(s)						<37.2 [6] [16] [6]			ug/L	<37.2 [6] [16] [6]	<37.2 [6] [16] [6]
Benzo(g,h,i)perylene	<18.6 [4]	<18.6 [3]	<18.6 [6]	<19.0 [3]	<19.0 [6]	<18.6 [6]	<38.5 [3]	<38.5 [11]	ug/L	<18.6 [6]	<38.5 [11]
Carbazole	36.9 [4]	82.9 [3]	83.6 [6]	53.9 [3]	19.4 [6]	94.6 [6]	106 [3]	63.9 [11]	ug/L	19.4 [6]	106 [3]
Chrysene	<18.6 [4]	<18.6 [3]	<18.6 [6]	<19.0 [3]	<19.0 [6]	<18.6 [6]	<38.5 [3]	<38.5 [11]	ug/L	<18.6 [6]	<38.5 [11]
Dibenz(a,h)anthracene	<18.6 [4]	<18.6 [3]	<18.6 [6]	<19.0 [3]	<19.0 [6]	<18.6 [6]	<38.5 [3]	<38.5 [11]	ug/L	<18.6 [6]	<38.5 [11]
Dibenzofuran	<18.6 [4]	<18.6 [3]	<18.6 [6]	<19.0 [3]	<19.0 [6]	<18.6 [6]	<38.5 [3]	<38.5 [11]	ug/L	<18.6 [6]	<38.5 [11]
Fluoranthene	<18.6 [4]	<18.6 [3]	26.2 [6]	26.3 [3]	29.3 [6]	54.8 [6]	<38.5 [3]	<38.5 [11]	ug/L	<18.6 [3]	54.8 [6]
Fluorene	48.6 [4]	48.4 [3]	63.4 [6]	60.0 [3]	68.9 [6]	67.7 [6]	66.4 [3]	<38.5 [11]	ug/L	<38.5 [11]	68.9 [6]
Indeno(1,2,3-cd)pyrene	<18.6 [4]	<18.6 [3]	<18.6 [6]	<19.0 [3]	<19.0 [6]	<18.6 [6]	<38.5 [3]	<38.5 [11]	ug/L	<18.6 [6]	<38.5 [11]
2-Methylnaphthalene	325 [4]	274 [3]	397 [6]	387 [3]	272 [6]	365 [6]	74.4 [3]	189 [9] [11] [3]	ug/L	74.4 [3]	397 [6]
Naphthalene	3350 [4]	2620 [3]	4100 [3] [4] [6] [3] [4]	3940 [1] [3] [3]	2210 [4] [6] [3]	3460 [3] [6] [3]	440 [3]	1550 [9] [11] [3]	ug/L	440 [3]	4100 [3] [4] [6] [3] [4]
Phenanthrene	97.6 [4]	115 [3]	144 [6]	138 [3]	126 [6]	203 [6]	154 [3]	72.2 [11]	ug/L	72.2 [11]	203 [6]
Pyrene	<18.6 [4]	19.2 [3]	29.1 [6]	29.8 [3]	27.9 [6]	60.9 [6]	<38.5 [3]	<38.5 [11]	ug/L	<18.6 [4]	60.9 [6]
2-Chlorophenol	<233 [4]	<233 [3]	<233 [6]	<238 [3]	<238 [6]	<233 [6]	<481 [3]	<481 [11]	ug/L	<233 [6]	<481 [11]
2,4-Dichlorophenol	<233 [4]	<233 [3]	<233 [6]	<238 [3]	<238 [6]	<233 [6]	<481 [3]	<481 [11]	ug/L	<233 [6]	<481 [11]
2,4-Dimethylphenol	<233 [4]	<233 [3]	<233 [6]	<238 [3]	<238 [6]	<233 [6]	<481 [3]	<481 [11]	ug/L	<233 [6]	<481 [11]
4,6-Dinitro-2-methylphenol	<233 [4]	<233 [3]	<233 [6]	<238 [3]	<238 [6]	<233 [6]	<481 [3]	<481 [11]	ug/L	<233 [6]	<481 [11]
2-Methylphenol	<233 [4]	<233 [3]	<233 [6]	<238 [3]	<238 [6]	<233 [6]	<481 [3]	<481 [11]	ug/L	<233 [6]	<481 [11]
2-Nitrophenol	<233 [4]	<233 [3]	<233 [6]	<238 [3]	<238 [6]	<233 [6]	<481 [3]	<481 [11]	ug/L	<233 [6]	<481 [11]
4-Nitrophenol	<233 [4]	<233 [3]	<233 [6]	<238 [3]	<238 [6]	<233 [6]	<481 [3]	<481 [11]	ug/L	<233 [6]	<481 [11]
2,4,5-Trichlorophenol	<233 [4]	<233 [3]	<233 [6]	<238 [3]	<238 [6]	<233 [6]	<481 [3]	<481 [11]	ug/L	<233 [6]	<481 [11]
2,4,6-Trichlorophenol	<233 [4]	<233 [3]	<233 [6]	<238 [3]	<238 [6]	<233 [6]	<481 [3]	<481 [11]	ug/L	<233 [6]	<481 [11]
Pentachlorophenol (PCP)	<233 [4]	<233 [3]	<233 [6]	<238 [3]	<238 [6]	<233 [6]	<481 [3]	<481 [11]	ug/L	<233 [6]	<481 [11]
Phenol	<233 [4]	<233 [3]	<233 [6]	<238 [3]	<238 [6]	<233 [6]	<481 [3]	<481 [11]	ug/L	<233 [6]	<481 [11]
METALS											
Arsenic	2.03 [2] [3]	2.57	2.53	2.46	2.67	2.18	2.63	2.09	ug/L	2.03 [2] [3]	2.67
VOLATILE ORGANICS											
Acetone	<1000	<1000	<400	<400	<400	<400	<400	<200	ug/L	<200	<1000
Benzene	2100	2850	3150	2380	1610	2690	1740	1880	ug/L	1610	3150
2-Butanone (MEK)	<500	<500	<200	<200	<200	<200	<200	<100	ug/L	<100	<500
1,1-Dichloroethene	<25.0	<25.0	<10.0	<10.0	<10.0	<10.0	<10.0	<5.00	ug/L	<5.00	<25.0
cis-1,2-Dichloroethene	<25.0	<25.0	<10.0	<10.0	<10.0	<10.0	<10.0	<5.00	ug/L	<5.00	<25.0
trans-1,2-Dichloroethene	<25.0	<25.0	<10.0	<10.0	<10.0	<10.0	<10.0	<5.00	ug/L	<5.00	<25.0
Ethylbenzene	186	234	342	229	60.6	286	42	44.5	ug/L	42	342
Tetrachloroethene (PCE)	<25.0	<25.0	<10.0	<10.0	<10.0	<10.0	<10.0	<5.00	ug/L	<5.00	<25.0
Toluene	47	65.5	79.2	59	39.4	77.4	27.2	22	ug/L	22	79.2
Trichloroethene (TCE)	<25.0	<25.0	<10.0	<10.0	<10.0	<10.0	<10.0	<5.00	ug/L	<5.00	<25.0
Vinyl chloride	<25.0	<25.0	<10.0	<10.0	<10.0	<10.0	<10.0	<5.00	ug/L	<5.00	<25.0
m,p-Xylene	91	132	181	123	74.8	180	35.4	50.7	ug/L	35.4	181
o-Xylene	56	77.5	103	78.2	51.6	106	35.2	41.6	ug/L	35.2	106

FootNumber	Qualifier	TextBody
1	A-01	Ending CCV fails at 89% (limit 90-110). Data possibly biased slightly low.
2	A-01a	Used HCl preserved VOA. No H2SO4 preserved provided.
3	B	Analyte detected in the associated extraction blank.
4	B-01	Analyte detected in the extraction blank at a level greater than the MRL. All associated samples contain the same analyte at a level that is greater than 10 times the method blank.
5	C-05	Extract has undergone a GPC (Gel-Permeation Chromotography) cleanup per EPA 3640A.
6	Q-26	Peak separation for Benzo(b) and Benzo(k)fluoranthenes does not meet method specified criteria. Reported result includes the combined area of the two isomers and should be considered the total of Benzo(b+k)F
7	R-01	The Reporting Limit for this analyte has been raised to account for matrix interference.
8	S-01	Surrogate recovery for this sample is not available due to sample dilution required from high analyte concentration and/or matrix interference.
9	S-04	Surrogate recovery is outside of established control limits due to a sample matrix effect.
10	S-05	Surrogate recovery cannot be accurately quantified due to sample dilution required from high analyte concentration and/or matrix interference.
11	S-06	Surrogate recovery is outside of established control limits.
12	S-07	Surrogate recovery above control limits. Related target analytes were not detected, or detected below reporting limits, therefore data quality is not affected.

Bag Filter Effluent	Units	08/26/09	08/25/09	08/21/09	08/19/09	08/18/09	08/12/09	08/11/09	08/07/09	08/03/09	Units	Min	Max
Total Suspended Solids	mg/L	5	<5.00	6	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	mg/L	<5.00	6
Total Organic Carbon	mg/L	29	21.1	17.5	20.3	18.9	20.9	24.6	21.5	23.4 [1] [1]	mg/L	17.5	29
Iron	ug/L	366 [5] [6]	419 [4] [6]	427 [7] [6]	418 [4] [6]	411 [7] [6]	413 [10] [6]	467 [7] [6]	442 [4] [6]	2880 [13] [6]	ug/L	366 [5] [6]	2880 [13] [6]
Manganese	ug/L	49.0 [5] [6]	165 [4] [6]	62.2 [7] [6]	104 [4] [6]	223 [7] [6]	110 [10] [6]	123 [7] [6]	169 [4] [6]	578 [13] [6]	ug/L	49.0 [5] [6]	578 [13] [6]
CYANIDE													
Cyanide, Total	mg/L	0.763	0.718	0.716	0.773	0.807	0.706	0.709	0.611	0.703	mg/L	0.611	0.807
Cyanide, WAD	mg/L	0.0801	0.0755	0.0532	0.0671	0.083	0.0585	0.0161	0.0827	0.124	mg/L	0.0532	0.124
Cyanide, Amenable	mg/L	<0.0100	<0.0100	<0.0100	0.0482	0.138	<0.0100	<0.0100	<0.0100	<0.0100	mg/L	<0.0100	0.138
CATC, chlorinated	mg/L	0.854	0.785	0.789	0.725	0.668	0.876	0.808	0.858	0.804	mg/L	0.668	0.876
Cyanide, Free	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	0.0102	<0.0100	mg/L	<0.0100	0.0102
CATC, total	mg/L	0.763	0.718	0.716	0.773	0.807	0.706	0.709	0.611	0.703	mg/L	0.611	0.807
Available Cyanide	mg/L		0.0089	0.0051			0.033		0.029		mg/L	0.0051	0.0330
SEMI-VOLATILE ORGANICS													
Acenaphthylene	ug/L	52.2 [4]	104 [3]	69.8 [6]	67.2 [3]	35.4 [6]	73.1 [9]	52.3 [6]	84.3 [3]	106 [11]	ug/L	35.4 [6]	106 [11]
Acenaphthene	ug/L	126 [4]	142 [3]	123 [6]	118 [3]	101 [6]	107 [9]	104 [6]	156 [3]	146 [11]	ug/L	101 [6]	156 [3]
Anthracene	ug/L	<18.6 [4]	<18.6 [3]	<18.6 [6]	<19.0 [3]	<18.6 [6]	<18.6 [9]	<18.6 [6]	<39.6 [3]	10.7 [11]	ug/L	10.7 [11]	<39.6 [3]
Benz(a)anthracene	ug/L	<18.6 [4]	<18.6 [3]	<18.6 [6]	<19.0 [3]	<18.6 [6]	<18.6 [9]	<18.6 [6]	<39.6 [3]	<3.81 [11]	ug/L	<3.81 [11]	<39.6 [3]
Benzo(a)pyrene	ug/L	<18.6 [4]	<18.6 [3]	24.2 [6]	<19.0 [3]	<18.6 [6]	<21.4 [9] [18] [8]	<23.3 [6] [17] [8]	<39.6 [3]	<4.76 [11] [28] [8]	ug/L	<4.76 [11] [28] [8]	<39.6 [3]
Benzo(b)fluoranthene	ug/L	<18.6 [4]	<18.6 [3]	20.4 [6]	<19.0 [3]	<18.6 [6]	<18.6 [9]	<18.6 [6]	<39.6 [3]	<3.81 [11]	ug/L	<3.81 [11]	<39.6 [3]
Benzo(k)fluoranthene	ug/L	<18.6 [4]	<18.6 [3]	<18.6 [6]	<19.0 [3]	<18.6 [6]	<18.6 [9]	<18.6 [6]	<39.6 [3]	<3.81 [11]	ug/L	<3.81 [11]	<39.6 [3]
Benzo(g,h,i)perylene	ug/L	<18.6 [4]	<18.6 [3]	<18.6 [6]	<19.0 [3]	<18.6 [6]	<18.6 [9]	<18.6 [6]	<39.6 [3]	<3.81 [11]	ug/L	<3.81 [11]	<39.6 [3]
Carbazole	ug/L	79.6 [4]	81.7 [3]	94.0 [6]	82.0 [3]	88.3 [6]	97.5 [9]	73.2 [6]	112 [3]	82.0 [11]	ug/L	73.2 [6]	97.5 [9]
Chrysene	ug/L	<18.6 [4]	<18.6 [3]	<18.6 [6]	<19.0 [3]	<18.6 [6]	<18.6 [9]	<18.6 [6]	<39.6 [3]	<3.81 [11]	ug/L	<3.81 [11]	<39.6 [3]
Dibenz(a,h)anthracene	ug/L	<18.6 [4]	<18.6 [3]	<18.6 [6]	<19.0 [3]	<18.6 [6]	<18.6 [9]	<18.6 [6]	<39.6 [3]	<3.81 [11]	ug/L	<3.81 [11]	<39.6 [3]
Dibenzofuran	ug/L	<18.6 [4]	<18.6 [3]	<18.6 [6]	<19.0 [3]	<18.6 [6]	<18.6 [9]	<18.6 [6]	<39.6 [3]	13.0 [11]	ug/L	13.0 [11]	<39.6 [3]
Fluoranthene	ug/L	<18.6 [4]	<18.6 [3]	22.9 [6]	<19.0 [3]	25.2 [6]	30.8 [9]	27.4 [6]	<39.6 [3]	13.6 [11]	ug/L	13.6 [11]	<39.6 [3]
Fluorene	ug/L	55.1 [4]	57.4 [3]	57.1 [6]	50.4 [3]	49.0 [6]	47.1 [9]	44.0 [6]	68.9 [3]	60.6 [11]	ug/L	44.0 [6]	68.9 [3]
Indeno(1,2,3-cd)pyrene	ug/L	<18.6 [4]	<18.6 [3]	<18.6 [6]	<19.0 [3]	<18.6 [6]	<18.6 [9]	<18.6 [6]	<39.6 [3]	<3.81 [11]	ug/L	<3.81 [11]	<39.6 [3]
2-Methylnaphthalene	ug/L	385 [4]	423 [3]	366 [6]	327 [3]	226 [6]	297 [9]	166 [6]	60.4 [3]	409 [9] [11] [4]	ug/L	60.4 [3]	423 [3]
Naphthalene	ug/L	3890 [4]	4120 [3]	3850 [3] [6] [4]	3400 [1] [3] [4]	1720 [4] [6] [4]	2980 [5] [9] [4]	1500 [3] [6] [4]	303 [3]	3140 [9] [11] [4]	ug/L	303 [3]	4120 [3]
Phenanthrene	ug/L	116 [4]	111 [3]	125 [6]	123 [3]	119 [6]	120 [9]	123 [6]	148 [3]	129 [11]	ug/L	111 [3]	148 [3]
Pyrene	ug/L	<18.6 [4]	<18.6 [3]	23.6 [6] [17] [7]	<19.0 [3]	24.9 [6]	33.2 [9]	29.1 [6]	<39.6 [3]	13.5 [11]	ug/L	13.5 [11]	<39.6 [3]
2-Chlorophenol	ug/L	<233 [4]	<233 [3]	<233 [6]	<238 [3]	<233 [6]	<233 [9]	<233 [6]	<495 [3]	<47.6 [11]	ug/L	<47.6 [11]	<495 [3]
2,4-Dichlorophenol	ug/L	<233 [4]	<233 [3]	<233 [6]	<238 [3]	<233 [6]	<233 [9]	<233 [6]	<495 [3]	<47.6 [11]	ug/L	<47.6 [11]	<495 [3]
2,4-Dimethylphenol	ug/L	<233 [4]	<233 [3]	<233 [6]	<238 [3]	<233 [6]	<233 [9]	<233 [6]	<495 [3]	<47.6 [11]	ug/L	<47.6 [11]	<495 [3]
4,6-Dinitro-2-methylphenol	ug/L	<233 [4]	<233 [3]	<233 [6]	<238 [3]	<233 [6]	<233 [9]	<233 [6]	<495 [3]	<47.6 [11]	ug/L	<47.6 [11]	<495 [3]
2-Methylphenol	ug/L	<233 [4]	<233 [3]	<233 [6]	<238 [3]	<233 [6]	<233 [9]	<233 [6]	<495 [3]	<47.6 [11]	ug/L	<47.6 [11]	<495 [3]
2-Nitrophenol	ug/L	<233 [4]	<233 [3]	<233 [6]	<238 [3]	<233 [6]	<233 [9]	<233 [6]	<495 [3]	<47.6 [11]	ug/L	<47.6 [11]	<495 [3]
4-Nitrophenol	ug/L	<233 [4]	<233 [3]	<233 [6]	<238 [3]	<233 [6]	<233 [9]	<233 [6]	<495 [3]	<47.6 [11]	ug/L	<47.6 [11]	<495 [3]
2,4,5-Trichlorophenol	ug/L	<233 [4]	<233 [3]	<233 [6]	<238 [3]	<233 [6]	<233 [9]	<233 [6]	<495 [3]	<47.6 [11]	ug/L	<47.6 [11]	<495 [3]
2,4,6-Trichlorophenol	ug/L	<233 [4]	<233 [3]	<233 [6]	<238 [3]	<233 [6]	<233 [9]	<233 [6]	<495 [3]	<47.6 [11]	ug/L	<47.6 [11]	<495 [3]
Pentachlorophenol (PCP)	ug/L	<233 [4]	<233 [3]	<233 [6]	<238 [3]	<233 [6]	<233 [9]	<233 [6]	<495 [3]	<47.6 [11]	ug/L	<47.6 [11]	<495 [3]
Phenol	ug/L	<233 [4]	<233 [3]	<233 [6]	<238 [3]	<233 [6]	<233 [9]	<233 [6]	<495 [3]	65.9 [11]	ug/L	65.9 [11]	<495 [3]
METALS													
Hexavalent Chromium	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	<0.0400 [20] [8]	<0.0100	<0.0100	<0.0200		mg/L	<0.0100	<0.0400 [20] [8]
Silver	ug/L	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Arsenic	ug/L	2.09	1.50 [1] [4]	2.40 [3] [4]	2.10 [1] [4]	1.31	1.92	1.87	1.63	1.7	ug/L	1.31	2.40 [3] [4]
Cadmium	ug/L	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Chromium	ug/L	<1.00	<1.00	<1.00	1.29	<1.00	1.02	<1.00	<1.00	1.17	ug/L	<1.00	1.29
Copper	ug/L	<5.00	15.6	7.13	11.9	21.4	36.5	14	33.3	39.8	ug/L	<5.00	39.8
Iron	ug/L	904	443	887	627	860	701	591	724	648	ug/L	443	904
Mercury	ug/L	<0.0100	0.0192	0.073	0.0676	0.0969	0.253 [2] [3]	0.0798	0.117 [1] [2]	0.108	ug/L	<0.0100	0.253 [2] [3]
Manganese	ug/L	53.7	201	83.8	108	330	118	131	112	51.6	ug/L	51.6	330
Nickel	ug/L	<1.00	1.39	<1.00	<1.00	3.76	3.1	1.17	1.49	7.09	ug/L	<1.00	7.09
Lead	ug/L	<1.00	3.48	3.76	6.86	6.61	7.19	3.79	14.7	18.1	ug/L	<1.00	18.1
Selenium	ug/L	2.64	1.96 [1] [4]	3.23	2.14	1.54	1.76	2.27	1.89	2.21	ug/L	1.54	2.64
Zinc	ug/L	8.62	116	10.6	45.1	156	150	60.7	160	341	ug/L	8.62	341
Chromium	ug/L		<1.00								ug/L	<1.00	<1.00
Hardness (Calc by 6020)	mg CaCO3/L									345	mg CaCO3/L	345	345
Trivalent Chromium	ug/L	<11.0	<11.0	<11.0	<11.0	<41.0	<11.0	<11.0	<21.0	1.17	ug/L	1.17	<41.0
VOLATILE ORGANICS													
Acetone	ug/L	<1000	<1000	<400	<400	<400	<400	<400	<200	<200	ug/L	<200	<1000
Benzene	ug/L	3300	2930	2990	2410	1340	2460	1650	1700	1760	ug/L	1340	3300
2-Butanone (MEK)	ug/L	<500	<500	<200	<200	<200	<200	<200	<100	<100	ug/L	<100	<500
1,1-Dichloroethene	ug/L	<25.0	<25.0	<10.0	<10.0	<10.0	<10.0	<10.0	<5.00	<5.00	ug/L	<5.00	<25.0
cis-1,2-Dichloroethene	ug/L	<25.0	<25.0	<10.0	<10.0	<10.0	<10.0	<10.0	<5.00	<5.00	ug/L	<5.00	<25.0
trans-1,2-Dichloroethene	ug/L	<25.0	<25.0	<10.0	<10.0	<10.0	<10.0	<10.0	<5.00	<5.00	ug/L	<5.00	<25.0
Ethylbenzene	ug/L	330	238	318	240	47.6	252	125	49.2	40.7	ug/L	40.7	330
Tetrachloroethene (PCE)	ug/L	<25.0	<25.0	<10.0	<10.0	<10.0	<10.0	<10.0	<5.00	<5.00	ug/L	<5.00	<25.0
Toluene	ug/L	80.5	68	77.2	61.4	30	66	37.2	31.6	22.2	ug/L	22.2	80.5
Trichloroethene (TCE)	ug/L	<25.0	<25.0	<10.0	<10.0	<10.0	<10.0	<10.0	<5.00	<5.00	ug/L	<5.00	<25.0
Vinyl chloride	ug/L	<25.0	<25.0	<10.0	<10.0	<10.0	<10.0	<10.0	<5.00	<5.00	ug/L	<5.00	<25.0
m,p-Xylene	ug/L	178	136	178	143	57	157	78.6	74.8	56.1	ug/L	56.1	178
o-Xylene	ug/L	110	83.5	103	90.2	39.6	93.8	52	55.5	42.9	ug/L	39.6	110

FootNumber	Qualifier	TextBody
1	A-01	Ending CCV fails at 89% (limit 90-110). Data possibly biased slightly low.
2	A-01	Low level mercury samples are supposed to be preserved within 24 hours of sampling. This sample was not properly preserved until 8/10/09 @ 14:30, approximately 72 hours after sampling.
3	A-01a	Low level mercury samples are preferably preserved within 24 hours of sampling. This sample was preserved on 8/17/09 @ 11:45, approximately 110 hours after sampling.
4	B	Analyte detected in the associated extraction blank.
5	C-05	Extract has undergone a GPC (Gel-Permeation Chromotography) cleanup per EPA 3640A.
6	FILT	Sample was lab filtered and acid preserved prior to analysis. See sample preparation section of report for date and time of filtration.
7	Q-29	Recovery for Lab Control Spike (LCS) is above the upper control limit. Data may be biased high.
8	R-01	The Reporting Limit for this analyte has been raised to account for matrix interference.
9	S-01	Surrogate recovery for this sample is not available due to sample dilution required from high analyte concentration and/or matrix interference.
10	S-04	Surrogate recovery is outside of established control limits due to a sample matrix effect.
11	S-05	Surrogate recovery cannot be accurately quantified due to sample dilution required from high analyte concentration and/or matrix interference.
12	S-06	Surrogate recovery is outside of established control limits.

	Units	08/26/09	08/25/09	08/21/09	08/19/09	08/18/09	08/12/09	08/11/09	08/07/09	08/03/09	Units	Min	Max
GAC Midpoint													
Total Organic Carbon	mg/L	<2.00	2.04	2.82	8.15	3.34	2.5	<2.22 [1] [1]	2.14	<2.00	mg/L	<2.00	8.15
SEMI-VOLATILE ORGANICS													
Acenaphthylene	ug/L	<0.0777 [4]	<0.0816 [3]	<0.0777 [6]	<0.0777 [3]	<0.0777 [6]	0.0876 [6]		0.103 [3]	<0.0777	ug/L	<0.0777	0.103 [3]
Acenaphthene	ug/L	<0.0777 [4]	<0.0816 [3]	<0.0777 [6]	<0.0777 [3]	<0.0777 [6]	<0.0800 [6]		0.137 [3]	<0.0777	ug/L	<0.0777	0.137 [3]
Anthracene	ug/L	<0.0777 [4]	<0.0816 [3]	<0.0777 [6]	<0.0777 [3]	<0.0777 [6]	0.119 [6]		<0.0760 [3]	<0.0777	ug/L	<0.0760 [3]	0.119 [6]
Benz(a)anthracene	ug/L	<0.0777 [4]	<0.0816 [3]	0.114 [6]	0.0975 [3]	0.137 [6]	0.592 [6]		<0.0760 [3]	<0.0777	ug/L	<0.0760 [3]	0.592 [6]
Benzo(a)pyrene	ug/L	0.0926 [4]	<0.0857 [3] [12] [8]	0.201 [6]	0.167 [3]	0.233 [6]	0.890 [6]		<0.114 [3] [14] [8]	<0.0971 [28] [8]	ug/L	<0.0857 [3] [12] [8]	0.201 [6]
Benzo(b)fluoranthene	ug/L		<0.0816 [3]						<0.0760 [3]		ug/L	<0.0760 [3]	<0.0816 [3]
Benzo(k)fluoranthene	ug/L		<0.0816 [3]						<0.0760 [3]		ug/L	<0.0760 [3]	<0.0816 [3]
Benzo(b+k)fluoranthene(s)	ug/L	<0.155 [4] [15] [6]		0.247 [6] [16] [6]	0.205 [3] [15] [6]	0.280 [6] [19] [6]	1.18 [6] [16] [6]			<0.155 [24] [6]	ug/L	1.18 [6] [16] [6]	0.280 [6] [19] [6]
Benzo(g,h,i)perylene	ug/L	<0.0777 [4]	<0.0816 [3]	0.153 [6]	<0.0777 [3]	0.135 [6]	0.670 [6]		<0.0760 [3]	<0.0777	ug/L	<0.0760 [3]	0.670 [6]
Carbazole	ug/L	<0.0777 [4]	<0.0816 [3]	<0.0777 [6]	<0.0777 [3]	<0.0777 [6]	<0.0800 [6]		0.107 [3]	<0.0777	ug/L	<0.0777	0.107 [3]
Chrysene	ug/L	<0.0777 [4]	<0.0816 [3]	0.106 [6]	0.0897 [3]	0.130 [6]	0.647 [6]		<0.0760 [3]	<0.0777	ug/L	<0.0760 [3]	0.647 [6]
Dibenz(a,h)anthracene	ug/L	<0.0777 [4]	<0.0816 [3]	<0.0777 [6]	<0.0777 [3]	<0.0777 [6]	<0.0800 [6]		<0.0760 [3]	<0.0777	ug/L	<0.0760 [3]	<0.0816 [3]
Dibenzofuran	ug/L	<0.0777 [4]	<0.0816 [3]	<0.0777 [6]	<0.0777 [3]	<0.0777 [6]	<0.0800 [6]		<0.0760 [3]	<0.0777	ug/L	<0.0760 [3]	<0.0816 [3]
Fluoranthene	ug/L	0.106 [4]	<0.0816 [3]	0.273 [6]	0.215 [3]	0.300 [6]	1.13 [6]		0.196 [3]	0.0806	ug/L	0.0806	0.300 [6]
Fluorene	ug/L	<0.0777 [4]	<0.0816 [3]	<0.0777 [6]	<0.0777 [3]	<0.0777 [6]	<0.0800 [6]		<0.0760 [3]	<0.0777	ug/L	<0.0760 [3]	<0.0800 [6]
Indeno(1,2,3-cd)pyrene	ug/L	<0.0777 [4]	<0.0816 [3]	0.113 [6]	<0.0777 [3]	0.0905 [6]	0.473 [6]		<0.0760 [3]	<0.0777	ug/L	<0.0760 [3]	0.473 [6]
2-Methylnaphthalene	ug/L	<0.0777 [4]	<0.0816 [3]	<0.0777 [6]	<0.0777 [3]	<0.0777 [6]	<0.0800 [6]		0.114 [3]	<0.0777	ug/L	<0.0777	0.114 [3]
Naphthalene	ug/L	0.327 [4]	0.215 [3]	0.199 [3] [6] [4]	0.157 [1] [3] [4]	0.144 [3] [4] [6] [2] [4]	0.142 [3] [6] [4]		0.765 [3]	).143 [3] [9] [3] [4]	ug/L	).143 [3] [9] [3] [4]	0.765 [3]
Phenanthrene	ug/L	0.0848 [4]	<0.0816 [3]	0.167 [6]	0.156 [3]	0.263 [6]	0.617 [6]		0.250 [3]	<0.0777	ug/L	<0.0777	0.617 [6]
Pyrene	ug/L	0.148 [4]	<0.0816 [3]	0.395 [6] [17] [7]	0.291 [3]	0.402 [6]	1.63 [6]		0.237 [3]	0.0927	ug/L	<0.0816 [3]	0.402 [6]
2-Chlorophenol	ug/L	<0.971 [4]	<1.02 [3]	<0.971 [6]	<0.971 [3]	<0.971 [6]	<1.00 [6]		<0.951 [3]	<0.971	ug/L	<0.951 [3]	<1.02 [3]
2,4-Dichlorophenol	ug/L	<0.971 [4]	<1.02 [3]	<0.971 [6]	<0.971 [3]	<0.971 [6]	<1.00 [6]		<0.951 [3]	<0.971	ug/L	<0.951 [3]	<1.02 [3]
2,4-Dimethylphenol	ug/L	<0.971 [4]	<1.02 [3]	<0.971 [6]	<0.971 [3]	<0.971 [6]	<1.00 [6]		<0.951 [3]	<0.971	ug/L	<0.951 [3]	<1.02 [3]
4,6-Dinitro-2-methylphenol	ug/L	<0.971 [4]	<1.02 [3]	<0.971 [6]	<0.971 [3]	<0.971 [6]	<1.00 [6]		<0.951 [3]	<0.971	ug/L	<0.951 [3]	<1.02 [3]
2-Methylphenol	ug/L	<0.971 [4]	<1.02 [3]	<0.971 [6]	<0.971 [3]	<0.971 [6]	<1.00 [6]		<0.951 [3]	<0.971	ug/L	<0.951 [3]	<1.02 [3]
2-Nitrophenol	ug/L	<0.971 [4]	<1.02 [3]	<0.971 [6]	<0.971 [3]	<0.971 [6]	<1.00 [6]		<0.951 [3]	<0.971	ug/L	<0.951 [3]	<1.02 [3]
4-Nitrophenol	ug/L	<0.971 [4]	<1.02 [3]	<0.971 [6]	<0.971 [3]	<0.971 [6]	<1.00 [6]		<0.951 [3]	<0.971	ug/L	<0.951 [3]	<1.02 [3]
2,4,5-Trichlorophenol	ug/L	<0.971 [4]	<1.02 [3]	<0.971 [6]	<0.971 [3]	<0.971 [6]	<1.00 [6]		<0.951 [3]	<0.971	ug/L	<0.951 [3]	<1.02 [3]
2,4,6-Trichlorophenol	ug/L	<0.971 [4]	<1.02 [3]	<0.971 [6]	<0.971 [3]	<0.971 [6]	<1.00 [6]		<0.951 [3]	<0.971	ug/L	<0.951 [3]	<1.02 [3]
Pentachlorophenol (PCP)	ug/L	<0.971 [4]	<1.02 [3]	<0.971 [6]	<0.971 [3]	<0.971 [6]	<1.00 [6]		<0.951 [3]	<0.971	ug/L	<0.951 [3]	<1.02 [3]
Phenol	ug/L	<0.971 [4]	<1.02 [3]	<0.971 [6]	<0.971 [3]	<0.971 [6]	<1.00 [6]		<0.951 [3]	<0.971	ug/L	<0.951 [3]	<1.02 [3]
VOLATILE ORGANICS													
Acetone	ug/L	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0			<20.0	ug/L	<20.0	<20.0
Benzene	ug/L	1.12	<0.250	<0.500 [19] [9]	<0.550 [18] [9]	<0.500 [22] [9]	<0.250			<0.250	ug/L	<0.250	1.12
2-Butanone (MEK)	ug/L	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0			<10.0	ug/L	<10.0	<10.0
1,1-Dichloroethene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500			<0.500	ug/L	<0.500	<0.500
cis-1,2-Dichloroethene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500			<0.500	ug/L	<0.500	<0.500
trans-1,2-Dichloroethene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500			<0.500	ug/L	<0.500	<0.500
Ethylbenzene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500			<0.500	ug/L	<0.500	<0.500
Tetrachloroethene (PCE)	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500			<0.500	ug/L	<0.500	<0.500
Toluene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500			<0.500	ug/L	<0.500	<0.500
Trichloroethene (TCE)	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500			<0.500	ug/L	<0.500	<0.500
Vinyl chloride	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500			<0.500	ug/L	<0.500	<0.500
m,p-Xylene	ug/L	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00			<1.00	ug/L	<1.00	<1.00
o-Xylene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500			<0.500	ug/L	<0.500	<0.500

FootNumber	Qualifier	TextBody
1	A-01	Due to high alkalinity, H3PO4 was added to remove excess IOC.
2	A-01b	Naphthalene detected in sample is less then ten times the level detected in the method blank. Results may be biased high.
3	A-01b	Result less than 10 times the amount detected in the method blank. Results may be biased high.
4	B	Analyte detected in the associated extraction blank.
5	C-05	Extract has undergone a GPC (Gel-Permeation Chromotography) cleanup per EPA 3640A.
6	Q-26	Peak separation for Benzo(b) and Benzo(k)fluoranthenes does not meet method specified criteria. Reported result includes the combined area of the two isomers and should be considered the total of Benzo(b+k)Fluoranthenes.
7	Q-29	Recovery for Lab Control Spike (LCS) is above the upper control limit. Data may be biased high.
8	R-01	The Reporting Limit for this analyte has been raised to account for matrix interference.
9	R-06	Reporting level raised due to possible carryover from a previous sample.
10	S-04	Surrogate recovery is outside of established control limits due to a sample matrix effect.
11	S-06	Surrogate recovery is outside of established control limits.

	Units	08/26/09	08/25/09	08/21/09	08/19/09	08/18/09	08/12/09	08/07/09	08/03/09	Units	Min	Max
GAC Effluent												
Total Organic Carbon	mg/L	<2.00	3.07	<2.00	7.1	3.77	2.8	<2.00	3.41	mg/L	<2.00	7.1
SEMI-VOLATILE ORGANICS												
Acenaphthylene	ug/L	<0.0769 [4]	<0.0777 [3]	<0.0748 [6]	<0.762 [3] [17]	<0.0784 [6]	<0.0762 [9]	<0.756 [3] [15]	0.392 [11]	ug/L	<0.0748 [6]	<0.762 [3] [17]
Acenaphthene	ug/L	<0.0769 [4]	<0.0777 [3]	<0.0748 [6]	<0.762 [3] [17]	<0.0784 [6]	<0.0762 [9]	<0.756 [3] [15]	0.404 [11]	ug/L	<0.0748 [6]	<0.762 [3] [17]
Anthracene	ug/L	<0.0769 [4]	<0.0777 [3]	<0.0748 [6]	<0.762 [3] [17]	<0.0784 [6]	<0.0762 [9]	<0.756 [3] [15]	<0.377 [11]	ug/L	<0.0748 [6]	<0.762 [3] [17]
Benz(a)anthracene	ug/L	<0.0769 [4]	<0.0777 [3]	<0.0748 [6]	<0.762 [3] [17]	0.0932 [6]	0.156 [9]	<0.756 [3] [15]	<0.377 [11]	ug/L	<0.0748 [6]	<0.762 [3] [17]
Benzo(a)pyrene	ug/L	<0.0808 [4] [17] [8]	0.0995 [3]	0.148 [6]	<0.762 [3] [17]	0.168 [6]	0.255 [9]	<0.756 [3] [15]	<0.377 [11]	ug/L	<0.0808 [4] [17] [8]	<0.762 [3] [17]
Benzo(b)fluoranthene	ug/L	<0.0769 [4]	0.0852 [3] [11] [6]		<0.762 [3] [17]			<0.756 [3] [15]	<0.377 [11]	ug/L	<0.0769 [4]	<0.762 [3] [17]
Benzo(k)fluoranthene	ug/L	<0.0769 [4]	<0.0777 [3] [11] [6]		<0.762 [3] [17]			<0.756 [3] [15]	<0.377 [11]	ug/L	<0.0769 [4]	<0.762 [3] [17]
Benzo(b+k)fluoranthene(s)	ug/L			0.185 [6] [16] [5]		0.228 [6] [19] [5]	0.386 [9] [17] [5]			ug/L	0.185 [6] [16] [5]	0.386 [9] [17] [5]
Benzo(g,h,i)perylene	ug/L	<0.0769 [4]	<0.0777 [3]	0.123 [6]	<0.762 [3] [17]	0.112 [6]	0.249 [9]	<0.756 [3] [15]	<0.377 [11]	ug/L	<0.0769 [4]	<0.762 [3] [17]
Carbazole	ug/L	<0.0769 [4]	<0.0777 [3]	<0.0748 [6]	<0.762 [3] [17]	<0.0784 [6]	<0.0762 [9]	<0.756 [3] [15]	0.425 [11]	ug/L	<0.0748 [6]	<0.762 [3] [17]
Chrysene	ug/L	<0.0769 [4]	<0.0777 [3]	<0.0748 [6]	<0.762 [3] [17]	0.0835 [6]	0.152 [9]	<0.756 [3] [15]	<0.377 [11]	ug/L	<0.0748 [6]	<0.762 [3] [17]
Dibenz(a,h)anthracene	ug/L	<0.0769 [4]	<0.0777 [3]	<0.0748 [6]	<0.762 [3] [17]	<0.0784 [6]	<0.0762 [9]	<0.756 [3] [15]	<0.377 [11]	ug/L	<0.0748 [6]	<0.762 [3] [17]
Dibenzofuran	ug/L	<0.0769 [4]	<0.0777 [3]	<0.0748 [6]	<0.762 [3] [17]	<0.0784 [6]	<0.0762 [9]	<0.756 [3] [15]	<0.377 [11]	ug/L	<0.0748 [6]	<0.762 [3] [17]
Fluoranthene	ug/L	<0.0769 [4]	<0.0777 [3]	0.0996 [6]	<0.762 [3] [17]	0.210 [6]	0.210 [9]	<0.756 [3] [15]	<0.377 [11]	ug/L	<0.0769 [4]	<0.762 [3] [17]
Fluorene	ug/L	<0.0769 [4]	<0.0777 [3]	<0.0748 [6]	<0.762 [3] [17]	<0.0784 [6]	<0.0762 [9]	<0.756 [3] [15]	<0.377 [11]	ug/L	<0.0748 [6]	<0.762 [3] [17]
Indeno(1,2,3-cd)pyrene	ug/L	<0.0769 [4]	<0.0777 [3]	0.0831 [6]	<0.762 [3] [17]	<0.0784 [6]	0.178 [9]	<0.756 [3] [15]	<0.377 [11]	ug/L	<0.0769 [4]	<0.762 [3] [17]
2-Methylnaphthalene	ug/L	<0.0769 [4]	<0.0777 [3]	<0.0748 [6]	<0.762 [3] [17]	<0.0784 [6]	<0.0762 [9]	<0.756 [3] [15]	1.11 [9] [11] [3]	ug/L	<0.0748 [6]	<0.756 [3] [15]
Naphthalene	ug/L	0.142 [4]	0.158 [3]	<0.0748 [6]	<0.762 [3] [17]	0.105 [3] [4] [6] [2] [3]	0.123 [5] [9] [3]	<0.756 [3] [15]	8.73 [2] [9] [11] [1] [3]	ug/L	<0.0748 [6]	8.73 [2] [9] [11] [1] [3]
Phenanthrene	ug/L	<0.0769 [4]	<0.0777 [3]	<0.0748 [6]	<0.762 [3] [17]	0.155 [6]	0.0921 [9]	<0.756 [3] [15]	<0.377 [11]	ug/L	<0.0748 [6]	<0.377 [11]
Pyrene	ug/L	<0.0769 [4]	0.0952 [3]	0.138 [6] [17] [7]	<0.762 [3] [17]	0.276 [6]	0.296 [9]	<0.756 [3] [15]	<0.377 [11]	ug/L	<0.0769 [4]	<0.756 [3] [15]
2-Chlorophenol	ug/L	<0.962 [4]	<0.971 [3]	<0.935 [6]	<9.52 [3] [17]	<0.980 [6]	<0.952 [9]	<9.45 [3] [15]	<4.72 [11]	ug/L	<0.935 [6]	<9.52 [3] [17]
2,4-Dichlorophenol	ug/L	<0.962 [4]	<0.971 [3]	<0.935 [6]	<9.52 [3] [17]	<0.980 [6]	<0.952 [9]	<9.45 [3] [15]	<4.72 [11]	ug/L	<0.935 [6]	<9.52 [3] [17]
2,4-Dimethylphenol	ug/L	<0.962 [4]	<0.971 [3]	<0.935 [6]	<9.52 [3] [17]	<0.980 [6]	<0.952 [9]	<9.45 [3] [15]	<4.72 [11]	ug/L	<0.935 [6]	<9.52 [3] [17]
4,6-Dinitro-2-methylphenol	ug/L	<0.962 [4]	<0.971 [3]	<0.935 [6]	<9.52 [3] [17]	<0.980 [6]	<0.952 [9]	<9.45 [3] [15]	<4.72 [11]	ug/L	<0.935 [6]	<9.52 [3] [17]
2-Methylphenol	ug/L	<0.962 [4]	<0.971 [3]	<0.935 [6]	<9.52 [3] [17]	<0.980 [6]	<0.952 [9]	<9.45 [3] [15]	<4.72 [11]	ug/L	<0.935 [6]	<9.52 [3] [17]
2-Nitrophenol	ug/L	<0.962 [4]	<0.971 [3]	<0.935 [6]	<9.52 [3] [17]	<0.980 [6]	<0.952 [9]	<9.45 [3] [15]	<4.72 [11]	ug/L	<0.935 [6]	<9.52 [3] [17]
4-Nitrophenol	ug/L	<0.962 [4]	<0.971 [3]	<0.935 [6]	<9.52 [3] [17]	<0.980 [6]	<0.952 [9]	<9.45 [3] [15]	<4.72 [11]	ug/L	<0.935 [6]	<9.52 [3] [17]
2,4,5-Trichlorophenol	ug/L	<0.962 [4]	<0.971 [3]	<0.935 [6]	<9.52 [3] [17]	<0.980 [6]	<0.952 [9]	<9.45 [3] [15]	<4.72 [11]	ug/L	<0.935 [6]	<9.52 [3] [17]
2,4,6-Trichlorophenol	ug/L	<0.962 [4]	<0.971 [3]	<0.935 [6]	<9.52 [3] [17]	<0.980 [6]	<0.952 [9]	<9.45 [3] [15]	<4.72 [11]	ug/L	<0.935 [6]	<9.52 [3] [17]
Pentachlorophenol (PCP)	ug/L	<0.962 [4]	<0.971 [3]	<0.935 [6]	<9.52 [3] [17]	<0.980 [6]	<0.952 [9]	<9.45 [3] [15]	<4.72 [11]	ug/L	<0.935 [6]	<9.52 [3] [17]
Phenol	ug/L	<0.962 [4]	<0.971 [3]	<0.935 [6]	<9.52 [3] [17]	<0.980 [6]	<0.952 [9]	<9.45 [3] [15]	<4.72 [11]	ug/L	<0.935 [6]	<9.52 [3] [17]
METALS												
Arsenic	ug/L	2.34 [2] [3]	2.37	2.96	2.86	4.12	3.52	3.81	6.07	ug/L	2.34 [2] [3]	6.07
VOLATILE ORGANICS												
Acetone	ug/L	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	ug/L	<20.0	<20.0
Benzene	ug/L	<0.250	<0.250	<0.250	<0.250	<0.250	<0.250	<0.250	<0.250	ug/L	<0.250	<0.250
2-Butanone (MEK)	ug/L	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	ug/L	<10.0	<10.0
1,1-Dichloroethene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	ug/L	<0.500	<0.500
cis-1,2-Dichloroethene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	ug/L	<0.500	<0.500
trans-1,2-Dichloroethene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	ug/L	<0.500	<0.500
Ethylbenzene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	ug/L	<0.500	<0.500
Tetrachloroethene (PCE)	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	ug/L	<0.500	<0.500
Toluene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	ug/L	<0.500	<0.500
Trichloroethene (TCE)	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	ug/L	<0.500	<0.500
Vinyl chloride	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	ug/L	<0.500	<0.500
m,p-Xylene	ug/L	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
o-Xylene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	ug/L	<0.500	<0.500

FootNumber	Qualifier	TextBody
1	A-01a	Result less than 10 times amount detected in method blank. Results may be biased high.
2	A-01b	Naphthalene detected in sample is less then ten times the level detected in the method blank. Results may be biased high.
3	B	Analyte detected in the associated extraction blank.
4	C-05	Extract has undergone a GPC (Gel-Permeation Chromotography) cleanup per EPA 3640A.
5	Q-26	Peak separation for Benzo(b) and Benzo(k)fluoranthenes does not meet method specified criteria. Reported result includes the combined area of the two isomers and should be considered the total of Benzo(b+k)Fluoranthenes.
6	Q-28	Peak separation for Benzo(b) and Benzo(k)fluoranthenes does not meet method specified criteria. Data not reported. See result for Benzo(b+k)Fluoranthene(s).
7	Q-29	Recovery for Lab Control Spike (LCS) is above the upper control limit. Data may be biased high.
8	R-01	The Reporting Limit for this analyte has been raised to account for matrix interference.
9	R-04	Reporting levels elevated due to dilution necessary for analysis.
10	S-04	Surrogate recovery is outside of established control limits due to a sample matrix effect.
11	S-05	Surrogate recovery cannot be accurately quantified due to sample dilution required from high analyte concentration and/or matrix interference.
12	S-06	Surrogate recovery is outside of established control limits.

Effluent Storage Tank	Units	09/09/09	08/26/09	08/25/09	08/21/09	08/19/09	08/18/09	08/12/09	08/11/09	08/07/09	08/03/09	07/29/09	Units	Min	Max
pH	pH Units	7.14	7.95	7.89	7.84	7.65	7.62	7.58	7.6	7.74	7.91	8.23	pH Units	7.14	8.23
pH Temperature	pH Units	24.2	21.8	21.3	23.6	23.9	16.2	16.3	20.2	15.9	20.6	31.8	pH Units	15.9	31.8
Total Dissolved Solids	mg/L	1300	1360	1720	1610	1600	1490	1600	1540	1590	1500	518	mg/L	518	1720
Total Suspended Solids	mg/L	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	mg/L	<5.00	<5.00
Total Organic Carbon	mg/L	7.97	3.97	2.03	<2.00	6.83	3.85	2.09	<2.00	<2.00	2.82 [1] [2]	2.95	mg/L	<2.00	7.97
Total Iron	ug/L	338 [6] [9]	279 [5] [9]	337 [4] [9]	337 [7] [9]		171 [7] [9]	158 [10] [9]	162 [7] [9]	125 [4] [9]	157 [13] [9]	<100 [4] [9]	ug/L	<100 [4] [9]	338 [6] [9]
Total Manganese	ug/L	171 [6] [9]	9.44 [5] [9]	63.9 [4] [9]	42.7 [7] [9]		53.1 [7] [9]	64.9 [10] [9]	118 [7] [9]	63.5 [4] [9]	100 [13] [9]	43.0 [4] [9]	ug/L	9.44 [5] [9]	171 [6] [9]
CYANIDE															
Cyanide, Total	mg/L	0.712	0.554	0.627	0.558	0.333	0.26	0.183	0.133	0.135	0.0929	0.0200 [1] [2] [1] [6]	mg/L	0.0200 [1] [2] [1] [6]	0.712
Cyanide, WAD	mg/L	0.0449	0.0441	0.0463	0.0392	0.0738	0.0238	0.0175	0.0689	0.0244	0.0165	0.0101	mg/L	0.0101	0.0738
Cyanide, Amenable	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	<0.00500	<0.00500	<0.00500	<0.00500	<0.00500	<0.00500	<0.00500	mg/L	<0.00500	<0.0100
CATC, chlorinated	mg/L	0.739	0.584	0.668	0.589	0.347	0.259	0.226	0.142	0.153	0.1	0.0193	mg/L	0.0193	0.739
Cyanide, Free	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	mg/L	<0.0100	<0.0100
CATC, total	mg/L	0.712	0.554	0.627	0.558	0.333	0.26	0.183	0.133	0.135	0.0929	0.0200 [2] [6]	mg/L	0.0200 [2] [6]	0.712
Available Cyanide	mg/L			<0.0020	<0.0020			<0.0020		<0.0020			mg/L	<0.0020	<0.0020
SEMIVOLATILE ORGANICS															
Acenaphthylene	ug/L	0.169 [5]	<0.0792 [4]	<0.0769 [3]	<0.0784 [6]	<0.0800 [3]	<0.0800 [6]	<0.0816 [9]	<0.0808 [6]	<0.0800 [3]	<0.0816 [11]	<0.0784	ug/L	<0.0769 [3]	0.169 [5]
Acenaphthene	ug/L	<0.0762 [5]	<0.0792 [4]	<0.0769 [3]	<0.0784 [6]	<0.0800 [3]	<0.0800 [6]	<0.0816 [9]	<0.0808 [6]	<0.0800 [3]	<0.0816 [11]	<0.0784	ug/L	<0.0762 [5]	<0.0816 [11]
Anthracene	ug/L	0.0863 [5]	<0.0792 [4]	<0.0769 [3]	<0.0784 [6]	<0.0800 [3]	<0.0800 [6]	<0.0816 [9]	<0.0808 [6]	<0.0800 [3]	<0.0816 [11]	<0.0784	ug/L	<0.0769 [3]	0.0863 [5]
Benz(a)anthracene	ug/L	0.625 [5]	<0.0792 [4]	<0.0769 [3]	<0.0784 [6]	<0.0800 [3]	0.0893 [6]	<0.0816 [9]	<0.0808 [6]	<0.0800 [3]	<0.0816 [11]	<0.0784	ug/L	0.625 [5]	0.0893 [6]
Benzo(a)pyrene	ug/L	1.84 [5]	0.0832 [4] [17] [12]	0.0865 [3] [12] [12]	0.117 [6]	<0.114 [3] [16] [12]	0.133 [6]	0.171 [9]	0.104 [6]	<0.100 [3] [14] [12]	<0.102 [11] [28] [12]	<0.0784	ug/L	<0.0784	1.84 [5]
Benzo(b)fluoranthene	ug/L		<0.0792 [4]	<0.0769 [3]		<0.0800 [3]				<0.0800 [3]	<0.0816 [11]	<0.0784	ug/L	<0.0769 [3]	<0.0816 [11]
Benzo(k)fluoranthene	ug/L		<0.0792 [4]	<0.0769 [3]		<0.0800 [3]				<0.0800 [3]	<0.0816 [11]	<0.0784	ug/L	<0.0769 [3]	<0.0816 [11]
Benzo(b+k)fluoranthene(s)	ug/L	2.22 [5] [15] [10]			<0.157 [6] [16] [10]		0.217 [6] [19] [10]		0.164 [6] [16] [10]				ug/L	<0.157 [6] [16] [10]	2.22 [5] [15] [10]
Benzo(g,h,i)perylene	ug/L	1.74 [5]	<0.0792 [4]	<0.0769 [3]	0.0913 [6]	<0.0800 [3]	0.110 [6]	0.123 [9]	0.107 [6]	<0.0800 [3]	<0.0816 [11]	<0.0784	ug/L	<0.0769 [3]	1.74 [5]
Carbazole	ug/L	<0.0762 [5]	<0.0792 [4]	<0.0769 [3]	<0.0784 [6]	<0.0800 [3]	<0.0800 [6]	<0.0816 [9]	<0.0808 [6]	<0.0800 [3]	<0.0816 [11]	<0.0784	ug/L	<0.0762 [5]	<0.0816 [9]
Chrysene	ug/L	0.743 [5]	<0.0792 [4]	<0.0769 [3]	<0.0784 [6]	<0.0800 [3]	<0.0800 [6]	<0.0816 [9]	<0.0808 [6]	<0.0800 [3]	<0.0816 [11]	<0.0784	ug/L	<0.0769 [3]	<0.0816 [11]
Dibenz(a,h)anthracene	ug/L	0.171 [5]	<0.0792 [4]	<0.0769 [3]	<0.0784 [6]	<0.0800 [3]	<0.0800 [6]	<0.0816 [9]	<0.0808 [6]	<0.0800 [3]	<0.0816 [11]	<0.0784	ug/L	<0.0769 [3]	0.171 [5]
Dibenzofuran	ug/L	<0.0762 [5]	<0.0792 [4]	<0.0769 [3]	<0.0784 [6]	<0.0800 [3]	<0.0800 [6]	<0.0816 [9]	<0.0808 [6]	<0.0800 [3]	<0.0816 [11]	<0.0784	ug/L	<0.0762 [5]	<0.0816 [9]
Fluoranthene	ug/L	0.660 [5]	<0.0792 [4]	<0.0769 [3]	<0.0784 [6]	<0.0800 [3]	0.191 [6]	0.111 [9]	0.104 [6]	0.127 [3]	<0.0816 [11]	0.0794	ug/L	<0.0769 [3]	0.660 [5]
Fluorene	ug/L	<0.0762 [5]	<0.0792 [4]	<0.0769 [3]	<0.0784 [6]	<0.0800 [3]	<0.0800 [6]	<0.0816 [9]	<0.0808 [6]	<0.0800 [3]	<0.0816 [11]	<0.0784	ug/L	<0.0762 [5]	<0.0816 [9]
Indeno(1,2,3-cd)pyrene	ug/L	1.57 [5]	<0.0792 [4]	<0.0769 [3]	<0.0784 [6]	<0.0800 [3]	<0.0800 [6]	0.0818 [9]	<0.0808 [6]	<0.0800 [3]	<0.0816 [11]	<0.0784	ug/L	<0.0769 [3]	1.57 [5]
2-Methylnaphthalene	ug/L	<0.0762 [5]	<0.0792 [4]	<0.0769 [3]	<0.0784 [6]	<0.0800 [3]	<0.0800 [6]	<0.0816 [9]	<0.0808 [6]	<0.0800 [3]	0.104 [9] [11] [6]	<0.0784	ug/L	<0.0769 [3]	0.104 [9] [11] [6]
Naphthalene	ug/L	<0.0762 [5]	<0.0792 [4]	0.0795 [3]	0.0986 [3] [6] [6]	0.0837 [1] [3] [6]	0.144 [3] [4] [6] [5] [6]	<0.0816 [8] [9] [7]	0.0809 [3] [6] [6]	0.201 [3]	0.955 [2] [9] [11] [4] [6]	<0.0784	ug/L	<0.0762 [5]	0.955 [2] [9] [11] [4] [6]
Phenanthrene	ug/L	0.317 [5]	<0.0792 [4]	<0.0769 [3]	<0.0784 [6]	<0.0800 [3]	0.118 [6]	<0.0816 [9]	<0.0808 [6]	0.121 [3]	<0.0816 [11]	<0.0784	ug/L	<0.0769 [3]	0.317 [5]
Pyrene	ug/L	0.980 [5]	<0.0792 [4]	<0.0769 [3]	<0.0784 [6]	<0.0800 [3]	0.247 [6]	0.138 [9]	0.125 [6]	0.148 [3]	<0.0816 [11]	<0.0784	ug/L	<0.0769 [3]	0.980 [5]
2-Chlorophenol	ug/L	<0.952 [5]	<0.990 [4]	<0.962 [3]	<0.980 [6]	<1.00 [3]	<1.00 [6]	<1.02 [9]	<1.01 [6]	<1.00 [3]	<1.02 [11]	<0.980	ug/L	<0.952 [5]	<1.02 [11]
2,4-Dichlorophenol	ug/L	<0.952 [5]	<0.990 [4]	<0.962 [3]	<0.980 [6]	<1.00 [3]	<1.00 [6]	<1.02 [9]	<1.01 [6]	<1.00 [3]	<1.02 [11]	<0.980	ug/L	<0.952 [5]	<1.02 [11]
2,4-Dimethylphenol	ug/L	<0.952 [5]	<0.990 [4]	<0.962 [3]	<0.980 [6]	<1.00 [3]	<1.00 [6]	<1.02 [9]	<1.01 [6]	<1.00 [3]	<1.02 [11]	<0.980	ug/L	<0.952 [5]	<1.02 [11]
4,6-Dinitro-2-methylphenol	ug/L	<0.952 [5]	<0.990 [4]	<0.962 [3]	<0.980 [6]	<1.00 [3]	<1.00 [6]	<1.02 [9]	<1.01 [6]	<1.00 [3]	<1.02 [11]	<0.980	ug/L	<0.952 [5]	<1.02 [11]
2-Methylphenol	ug/L	<0.952 [5]	<0.990 [4]	<0.962 [3]	<0.980 [6]	<1.00 [3]	<1.00 [6]	<1.02 [9]	<1.01 [6]	<1.00 [3]	<1.02 [11]	<0.980	ug/L	<0.952 [5]	<1.02 [11]
2-Nitrophenol	ug/L	<0.952 [5]	<0.990 [4]	<0.962 [3]	<0.980 [6]	<1.00 [3]	<1.00 [6]	<1.02 [9]	<1.01 [6]	<1.00 [3]	<1.02 [11]	<0.980	ug/L	<0.952 [5]	<1.02 [11]
4-Nitrophenol	ug/L	<3.81 [5]	<0.990 [4]	<0.962 [3]	<0.980 [6]	<1.00 [3]	<1.00 [6]	<1.02 [9]	<1.01 [6]	<1.00 [3]	<1.02 [11]	<0.980	ug/L	<3.81 [5]	<1.02 [11]
2,4,5-Trichlorophenol	ug/L	<0.952 [5]	<0.990 [4]	<0.962 [3]	<0.980 [6]	<1.00 [3]	<1.00 [6]	<1.02 [9]	<1.01 [6]	<1.00 [3]	<1.02 [11]	<0.980	ug/L	<0.952 [5]	<1.02 [11]
2,4,6-Trichlorophenol	ug/L	<0.952 [5]	<0.990 [4]	<0.962 [3]	<0.980 [6]	<1.00 [3]	<1.00 [6]	<1.02 [9]	<1.01 [6]	<1.00 [3]	<1.02 [11]	<0.980	ug/L	<0.952 [5]	<1.02 [11]
Pentachlorophenol (PCP)	ug/L	<0.952 [5]	<0.990 [4]	<0.962 [3]	<0.980 [6]	<1.00 [3]	<1.00 [6]	<1.02 [9]	<1.01 [6]	<1.00 [3]	<1.02 [11]	<0.980	ug/L	<0.952 [5]	<1.02 [11]
Phenol	ug/L	<0.952 [5]	<0.990 [4]	<0.962 [3]	<0.980 [6]	<1.00 [3]	<1.00 [6]	<1.02 [9]	<1.01 [6]	<1.00 [3]	<1.02 [11]	5.84	ug/L	<0.952 [5]	5.84
METALS															
Hexavalent Chromium	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0400 [20] [12]	<0.0100	<0.0100	<0.0200		<0.0100	mg/L	<0.0100	<0.0400 [20] [12]
Silver	ug/L	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Arsenic	ug/L	4.02	2.79	2.67 [1] [6]	3.32 [3] [6]	2.92 [1] [6]	3.82	4.02	3.83	3.87	7.48	30.5	ug/L	2.67 [1] [6]	30.5
Cadmium	ug/L	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Chromium	ug/L	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	2.2	ug/L	<1.00	2.2
Copper	ug/L	<5.00	<5.00	<5.00	10.1	<5.00	19.6	6.14	8.62	<5.00	<5.00	17.9	ug/L	<5.00	17.9
Dissolved Iron	ug/L	577	432	409	761	283	464	255	234	222	168	1990	ug/L	168	1990
Mercury	ug/L	0.0107	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	0.0130 [2] [3]	<0.0100	<0.0100	<0.0100	0.0176	ug/L	<0.0100	0.0176
Dissolved Manganese	ug/L	175	11.5	67	55	65.5	62.2	66.1	121	68	98.3	47.1	ug/L	11.5	175
Nickel	ug/L	3.29	2.57	3.09	7.92	4.57	9.98	9.68	11.7	7.63	8.42	31.5	ug/L	2.57	31.5
Lead	ug/L	<1.00	<1.00	<1.00	1.93	<1.00	7.66	2.7	2.27	<1.00	1.82	4.34	ug/L	<1.00	7.66
Selenium	ug/L	5.6	4.5	3.94 [1] [6]	5.3	2.19	2.02	3.01	2.93	2.19	1.86	1.9	ug/L	1.86	5.6
Zinc	ug/L	6.26	9.11	6.5	17.3	9.02	30.6	21	17.9	8.18	6.66	30.7	ug/L	6.26	30.7
Calcium	ug/L	6950	8540	15300	9300	14100	10200	13000	18000	14200	21700	13300	ug/L	6950	21700
Chromium	ug/L			<1.00									ug/L	<1.00	<1.00
Hardness (Calc by 6020)	mg CaCO3/L	173	204	234	181	313	313	342	352	351	360	133	mg CaCO3/L	133	360
Magnesium	ug/L	37800	44500	47600	38300	67500	69900	75100	74600	76600	74300	24200	ug/L	24200	76600
Trivalent Chromium	ug/L	<11.0	<11.0	<11.0	<11.0	<11.0	<41.0	<11.0	<11.0	<21.0	<1.00	<11.0	ug/L	<1.00	<41.0
SEMI-VOLATILE ORGANICS															
Acetone	ug/L	<20.0 [16] [11]	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<200 [11] [12] [11]	ug/L	<20.0	<200 [11] [12] [11]
Benzene	ug/L	<0.250	<0.250	<0.250	<0.250	<0.250	<0.250	<0.250	<0.250	<0.250	<0.250	<2.50 [12]	ug/L	<0.250	<2.50 [12]
2-Butanone (MEK)	ug/L	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<100 [11] [12] [11]	ug/L	<10.0	<100 [11] [12] [11]
1,1-Dichloroethene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<5.00 [12]	ug/L	<5.00 [12]	<5.00 [12]
cis-1,2-Dichloroethene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<5.00 [12]	ug/L	<5.00 [12]	<5.00 [12]
trans-1,2-Dichloroethene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<5.00 [12]	ug/L	<5.00 [12]	<5.00 [12]
Ethylbenzene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<5.00 [12]	ug/L	<5.00 [12]	<5.00 [12]
Tetrachloroethene (PCE)	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<5.00 [12]	ug/L	<5.00 [12]	<5.00 [12]
Toluene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<5.00 [12]	ug/L	<5.00 [12]	<5.00 [12]
Trichloroethene (TCE)	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<5.00 [12]	ug/L	<5.00 [12]	<5.00 [12]
Vinyl chloride	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<5.00 [12]	ug/L	<5.00 [12]	<5.00 [12]
m,p-Xylene	ug/L	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<10.0 [12]	ug/L	<1.00	<10.0 [12]
o-Xylene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<5.00 [12]	ug/L	<0.500	<5.00 [12]

FootNumber	Qualifier	TextBody
1	A-01	Analyte detected in the method blank at the MRL. All samples less than 10 times the MRL may be biased high.
2	A-01	Ending CCV fails at 89% (limit 90-110). Data possibly biased slightly low.
3	A-01a	Low level mercury samples are preferably preserved within 24 hours of sampling. This sample was preserved on 8/17/09 @ 11:45, approximately 110 hours after sampling.
4	A-01a	Result less than 10 times amount detected in method blank. Results may be biased high.
5	A-01b	Naphthalene detected in sample is less then ten times the level detected in the method blank. Results may be biased high.
6	B	Analyte detected in the associated extraction blank.
7	B-05	Analyte was detected in the Method Blank at a level above the MRL. This analyte was not detected above the MRL in any of the associated samples.
8	C-05	Extract has undergone a GPC (Gel-Permeation Chromotography) cleanup per EPA 3640A.
9	FILT	Sample was lab filtered and acid preserved prior to analysis. See sample preparation section of report for date and time of filtration.
10	Q-26	Peak separation for Benzo(b) and Benzo(k)fluoranthenes does not meet method specified criteria. Reported result includes the combined area of the two isomers and should be considered the total of Benzo(b+k)Fluoranthenes.
11	Q-30	Recovery for Lab Control Spike (LCS) is below the lower control limit. Data may be biased low.
12	R-01	The Reporting Limit for this analyte has been raised to account for matrix interference.
13	R-04	Reporting levels elevated due to dilution necessary for analysis.
14	S-04	Surrogate recovery is outside of established control limits due to a sample matrix effect.
15	S-06	Surrogate recovery is outside of established control limits.

Attachment F: Siltronic Pilot Plant Results—Through Process

31-Jul-09	Units	Influent S-1	EQ Effluent S-2	Clarifier Effluent S-3	AOP Effluent S-4	GAC Effluent NW-9S
pH	pH Units					
pH Temperature	pH Units					
Total Dissolved Solids	mg/L					
Total Suspended Solids	mg/L					
Total Organic Carbon	mg/L				9.11	
Total Iron	mg/L			9340		
Total Manganese	mg/L			366		
CYANIDE						
Cyanide, Total	mg/L				0.0479	
Cyanide, WAD	mg/L				0.0228	
Cyanide, Amenable	mg/L				<0.00500	
CATC, chlorinated	mg/L				0.0456	
Cyanide, Free	mg/L				<0.0100	
CATC, total	mg/L				0.0479	
SEMI-VOLATILE ORGANICS						
Acenaphthylene	ug/L				<0.0769	
Acenaphthene	ug/L				<0.0769	
Anthracene	ug/L				<0.0769	
Benz(a)anthracene	ug/L				<0.0769	
Benzo(a)pyrene	ug/L				<0.0769	
Benzo(b)fluoranthene	ug/L				<0.0769	
Benzo(k)fluoranthene	ug/L				<0.0769	
Benzo(g,h,i)perylene	ug/L				<0.0769	
Carbazole	ug/L				<0.0769	
Chrysene	ug/L				<0.0769	
Dibenz(a,h)anthracene	ug/L				<0.0769	
Dibenzofuran	ug/L				<0.0769	
Fluoranthene	ug/L				<0.0769	
Fluorene	ug/L				<0.0769	
Indeno(1,2,3-cd)pyrene	ug/L				<0.0769	
2-Methylnaphthalene	ug/L				<0.0769	
Naphthalene	ug/L				0.234	
Phenanthrene	ug/L				<0.0769	
Pyrene	ug/L				<0.0769	
2-Chlorophenol	ug/L				<0.962	
2,4-Dichlorophenol	ug/L				<0.962	
2,4-Dimethylphenol	ug/L				<0.962	
4,6-Dinitro-2-methylphenol	ug/L				<0.962	
2-Methylphenol	ug/L				<0.962	
2-Nitrophenol	ug/L				<0.962	
4-Nitrophenol	ug/L				<0.962	
2,4,5-Trichlorophenol	ug/L				<0.962	
2,4,6-Trichlorophenol	ug/L				<0.962	
Pentachlorophenol (PCP)	ug/L				<0.962	
Phenol	ug/L				<0.962	
METALS						
Hexavalent Chromium	mg/L					
Silver	ug/L					
Arsenic	ug/L			4.39	5.16	
Cadmium	ug/L					
Chromium	ug/L					
Copper	ug/L					
Dissolved Iron	ug/L			173 [4] [2]		
Mercury	ug/L					
Dissolved Manganese	ug/L			10.2 [4] [2]		
Nickel	ug/L					
Lead	ug/L					
Selenium	ug/L					
Zinc	ug/L					
Calcium	ug/L					
Chromium	ug/L					
Hardness (Calc by 6020)	mg CaCO3/L					
Magnesium	ug/L					
Trivalent Chromium	ug/L					
VOLATILE ORGANICS						
Acetone	ug/L				133 [15]	
Benzene	ug/L				<0.250 [15]	
2-Butanone (MEK)	ug/L				50.4 [15]	
1,1-Dichloroethene	ug/L				<0.500 [15]	
cis-1,2-Dichloroethene	ug/L				5.22 [15]	
trans-1,2-Dichloroethene	ug/L				0.640 [15]	
Ethylbenzene	ug/L				<0.500 [15]	
Tetrachloroethene (PCE)	ug/L				<0.500 [15]	
Toluene	ug/L				<0.500 [15]	
Trichloroethene (TCE)	ug/L				1.06 [15]	
Vinyl chloride	ug/L				<0.500 [15]	
m,p-Xylene	ug/L				<1.00 [15]	
o-Xylene	ug/L				<0.500 [15]	

3-Aug-09	Units	Influent S-1	EQ Effluent S-2	Clarifier Effluent S-3	AOP Effluent S-4	GAC Effluent NW-9S
pH	pH Units	6.85				
pH Temperature	pH Units	18.4				
Total Dissolved Solids	mg/L	462				
Total Suspended Solids	mg/L	<5.00				
Total Organic Carbon	mg/L	10.7 [1] [1]			5.38	
Total Iron	mg/L			4640		
Total Manganese	mg/L			244		
CYANIDE						
Cyanide, Total	mg/L	0.338			0.0733	
Cyanide, WAD	mg/L	0.0617			0.0402	
Cyanide, Amenable	mg/L	<0.0250			<0.00500	
CATC, chlorinated	mg/L	0.434			0.0815	
Cyanide, Free	mg/L	<0.0100			0.0154	
CATC, total	mg/L	0.338			0.0733	
SEMI-VOLATILE ORGANICS						
Acenaphthylene	ug/L				<0.0755 [5] [11]	
Acenaphthene	ug/L				<0.0755 [5] [11]	
Anthracene	ug/L				<0.0755 [5] [11]	
Benz(a)anthracene	ug/L				<0.0755 [5] [11]	
Benzo(a)pyrene	ug/L				<0.0755 [5] [11]	
Benzo(b)fluoranthene	ug/L				<0.0755 [5] [11]	
Benzo(k)fluoranthene	ug/L				<0.0755 [5] [11]	
Benzo(g,h,i)perylene	ug/L				<0.0755 [5] [11]	
Carbazole	ug/L				<0.113 [5] [11] [28] [9]	
Chrysene	ug/L				<0.0755 [5] [11]	
Dibenz(a,h)anthracene	ug/L				<0.0755 [5] [11]	
Dibenzofuran	ug/L				<0.0755 [5] [11]	
Fluoranthene	ug/L				<0.0755 [5] [11]	
Fluorene	ug/L				<0.0755 [5] [11]	
Indeno(1,2,3-cd)pyrene	ug/L				<0.0755 [5] [11]	
2-Methylnaphthalene	ug/L				<0.0755 [5] [11]	
Naphthalene	ug/L				0.672 [2] [5] [9] [11] [2] [5]	
Phenanthrene	ug/L				<0.0755 [5] [11]	
Pyrene	ug/L				<0.0755 [5] [11]	
2-Chlorophenol	ug/L				<0.943 [5] [11]	
2,4-Dichlorophenol	ug/L				<0.943 [5] [11]	
2,4-Dimethylphenol	ug/L				<0.943 [5] [11]	
4,6-Dinitro-2-methylphenol	ug/L				<0.943 [5] [11]	
2-Methylphenol	ug/L				<0.943 [5] [11]	
2-Nitrophenol	ug/L				<0.943 [5] [11]	
4-Nitrophenol	ug/L				<0.943 [5] [11]	
2,4,5-Trichlorophenol	ug/L				<0.943 [5] [11]	
2,4,6-Trichlorophenol	ug/L				<0.943 [5] [11]	
Pentachlorophenol (PCP)	ug/L				<0.943 [5] [11]	
Phenol	ug/L				<0.943 [5] [11]	
METALS						
Hexavalent Chromium	mg/L					
Silver	ug/L	<0.0100				
Arsenic	ug/L	2.93		4.01	4.76	
Cadmium	ug/L	<1.00				
Chromium	ug/L	<1.00				
Copper	ug/L	<5.00				
Dissolved Iron	ug/L	2060		153 [13] [2]		
Mercury	ug/L	<0.0100				
Dissolved Manganese	ug/L	1380		2.81 [13] [2]		
Nickel	ug/L	12.1				
Lead	ug/L	3.92				
Selenium	ug/L	5				
Zinc	ug/L	12.8				
Calcium	ug/L	62800				
Chromium	ug/L					
Hardness (Calc by 6020)	mg CaCO3/L	318				
Magnesium	ug/L	39100				
Trivalent Chromium	ug/L	<1.00				
VOLATILE ORGANICS						
Acetone	ug/L	<200			65.3 [26] [8]	
Benzene	ug/L	42.1			<0.250	
2-Butanone (MEK)	ug/L	247			34.4 [26] [8]	
1,1-Dichloroethene	ug/L	<5.00			<0.500	
cis-1,2-Dichloroethene	ug/L	1060			14.5	
trans-1,2-Dichloroethene	ug/L	<5.00			0.64	
Ethylbenzene	ug/L	5.9			<0.500	
Tetrachloroethene (PCE)	ug/L	<5.00			<0.500	
Toluene	ug/L	<5.00			<0.500	
Trichloroethene (TCE)	ug/L	80.4			1.89	
Vinyl chloride	ug/L	172			<0.500	
m,p-Xylene	ug/L	<10.0			<1.00	
o-Xylene	ug/L	<5.00			<0.500	

4-Aug-09	Units	Influent S-1	EQ Effluent S-2	Clarifier Effluent S-3	AOP Effluent S-4	GAC Effluent NW-9S
pH	pH Units	6.85	10.2			
pH Temperature	pH Units	17.4	17.1			
Total Dissolved Solids	mg/L	441	744			
Total Suspended Solids	mg/L	22	25			
Total Organic Carbon	mg/L	9.35	7.56		6.9	
Total Iron	mg/L			4070		
Total Manganese	mg/L			224		
CYANIDE						
Cyanide, Total	mg/L	0.362	0.463		0.031	
Cyanide, WAD	mg/L	0.0504	0.0878		0.0174	
Cyanide, Amenable	mg/L	<0.00500	0.0351		<0.00500	
CATC, chlorinated	mg/L	0.4	0.428		0.0287	
Cyanide, Free	mg/L	<0.0100	0.0206		<0.0100	
CATC, total	mg/L	0.362	0.463		0.031	
SEMI-VOLATILE ORGANICS						
Acenaphthylene	ug/L	<1.90 [4]	0.217 [4]		<0.0769 [4]	
Acenaphthene	ug/L	2.61 [4]	0.642 [4]		<0.0769 [4]	
Anthracene	ug/L	<1.90 [4]	0.184 [4] [6] [7]		<0.0769 [4]	
Benz(a)anthracene	ug/L	<1.90 [4]	<0.0762 [4]		<0.0769 [4]	
Benzo(a)pyrene	ug/L	<1.90 [4]	<0.952 [4] [18] [8]		<0.0769 [4]	
Benzo(b)fluoranthene	ug/L	<1.90 [4]	<0.762 [4]		<0.0769 [4]	
Benzo(k)fluoranthene	ug/L	<1.90 [4]	<0.762 [4]		<0.0769 [4]	
Benzo(g,h,i)perylene	ug/L	<1.90 [4]	<0.0762 [4]		<0.0769 [4]	
Carbazole	ug/L	3.88 [4]	3.24 [4]		<0.0769 [4]	
Chrysene	ug/L	<1.90 [4]	0.116 [4]		<0.0769 [4]	
Dibenz(a,h)anthracene	ug/L	<1.90 [4]	<0.0762 [4]		<0.0769 [4]	
Dibenzofuran	ug/L	<1.90 [4]	0.211 [4]		<0.0769 [4]	
Fluoranthene	ug/L	<1.90 [4]	0.762 [4]		<0.0769 [4]	
Fluorene	ug/L	<1.90 [4]	0.292 [4]		<0.0769 [4]	
Indeno(1,2,3-cd)pyrene	ug/L	<1.90 [4]	<0.0762 [4]		<0.0769 [4]	
2-Methylnaphthalene	ug/L	9.16 [4]	1.17 [4]		<0.0769 [4]	
Naphthalene	ug/L	196 [2] [4] [2]	36.6 [2] [4] [3]		0.248 [2] [4] [5]	
Phenanthrene	ug/L	<1.90 [4]	2.22 [4]		<0.0769 [4]	
Pyrene	ug/L	<1.90 [4]	0.401 [4]		<0.0769 [4]	
2-Chlorophenol	ug/L	<23.8 [4]	<0.952 [4]		<0.962 [4]	
2,4-Dichlorophenol	ug/L	<23.8 [4]	<0.952 [4]		<0.962 [4]	
2,4-Dimethylphenol	ug/L	<23.8 [4]	<0.952 [4]		<0.962 [4]	
4,6-Dinitro-2-methylphenol	ug/L	<23.8 [4]	<0.952 [4]		<0.962 [4]	
2-Methylphenol	ug/L	<23.8 [4]	<0.952 [4]		<0.962 [4]	
2-Nitrophenol	ug/L	<23.8 [4]	<0.952 [4]		<0.962 [4]	
4-Nitrophenol	ug/L	<23.8 [4]	<0.952 [4]		<0.962 [4]	
2,4,5-Trichlorophenol	ug/L	<23.8 [4]	<0.952 [4]		<0.962 [4]	
2,4,6-Trichlorophenol	ug/L	<23.8 [4]	<0.952 [4]		<0.962 [4]	
Pentachlorophenol (PCP)	ug/L	<23.8 [4]	<0.952 [4]		<0.962 [4]	
Phenol	ug/L	<23.8 [4]	<0.952 [4]		<0.962 [4]	
METALS						
Hexavalent Chromium	mg/L	<0.0100	<0.0100			
Silver	ug/L	<1.00	<1.00			
Arsenic	ug/L	4.91	3.83	4.4	5.2	
Cadmium	ug/L	<1.00	<1.00			
Chromium	ug/L	<1.00	1			
Copper	ug/L	<5.00	7.07			
Dissolved Iron	ug/L	14700	3630	<100 [5] [2]		
Mercury	ug/L	<0.0100	<0.0100			
Dissolved Manganese	ug/L	1370	219	6.30 [5] [2]		
Nickel	ug/L	2.43	1.32			
Lead	ug/L	1.74	<1.00			
Selenium	ug/L	4.11	4.58			
Zinc	ug/L	7.11	12.4			
Calcium	ug/L	61800	3350			
Chromium	ug/L					
Hardness (Calc by 6020)	mg CaCO3/L	313	157			
Magnesium	ug/L	38400	36200			
Trivalent Chromium	ug/L	<11.0	<11.0			
VOLATILE ORGANICS						
Acetone	ug/L	<200	<400 [19]		104 [17] [8]	
Benzene	ug/L	54.3	9.00 [19]		<0.250	
2-Butanone (MEK)	ug/L	<100	<200 [19]		30.9 [17] [8]	
1,1-Dichloroethene	ug/L	9.1	<10.0 [19]		<0.500	
cis-1,2-Dichloroethene	ug/L	1560	275 [19]		4.77	
trans-1,2-Dichloroethene	ug/L	7.4	<10.0 [19]		<0.500	
Ethylbenzene	ug/L	17.8	<10.0 [19]		<0.500	
Tetrachloroethene (PCE)	ug/L	<5.00	<10.0 [19]		<0.500	
Toluene	ug/L	7.3	<10.0 [19]		<0.500	
Trichloroethene (TCE)	ug/L	208	29.0 [19]		0.52	
Vinyl chloride	ug/L	333	21.4 [19]		<0.500	
m,p-Xylene	ug/L	25	27.4 [19]		<1.00	
o-Xylene	ug/L	9.1	11.2 [19]		<0.500	

5-Aug-09	Units	Influent S-1	EQ Effluent S-2	Clarifier Effluent S-3	AOP Effluent S-4	GAC Effluent NW-9S
pH	pH Units	6.96	9.69			
pH Temperature	pH Units	18.4	17.7			
Total Dissolved Solids	mg/L	437	608			
Total Suspended Solids	mg/L	35	34			
Total Organic Carbon	mg/L	13.6	4.01		3.1	
Total Iron	mg/L			2320		
Total Manganese	mg/L			327		
CYANIDE						
Cyanide, Total	mg/L	0.245	0.283		0.0558	
Cyanide, WAD	mg/L	0.0603	0.0635		0.0442	
Cyanide, Amenable	mg/L	<0.00500	<0.00500		<0.00500	
CATC, chlorinated	mg/L	0.387	0.4		0.0591	
Cyanide, Free	mg/L	<0.0100	<0.0100		0.0163	
CATC, total	mg/L	0.245	0.283		0.0558	
Available Cyanide	mg/L	0.0042	0.0059		0.034	
SEMI-VOLATILE ORGANICS						
Acenaphthylene	ug/L	<1.86 [2]	0.563 [2]		<0.0755 [2]	
Acenaphthene	ug/L	<1.86 [2]	1.92 [2]		<0.0755 [2]	
Anthracene	ug/L	<1.86 [2]	<0.0784 [2]		<0.0755 [2]	
Benz(a)anthracene	ug/L	<1.86 [2]	<0.0784 [2]		<0.0755 [2]	
Benzo(a)pyrene	ug/L	<1.86 [2]	<0.0980 [2] [12] [8]		<0.0755 [2]	
Benzo(b)fluoranthene	ug/L	<1.86 [2]	<0.0784 [2]		<0.0755 [2]	
Benzo(k)fluoranthene	ug/L	<1.86 [2]	<0.0784 [2]		<0.0755 [2]	
Benzo(g,h,i)perylene	ug/L	<1.86 [2]	<0.0784 [2]		<0.0755 [2]	
Carbazole	ug/L	3.16 [2]	2.48 [2]		<0.0755 [2]	
Chrysene	ug/L	<1.86 [2]	<0.0784 [2]		<0.0755 [2]	
Dibenz(a,h)anthracene	ug/L	<1.86 [2]	<0.0784 [2]		<0.0755 [2]	
Dibenzofuran	ug/L	<1.86 [2]	0.0859 [2]		<0.0755 [2]	
Fluoranthene	ug/L	<1.86 [2]	<0.0784 [2]		<0.0755 [2]	
Fluorene	ug/L	<1.86 [2]	0.376 [2]		<0.0755 [2]	
Indeno(1,2,3-cd)pyrene	ug/L	<1.86 [2]	<0.0784 [2]		<0.0755 [2]	
2-Methylnaphthalene	ug/L	2.91 [2]	6.63 [2]		<0.0755 [2]	
Naphthalene	ug/L	95.6 [2]	141 [2]		<0.113 [2] [12] [9]	
Phenanthrene	ug/L	<1.86 [2]	0.258 [2]		<0.0755 [2]	
Pyrene	ug/L	<1.86 [2]	<0.0784 [2]		<0.0755 [2]	
2-Chlorophenol	ug/L	<23.3 [2]	<0.980 [2]		<0.943 [2]	
2,4-Dichlorophenol	ug/L	<23.3 [2]	<0.980 [2]		<0.943 [2]	
2,4-Dimethylphenol	ug/L	<23.3 [2]	<0.980 [2]		<0.943 [2]	
4,6-Dinitro-2-methylphenol	ug/L	<23.3 [2]	<0.980 [2]		<0.943 [2]	
2-Methylphenol	ug/L	<23.3 [2]	<0.980 [2]		<0.943 [2]	
2-Nitrophenol	ug/L	<23.3 [2]	<0.980 [2]		<0.943 [2]	
4-Nitrophenol	ug/L	<23.3 [2]	<0.980 [2]		<0.943 [2]	
2,4,5-Trichlorophenol	ug/L	<23.3 [2]	<0.980 [2]		<0.943 [2]	
2,4,6-Trichlorophenol	ug/L	<23.3 [2]	<0.980 [2]		<0.943 [2]	
Pentachlorophenol (PCP)	ug/L	<23.3 [2]	<0.980 [2]		<0.943 [2]	
Phenol	ug/L	<23.3 [2]	<0.980 [2]		<0.943 [2]	
METALS						
Hexavalent Chromium	mg/L	<0.0100	<0.0100			
Silver	ug/L	<1.00	<1.00			
Arsenic	ug/L	5.06	3.72	3.92	4.43	
Cadmium	ug/L	<1.00	<1.00			
Chromium	ug/L	<1.00	<1.00			
Copper	ug/L	<5.00	<5.00			
Dissolved Iron	ug/L	14300	2220	167 [4] [2]		
Mercury	ug/L	<0.0100	<0.0100			
Dissolved Manganese	ug/L	1380	351	34.5 [4] [2]		
Nickel	ug/L	5.73	1.49			
Lead	ug/L	2.79	1.31			
Selenium	ug/L	2.86	3.06			
Zinc	ug/L	7.08	<4.00			
Calcium	ug/L	62500	8480			
Chromium	ug/L					
Hardness (Calc by 6020)	mg CaCO3/L	312	160			
Magnesium	ug/L	37900	33800			
Trivalent Chromium	ug/L	<11.0	<11.0			
VOLATILE ORGANICS						
Acetone	ug/L	<200	<200		46.7	
Benzene	ug/L	51.4	29.2		<0.250	
2-Butanone (MEK)	ug/L	<100	<100		14.8	
1,1-Dichloroethene	ug/L	<5.00	<5.00		<0.500	
cis-1,2-Dichloroethene	ug/L	1580	950		<0.500	
trans-1,2-Dichloroethene	ug/L	<5.00	<5.00		0.52	
Ethylbenzene	ug/L	13.7	9		<0.500	
Tetrachloroethene (PCE)	ug/L	<5.00	<5.00		<0.500	
Toluene	ug/L	7.3	5.1		<0.500	
Trichloroethene (TCE)	ug/L	70.6	87.9		1.72	
Vinyl chloride	ug/L	344	98.2		<0.500	
m,p-Xylene	ug/L	20	14.3		<1.00	
o-Xylene	ug/L	7.4	5.4		<0.500	

6-Aug-09	Units	Influent S-1	EQ Effluent S-2	Clarifier Effluent S-3	AOP Effluent S-4	GAC Effluent NW-9S
pH	pH Units	6.83	9.7			
pH Temperature	pH Units	22.8	22.5			
Total Dissolved Solids	mg/L	471	659			
Total Suspended Solids	mg/L	60	16			
Total Organic Carbon	mg/L	12.5	5.73		6.62	
Total Iron	mg/L			1890		
Total Manganese	mg/L			259		
CYANIDE						
Cyanide, Total	mg/L	0.259	0.321		0.0413	
Cyanide, WAD	mg/L	0.0468	0.0489		0.0267	
Cyanide, Amenable	mg/L	<0.00500	<0.00500		<0.00500	
CATC, chlorinated	mg/L	0.401	0.401		0.0634	
Cyanide, Free	mg/L	<0.0100	<0.0100		<0.0100	
CATC, total	mg/L	0.259	0.321		0.0413	
Available Cyanide	mg/L	0.0035	0.0048		0.020	
SEMI-VOLATILE ORGANICS						
Acenaphthylene	ug/L	<1.90 [2]	0.419 [2]		<0.0762 [2]	
Acenaphthene	ug/L	<1.90 [2]	1.36 [2]		<0.0762 [2]	
Anthracene	ug/L	<1.90 [2]	<0.0777 [2]		<0.0762 [2]	
Benz(a)anthracene	ug/L	<1.90 [2]	<0.0777 [2]		<0.0762 [2]	
Benzo(a)pyrene	ug/L	<2.38 [2] [12] [6]	<0.0971 [2] [12] [8]		<0.0762 [2]	
Benzo(b)fluoranthene	ug/L	<2.38 [2]	<0.0777 [2]		<0.0762 [2]	
Benzo(k)fluoranthene	ug/L	<1.90 [2]	<0.0777 [2]		<0.0762 [2]	
Benzo(g,h,i)perylene	ug/L	<1.90 [2]	<0.0777 [2]		<0.0762 [2]	
Carbazole	ug/L	3.87 [2]	2.06 [2]		<0.0762 [2]	
Chrysene	ug/L	<1.90 [2]	<0.0777 [2]		<0.0762 [2]	
Dibenz(a,h)anthracene	ug/L	<1.90 [2]	<0.0777 [2]		<0.0762 [2]	
Dibenzofuran	ug/L	<1.90 [2]	<0.0777 [2]		<0.0762 [2]	
Fluoranthene	ug/L	<1.90 [2]	<0.0777 [2]		<0.0762 [2]	
Fluorene	ug/L	<1.90 [2]	0.262 [2]		<0.0762 [2]	
Indeno(1,2,3-cd)pyrene	ug/L	<1.90 [2]	<0.0777 [2]		<0.0762 [2]	
2-Methylnaphthalene	ug/L	5.46 [2]	4.42 [2]		<0.0762 [2]	
Naphthalene	ug/L	113 [2]	104 [2]		<0.114 [2] [12] [9]	
Phenanthrene	ug/L	<1.90 [2]	0.190 [2]		<0.0762 [2]	
Pyrene	ug/L	<1.90 [2]	<0.0777 [2]		<0.0762 [2]	
2-Chlorophenol	ug/L	<23.8 [2]	<0.971 [2]		<0.952 [2]	
2,4-Dichlorophenol	ug/L	<23.8 [2]	<0.971 [2]		<0.952 [2]	
2,4-Dimethylphenol	ug/L	<23.8 [2]	<0.971 [2]		<0.952 [2]	
4,6-Dinitro-2-methylphenol	ug/L	<23.8 [2]	<0.971 [2]		<0.952 [2]	
2-Methylphenol	ug/L	<23.8 [2]	<0.971 [2]		<0.952 [2]	
2-Nitrophenol	ug/L	<23.8 [2]	<0.971 [2]		<0.952 [2]	
4-Nitrophenol	ug/L	<23.8 [2]	<0.971 [2]		<0.952 [2]	
2,4,5-Trichlorophenol	ug/L	<23.8 [2]	<0.971 [2]		<0.952 [2]	
2,4,6-Trichlorophenol	ug/L	<23.8 [2]	<0.971 [2]		<0.952 [2]	
Pentachlorophenol (PCP)	ug/L	<23.8 [2]	<0.971 [2]		<0.952 [2]	
Phenol	ug/L	<23.8 [2]	<0.971 [2]		<0.952 [2]	
METALS						
Hexavalent Chromium	mg/L	<0.0100	<0.0100			
Silver	ug/L	<1.00	<1.00			
Arsenic	ug/L	7.54	4	3.93	4.56	
Cadmium	ug/L	<1.00	<1.00			
Chromium	ug/L	<1.00	<1.00			
Copper	ug/L	<5.00	<5.00			
Dissolved Iron	ug/L	30100	1900	1890		
Mercury	ug/L	<0.0100	<0.0100			
Dissolved Manganese	ug/L	1250	270	259		
Nickel	ug/L	1.22	1.77			
Lead	ug/L	<1.00	1.5			
Selenium	ug/L	2.72	2.99			
Zinc	ug/L	<4.00	5.37			
Calcium	ug/L	61800	4460			
Chromium	ug/L					
Hardness (Calc by 6020)	mg CaCO3/L	310	147			
Magnesium	ug/L	37700	32900			
Trivalent Chromium	ug/L	<11.0	<11.0			
VOLATILE ORGANICS						
Acetone	ug/L	<200	<200		51.4	
Benzene	ug/L	102	18.4		<0.250	
2-Butanone (MEK)	ug/L	<100	<100		47.4	
1,1-Dichloroethene	ug/L	16	<5.00		<0.500	
cis-1,2-Dichloroethene	ug/L	1720	624		6.82	
trans-1,2-Dichloroethene	ug/L	12.1	<5.00		<0.500	
Ethylbenzene	ug/L	22.2	5.3		<0.500	
Tetrachloroethene (PCE)	ug/L	<5.00	<5.00		<0.500	
Toluene	ug/L	13.5	<5.00		<0.500	
Trichloroethene (TCE)	ug/L	59.7	53		1.02	
Vinyl chloride	ug/L	638	44.7		<0.500	
m,p-Xylene	ug/L	16.1	<10.0		<1.00	
o-Xylene	ug/L	11.6	<5.00		<0.500	

10-Aug-09	Units	Influent S-1	EQ Effluent S-2	Clarifier Effluent S-3	AOP Effluent S-4	GAC Effluent NW-9S
pH	pH Units	6.58	9.53			
pH Temperature	pH Units	21.6	23.7			
Total Dissolved Solids	mg/L	504	638			
Total Suspended Solids	mg/L	70	8			
Total Organic Carbon	mg/L	31.9	3.03		4.72 [1] [1]	
Total Iron	mg/L			1480		
Total Manganese	mg/L			202		
CYANIDE						
Cyanide, Total	mg/L	0.479	0.363		0.0405	
Cyanide, WAD	mg/L	0.0528	0.0443		0.0189	
Cyanide, Amenable	mg/L	<0.0100	<0.00500		0.0072	
CATC, chlorinated	mg/L	0.504	0.392		0.0333	
Cyanide, Free	mg/L	<0.0100	<0.0100		<0.0100	
CATC, total	mg/L	0.479	0.363		0.0405	
Available Cyanide	mg/L	<0.0020	0.0021		0.066	
SEMI-VOLATILE ORGANICS						
Acenaphthylene	ug/L	<1.86 [4]	<1.86 [4]		<0.0762 [4]	
Acenaphthene	ug/L	<1.86 [4]	<1.86 [4]		<0.0762 [4]	
Anthracene	ug/L	<1.86 [4]	<1.86 [4]		<0.0762 [4]	
Benz(a)anthracene	ug/L	<1.86 [4]	<1.86 [4]		<0.0762 [4]	
Benzo(a)pyrene	ug/L	<1.86 [4]	<2.09 [4] [15] [8]		<0.0762 [4]	
Benzo(b)fluoranthene	ug/L	<1.86 [4]	<1.86 [4]		<0.0762 [4]	
Benzo(k)fluoranthene	ug/L	<1.86 [4]	<1.86 [4]		<0.0762 [4]	
Benzo(g,h,i)perylene	ug/L	<1.86 [4]	<1.86 [4]		<0.0762 [4]	
Carbazole	ug/L	4.20 [4]	2.89 [4]		0.0784 [4]	
Chrysene	ug/L	<1.86 [4]	<1.86 [4]		<0.0762 [4]	
Dibenz(a,h)anthracene	ug/L	<1.86 [4]	<1.86 [4]		<0.0762 [4]	
Dibenzofuran	ug/L	<1.86 [4]	<1.86 [4]		<0.0762 [4]	
Fluoranthene	ug/L	<1.86 [4]	<1.86 [4]		<0.0762 [4]	
Fluorene	ug/L	<1.86 [4]	<1.86 [4]		<0.0762 [4]	
Indeno(1,2,3-cd)pyrene	ug/L	<1.86 [4]	<1.86 [4]		<0.0762 [4]	
2-Methylnaphthalene	ug/L	5.15 [4]	<1.86 [4]		<0.0762 [4]	
Naphthalene	ug/L	113 [4]	<1.86 [4]		<0.0762 [4]	
Phenanthrene	ug/L	<1.86 [4]	<1.86 [4]		<0.0762 [4]	
Pyrene	ug/L	<1.86 [4]	<1.86 [4]		<0.0762 [4]	
2-Chlorophenol	ug/L	<23.3 [4]	<23.3 [4]		<0.952 [4]	
2,4-Dichlorophenol	ug/L	<23.3 [4]	<23.3 [4]		<0.952 [4]	
2,4-Dimethylphenol	ug/L	<23.3 [4]	<23.3 [4]		<0.952 [4]	
4,6-Dinitro-2-methylphenol	ug/L	<23.3 [4]	<23.3 [4]		<0.952 [4]	
2-Methylphenol	ug/L	<23.3 [4]	<23.3 [4]		<0.952 [4]	
2-Nitrophenol	ug/L	<23.3 [4]	<23.3 [4]		<0.952 [4]	
4-Nitrophenol	ug/L	<23.3 [4]	<23.3 [4]		<0.952 [4]	
2,4,5-Trichlorophenol	ug/L	<23.3 [4]	<23.3 [4]		<0.952 [4]	
2,4,6-Trichlorophenol	ug/L	<23.3 [4]	<23.3 [4]		<0.952 [4]	
Pentachlorophenol (PCP)	ug/L	<23.3 [4]	<23.3 [4]		<0.952 [4]	
Phenol	ug/L	<23.3 [4]	<23.3 [4]		<0.952 [4]	
METALS						
Hexavalent Chromium	mg/L	<0.0100	<0.0100			
Silver	ug/L	<1.00	<1.00			
Arsenic	ug/L	5.71	2.94	3.13	4.01	
Cadmium	ug/L	<1.00	<1.00			
Chromium	ug/L	<1.00	<1.00			
Copper	ug/L	<5.00	<5.00			
Dissolved Iron	ug/L	36000	1590	142 [5] [2]		
Mercury	ug/L	<0.0100	<0.0100			
Dissolved Manganese	ug/L	2030	221	8.04 [5] [2]		
Nickel	ug/L	1	1.18			
Lead	ug/L	<1.00	1.21			
Selenium	ug/L	5.6	4.29			
Zinc	ug/L	<4.00	4.52			
Calcium	ug/L	75700	2000			
Chromium	ug/L					
Hardness (Calc by 6020)	mg CaCO3/L	381	141			
Magnesium	ug/L	46700	33000			
Trivalent Chromium	ug/L	<11.0	<11.0			
VOLATILE ORGANICS						
Acetone	ug/L	<200	<40.0 [17]		43.3	
Benzene	ug/L	73	4.04 [17]		<0.250	
2-Butanone (MEK)	ug/L	<100	<20.0 [17]		<10.0	
1,1-Dichloroethene	ug/L	16.6	<1.00 [17]		<0.500	
cis-1,2-Dichloroethene	ug/L	1560	206 [17]		1.82	
trans-1,2-Dichloroethene	ug/L	11.7	1.54 [17]		<0.500	
Ethylbenzene	ug/L	18.8	<1.00 [17]		<0.500	
Tetrachloroethene (PCE)	ug/L	7	<1.00 [17]		<0.500	
Toluene	ug/L	15.2	<1.00 [17]		<0.500	
Trichloroethene (TCE)	ug/L	44	8.60 [17]		<0.500	
Vinyl chloride	ug/L	698	3.12 [17]		<0.500	
m,p-Xylene	ug/L	23.7	98.2		<1.00	
o-Xylene	ug/L	13.6	<1.00 [17]		<0.500	

12-Aug-09	Units	Influent S-1	EQ Effluent S-2	Clarifier Effluent S-3	AOP Effluent S-4	GAC Effluent NW-9S
pH	pH Units	6.62	9.87			7.31
pH Temperature	pH Units	20.8	21.1			22
Total Dissolved Solids	mg/L	423	660			718
Total Suspended Solids	mg/L	62.9	27			<5.00
Total Organic Carbon	mg/L	11.3	<2.00		<2.00	<2.00
Total Iron	mg/L			1010		<100 [5] [4]
Total Manganese	mg/L			189		34.6 [5] [4]
CYANIDE						
Cyanide, Total	mg/L	0.353			0.0691	0.0226
Cyanide, WAD	mg/L	0.0619			0.0312	0.0079
Cyanide, Amenable	mg/L	3.17			0.0166	<0.00500
CATC, chlorinated	mg/L	0.359			0.0525	0.026
Cyanide, Free	mg/L	<0.0100			0.0324	<0.0100
CATC, total	mg/L	3.53			0.0691	0.0226
Available Cyanide	mg/L	0.0088	0.0035		0.059	<0.0020
SEMI-VOLATILE ORGANICS						
Acenaphthylene	ug/L	<1.86 [5]	<1.86 [5] [15]		<0.0762 [5]	<0.0762 [4]
Acenaphthene	ug/L	<1.86 [5]	<1.86 [5] [15]		<0.0762 [5]	<0.0762 [4]
Anthracene	ug/L	<1.86 [5]	<1.86 [5] [15]		<0.0762 [5]	<0.0762 [4]
Benz(a)anthracene	ug/L	<1.86 [5]	<1.86 [5] [15]		<0.0762 [5]	<0.0762 [4]
Benzo(a)pyrene	ug/L	<1.86 [5]	<2.14 [5] [14] [15] [8]		<0.0762 [5]	<0.0762 [4]
Benzo(b)fluoranthene	ug/L	<1.86 [5]	<1.86 [5] [15]		<0.0762 [5]	<0.0762 [4]
Benzo(k)fluoranthene	ug/L	<1.86 [5]	<1.86 [5] [15]		<0.0762 [5]	<0.0762 [4]
Benzo(g,h,i)perylene	ug/L	<1.86 [5]	<1.86 [5] [15]		<0.0762 [5]	<0.0762 [4]
Carbazole	ug/L	3.46 [5]	2.92 [5] [15]		<0.0762 [5]	<0.0762 [4]
Chrysene	ug/L	<1.86 [5]	<1.86 [5] [15]		<0.0762 [5]	<0.0762 [4]
Dibenz(a,h)anthracene	ug/L	<1.86 [5]	<1.86 [5] [15]		<0.0762 [5]	<0.0762 [4]
Dibenzofuran	ug/L	<1.86 [5]	<1.86 [5] [15]		<0.0762 [5]	<0.0762 [4]
Fluoranthene	ug/L	<1.86 [5]	<1.86 [5] [15]		<0.0762 [5]	<0.0762 [4]
Fluorene	ug/L	<1.86 [5]	<1.86 [5] [15]		<0.0762 [5]	<0.0762 [4]
Indeno(1,2,3-cd)pyrene	ug/L	<1.86 [5]	<1.86 [5] [15]		<0.0762 [5]	<0.0762 [4]
2-Methylnaphthalene	ug/L	4.13 [5]	<1.86 [5] [15]		<0.0762 [5]	<0.0762 [4]
Naphthalene	ug/L	68.5 [3] [5] [2]	2.01 [3] [5] [15] [3]		<0.0762 [5]	0.172 [2] [4] [1]
Phenanthrene	ug/L	<1.86 [5]	<1.86 [5] [15]		<0.0762 [5]	<0.0762 [4]
Pyrene	ug/L	<1.86 [5]	<1.86 [5] [15]		<0.0762 [5]	<0.0762 [4]
2-Chlorophenol	ug/L	<23.3 [5]	<23.3 [5] [15]		<0.952 [5]	<0.952 [4]
2,4-Dichlorophenol	ug/L	<23.3 [5]	<23.3 [5] [15]		<0.952 [5]	<0.952 [4]
2,4-Dimethylphenol	ug/L	<23.3 [5]	<23.3 [5] [15]		<0.952 [5]	<0.952 [4]
4,6-Dinitro-2-methylphenol	ug/L	<23.3 [5]	<23.3 [5] [15]		<0.952 [5]	<0.952 [4]
2-Methylphenol	ug/L	<23.3 [5]	<23.3 [5] [15]		<0.952 [5]	<0.952 [4]
2-Nitrophenol	ug/L	<23.3 [5]	<23.3 [5] [15]		<0.952 [5]	<0.952 [4]
4-Nitrophenol	ug/L	<23.3 [5]	<23.3 [5] [15]		<0.952 [5]	<0.952 [4]
2,4,5-Trichlorophenol	ug/L	<23.3 [5]	<23.3 [5] [15]		<0.952 [5]	<0.952 [4]
2,4,6-Trichlorophenol	ug/L	<23.3 [5]	<23.3 [5] [15]		<0.952 [5]	<0.952 [4]
Pentachlorophenol (PCP)	ug/L	<23.3 [5]	<23.3 [5] [15]		<0.952 [5]	<0.952 [4]
Phenol	ug/L	<23.3 [5]	<23.3 [5] [15]		<0.952 [5]	<0.952 [4]
METALS						
Hexavalent Chromium	mg/L	0.0398	<0.100 [14] [8]			<0.0100 [6] [5]
Silver	ug/L	<1.00	<1.00			<1.00
Arsenic	ug/L	5.2	3.32	3.19	4.03	5.99
Cadmium	ug/L	<1.00	<1.00			<1.00
Chromium	ug/L	2.96	<1.00			<1.00
Copper	ug/L	145	<5.00			<5.00
Dissolved Iron	ug/L	32200	775	152 [6] [2]		378
Mercury	ug/L	<0.0100	<0.0100			<0.0100
Dissolved Manganese	ug/L	1530	178	21.8 [6] [2]		56.2
Nickel	ug/L	24.1	1			4.81
Lead	ug/L	39.7	6.32			<1.00
Selenium	ug/L	4.79	4.61			2.1
Zinc	ug/L	311	<4.00			4.92
Calcium	ug/L	56800	4790			3230
Chromium	ug/L					
Hardness (Calc by 6020)	mg CaCO3/L	298	134			135
Magnesium	ug/L	38100	29700			30700
Trivalent Chromium	ug/L	<11.0	<101			<11.0
VOLATILE ORGANICS						
Acetone	ug/L	<200	<40.0		33.0 [19]	<20.0 [15]
Benzene	ug/L	23.2	22.6		<0.250 [19]	<0.250 [15]
2-Butanone (MEK)	ug/L	<100	<20.0		<10.0 [19]	<10.0 [15]
1,1-Dichloroethene	ug/L	<5.00	2.78		<0.500 [19]	<0.500 [15]
cis-1,2-Dichloroethene	ug/L	761	880 [19]		7.23 [19]	<0.500 [15]
trans-1,2-Dichloroethene	ug/L	<5.00	5.7		<0.500 [19]	<0.500 [15]
Ethylbenzene	ug/L	8.2	10.2		<0.500 [19]	<0.500 [15]
Tetrachloroethene (PCE)	ug/L	<5.00	<1.00		<0.500 [19]	<0.500 [15]
Toluene	ug/L	<5.00	3.08		<0.500 [19]	<0.500 [15]
Trichloroethene (TCE)	ug/L	<5.00	1.18		<0.500 [19]	<0.500 [15]
Vinyl chloride	ug/L	43.7	113		<0.500 [19]	<0.500 [15]
m,p-Xylene	ug/L	13.1	13.2		<1.00 [19]	<1.00 [15]
o-Xylene	ug/L	<5.00	5.02		<0.500 [19]	<0.500 [15]

18-Aug-09	Units	Influent S-1	EQ Effluent S-2	Clarifier Effluent S-3	AOP Effluent S-4	GAC Effluent NW-9S (8-20)
pH	pH Units	6.56	9.88			
pH Temperature	pH Units	13.1	18.8			
Total Dissolved Solids	mg/L	432	638			
Total Suspended Solids	mg/L	61	31			
Total Organic Carbon	mg/L	19.1	7.44		8.8	
Total Iron	mg/L			4280		
Total Manganese	mg/L			247		
CYANIDE						
Cyanide, Total	mg/L	0.416	0.39		0.143	
Cyanide, WAD	mg/L	0.0617	0.0543		0.06	
Cyanide, Amenable	mg/L	<0.00500	<0.00500		0.0365	
CATC, chlorinated	mg/L	0.455	0.422		0.106	
Cyanide, Free	mg/L	<0.0100	<0.0100		0.0474	
CATC, total	mg/L	0.416	0.39		0.143	
SEMI-VOLATILE ORGANICS						
Acenaphthylene	ug/L	0.879 [6]	<0.0792 [6]		<0.0769 [6]	
Acenaphthene	ug/L	2.20 [6]	0.550 [6]		<0.0769 [6]	
Anthracene	ug/L	<0.755 [6]	<0.0792 [6]		<0.0769 [6]	
Benz(a)anthracene	ug/L	<0.755 [6]	<0.0792 [6]		<0.0769 [6]	
Benzo(a)pyrene	ug/L	<0.755 [6]	<0.0990 [6] [19] [8]		<0.0769 [6]	
Benzo(b)fluoranthene	ug/L	<0.755 [6]	<0.0792 [6]		<0.0769 [6]	
Benzo(k)fluoranthene	ug/L	<0.755 [6]	<0.0792 [6]		<0.0769 [6]	
Benzo(g,h,i)perylene	ug/L	<0.755 [6]	<0.0792 [6]		<0.0769 [6]	
Carbazole	ug/L	3.07 [6]	0.831 [6]		<0.0769 [6]	
Chrysene	ug/L	<0.755 [6]	<0.0792 [6]		<0.0769 [6]	
Dibenz(a,h)anthracene	ug/L	<0.755 [6]	<0.0792 [6]		<0.0769 [6]	
Dibenzofuran	ug/L	<0.755 [6]	<0.0792 [6]		<0.0769 [6]	
Fluoranthene	ug/L	<0.755 [6]	0.0811 [6]		<0.0769 [6]	
Fluorene	ug/L	<0.755 [6]	<0.119 [6] [19] [8]		<0.0769 [6]	
Indeno(1,2,3-cd)pyrene	ug/L	<0.755 [6]	<0.0792 [6]		<0.0769 [6]	
2-Methylnaphthalene	ug/L	6.40 [6]	0.0899 [6]		<0.0769 [6]	
Naphthalene	ug/L	111 [4] [6] [2]	0.196 [3] [4] [6] [1] [3]		<0.0769 [6]	
Phenanthrene	ug/L	<0.755 [6]	<0.0792 [6]		<0.0769 [6]	
Pyrene	ug/L	<0.755 [6]	0.0891 [6]		<0.0769 [6]	
2-Chlorophenol	ug/L	<9.43 [6]	<0.990 [6]		<0.962 [6]	
2,4-Dichlorophenol	ug/L	<9.43 [6]	<0.990 [6]		<0.962 [6]	
2,4-Dimethylphenol	ug/L	<9.43 [6]	<0.990 [6]		<0.962 [6]	
4,6-Dinitro-2-methylphenol	ug/L	<9.43 [6]	<0.990 [6]		<0.962 [6]	
2-Methylphenol	ug/L	<9.43 [6]	<0.990 [6]		<0.962 [6]	
2-Nitrophenol	ug/L	<9.43 [6]	<0.990 [6]		<0.962 [6]	
4-Nitrophenol	ug/L	<9.43 [6]	<0.990 [6]		<0.962 [6]	
2,4,5-Trichlorophenol	ug/L	<9.43 [6]	<0.990 [6]		<0.962 [6]	
2,4,6-Trichlorophenol	ug/L	<9.43 [6]	<0.990 [6]		<0.962 [6]	
Pentachlorophenol (PCP)	ug/L	<9.43 [6]	<0.990 [6]		<0.962 [6]	
Phenol	ug/L	<9.43 [6]	<0.990 [6]		<0.962 [6]	
METALS						
Hexavalent Chromium	mg/L	.0200 [8] [19] [5] [6]	<0.0200 [8] [19] [6] [8]			
Silver	ug/L	<1.00	<1.00			
Arsenic	ug/L	7.34	3.7	3.82	4.52	
Cadmium	ug/L	<1.00	<1.00			
Chromium	ug/L	<1.00	<1.00			
Copper	ug/L	<5.00	<5.00			
Dissolved Iron	ug/L	31100	4510	167 [7] [2]		
Mercury	ug/L	<0.0100	<0.0100			
Dissolved Manganese	ug/L	1390	258	7.92 [7] [2]		
Nickel	ug/L	1.07	<1.00			
Lead	ug/L	1.6	<1.00			
Selenium	ug/L	5.18	4.71			
Zinc	ug/L	<4.00	<4.00			
Calcium	ug/L	65300	6720			
Chromium	ug/L					
Hardness (Calc by 6020)	mg CaCO3/L	321	143			
Magnesium	ug/L	38500	30700			
Trivalent Chromium	ug/L	<21.0	<21.0			
VOLATILE ORGANICS						
Acetone	ug/L	<400	<200		42.5	
Benzene	ug/L	75.4	7.8		<0.250	
2-Butanone (MEK)	ug/L	<200	<100		<10.0	
1,1-Dichloroethene	ug/L	14.2	<5.00		<0.500	
cis-1,2-Dichloroethene	ug/L	1760	390		14.6	
trans-1,2-Dichloroethene	ug/L	<10.0	13.4		0.97	
Ethylbenzene	ug/L	14.2	<5.00		<0.500	
Tetrachloroethene (PCE)	ug/L	<10.0	<5.00		<0.500	
Toluene	ug/L	10.4	<5.00		<0.500	
Trichloroethene (TCE)	ug/L	233	17.5		0.85	
Vinyl chloride	ug/L	676	29.9		<0.500	
m,p-Xylene	ug/L	<20.0	<10.0		<1.00	
o-Xylene	ug/L	<10.0	<5.00		<0.500	

19-Aug-09	Units	Influent S-1	EQ Effluent S-2	Clarifier Effluent S-3	AOP Effluent S-4	GAC Effluent NW-9S (8-20)
pH	pH Units	6.59	9.79			7.55
pH Temperature	pH Units	16.3	16.4			16
Total Dissolved Solids	mg/L	494	636			1060
Total Suspended Solids	mg/L	44	56			<5.00
Total Organic Carbon	mg/L	14.4	7.47		7.23	2.95
Total Iron	mg/L			3140		<100 [6] [4]
Total Manganese	mg/L			253		25.6 [6] [4]
CYANIDE						
Cyanide, Total	mg/L	0.406	0.366		0.118	0.0801
Cyanide, WAD	mg/L	0.0554	0.0543		0.0448	0.0139
Cyanide, Amenable	mg/L	<0.00500	<0.00500		0.0348	<0.00500
CATC, chlorinated	mg/L	0.415	0.413		0.0829	0.0886
Cyanide, Free	mg/L	<0.0100	<0.0100		0.034	<0.0100
CATC, total	mg/L	0.406	0.366		0.118	0.0801
SEMI-VOLATILE ORGANICS						
Acenaphthylene	ug/L	0.794 [4]	<0.0842 [1] [4]		<0.0800 [1] [4]	<0.0769 [5]
Acenaphthene	ug/L	2.67 [4]	0.603 [1] [4]		<0.0800 [1] [4]	<0.0769 [5]
Anthracene	ug/L	<0.755 [4]	<0.0842 [1] [4]		<0.0800 [1] [4]	<0.0769 [5]
Benz(a)anthracene	ug/L	<0.755 [4]	<0.0842 [1] [4]		<0.0800 [1] [4]	<0.0769 [5]
Benzo(a)pyrene	ug/L	<0.755 [4]	<0.0842 [1] [4]		<0.0800 [1] [4]	<0.0808 [5] [17] [7]
Benzo(b)fluoranthene	ug/L	<0.755 [4]	<0.0842 [1] [4]		<0.0800 [1] [4]	<0.0769 [5]
Benzo(k)fluoranthene	ug/L	<0.755 [4]	<0.0842 [1] [4]		<0.0800 [1] [4]	<0.0769 [5]
Benzo(g,h,i)perylene	ug/L	<0.755 [4]	<0.0842 [1] [4]		<0.0800 [1] [4]	<0.0769 [5]
Carbazole	ug/L	3.82 [4]	1.05 [1] [4]		<0.0800 [1] [4]	<0.0769 [5]
Chrysene	ug/L	<0.755 [4]	<0.0842 [1] [4]		<0.0800 [1] [4]	<0.0769 [5]
Dibenz(a,h)anthracene	ug/L	<0.755 [4]	<0.0842 [1] [4]		<0.0800 [1] [4]	<0.0769 [5]
Dibenzofuran	ug/L	<0.755 [4]	<0.0842 [1] [4]		<0.0800 [1] [4]	<0.0769 [5]
Fluoranthene	ug/L	<0.755 [4]	<0.0842 [1] [4]		<0.0800 [1] [4]	<0.0769 [5]
Fluorene	ug/L	<0.755 [4]	0.105 [1] [4] [15] [8]		<0.0800 [1] [4]	<0.0769 [5]
Indeno(1,2,3-cd)pyrene	ug/L	<0.755 [4]	<0.0842 [1] [4]		<0.0800 [1] [4]	<0.0769 [5]
2-Methylnaphthalene	ug/L	9.20 [4]	<0.0842 [1] [4]		<0.0800 [1] [4]	<0.0769 [5]
Naphthalene	ug/L	167 [2] [4] [2]	0.119 [1] [2] [4] [3]		0.134 [1] [2] [4] [5]	127 [2] [3] [5] [1] [2]
Phenanthrene	ug/L	<0.755 [4]	<0.0842 [1] [4]		<0.0800 [1] [4]	<0.0769 [5]
Pyrene	ug/L	<0.755 [4]	<0.0842 [1] [4]		<0.0800 [1] [4]	<0.0769 [5]
2-Chlorophenol	ug/L	<9.43 [4]	<1.05 [1] [4]		<1.00 [1] [4]	<0.962 [5]
2,4-Dichlorophenol	ug/L	<9.43 [4]	<1.05 [1] [4]		<1.00 [1] [4]	<0.962 [5]
2,4-Dimethylphenol	ug/L	<9.43 [4]	<1.05 [1] [4]		<1.00 [1] [4]	<0.962 [5]
4,6-Dinitro-2-methylphenol	ug/L	<9.43 [4]	<1.05 [1] [4]		<1.00 [1] [4]	<0.962 [5]
2-Methylphenol	ug/L	<9.43 [4]	<1.05 [1] [4]		<1.00 [1] [4]	<0.962 [5]
2-Nitrophenol	ug/L	<9.43 [4]	<1.05 [1] [4]		<1.00 [1] [4]	<0.962 [5]
4-Nitrophenol	ug/L	<9.43 [4]	<1.05 [1] [4]		<1.00 [1] [4]	<0.962 [5]
2,4,5-Trichlorophenol	ug/L	<9.43 [4]	<1.05 [1] [4]		<1.00 [1] [4]	<0.962 [5]
2,4,6-Trichlorophenol	ug/L	<9.43 [4]	<1.05 [1] [4]		<1.00 [1] [4]	<0.962 [5]
Pentachlorophenol (PCP)	ug/L	<9.43 [4]	<1.05 [1] [4]		<1.00 [1] [4]	<0.962 [5]
Phenol	ug/L	<9.43 [4]	<1.05 [1] [4]		<1.00 [1] [4]	<0.962 [5]
METALS						
Hexavalent Chromium	mg/L	<0.0100	<0.0100			<0.0100
Silver	ug/L	<1.00	<1.00			<1.00
Arsenic	ug/L	7.81	3.97 [2] [3]	3.98 [2] [1]	4.31	4.83 [2] [1]
Cadmium	ug/L	<1.00	<1.00			<1.00
Chromium	ug/L	1.04	1.02			<1.00
Copper	ug/L	<5.00	<5.00			<5.00
Dissolved Iron	ug/L	30500	3310	123 [5] [2]		463
Mercury	ug/L	<0.0100	<0.0100			0.0136
Dissolved Manganese	ug/L	1380	359	15.5 [5] [2]		45.9
Nickel	ug/L	1.01	1.72			2.99
Lead	ug/L	<1.00	1.8			<1.00
Selenium	ug/L	3.51	3.78			2.73
Zinc	ug/L	<4.00	<4.00			5.27
Calcium	ug/L	62700	5680			3310
Chromium	ug/L					
Hardness (Calc by 6020)	mg CaCO3/L	317	155			131
Magnesium	ug/L	38900	34200			29900
Trivalent Chromium	ug/L	<11.0	<11.0			<11.0
VOLATILE ORGANICS						
Acetone	ug/L	<400	<200		30	<20.0
Benzene	ug/L	80.4	9.9		<0.250	<0.250
2-Butanone (MEK)	ug/L	<200	<100		<10.0	<10.0
1,1-Dichloroethene	ug/L	12.4	<5.00		<0.500	<0.500
cis-1,2-Dichloroethene	ug/L	1940	488		13.4	<0.500
trans-1,2-Dichloroethene	ug/L	10.4	<5.00		0.67	<0.500
Ethylbenzene	ug/L	16.2	<5.00		<0.500	<0.500
Tetrachloroethene (PCE)	ug/L	<10.0	<5.00		<0.500	<0.500
Toluene	ug/L	10.6	<5.00		<0.500	<0.500
Trichloroethene (TCE)	ug/L	168	31.7		1.1	<0.500
Vinyl chloride	ug/L	706	37.7		<0.500	<0.500
m,p-Xylene	ug/L	<20.0	<10.0		<1.00	<1.00
o-Xylene	ug/L	<10.0	<5.00		<0.500	<0.500

21-Aug-09	Units	Influent S-1	EQ Effluent S-2	Clarifier Effluent S-3	AOP Effluent S-4	GAC Effluent NW-9S
pH	pH Units	6.58	9.82			
pH Temperature	pH Units	18.8	19.5			
Total Dissolved Solids	mg/L	477	620			
Total Suspended Solids	mg/L	57	24			
Total Organic Carbon	mg/L	11.1	8.34		5.19	
Total Iron	mg/L			3880		
Total Manganese	mg/L			304		
CYANIDE						
Cyanide, Total	mg/L	0.356	0.333		0.118	
Cyanide, WAD	mg/L	0.0479	0.0438		0.0386	
Cyanide, Amenable	mg/L	<0.00500	<0.00500		0.0159	
CATC, chlorinated	mg/L	0.371	0.398		0.102	
Cyanide, Free	mg/L	<0.0100	<0.0100		0.0376	
CATC, total	mg/L	0.356	0.333		0.118	
Available Cyanide	mg/L	<0.0020	<0.0020		0.032	<0.0020
SEMI-VOLATILE ORGANICS						
Acenaphthylene	ug/L	<0.816 [4]	0.182 [4]		<0.0762 [4]	
Acenaphthene	ug/L	1.73 [4]	1.07 [4]		<0.0762 [4]	
Anthracene	ug/L	<0.816 [4]	<0.0816 [4]		<0.0762 [4]	
Benz(a)anthracene	ug/L	<0.816 [4]	<0.0816 [4]		<0.0762 [4]	
Benzo(a)pyrene	ug/L	<0.816 [4]	<0.0898 [4] [16] [8]		<0.0800 [4] [16] [9]	
Benzo(b)fluoranthene	ug/L	<0.816 [4]	<0.0816 [4]		<0.0762 [4]	
Benzo(k)fluoranthene	ug/L	<0.816 [4]	<0.0816 [4]		<0.0762 [4]	
Benzo(g,h,i)perylene	ug/L	<0.816 [4]	<0.0816 [4]		<0.0762 [4]	
Carbazole	ug/L	2.76 [4]	1.68 [4]		<0.0762 [4]	
Chrysene	ug/L	<0.816 [4]	<0.0816 [4]		<0.0762 [4]	
Dibenz(a,h)anthracene	ug/L	<0.816 [4]	<0.0816 [4]		<0.0762 [4]	
Dibenzofuran	ug/L	<0.816 [4]	<0.0816 [4]		<0.0762 [4]	
Fluoranthene	ug/L	<0.816 [4]	<0.0816 [4]		<0.0762 [4]	
Fluorene	ug/L	<0.816 [4]	0.126 [4] [6] [7]		<0.0762 [4]	
Indeno(1,2,3-cd)pyrene	ug/L	<0.816 [4]	<0.0816 [4]		<0.0762 [4]	
2-Methylnaphthalene	ug/L	5.56 [4]	<0.0816 [4]		<0.0762 [4]	
Naphthalene	ug/L	104 [1] [2] [4] [2] [3]	283 [1] [2] [4] [3] [4]		0.213 [1] [2] [4] [5] [6]	
Phenanthrene	ug/L	<0.816 [4]	<0.0816 [4]		<0.0762 [4]	
Pyrene	ug/L	<0.816 [4]	<0.0816 [4]		<0.0762 [4]	
2-Chlorophenol	ug/L	<10.2 [4]	<1.02 [4]		<0.952 [4]	
2,4-Dichlorophenol	ug/L	<10.2 [4]	<1.02 [4]		<0.952 [4]	
2,4-Dimethylphenol	ug/L	<10.2 [4]	<1.02 [4]		<0.952 [4]	
4,6-Dinitro-2-methylphenol	ug/L	<10.2 [4]	<1.02 [4]		<0.952 [4]	
2-Methylphenol	ug/L	<10.2 [4]	<1.02 [4]		<0.952 [4]	
2-Nitrophenol	ug/L	<10.2 [4]	<1.02 [4]		<0.952 [4]	
4-Nitrophenol	ug/L	<10.2 [4]	<1.02 [4]		<0.952 [4]	
2,4,5-Trichlorophenol	ug/L	<10.2 [4]	<1.02 [4]		<0.952 [4]	
2,4,6-Trichlorophenol	ug/L	<10.2 [4]	<1.02 [4]		<0.952 [4]	
Pentachlorophenol (PCP)	ug/L	<10.2 [4]	<1.02 [4]		<0.952 [4]	
Phenol	ug/L	<10.2 [4]	<1.02 [4]		<0.952 [4]	
METALS						
Hexavalent Chromium	mg/L	<0.0100	<0.0100			
Silver	ug/L	<1.00	<1.00			
Arsenic	ug/L	7.59	4.36 [1] [3]	4.38 [1] [1]	4.77	
Cadmium	ug/L	<1.00	<1.00			
Chromium	ug/L	1.27	1.07			
Copper	ug/L	<5.00	<5.00			
Dissolved Iron	ug/L	30500	4330	253 [5] [2]		
Mercury	ug/L	<0.0100	<0.0100			
Dissolved Manganese	ug/L	1380	309	22.2 [5] [2]		
Nickel	ug/L	1.12	1.63			
Lead	ug/L	<1.00	1.34			
Selenium	ug/L	3.97	5.51			
Zinc	ug/L	<4.00	4.01			
Calcium	ug/L	58200	5630			
Chromium	ug/L					
Hardness (Calc by 6020)	mg CaCO3/L	295	150			
Magnesium	ug/L	36300	33000			
Trivalent Chromium	ug/L	<11.0	<11.0			
VOLATILE ORGANICS						
Acetone	ug/L	<400	<200		38.6	
Benzene	ug/L	85	15.2		<0.250	
2-Butanone (MEK)	ug/L	<200	<100		<10.0	
1,1-Dichloroethene	ug/L	11.8	<5.00		<0.500	
cis-1,2-Dichloroethene	ug/L	1550	519		15	
trans-1,2-Dichloroethene	ug/L	<10.0	<5.00		0.57	
Ethylbenzene	ug/L	18.2	<5.00		<0.500	
Tetrachloroethene (PCE)	ug/L	<10.0	<5.00		<0.500	
Toluene	ug/L	11.2	<5.00		<0.500	
Trichloroethene (TCE)	ug/L	107	46		1.77	
Vinyl chloride	ug/L	664	61.3		<0.500	
m,p-Xylene	ug/L	<20.0	<10.0		<1.00	
o-Xylene	ug/L	<10.0	<5.00		<0.500	

25-Aug-09	Units	Influent S-1	EQ Effluent S-2	Clarifier Effluent S-3	AOP Effluent S-4	GAC Effluent NW-9S
pH	pH Units	6.61	9.96			
pH Temperature	pH Units	19.3	18.8			
Total Dissolved Solids	mg/L	515	709			
Total Suspended Solids	mg/L	31	20			
Total Organic Carbon	mg/L	10.3	8.07		6.21	
Total Iron	mg/L			3280		
Total Manganese	mg/L			236		
CYANIDE						
Cyanide, Total	mg/L	0.467	0.396		0.135	
Cyanide, WAD	mg/L	0.051	0.0528		0.0331	
Cyanide, Amenable	mg/L	<0.0100	<0.00500		0.0202	
CATC, chlorinated	mg/L	0.488	0.407		0.115	
Cyanide, Free	mg/L	<0.0100	<0.0100		0.0342	
CATC, total	mg/L	0.467	0.396		0.135	
Available Cyanide	mg/L	0.0025	<0.0020		0.076	
SEMI-VOLATILE ORGANICS						
Acenaphthylene	ug/L	<0.825 [3]	0.186 [3]		<0.0755 [3]	
Acenaphthene	ug/L	1.78 [3]	0.924 [3]		<0.0755 [3]	
Anthracene	ug/L	<0.825 [3]	<0.0808 [3]		<0.0755 [3]	
Benz(a)anthracene	ug/L	<0.825 [3]	<0.0808 [3]		<0.0755 [3]	
Benzo(a)pyrene	ug/L	<0.825 [3]	<0.0808 [3]		<0.0755 [3]	
Benzo(b)fluoranthene	ug/L	<0.825 [3]	<0.0808 [3]		<0.0755 [3]	
Benzo(k)fluoranthene	ug/L	<0.825 [3]	<0.0808 [3]		<0.0755 [3]	
Benzo(g,h,i)perylene	ug/L	<0.825 [3]	<0.0808 [3]		<0.0755 [3]	
Carbazole	ug/L	1.53 [3]	1.33 [3]		<0.0755 [3]	
Chrysene	ug/L	<0.825 [3]	<0.0808 [3]		<0.0755 [3]	
Dibenz(a,h)anthracene	ug/L	<0.825 [3]	<0.0808 [3]		<0.0755 [3]	
Dibenzofuran	ug/L	<0.825 [3]	<0.0808 [3]		<0.0755 [3]	
Fluoranthene	ug/L	<0.825 [3]	<0.0808 [3]		<0.0755 [3]	
Fluorene	ug/L	<0.825 [3]	0.0998 [3]		<0.0755 [3]	
Indeno(1,2,3-cd)pyrene	ug/L	<0.825 [3]	<0.0808 [3]		<0.0755 [3]	
2-Methylnaphthalene	ug/L	4.71 [3]	0.129 [3]		<0.0755 [3]	
Naphthalene	ug/L	86.2 [3]	1.49 [3]		0.133 [3]	
Phenanthrene	ug/L	<0.825 [3]	0.0966 [3]		<0.0755 [3]	
Pyrene	ug/L	<0.825 [3]	<0.0808 [3]		<0.0755 [3]	
2-Chlorophenol	ug/L	<10.3 [3]	<1.01 [3]		<0.943 [3]	
2,4-Dichlorophenol	ug/L	<10.3 [3]	<1.01 [3]		<0.943 [3]	
2,4-Dimethylphenol	ug/L	<10.3 [3]	<1.01 [3]		<0.943 [3]	
4,6-Dinitro-2-methylphenol	ug/L	<10.3 [3]	<1.01 [3]		<0.943 [3]	
2-Methylphenol	ug/L	<10.3 [3]	<1.01 [3]		<0.943 [3]	
2-Nitrophenol	ug/L	<10.3 [3]	<1.01 [3]		<0.943 [3]	
4-Nitrophenol	ug/L	<10.3 [3]	<1.01 [3]		<0.943 [3]	
2,4,5-Trichlorophenol	ug/L	<10.3 [3]	<1.01 [3]		<0.943 [3]	
2,4,6-Trichlorophenol	ug/L	<10.3 [3]	<1.01 [3]		<0.943 [3]	
Pentachlorophenol (PCP)	ug/L	<10.3 [3]	<1.01 [3]		<0.943 [3]	
Phenol	ug/L	<10.3 [3]	<1.01 [3]		<0.943 [3]	
METALS						
Hexavalent Chromium	mg/L	<0.0100	0.0173			
Silver	ug/L	<1.00	<1.00			
Arsenic	ug/L	7.31	5.03 [1] [3]	4.3	4.93	
Cadmium	ug/L	<1.00	<1.00			
Chromium	ug/L	<1.00	<1.00			
Copper	ug/L	<5.00	<5.00			
Dissolved Iron	ug/L	31100	5300	192 [4] [2]		
Mercury	ug/L	<0.0100	<0.0100			
Dissolved Manganese	ug/L	1260	298	23.1 [4] [2]		
Nickel	ug/L	1.08	1.44			
Lead	ug/L	<1.00	<1.00			
Selenium	ug/L	4.80 [1] [2]	5.21 [1] [3]			
Zinc	ug/L	4.33	<4.00			
Calcium	ug/L	58500	5850			
Chromium	ug/L	<1.00	<1.00			
Hardness (Calc by 6020)	mg CaCO3/L	309	153			
Magnesium	ug/L	39600	33600			
Trivalent Chromium	ug/L	<11.0	<11.0			
SEMI-VOLATILE ORGANICS						
Acetone	ug/L	<400	<200		36.8	
Benzene	ug/L	69.6	12.4		<0.250	
2-Butanone (MEK)	ug/L	<200	<100		<10.0	
1,1-Dichloroethene	ug/L	17.2	<5.00		<0.500	
cis-1,2-Dichloroethene	ug/L	2530	545		22.1	
trans-1,2-Dichloroethene	ug/L	<10.0	<5.00		1.08	
Ethylbenzene	ug/L	<10.0	<5.00		<0.500	
Tetrachloroethene (PCE)	ug/L	<10.0	<5.00		<0.500	
Toluene	ug/L	10.8	<5.00		<0.500	
Trichloroethene (TCE)	ug/L	372	44.7		3.11	
Vinyl chloride	ug/L	890	60.7		<0.500	
m,p-Xylene	ug/L	<20.0	<10.0		<1.00	
o-Xylene	ug/L	<10.0	<5.00		<0.500	

26-Aug-09	Units	Influent S-1	EQ Effluent S-2	Clarifier Effluent S-3	AOP Effluent S-4	GAC Effluent NW-9S (8-28)
pH	pH Units	6.56	9.76			7.6
pH Temperature	pH Units	19.6	19.3			19.5
Total Dissolved Solids	mg/L	458	664			723
Total Suspended Solids	mg/L	59	5			16
Total Organic Carbon	mg/L	7.92	5.01		5.76	3.72
Total Iron	mg/L			4870		<100 [4] [4]
Total Manganese	mg/L			270		46.3 [4] [4]
CYANIDE						
Cyanide, Total	mg/L	0.399	0.348		0.187	0.152
Cyanide, WAD	mg/L	0.0484	0.0508		0.0667	0.0288
Cyanide, Amenable	mg/L	<0.00500	<0.00500		0.0116	0.0146
CATC, chlorinated	mg/L	0.436	0.42		0.175	0.137
Cyanide, Free	mg/L	<0.0100	<0.0100		0.0536	<0.0100
CATC, total	mg/L	0.399	0.348		0.187	0.152
SEMI-VOLATILE ORGANICS						
Acenaphthylene	ug/L	<0.792 [3]	0.0894 [3]		<0.0769 [3]	<0.0816 [3]
Acenaphthene	ug/L	2.54 [3]	0.716 [3]		<0.0769 [3]	<0.0816 [3]
Anthracene	ug/L	<0.792 [3]	<0.0755 [3]		<0.0769 [3]	<0.0816 [3]
Benz(a)anthracene	ug/L	<0.792 [3]	<0.0755 [3]		<0.0769 [3]	<0.0816 [3]
Benzo(a)pyrene	ug/L	<0.792 [3]	<0.0755 [3]		<0.0769 [3]	<0.0816 [3]
Benzo(b)fluoranthene	ug/L	<0.792 [3]	<0.0755 [3]		<0.0769 [3]	<0.0816 [3]
Benzo(k)fluoranthene	ug/L	<0.792 [3]	<0.0755 [3]		<0.0769 [3]	<0.0816 [3]
Benzo(g,h,i)perylene	ug/L	<0.792 [3]	<0.0755 [3]		<0.0769 [3]	<0.0816 [3]
Carbazole	ug/L	2.39 [3]	0.859 [3]		<0.0769 [3]	<0.0816 [3]
Chrysene	ug/L	<0.792 [3]	<0.0755 [3]		<0.0769 [3]	<0.0816 [3]
Dibenz(a,h)anthracene	ug/L	<0.792 [3]	<0.0755 [3]		<0.0769 [3]	<0.0816 [3]
Dibenzofuran	ug/L	<0.792 [3]	<0.0755 [3]		<0.0769 [3]	<0.0816 [3]
Fluoranthene	ug/L	<0.792 [3]	<0.0755 [3]		<0.0769 [3]	<0.0816 [3]
Fluorene	ug/L	<0.792 [3]	<0.0755 [3]		<0.0769 [3]	<0.0816 [3]
Indeno(1,2,3-cd)pyrene	ug/L	<0.792 [3]	<0.0755 [3]		<0.0769 [3]	<0.0816 [3]
2-Methylnaphthalene	ug/L	8.91 [3]	<0.0755 [3]		<0.0769 [3]	<0.0816 [3]
Naphthalene	ug/L	147 [3]	0.0902 [3]		0.707 [3]	<0.0816 [3]
Phenanthrene	ug/L	<0.792 [3]	<0.0755 [3]		<0.0769 [3]	<0.0816 [3]
Pyrene	ug/L	<0.792 [3]	<0.0755 [3]		<0.0769 [3]	<0.0816 [3]
2-Chlorophenol	ug/L	<9.90 [3]	<0.943 [3]		<0.962 [3]	<1.02 [3]
2,4-Dichlorophenol	ug/L	<9.90 [3]	<0.943 [3]		<0.962 [3]	<1.02 [3]
2,4-Dimethylphenol	ug/L	<9.90 [3]	<0.943 [3]		<0.962 [3]	<1.02 [3]
4,6-Dinitro-2-methylphenol	ug/L	<9.90 [3]	<0.943 [3]		<0.962 [3]	<1.02 [3]
2-Methylphenol	ug/L	<9.90 [3]	<0.943 [3]		<0.962 [3]	<1.02 [3]
2-Nitrophenol	ug/L	<9.90 [3]	<0.943 [3]		<0.962 [3]	<1.02 [3]
4-Nitrophenol	ug/L	<9.90 [3]	<0.943 [3]		<0.962 [3]	<4.08 [3]
2,4,5-Trichlorophenol	ug/L	<9.90 [3]	<0.943 [3]		<0.962 [3]	<1.02 [3]
2,4,6-Trichlorophenol	ug/L	<9.90 [3]	<0.943 [3]		<0.962 [3]	<1.02 [3]
Pentachlorophenol (PCP)	ug/L	<9.90 [3]	<0.943 [3]		<0.962 [3]	<1.02 [3]
Phenol	ug/L	<9.90 [3]	<0.943 [3]		<0.962 [3]	<1.02 [3]
METALS						
Hexavalent Chromium	mg/L	<0.0100	<0.0100			<0.0100
Silver	ug/L	<1.00	<1.00			<1.00
Arsenic	ug/L	7.00 [1] [2]	4.32 [1] [3]	4.99 [1] [1]	5.44	3.73
Cadmium	ug/L	<1.00	<1.00			<1.00
Chromium	ug/L	<1.00	<1.00			<1.00
Copper	ug/L	<5.00	<5.00			<5.00
Dissolved Iron	ug/L	30900	5040	165 [4] [2]		644
Mercury	ug/L	<0.0100	<0.0100			<0.0100
Dissolved Manganese	ug/L	1370	277	14.7 [4] [2]		75.9
Nickel	ug/L	1.06	1.12			2.66
Lead	ug/L	3.28	<1.00			<1.00
Selenium	ug/L	4.18 [1] [2]	4.84 [1] [3]			2.54
Zinc	ug/L	<4.00	7.78			5.4
Calcium	ug/L	60400	2920			5830
Chromium	ug/L	<1.00	<1.00			
Hardness (Calc by 6020)	mg CaCO3/L	309	147			150
Magnesium	ug/L	38300	34000			32800
Trivalent Chromium	ug/L	<11.0	<11.0			<11.0
SEMI-VOLATILE ORGANICS						
Acetone	ug/L	<400	<200		20.6	<20.0
Benzene	ug/L	72	9.2		0.62	<0.250
2-Butanone (MEK)	ug/L	<200	<100		<10.0	<10.0
1,1-Dichloroethene	ug/L	13.2	<5.00		<0.500	<0.500
cis-1,2-Dichloroethene	ug/L	1490	420		50	<0.500
trans-1,2-Dichloroethene	ug/L	<10.0	<5.00		2.16	<0.500
Ethylbenzene	ug/L	14.8	<5.00		<0.500	<0.500
Tetrachloroethene (PCE)	ug/L	<10.0	<5.00		<0.500	<0.500
Toluene	ug/L	<10.0	<5.00		<0.500	<0.500
Trichloroethene (TCE)	ug/L	106	33.7		4.88	<0.500
Vinyl chloride	ug/L	715	43.7		1.21	<0.500
m,p-Xylene	ug/L	<20.0	<10.0		<1.00	<1.00
o-Xylene	ug/L	<10.0	<5.00		<0.500	<0.500

Attachment G: Siltronic Pilot Plant Results—By Sample Point

Siltronic Influent	Units	08/26/09	08/25/09	08/21/09	08/19/09	08/18/09	08/12/09	08/10/09	08/06/09	08/05/09	08/04/09	08/03/09	Units	Min	Max
pH	pH Units	6.56	6.61	6.58	6.59	6.56	6.62	6.58	6.83	6.96	6.85	6.85	pH Units	6.56	6.96
pH Temperature	pH Units	19.6	19.3	18.8	16.3	13.1	20.8	21.6	22.8	18.4	17.4	18.4	pH Units	13.1	22.8
Total Dissolved Solids	mg/L	458	515	477	494	432	423	504	471	437	441	462	mg/L	423	504
Total Suspended Solids	mg/L	59.0	31.0	57.0	44.0	61.0	62.9	70.0	60.0	35.0	22.0	<5.00	mg/L	<5.00	70.0
Total Organic Carbon	mg/L	7.92	10.3	11.1	14.4	19.1	11.3	31.9	12.5	13.6	9.35	10.7 [1] [1]	mg/L	7.92	31.9
CYANIDE															
Cyanide, Total	mg/L	0.399	0.467	0.356	0.406	0.416	0.353	0.479	0.259	0.245	0.362	0.338	mg/L	0.245	0.479
Cyanide, WAD	mg/L	0.0484	0.0510	0.0479	0.0554	0.0617	0.0619	0.0528	0.0468	0.0603	0.0504	0.0617	mg/L	0.0468	0.0617
Cyanide, Amenable	mg/L	<0.00500	<0.0100	<0.00500	<0.00500	<0.00500	3.17	<0.0100	<0.00500	<0.00500	<0.00500	<0.0250	mg/L	<0.00500	3.17
CATC, chlorinated	mg/L	0.436	0.488	0.371	0.415	0.455	0.359	0.504	0.401	0.387	0.400	0.434	mg/L	0.359	0.504
Cyanide, Free	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	mg/L	<0.0100	<0.0100
CATC, total	mg/L	0.399	0.467	0.356	0.406	0.416	3.53	0.479	0.259	0.245	0.362	0.338	mg/L	0.245	0.479
Available Cyanide	mg/L		0.0025	<0.0020			0.0088	<0.0020	0.0035	0.0042			mg/L	<0.0020	0.0088
SEMI-VOLATILE ORGANIC															
Acenaphthylene	ug/L	<0.792 [3]	<0.825 [3]	<0.816 [4]	0.794 [4]	0.879 [6]	<1.86 [5]	<1.86 [4]	<1.90 [2]	<1.86 [2]	<1.90 [4]		ug/L	<0.792 [3]	0.879 [6]
Acenaphthene	ug/L	2.54 [3]	1.78 [3]	1.73 [4]	2.67 [4]	2.20 [6]	<1.86 [5]	<1.86 [4]	<1.90 [2]	<1.86 [2]	2.61 [4]		ug/L	1.73 [4]	2.67 [4]
Anthracene	ug/L	<0.792 [3]	<0.825 [3]	<0.816 [4]	<0.755 [4]	<0.755 [6]	<1.86 [5]	<1.86 [4]	<1.90 [2]	<1.86 [2]	<1.90 [4]		ug/L	<0.755 [6]	<1.90 [4]
Benz(a)anthracene	ug/L	<0.792 [3]	<0.825 [3]	<0.816 [4]	<0.755 [4]	<0.755 [6]	<1.86 [5]	<1.86 [4]	<1.90 [2]	<1.86 [2]	<1.90 [4]		ug/L	<0.755 [6]	<1.90 [4]
Benzo(a)pyrene	ug/L	<0.792 [3]	<0.825 [3]	<0.816 [4]	<0.755 [4]	<0.755 [6]	<1.86 [5]	<1.86 [4]	<2.38 [2] [12] [6]	<1.86 [2]	<1.90 [4]		ug/L	<0.755 [4]	<2.38 [2] [12] [6]
Benzo(b)fluoranthene	ug/L	<0.792 [3]	<0.825 [3]	<0.816 [4]	<0.755 [4]	<0.755 [6]	<1.86 [5]	<1.86 [4]	<2.38 [2]	<1.86 [2]	<1.90 [4]		ug/L	<0.755 [4]	<2.38 [2] [12] [6]
Benzo(k)fluoranthene	ug/L	<0.792 [3]	<0.825 [3]	<0.816 [4]	<0.755 [4]	<0.755 [6]	<1.86 [5]	<1.86 [4]	<1.90 [2]	<1.86 [2]	<1.90 [4]		ug/L	<0.755 [6]	<1.90 [4]
Benzo(g,h,i)perylene	ug/L	<0.792 [3]	<0.825 [3]	<0.816 [4]	<0.755 [4]	<0.755 [6]	<1.86 [5]	<1.86 [4]	<1.90 [2]	<1.86 [2]	<1.90 [4]		ug/L	<0.755 [6]	<1.90 [4]
Carbazole	ug/L	2.39 [3]	1.53 [3]	2.76 [4]	3.82 [4]	3.07 [6]	3.46 [5]	4.20 [4]	3.87 [2]	3.16 [2]	3.88 [4]		ug/L	1.53 [3]	4.20 [4]
Chrysene	ug/L	<0.792 [3]	<0.825 [3]	<0.816 [4]	<0.755 [4]	<0.755 [6]	<1.86 [5]	<1.86 [4]	<1.90 [2]	<1.86 [2]	<1.90 [4]		ug/L	<0.755 [6]	<1.90 [4]
Dibenz(a,h)anthracene	ug/L	<0.792 [3]	<0.825 [3]	<0.816 [4]	<0.755 [4]	<0.755 [6]	<1.86 [5]	<1.86 [4]	<1.90 [2]	<1.86 [2]	<1.90 [4]		ug/L	<0.755 [6]	<1.90 [4]
Dibenzofuran	ug/L	<0.792 [3]	<0.825 [3]	<0.816 [4]	<0.755 [4]	<0.755 [6]	<1.86 [5]	<1.86 [4]	<1.90 [2]	<1.86 [2]	<1.90 [4]		ug/L	<0.755 [6]	<1.90 [4]
Fluoranthene	ug/L	<0.792 [3]	<0.825 [3]	<0.816 [4]	<0.755 [4]	<0.755 [6]	<1.86 [5]	<1.86 [4]	<1.90 [2]	<1.86 [2]	<1.90 [4]		ug/L	<0.755 [6]	<1.90 [4]
Fluorene	ug/L	<0.792 [3]	<0.825 [3]	<0.816 [4]	<0.755 [4]	<0.755 [6]	<1.86 [5]	<1.86 [4]	<1.90 [2]	<1.86 [2]	<1.90 [4]		ug/L	<0.755 [6]	<1.90 [4]
Indeno(1,2,3-cd)pyrene	ug/L	<0.792 [3]	<0.825 [3]	<0.816 [4]	<0.755 [4]	<0.755 [6]	<1.86 [5]	<1.86 [4]	<1.90 [2]	<1.86 [2]	<1.90 [4]		ug/L	<0.755 [6]	<1.90 [4]
2-Methylnaphthalene	ug/L	8.91 [3]	4.71 [3]	5.56 [4]	9.20 [4]	6.40 [6]	4.13 [5]	5.15 [4]	5.46 [2]	2.91 [2]	9.16 [4]		ug/L	2.91 [2]	9.20 [4]
Naphthalene	ug/L	147 [3]	86.2 [3]	04 [1] [2] [4] [2] [3]	167 [2] [4] [2]	111 [4] [6] [2]	68.5 [3] [5] [2]	113 [4]	113 [2]	95.6 [2]	196 [2] [4] [2]		ug/L	68.5 [3] [5] [2]	196 [2] [4] [2]
Phenanthrene	ug/L	<0.792 [3]	<0.825 [3]	<0.816 [4]	<0.755 [4]	<0.755 [6]	<1.86 [5]	<1.86 [4]	<1.90 [2]	<1.86 [2]	<1.90 [4]		ug/L	<0.755 [6]	<1.90 [4]
Pyrene	ug/L	<0.792 [3]	<0.825 [3]	<0.816 [4]	<0.755 [4]	<0.755 [6]	<1.86 [5]	<1.86 [4]	<1.90 [2]	<1.86 [2]	<1.90 [4]		ug/L	<0.755 [6]	<1.90 [4]
2-Chlorophenol	ug/L	<9.90 [3]	<10.3 [3]	<10.2 [4]	<9.43 [4]	<9.43 [6]	<23.3 [5]	<23.3 [4]	<23.8 [2]	<23.3 [2]	<23.8 [4]		ug/L	<9.43 [6]	<23.8 [4]
2,4-Dichlorophenol	ug/L	<9.90 [3]	<10.3 [3]	<10.2 [4]	<9.43 [4]	<9.43 [6]	<23.3 [5]	<23.3 [4]	<23.8 [2]	<23.3 [2]	<23.8 [4]		ug/L	<9.43 [6]	<23.8 [4]
2,4-Dimethylphenol	ug/L	<9.90 [3]	<10.3 [3]	<10.2 [4]	<9.43 [4]	<9.43 [6]	<23.3 [5]	<23.3 [4]	<23.8 [2]	<23.3 [2]	<23.8 [4]		ug/L	<9.43 [6]	<23.8 [4]
4,6-Dinitro-2-methylphenol	ug/L	<9.90 [3]	<10.3 [3]	<10.2 [4]	<9.43 [4]	<9.43 [6]	<23.3 [5]	<23.3 [4]	<23.8 [2]	<23.3 [2]	<23.8 [4]		ug/L	<9.43 [6]	<23.8 [4]
2-Methylphenol	ug/L	<9.90 [3]	<10.3 [3]	<10.2 [4]	<9.43 [4]	<9.43 [6]	<23.3 [5]	<23.3 [4]	<23.8 [2]	<23.3 [2]	<23.8 [4]		ug/L	<9.43 [6]	<23.8 [4]
2-Nitrophenol	ug/L	<9.90 [3]	<10.3 [3]	<10.2 [4]	<9.43 [4]	<9.43 [6]	<23.3 [5]	<23.3 [4]	<23.8 [2]	<23.3 [2]	<23.8 [4]		ug/L	<9.43 [6]	<23.8 [4]
4-Nitrophenol	ug/L	<9.90 [3]	<10.3 [3]	<10.2 [4]	<9.43 [4]	<9.43 [6]	<23.3 [5]	<23.3 [4]	<23.8 [2]	<23.3 [2]	<23.8 [4]		ug/L	<9.43 [6]	<23.8 [4]
2,4,5-Trichlorophenol	ug/L	<9.90 [3]	<10.3 [3]	<10.2 [4]	<9.43 [4]	<9.43 [6]	<23.3 [5]	<23.3 [4]	<23.8 [2]	<23.3 [2]	<23.8 [4]		ug/L	<9.43 [6]	<23.8 [4]
2,4,6-Trichlorophenol	ug/L	<9.90 [3]	<10.3 [3]	<10.2 [4]	<9.43 [4]	<9.43 [6]	<23.3 [5]	<23.3 [4]	<23.8 [2]	<23.3 [2]	<23.8 [4]		ug/L	<9.43 [6]	<23.8 [4]
Pentachlorophenol (PCP)	ug/L	<9.90 [3]	<10.3 [3]	<10.2 [4]	<9.43 [4]	<9.43 [6]	<23.3 [5]	<23.3 [4]	<23.8 [2]	<23.3 [2]	<23.8 [4]		ug/L	<9.43 [6]	<23.8 [4]
Phenol	ug/L	<9.90 [3]	<10.3 [3]	<10.2 [4]	<9.43 [4]	<9.43 [6]	<23.3 [5]	<23.3 [4]	<23.8 [2]	<23.3 [2]	<23.8 [4]		ug/L	<9.43 [6]	<23.8 [4]
METALS															
Hexavalent Chromium	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	0200 [8] [19] [5] [6]	0.0398	<0.0100	<0.0100	<0.0100	<0.0100		mg/L	<0.0100	0.0398
Silver	ug/L	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<0.0100	ug/L	<0.0100	<0.0100
Arsenic	ug/L	7.00 [1] [2]	7.31	7.59	7.81	7.34	5.20	5.71	7.54	5.06	4.91	2.93	ug/L	2.93	7.81
Cadmium	ug/L	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Chromium	ug/L	<1.00	<1.00	1.27	1.04	<1.00	2.96	<1.00	<1.00	<1.00	<1.00	<1.00	ug/L	<1.00	2.96
Copper	ug/L	<5.00	<5.00	<5.00	<5.00	<5.00	145	<5.00	<5.00	<5.00	<5.00	<5.00	ug/L	<5.00	145
Iron	ug/L	30900	31100	30500	30500	31100	32200	36000	30100	14300	14700	2060	ug/L	2060	36000
Mercury	ug/L	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	ug/L	<0.0100	<0.0100
Manganese	ug/L	1370	1260	1380	1380	1390	1530	2030	1250	1380	1370	1380	ug/L	1250	1530
Nickel	ug/L	1.06	1.08	1.12	1.01	1.07	24.1	1.00	1.22	5.73	2.43	12.1	ug/L	1.00	24.1
Lead	ug/L	3.28	<1.00	<1.00	<1.00	1.60	39.7	<1.00	<1.00	2.79	1.74	3.92	ug/L	<1.00	39.7
Selenium	ug/L	4.18 [1] [2]	4.80 [1] [2]	3.97	3.51	5.18	4.79	5.60	2.72	2.86	4.11	5.00	ug/L	2.72	5.60
Zinc	ug/L	<4.00	4.33	<4.00	<4.00	<4.00	311	<4.00	<4.00	7.08	7.11	12.8	ug/L	<4.00	311
Calcium	ug/L	60400	58500	58200	62700	65300	56800	75700	61800	62500	61800	62800	ug/L	56800	75700
Chromium	ug/L	<1.00	<1.00										ug/L	<1.00	<1.00
Hardness (Calc by 6020)	mg CaCO3/L	309	309	295	317	321	298	381	310	312	313	318	mg CaCO3/L	295	381
Magnesium	ug/L	38300	39600	36300	38900	38500	38100	46700	37700	37900	38400	39100	ug/L	36300	46700
Trivalent Chromium	ug/L	<11.0	<11.0	<11.0	<11.0	<21.0	<11.0	<11.0	<11.0	<11.0	<11.0	<1.00	ug/L	<1.00	<21.0
VOLATILE ORGANICS															
Acetone	ug/L	<400	<400	<400	<400	<400	<200	<200	<200	<200	<200	<200	ug/L	<200	<400
Benzene	ug/L	72.0	69.6	85.0	80.4	75.4	23.2	73.0	102	51.4	54.3	42.1	ug/L	23.2	102
2-Butanone (MEK)	ug/L	<200	<200	<200	<200	<200	<100	<100	<100	<100	<100	247	ug/L	<100	247
1,1-Dichloroethene	ug/L	13.2	17.2	11.8	12.4	14.2	<5.00	16.6	16.0	<5.00	9.10	<5.00	ug/L	<5.00	17.2
cis-1,2-Dichloroethene	ug/L	1490	2530	1550	1940	1760	761	1560	1720	1580	1560	1060	ug/L	761	2530
trans-1,2-Dichloroethene	ug/L	<10.0	<10.0	<10.0	10.4	<10.0	<5.00	11.7	12.1	<5.00	7.40	<5.00	ug/L	<5.00	12.1
Ethylbenzene	ug/L	14.8	<10.0	18.2	16.2	14.2	8.20	18.8	22.2	13.7	17.8	5.90	ug/L	5.90	22.2
Tetrachloroethene (PCE)	ug/L	<10.0	<10.0	<10.0	<10.0	<10.0	<5.00	7.00	<5.00	<5.00	<5.00	<5.00	ug/L	<5.00	<10.0
Toluene	ug/L	<10.0	10.8	11.2	10.6	10.4	<5.00	15.2	13.5	7.30	7.30	<5.00	ug/L	<5.00	15.2
Trichloroethene (TCE)	ug/L	106	372	107	168	233	<5.00	44.0	59.7	70.6	208	80.4	ug/L	<5.00	372
Vinyl chloride	ug/L	715	890	664	706	676	43.7	698	638	344	333	172	ug/L	43.7	890
m,p-Xylene	ug/L	<20.0	<20.0	<20.0	<20.0	<20.0	13.1	23.7	16.1	20.0	25.0	<10.0	ug/L	<10.0	25.0
o-Xylene	ug/L	<10.0	<10.0	<10.0	<10.0	<10.0	<5.00	13.6	11.6	7.40	9.10	<5.00	ug/L	<5.00	13.6

FootNumber	Qualifier	
1	A-01	Ending CCV fails at 89% (limit 90-110). Data possibly biased slightly low.
2	B	Analyte detected in the associated extraction blank.
3	B-01	Analyte detected in the extraction blank at a level greater than the MRL. All associated samples contain the same analyte at a level that is greater than 10 times the method blank.
4	C-05	Extract has undergone a GPC (Gel-Permeation Chromotography) cleanup per EPA 3640A.
5	H-01	This sample was analyzed outside the EPA recommended holding time.
6	R-01	The Reporting Limit for this analyte has been raised to account for matrix interference.
7	S-04	Surrogate recovery is outside of established control limits due to a sample matrix effect.
8	S-05	Surrogate recovery cannot be accurately quantified due to sample dilution required from high analyte concentration and/or matrix interference.
9	S-07	Surrogate recovery above control limits. Related target analytes were not detected, or detected below reporting limits, therefore data quality is not affected.

Siltronic EQ Effluent	Units	08/26/09	08/25/09	08/21/09	08/19/09	08/18/09	08/12/09	08/10/09	08/06/09	08/05/09	08/04/09	Units	Min	Max
pH	pH Units	9.76	9.96	9.82	9.79	9.88	9.87	9.53	9.7	9.69	10.2	pH Units	9.53	10.2
pH Temperature	pH Units	19.3	18.8	19.5	16.4	18.8	21.1	23.7	22.5	17.7	17.1	pH Units	16.4	23.7
Total Dissolved Solids	mg/L	664	709	620	636	638	660	638	659	608	744	mg/L	608	744
Total Suspended Solids	mg/L	5.00	20.0	24.0	56.0	31.0	27.0	8	16	34	25	mg/L	5	56
Total Organic Carbon	mg/L	5.01	8.07	8.34	7.47	7.44	<2.00	3.03	5.73	4.01	7.56	mg/L	<2.00	8.34
CYANIDE														
Cyanide, Total	mg/L	0.348	0.396	0.333	0.366	0.390		0.363	0.321	0.283	0.463	mg/L	0.283	0.463
Cyanide, WAD	mg/L	0.0508	0.0528	0.0438	0.0543	0.0543		0.0443	0.0489	0.0635	0.0878	mg/L	0.0438	0.0878
Cyanide, Amenable	mg/L	<0.00500	<0.00500	<0.00500	<0.00500	<0.00500		<0.00500	<0.00500	<0.00500	0.0351	mg/L	<0.00500	0.0351
CATC, chlorinated	mg/L	0.420	0.407	0.398	0.413	0.422		0.392	0.401	0.4	0.428	mg/L	0.392	0.428
Cyanide, Free	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100		<0.0100	<0.0100	<0.0100	0.0206	mg/L	<0.0100	0.0206
CATC, total	mg/L	0.348	0.396	0.333	0.366	0.390		0.363	0.321	0.283	0.463	mg/L	0.283	0.463
Available Cyanide	mg/L		<0.0020	<0.0020			0.0035	0.0021	0.0048	0.0059		mg/L	<0.0020	0.0059
SEMI-VOLATILE ORGANICS														
Acenaphthylene	ug/L	0.0894 [3]	0.186 [3]	0.182 [4]	<0.0842 [1] [4]	<0.0792 [6]	<1.86 [5] [15]	<1.86 [4]	0.419 [2]	0.563 [2]	0.217 [4]	ug/L	<0.0792 [6]	<1.86 [4]
Acenaphthene	ug/L	0.716 [3]	0.924 [3]	1.07 [4]	0.603 [1] [4]	0.550 [6]	<1.86 [5] [15]	<1.86 [4]	1.36 [2]	1.92 [2]	0.642 [4]	ug/L	0.603 [1] [4]	1.92 [2]
Anthracene	ug/L	<0.0755 [3]	<0.0808 [3]	<0.0816 [4]	<0.0842 [1] [4]	<0.0792 [6]	<1.86 [5] [15]	<1.86 [4]	<0.0777 [2]	<0.0784 [2]	0.184 [4] [6] [7]	ug/L	<0.0755 [3]	<1.86 [5] [15]
Benz(a)anthracene	ug/L	<0.0755 [3]	<0.0808 [3]	<0.0816 [4]	<0.0842 [1] [4]	<0.0792 [6]	<1.86 [5] [15]	<1.86 [4]	<0.0777 [2]	<0.0784 [2]	<0.0762 [4]	ug/L	<0.0755 [3]	<1.86 [5] [15]
Benzo(a)pyrene	ug/L	<0.0755 [3]	<0.0808 [3]	<0.0898 [4] [16] [8]	<0.0842 [1] [4]	<0.0990 [6] [19] [8]	<2.14 [5] [14] [15] [8]	<2.09 [4] [15] [8]	<0.0971 [2] [12] [8]	<0.0980 [2] [12] [8]	<0.952 [4] [18] [8]	ug/L	<0.0755 [3]	<2.14 [5] [14] [15] [8]
Benzo(b)fluoranthene	ug/L	<0.0755 [3]	<0.0808 [3]	<0.0816 [4]	<0.0842 [1] [4]	<0.0792 [6]	<1.86 [5] [15]	<1.86 [4]	<0.0777 [2]	<0.0784 [2]	<0.762 [4]	ug/L	<0.0755 [3]	<1.86 [4]
Benzo(k)fluoranthene	ug/L	<0.0755 [3]	<0.0808 [3]	<0.0816 [4]	<0.0842 [1] [4]	<0.0792 [6]	<1.86 [5] [15]	<1.86 [4]	<0.0777 [2]	<0.0784 [2]	<0.762 [4]	ug/L	<0.0755 [3]	<1.86 [4]
Benzo(g,h,i)perylene	ug/L	<0.0755 [3]	<0.0808 [3]	<0.0816 [4]	<0.0842 [1] [4]	<0.0792 [6]	<1.86 [5] [15]	<1.86 [4]	<0.0777 [2]	<0.0784 [2]	<0.0762 [4]	ug/L	<0.0755 [3]	<1.86 [4]
Carbazole	ug/L	0.859 [3]	1.33 [3]	1.68 [4]	1.05 [1] [4]	0.831 [6]	2.92 [5] [15]	2.89 [4]	2.06 [2]	2.48 [2]	3.24 [4]	ug/L	0.831 [6]	3.24 [4]
Chrysene	ug/L	<0.0755 [3]	<0.0808 [3]	<0.0816 [4]	<0.0842 [1] [4]	<0.0792 [6]	<1.86 [5] [15]	<1.86 [4]	<0.0777 [2]	<0.0784 [2]	0.116 [4]	ug/L	<0.0755 [3]	<1.86 [4]
Dibenz(a,h)anthracene	ug/L	<0.0755 [3]	<0.0808 [3]	<0.0816 [4]	<0.0842 [1] [4]	<0.0792 [6]	<1.86 [5] [15]	<1.86 [4]	<0.0777 [2]	<0.0784 [2]	<0.0762 [4]	ug/L	<0.0755 [3]	<1.86 [4]
Dibenzofuran	ug/L	<0.0755 [3]	<0.0808 [3]	<0.0816 [4]	<0.0842 [1] [4]	<0.0792 [6]	<1.86 [5] [15]	<1.86 [4]	<0.0777 [2]	0.0859 [2]	0.211 [4]	ug/L	<0.0755 [3]	<1.86 [4]
Fluoranthene	ug/L	<0.0755 [3]	<0.0808 [3]	<0.0816 [4]	<0.0842 [1] [4]	0.0811 [6]	<1.86 [5] [15]	<1.86 [4]	<0.0777 [2]	<0.0784 [2]	0.762 [4]	ug/L	<0.0755 [3]	<1.86 [4]
Fluorene	ug/L	<0.0755 [3]	0.0998 [3]	0.126 [4] [6] [7]	<0.105 [1] [4] [15] [8]	<0.119 [6] [19] [8]	<1.86 [5] [15]	<1.86 [4]	0.262 [2]	0.376 [2]	0.292 [4]	ug/L	<0.0755 [3]	<1.86 [4]
Indeno(1,2,3-cd)pyrene	ug/L	<0.0755 [3]	<0.0808 [3]	<0.0816 [4]	<0.0842 [1] [4]	<0.0792 [6]	<1.86 [5] [15]	<1.86 [4]	<0.0777 [2]	<0.0784 [2]	<0.0762 [4]	ug/L	<0.0755 [3]	<1.86 [4]
2-Methylnaphthalene	ug/L	<0.0755 [3]	0.129 [3]	<0.0816 [4]	<0.0842 [1] [4]	0.0899 [6]	<1.86 [5] [15]	<1.86 [4]	4.42 [2]	6.63 [2]	1.17 [4]	ug/L	<0.0755 [3]	6.63 [2]
Naphthalene	ug/L	0.0902 [3]	1.49 [3]	0.283 [1] [2] [4] [3] [4]	0.119 [1] [2] [4] [3]	0.196 [3] [4] [6] [1] [3]	2.01 [3] [5] [15] [3]	<1.86 [4]	104 [2]	141 [2]	36.6 [2] [4] [3]	ug/L	0.0902 [3]	141 [2]
Phenanthrene	ug/L	<0.0755 [3]	0.0966 [3]	<0.0816 [4]	<0.0842 [1] [4]	<0.0792 [6]	<1.86 [5] [15]	<1.86 [4]	0.190 [2]	0.258 [2]	2.22 [4]	ug/L	<0.0755 [3]	2.22 [4]
Pyrene	ug/L	<0.0755 [3]	<0.0808 [3]	<0.0816 [4]	<0.0842 [1] [4]	0.0891 [6]	<1.86 [5] [15]	<1.86 [4]	<0.0777 [2]	<0.0784 [2]	0.401 [4]	ug/L	<0.0755 [3]	<1.86 [4]
2-Chlorophenol	ug/L	<0.943 [3]	<1.01 [3]	<1.02 [4]	<1.05 [1] [4]	<0.990 [6]	<23.3 [5] [15]	<23.3 [4]	<0.971 [2]	<0.980 [2]	<0.952 [4]	ug/L	<0.943 [3]	<23.3 [4]
2,4-Dichlorophenol	ug/L	<0.943 [3]	<1.01 [3]	<1.02 [4]	<1.05 [1] [4]	<0.990 [6]	<23.3 [5] [15]	<23.3 [4]	<0.971 [2]	<0.980 [2]	<0.952 [4]	ug/L	<0.943 [3]	<23.3 [4]
2,4-Dimethylphenol	ug/L	<0.943 [3]	<1.01 [3]	<1.02 [4]	<1.05 [1] [4]	<0.990 [6]	<23.3 [5] [15]	<23.3 [4]	<0.971 [2]	<0.980 [2]	<0.952 [4]	ug/L	<0.943 [3]	<23.3 [4]
4,6-Dinitro-2-methylphenol	ug/L	<0.943 [3]	<1.01 [3]	<1.02 [4]	<1.05 [1] [4]	<0.990 [6]	<23.3 [5] [15]	<23.3 [4]	<0.971 [2]	<0.980 [2]	<0.952 [4]	ug/L	<0.943 [3]	<23.3 [4]
2-Methylphenol	ug/L	<0.943 [3]	<1.01 [3]	<1.02 [4]	<1.05 [1] [4]	<0.990 [6]	<23.3 [5] [15]	<23.3 [4]	<0.971 [2]	<0.980 [2]	<0.952 [4]	ug/L	<0.943 [3]	<23.3 [4]
2-Nitrophenol	ug/L	<0.943 [3]	<1.01 [3]	<1.02 [4]	<1.05 [1] [4]	<0.990 [6]	<23.3 [5] [15]	<23.3 [4]	<0.971 [2]	<0.980 [2]	<0.952 [4]	ug/L	<0.943 [3]	<23.3 [4]
4-Nitrophenol	ug/L	<0.943 [3]	<1.01 [3]	<1.02 [4]	<1.05 [1] [4]	<0.990 [6]	<23.3 [5] [15]	<23.3 [4]	<0.971 [2]	<0.980 [2]	<0.952 [4]	ug/L	<0.943 [3]	<23.3 [4]
2,4,5-Trichlorophenol	ug/L	<0.943 [3]	<1.01 [3]	<1.02 [4]	<1.05 [1] [4]	<0.990 [6]	<23.3 [5] [15]	<23.3 [4]	<0.971 [2]	<0.980 [2]	<0.952 [4]	ug/L	<0.943 [3]	<23.3 [4]
2,4,6-Trichlorophenol	ug/L	<0.943 [3]	<1.01 [3]	<1.02 [4]	<1.05 [1] [4]	<0.990 [6]	<23.3 [5] [15]	<23.3 [4]	<0.971 [2]	<0.980 [2]	<0.952 [4]	ug/L	<0.943 [3]	<23.3 [4]
Pentachlorophenol (PCP)	ug/L	<0.943 [3]	<1.01 [3]	<1.02 [4]	<1.05 [1] [4]	<0.990 [6]	<23.3 [5] [15]	<23.3 [4]	<0.971 [2]	<0.980 [2]	<0.952 [4]	ug/L	<0.943 [3]	<23.3 [4]
Phenol	ug/L	<0.943 [3]	<1.01 [3]	<1.02 [4]	<1.05 [1] [4]	<0.990 [6]	<23.3 [5] [15]	<23.3 [4]	<0.971 [2]	<0.980 [2]	<0.952 [4]	ug/L	<0.943 [3]	<23.3 [4]
METALS														
Hexavalent Chromium	mg/L	<0.0100	0.0173	<0.0100	<0.0100	0.0200 [8] [19] [6] [8]	<0.100 [14] [8]	<0.0100	<0.0100	<0.0100	<0.0100	mg/L	<0.0100	<0.0200 [8] [19] [6] [8
Silver	ug/L	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Arsenic	ug/L	4.32 [1] [3]	5.03 [1] [3]	4.36 [1] [3]	3.97 [2] [3]	3.70	3.32	2.94	4	3.72	3.83	ug/L	2.94	5.03 [1] [3]
Cadmium	ug/L	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Chromium	ug/L	<1.00	<1.00	1.07	1.02	<1.00	<1.00	<1.00	<1.00	<1.00	1	ug/L	<1.00	<1.00
Copper	ug/L	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	7.07	ug/L	<5.00	7.07
Iron	ug/L	5040	5300	4330	3310	4510	775	1590	1900	2220	3630	ug/L	775	5300
Mercury	ug/L	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	ug/L	<0.0100	<0.0100
Manganese	ug/L	277	298	309	359	258	178	221	270	351	219	ug/L	178	359
Nickel	ug/L	1.12	1.44	1.63	1.72	<1.00	1.00	1.18	1.77	1.49	1.32	ug/L	1	1.77
Lead	ug/L	<1.00	<1.00	1.34	1.80	<1.00	6.32	1.21	1.5	1.31	<1.00	ug/L	<1.00	6.32
Selenium	ug/L	4.84 [1] [3]	5.21 [1] [3]	5.51	3.78	4.71	4.61	4.29	2.99	3.06	4.58	ug/L	2.99	5.51
Zinc	ug/L	7.78	<4.00	4.01	<4.00	<4.00	<4.00	4.52	5.37	<4.00	12.4	ug/L	<4.00	12.4
Calcium	ug/L	2920	5850	5630	5680	6720	4790	2000	4460	8480	3350	ug/L	2000	6720
Chromium	ug/L	<1.00	<1.00									ug/L	<1.00	<1.00
Hardness (Calc by 6020)	mg CaCO3/L	147	153	150	155	143	134	141	147	160	157	mg CaCO3/L	134	160
Magnesium	ug/L	34000	33600	33000	34200	30700	29700	33000	32900	33800	36200	ug/L	29700	36200
Trivalent Chromium	ug/L	<11.0	<11.0	<11.0	<11.0	<21.0	<101	<11.0	<11.0	<11.0	<11.0	ug/L	<11.0	<101
VOLATILE ORGANICS														
Acetone	ug/L	<200	<200	<200	<200	<200	<40.0	<40.0 [17]	<200	<200	<400 [19]	ug/L	<40.0	<400 [19]
Benzene	ug/L	9.20	12.4	15.2	9.90	7.80	22.6	4.04 [17]	18.4	29.2	9.00 [19]	ug/L	4.04 [17]	29.2
2-Butanone (MEK)	ug/L	<100	<100	<100	<100	<100	<20.0	<20.0 [17]	<100	<100	<200 [19]	ug/L	<20.0	<200 [19]
1,1-Dichloroethene	ug/L	<5.00	<5.00	<5.00	<5.00	<5.00	2.78	<1.00 [17]	<5.00	<5.00	<10.0 [19]	ug/L	2.78	<10.0 [19]
cis-1,2-Dichloroethene	ug/L	420	545	519	488	390	880 [19]	206 [17]	624	950	275 [19]	ug/L	206 [17]	950
trans-1,2-Dichloroethene	ug/L	<5.00	<5.00	<5.00	<5.00	13.4	5.70	1.54 [17]	<5.00	<5.00	<10.0 [19]	ug/L	1.54 [17]	13.4
Ethylbenzene	ug/L	<5.00	<5.00	<5.00	<5.00	<5.00	10.2	<1.00 [17]	5.3	9	<10.0 [19]	ug/L	<1.00 [17]	10.2
Tetrachloroethene (PCE)	ug/L	<5.00	<5.00	<5.00	<5.00	<5.00	<1.00	<1.00 [17]	<5.00	<5.00	<10.0 [19]	ug/L	<1.00	<10.0 [19]
Toluene	ug/L	<5.00	<5.00	<5.00	<5.00	<5.00	3.08	<1.00 [17]	<5.00	5.1	<10.0 [19]	ug/L	3.08	<10.0 [19]
Trichloroethene (TCE)	ug/L	33.7	44.7	46.0	31.7	17.5	1.18	8.60 [17]	53	87.9	29.0 [19]	ug/L	1.18	87.9
Vinyl chloride	ug/L	43.7	60.7	61.3	37.7	29.9	113	3.12 [17]	44.7	98.2	21.4 [19]	ug/L	3.12 [17]	98.2
m,p-Xylene	ug/L	<10.0	<10.0	<10.0	<10.0	<10.0	13.2	98.2	<10.0	14.3	27.4 [19]	ug/L	<10.0	98.2
o-Xylene	ug/L	<5.00	<5.00	<5.00	<5.00	<5.00	5.02	<1.00 [17]	<5.00	5.4	11.2 [19]	ug/L	<1.00 [17]	11.2 [19]

FootNumber	Qualifier	TextBody
1	A-01b	Naphthalene detected in sample is less then ten times the level detected in the method blank. Results may be biased high.
2	A-02	Naphthalene less than amount detected in blank. Potentially biased high.
3	B	Analyte detected in the associated extraction blank.
4	B-01	Analyte detected in the extraction blank at a level greater than the MRL. All associated samples contain the same analyte at a level that is greater than 10 times the method blank.
5	C-05	Extract has undergone a GPC (Gel-Permeation Chromotography) cleanup per EPA 3640A.
6	H-01	This sample was analyzed outside the EPA recommended holding time.
7	M-02	Due to matrix interference, this analyte cannot be accurately quantified. The reported result is estimated.
8	R-01	The Reporting Limit for this analyte has been raised to account for matrix interference.
9	R-04	Reporting levels elevated due to dilution necessary for analysis.
10	RR-1	Not Reported - Overdiluted. Sample will be Rerun.
11	S-04	Surrogate recovery is outside of established control limits due to a sample matrix effect.
12	S-06	Surrogate recovery is outside of established control limits.
13	S-07	Surrogate recovery above control limits. Related target analytes were not detected, or detected below reporting limits, therefore data quality is not affected.
14	X	See Case Narrative.

Siltronic IPC Effluent	Units	08/26/09	08/25/09	08/21/09	08/19/09	08/18/09	08/12/09	08/10/09	08/06/09	08/05/09	08/04/09	08/03/09	07/31/09	Units	Min	Max
Dissolved Iron	ug/L	165 [4] [2]	192 [4] [2]	253 [5] [2]	123 [5] [2]	167 [7] [2]	152 [6] [2]	142 [5] [2]	<100 [4] [2]	167 [4] [2]	<100 [5] [2]	153 [13] [2]	173 [4] [2]	ug/L	<100 [5] [2]	253 [5] [2]
Dissolved Manganese	ug/L	14.7 [4] [2]	23.1 [4] [2]	22.2 [5] [2]	15.5 [5] [2]	7.92 [7] [2]	21.8 [6] [2]	8.04 [5] [2]	29.3 [4] [2]	34.5 [4] [2]	6.30 [5] [2]	2.81 [13] [2]	10.2 [4] [2]	ug/L	2.81 [13] [2]	34.5 [4] [2]
Arsenic	ug/L	4.99 [1] [1]	4.3	4.38 [1] [1]	3.98 [2] [1]	3.82	3.19	3.13	3.93	3.92	4.4	4.01	4.39	ug/L	3.13	4.99 [1] [1]
Iron	ug/L	4870	3280	3880	3140	4280	1010	1480	1890	2320	4070	4640	9340	ug/L	1010	9340
Manganese	ug/L	270	236	304	253	247	189	202	259	327	224	244	366	ug/L	189	366
FootNumber	Qualifier	TextBody														
1	B	Analyte detected in the associated extraction blank.														
2	FILT	Sample was lab filtered and acid preserved prior to analysis. See sample preparation section of report for date and time of filtration.														

Siltronic AOP Effluent	Units	08/26/09	08/25/09	08/21/09	08/19/09	08/18/09	08/12/09	08/10/09	08/06/09	08/05/09	08/04/09	08/03/09	07/31/09	Units	Min	Max
Total Organic Carbon	mg/L	5.76	6.21	5.19	7.23	8.8	<2.00	4.72 [1] [1]	6.62	3.1	6.9	5.38	9.11	mg/L	<2.00	9.11
CYANIDE																
Cyanide, Total	mg/L	0.187	0.135	0.118	0.118	0.143	0.0691	0.0405	0.0413	0.0558	0.031	0.0733	0.0479	mg/L	0.031	0.187
Cyanide, WAD	mg/L	0.0667	0.0331	0.0386	0.0448	0.06	0.0312	0.0189	0.0267	0.0442	0.0174	0.0402	0.0228	mg/L	0.0174	0.0667
Cyanide, Amenable	mg/L	0.0116	0.0202	0.0159	0.0348	0.0365	0.0166	0.0072	<0.00500	<0.00500	<0.00500	<0.00500	<0.00500	mg/L	<0.00500	0.0365
CATC, chlorinated	mg/L	0.175	0.115	0.102	0.0829	0.106	0.0525	0.0333	0.0634	0.0591	0.0287	0.0815	0.0456	mg/L	0.0287	0.175
Cyanide, Free	mg/L	0.0536	0.0342	0.0376	0.034	0.0474	0.0324	<0.0100	<0.0100	0.0163	<0.0100	0.0154	<0.0100	mg/L	<0.0100	0.0536
CATC, total	mg/L	0.187	0.135	0.118	0.118	0.143	0.0691	0.0405	0.0413	0.0558	0.031	0.0733	0.0479	mg/L	0.031	0.187
Available Cyanide	mg/L		0.0760	0.0320			0.0590	0.0660	0.0200	0.0340				mg/L	0.0200	0.0760
SEMI-VOLATILE ORGANICS																
Acenaphthylene	ug/L	<0.0769 [3]	<0.0755 [3]	<0.0762 [4]	<0.0800 [1] [4]	<0.0769 [6]	<0.0762 [5]	<0.0762 [4]	<0.0762 [2]	<0.0755 [2]	<0.0769 [4]	<0.0755 [5] [11]	<0.0769	ug/L	<0.0755 [3]	<0.0800 [1] [4]
Acenaphthene	ug/L	<0.0769 [3]	<0.0755 [3]	<0.0762 [4]	<0.0800 [1] [4]	<0.0769 [6]	<0.0762 [5]	<0.0762 [4]	<0.0762 [2]	<0.0755 [2]	<0.0769 [4]	<0.0755 [5] [11]	<0.0769	ug/L	<0.0755 [3]	<0.0800 [1] [4]
Anthracene	ug/L	<0.0769 [3]	<0.0755 [3]	<0.0762 [4]	<0.0800 [1] [4]	<0.0769 [6]	<0.0762 [5]	<0.0762 [4]	<0.0762 [2]	<0.0755 [2]	<0.0769 [4]	<0.0755 [5] [11]	<0.0769	ug/L	<0.0755 [3]	<0.0800 [1] [4]
Benz(a)anthracene	ug/L	<0.0769 [3]	<0.0755 [3]	<0.0762 [4]	<0.0800 [1] [4]	<0.0769 [6]	<0.0762 [5]	<0.0762 [4]	<0.0762 [2]	<0.0755 [2]	<0.0769 [4]	<0.0755 [5] [11]	<0.0769	ug/L	<0.0755 [3]	<0.0800 [1] [4]
Benzo(a)pyrene	ug/L	<0.0769 [3]	<0.0755 [3]	<0.0800 [4] [16] [9]	<0.0800 [1] [4]	<0.0769 [6]	<0.0762 [5]	<0.0762 [4]	<0.0762 [2]	<0.0755 [2]	<0.0769 [4]	<0.0755 [5] [11]	<0.0769	ug/L	<0.0755 [3]	<0.0800 [1] [4]
Benzo(b)fluoranthene	ug/L	<0.0769 [3]	<0.0755 [3]	<0.0762 [4]	<0.0800 [1] [4]	<0.0769 [6]	<0.0762 [5]	<0.0762 [4]	<0.0762 [2]	<0.0755 [2]	<0.0769 [4]	<0.0755 [5] [11]	<0.0769	ug/L	<0.0755 [3]	<0.0800 [1] [4]
Benzo(k)fluoranthene	ug/L	<0.0769 [3]	<0.0755 [3]	<0.0762 [4]	<0.0800 [1] [4]	<0.0769 [6]	<0.0762 [5]	<0.0762 [4]	<0.0762 [2]	<0.0755 [2]	<0.0769 [4]	<0.0755 [5] [11]	<0.0769	ug/L	<0.0755 [3]	<0.0800 [1] [4]
Benzo(g,h,i)perylene	ug/L	<0.0769 [3]	<0.0755 [3]	<0.0762 [4]	<0.0800 [1] [4]	<0.0769 [6]	<0.0762 [5]	<0.0762 [4]	<0.0762 [2]	<0.0755 [2]	<0.0769 [4]	<0.0755 [5] [11]	<0.0769	ug/L	<0.0755 [3]	<0.0800 [1] [4]
Carbazole	ug/L	<0.0769 [3]	<0.0755 [3]	<0.0762 [4]	<0.0800 [1] [4]	<0.0769 [6]	<0.0762 [5]	0.0784 [4]	<0.0762 [2]	<0.0755 [2]	<0.0769 [4]	13 [5] [11] [28] [9]	<0.0769	ug/L	<0.0755 [3]	<0.0800 [1] [4]
Chrysene	ug/L	<0.0769 [3]	<0.0755 [3]	<0.0762 [4]	<0.0800 [1] [4]	<0.0769 [6]	<0.0762 [5]	<0.0762 [4]	<0.0762 [2]	<0.0755 [2]	<0.0769 [4]	<0.0755 [5] [11]	<0.0769	ug/L	<0.0755 [3]	<0.0800 [1] [4]
Dibenz(a,h)anthracene	ug/L	<0.0769 [3]	<0.0755 [3]	<0.0762 [4]	<0.0800 [1] [4]	<0.0769 [6]	<0.0762 [5]	<0.0762 [4]	<0.0762 [2]	<0.0755 [2]	<0.0769 [4]	<0.0755 [5] [11]	<0.0769	ug/L	<0.0755 [3]	<0.0800 [1] [4]
Dibenzofuran	ug/L	<0.0769 [3]	<0.0755 [3]	<0.0762 [4]	<0.0800 [1] [4]	<0.0769 [6]	<0.0762 [5]	<0.0762 [4]	<0.0762 [2]	<0.0755 [2]	<0.0769 [4]	<0.0755 [5] [11]	<0.0769	ug/L	<0.0755 [3]	<0.0800 [1] [4]
Fluoranthene	ug/L	<0.0769 [3]	<0.0755 [3]	<0.0762 [4]	<0.0800 [1] [4]	<0.0769 [6]	<0.0762 [5]	<0.0762 [4]	<0.0762 [2]	<0.0755 [2]	<0.0769 [4]	<0.0755 [5] [11]	<0.0769	ug/L	<0.0755 [3]	<0.0800 [1] [4]
Fluorene	ug/L	<0.0769 [3]	<0.0755 [3]	<0.0762 [4]	<0.0800 [1] [4]	<0.0769 [6]	<0.0762 [5]	<0.0762 [4]	<0.0762 [2]	<0.0755 [2]	<0.0769 [4]	<0.0755 [5] [11]	<0.0769	ug/L	<0.0755 [3]	<0.0800 [1] [4]
Indeno(1,2,3-cd)pyrene	ug/L	<0.0769 [3]	<0.0755 [3]	<0.0762 [4]	<0.0800 [1] [4]	<0.0769 [6]	<0.0762 [5]	<0.0762 [4]	<0.0762 [2]	<0.0755 [2]	<0.0769 [4]	<0.0755 [5] [11]	<0.0769	ug/L	<0.0755 [3]	<0.0800 [1] [4]
2-Methylnaphthalene	ug/L	<0.0769 [3]	<0.0755 [3]	<0.0762 [4]	<0.0800 [1] [4]	<0.0769 [6]	<0.0762 [5]	<0.0762 [4]	<0.0762 [2]	<0.0755 [2]	<0.0769 [4]	<0.0755 [5] [11]	<0.0769	ug/L	<0.0755 [3]	<0.0800 [1] [4]
Naphthalene	ug/L	0.707 [3]	0.133 [3]	13 [1] [2] [4] [5] [6]	0.134 [1] [2] [4] [5]	<0.0769 [6]	<0.0762 [5]	<0.0762 [4]	<0.114 [2] [12] [9]	<0.113 [2] [12] [9]	0.248 [2] [4] [5]	[5] [9] [11] [2] [5]	0.234	ug/L	<0.113 [2] [12] [9]	0.707 [3]
Phenanthrene	ug/L	<0.0769 [3]	<0.0755 [3]	<0.0762 [4]	<0.0800 [1] [4]	<0.0769 [6]	<0.0762 [5]	<0.0762 [4]	<0.0762 [2]	<0.0755 [2]	<0.0769 [4]	<0.0755 [5] [11]	<0.0769	ug/L	<0.0755 [3]	<0.0800 [1] [4]
Pyrene	ug/L	<0.0769 [3]	<0.0755 [3]	<0.0762 [4]	<0.0800 [1] [4]	<0.0769 [6]	<0.0762 [5]	<0.0762 [4]	<0.0762 [2]	<0.0755 [2]	<0.0769 [4]	<0.0755 [5] [11]	<0.0769	ug/L	<0.0755 [3]	<0.0800 [1] [4]
2-Chlorophenol	ug/L	<0.962 [3]	<0.943 [3]	<0.952 [4]	<1.00 [1] [4]	<0.962 [6]	<0.952 [5]	<0.952 [4]	<0.952 [2]	<0.943 [2]	<0.962 [4]	<0.943 [5] [11]	<0.962	ug/L	<0.943 [5] [11]	<1.00 [1] [4]
2,4-Dichlorophenol	ug/L	<0.962 [3]	<0.943 [3]	<0.952 [4]	<1.00 [1] [4]	<0.962 [6]	<0.952 [5]	<0.952 [4]	<0.952 [2]	<0.943 [2]	<0.962 [4]	<0.943 [5] [11]	<0.962	ug/L	<0.943 [5] [11]	<1.00 [1] [4]
2,4-Dimethylphenol	ug/L	<0.962 [3]	<0.943 [3]	<0.952 [4]	<1.00 [1] [4]	<0.962 [6]	<0.952 [5]	<0.952 [4]	<0.952 [2]	<0.943 [2]	<0.962 [4]	<0.943 [5] [11]	<0.962	ug/L	<0.943 [5] [11]	<1.00 [1] [4]
4,6-Dinitro-2-methylphenol	ug/L	<0.962 [3]	<0.943 [3]	<0.952 [4]	<1.00 [1] [4]	<0.962 [6]	<0.952 [5]	<0.952 [4]	<0.952 [2]	<0.943 [2]	<0.962 [4]	<0.943 [5] [11]	<0.962	ug/L	<0.943 [5] [11]	<1.00 [1] [4]
2-Methylphenol	ug/L	<0.962 [3]	<0.943 [3]	<0.952 [4]	<1.00 [1] [4]	<0.962 [6]	<0.952 [5]	<0.952 [4]	<0.952 [2]	<0.943 [2]	<0.962 [4]	<0.943 [5] [11]	<0.962	ug/L	<0.943 [5] [11]	<1.00 [1] [4]
2-Nitrophenol	ug/L	<0.962 [3]	<0.943 [3]	<0.952 [4]	<1.00 [1] [4]	<0.962 [6]	<0.952 [5]	<0.952 [4]	<0.952 [2]	<0.943 [2]	<0.962 [4]	<0.943 [5] [11]	<0.962	ug/L	<0.943 [5] [11]	<1.00 [1] [4]
4-Nitrophenol	ug/L	<0.962 [3]	<0.943 [3]	<0.952 [4]	<1.00 [1] [4]	<0.962 [6]	<0.952 [5]	<0.952 [4]	<0.952 [2]	<0.943 [2]	<0.962 [4]	<0.943 [5] [11]	<0.962	ug/L	<0.943 [5] [11]	<1.00 [1] [4]
2,4,5-Trichlorophenol	ug/L	<0.962 [3]	<0.943 [3]	<0.952 [4]	<1.00 [1] [4]	<0.962 [6]	<0.952 [5]	<0.952 [4]	<0.952 [2]	<0.943 [2]	<0.962 [4]	<0.943 [5] [11]	<0.962	ug/L	<0.943 [5] [11]	<1.00 [1] [4]
2,4,6-Trichlorophenol	ug/L	<0.962 [3]	<0.943 [3]	<0.952 [4]	<1.00 [1] [4]	<0.962 [6]	<0.952 [5]	<0.952 [4]	<0.952 [2]	<0.943 [2]	<0.962 [4]	<0.943 [5] [11]	<0.962	ug/L	<0.943 [5] [11]	<1.00 [1] [4]
Pentachlorophenol (PCP)	ug/L	<0.962 [3]	<0.943 [3]	<0.952 [4]	<1.00 [1] [4]	<0.962 [6]	<0.952 [5]	<0.952 [4]	<0.952 [2]	<0.943 [2]	<0.962 [4]	<0.943 [5] [11]	<0.962	ug/L	<0.943 [5] [11]	<1.00 [1] [4]
Phenol	ug/L	<0.962 [3]	<0.943 [3]	<0.952 [4]	<1.00 [1] [4]	<0.962 [6]	<0.952 [5]	<0.952 [4]	<0.952 [2]	<0.943 [2]	<0.962 [4]	<0.943 [5] [11]	<0.962	ug/L	<0.943 [5] [11]	<1.00 [1] [4]
METALS																
Arsenic	ug/L	5.44	4.93	4.77	4.31	4.52	4.03	4.01	4.56	4.43	5.2	4.76	5.16	ug/L	4.01	5.44
VOLATILE ORGANICS																
Acetone	ug/L	20.6	36.8	38.6	30	42.5	33.0 [19]	43.3	51.4	46.7	104 [17] [8]	65.3 [26] [8]	133 [15]	ug/L	20.6	133 [15]
Benzene	ug/L	0.62	<0.250	<0.250	<0.250	<0.250	<0.250 [19]	<0.250	<0.250	<0.250	<0.250	<0.250	<0.250 [15]	ug/L	<0.250 [15]	0.62
2-Butanone (MEK)	ug/L	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0 [19]	<10.0	47.4	14.8	30.9 [17] [8]	34.4 [26] [8]	50.4 [15]	ug/L	<10.0	50.4 [15]
1,1-Dichloroethene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [19]	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [15]	ug/L	<0.500 [15]	<0.500 [15]
cis-1,2-Dichloroethene	ug/L	50	22.1	15	13.4	14.6	7.23 [19]	1.82	6.82	<0.500	4.77	14.5	5.22 [15]	ug/L	1.82	50
trans-1,2-Dichloroethene	ug/L	2.16	1.08	0.57	0.67	0.97	<0.500 [19]	<0.500	<0.500	0.52	<0.500	0.64	0.640 [15]	ug/L	<0.500	2.16
Ethylbenzene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [19]	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [15]	ug/L	<0.500 [15]	<0.500 [15]
Tetrachloroethene (PCE)	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [19]	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [15]	ug/L	<0.500 [15]	<0.500 [15]
Toluene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [19]	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [15]	ug/L	<0.500 [15]	<0.500 [15]
Trichloroethene (TCE)	ug/L	4.88	3.11	1.77	1.1	0.85	<0.500 [19]	<0.500	1.02	1.72	0.52	1.89	1.06 [15]	ug/L	<0.500	4.88
Vinyl chloride	ug/L	1.21	<0.500	<0.500	<0.500	<0.500	<0.500 [19]	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [15]	ug/L	<0.500 [15]	1.21
m,p-Xylene	ug/L	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00 [19]	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00 [15]	ug/L	<1.00 [15]	<1.00 [15]
o-Xylene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [19]	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500 [15]	ug/L	<0.500 [15]	<0.500 [15]

FootNumber	Qualifier	TextBody
1	A-01	Due to high alkalinity, H3PO4 was added to drive off IOC.
2	A-01a	Result less than 10 times amount detected in method blank. Results may be biased high.
3	A-01d	Sample injected 2 minutes outside the 12 hour tune window. Data accepted.
4	A-02	Naphthalene less than amount detected in blank. Potentially biased high.
5	B	Analyte detected in the associated extraction blank.
6	B-01	Analyte detected in the extraction blank at a level greater than the MRL. All associated samples contain the same analyte at a level that is greater than 10 times the method blank.
7	C-05	Extract has undergone a GPC (Gel-Permeation Chromotography) cleanup per EPA 3640A.
8	Q-30	Recovery for Lab Control Spike (LCS) is below the lower control limit. Data may be biased low.
9	R-01	The Reporting Limit for this analyte has been raised to account for matrix interference.
10	S-04	Surrogate recovery is outside of established control limits due to a sample matrix effect.
11	S-06	Surrogate recovery is outside of established control limits.
12	V-01	Sample aliquot taken from VOA vial with headspace (air bubble greater than 6 mm diameter).

Final Siltronic Effluent Thru GAC	Units	08/28/09	08/20/09	08/12/09	Units	Min	Max
pH	pH Units	7.6	7.55	7.31	pH Units	7.31	7.6
pH Temperature	pH Units	19.5	16	22	pH Units	16	22
Total Dissolved Solids	mg/L	723	1060	718	mg/L	718	1060
Total Suspended Solids	mg/L	16	<5.00	<5.00	mg/L	<5.00	16
Total Organic Carbon	mg/L	3.72	2.95	<2.00	mg/L	<2.00	3.72
Iron	ug/L	<100 [4] [4]	<100 [6] [4]	<100 [5] [4]	ug/L	<100 [5] [4]	<100 [5] [4]
Manganese	ug/L	46.3 [4] [4]	25.6 [6] [4]	34.6 [5] [4]	ug/L	25.6 [6] [4]	46.3 [4] [4]
CYANIDE							
Cyanide, Total	mg/L	0.152	0.0801	0.0226	mg/L	0.0226	0.152
Cyanide, WAD	mg/L	0.0288	0.0139	0.0079	mg/L	0.0079	0.0288
Cyanide, Amenable	mg/L	0.0146	<0.00500	<0.00500	mg/L	<0.00500	0.0146
CATC, chlorinated	mg/L	0.137	0.0886	0.026	mg/L	0.026	0.137
Cyanide, Free	mg/L	<0.0100	<0.0100	<0.0100	mg/L	<0.0100	<0.0100
CATC, total	mg/L	0.152	0.0801	0.0226	mg/L	0.0226	0.152
Available Cyanide	mg/L		<0.0020	<0.0020	mg/L	<0.0020	<0.0020
SEMI-VOLATILE ORGANICS							
Acenaphthylene	ug/L	<0.0816 [3]	<0.0769 [5]	<0.0762 [4]	ug/L	<0.0762 [4]	<0.0816 [3]
Acenaphthene	ug/L	<0.0816 [3]	<0.0769 [5]	<0.0762 [4]	ug/L	<0.0762 [4]	<0.0816 [3]
Anthracene	ug/L	<0.0816 [3]	<0.0769 [5]	<0.0762 [4]	ug/L	<0.0762 [4]	<0.0816 [3]
Benz(a)anthracene	ug/L	<0.0816 [3]	<0.0769 [5]	<0.0762 [4]	ug/L	<0.0762 [4]	<0.0816 [3]
Benzo(a)pyrene	ug/L	<0.0816 [3]	<0.0808 [5] [17] [7]	<0.0762 [4]	ug/L	<0.0762 [4]	<0.0816 [3]
Benzo(b)fluoranthene	ug/L	<0.0816 [3]	<0.0769 [5]	<0.0762 [4]	ug/L	<0.0762 [4]	<0.0816 [3]
Benzo(k)fluoranthene	ug/L	<0.0816 [3]	<0.0769 [5]	<0.0762 [4]	ug/L	<0.0762 [4]	<0.0816 [3]
Benzo(g,h,i)perylene	ug/L	<0.0816 [3]	<0.0769 [5]	<0.0762 [4]	ug/L	<0.0762 [4]	<0.0816 [3]
Carbazole	ug/L	<0.0816 [3]	<0.0769 [5]	<0.0762 [4]	ug/L	<0.0762 [4]	<0.0816 [3]
Chrysene	ug/L	<0.0816 [3]	<0.0769 [5]	<0.0762 [4]	ug/L	<0.0762 [4]	<0.0816 [3]
Dibenz(a,h)anthracene	ug/L	<0.0816 [3]	<0.0769 [5]	<0.0762 [4]	ug/L	<0.0762 [4]	<0.0816 [3]
Dibenzofuran	ug/L	<0.0816 [3]	<0.0769 [5]	<0.0762 [4]	ug/L	<0.0762 [4]	<0.0816 [3]
Fluoranthene	ug/L	<0.0816 [3]	<0.0769 [5]	<0.0762 [4]	ug/L	<0.0762 [4]	<0.0816 [3]
Fluorene	ug/L	<0.0816 [3]	<0.0769 [5]	<0.0762 [4]	ug/L	<0.0762 [4]	<0.0816 [3]
Indeno(1,2,3-cd)pyrene	ug/L	<0.0816 [3]	<0.0769 [5]	<0.0762 [4]	ug/L	<0.0762 [4]	<0.0816 [3]
2-Methylnaphthalene	ug/L	<0.0816 [3]	<0.0769 [5]	<0.0762 [4]	ug/L	<0.0762 [4]	<0.0816 [3]
Naphthalene	ug/L	<0.0816 [3]	0.127 [2] [3] [5] [1] [2]	0.172 [2] [4] [1]	ug/L	<0.0816 [3]	0.172 [2] [4] [1]
Phenanthrene	ug/L	<0.0816 [3]	<0.0769 [5]	<0.0762 [4]	ug/L	<0.0762 [4]	<0.0816 [3]
Pyrene	ug/L	<0.0816 [3]	<0.0769 [5]	<0.0762 [4]	ug/L	<0.0762 [4]	<0.0816 [3]
2-Chlorophenol	ug/L	<1.02 [3]	<0.962 [5]	<0.952 [4]	ug/L	<0.952 [4]	<1.02 [3]
2,4-Dichlorophenol	ug/L	<1.02 [3]	<0.962 [5]	<0.952 [4]	ug/L	<0.952 [4]	<1.02 [3]
2,4-Dimethylphenol	ug/L	<1.02 [3]	<0.962 [5]	<0.952 [4]	ug/L	<0.952 [4]	<1.02 [3]
4,6-Dinitro-2-methylphenol	ug/L	<1.02 [3]	<0.962 [5]	<0.952 [4]	ug/L	<0.952 [4]	<1.02 [3]
2-Methylphenol	ug/L	<1.02 [3]	<0.962 [5]	<0.952 [4]	ug/L	<0.952 [4]	<1.02 [3]
2-Nitrophenol	ug/L	<1.02 [3]	<0.962 [5]	<0.952 [4]	ug/L	<0.952 [4]	<1.02 [3]
4-Nitrophenol	ug/L	<4.08 [3]	<0.962 [5]	<0.952 [4]	ug/L	<0.952 [4]	<4.08 [3]
2,4,5-Trichlorophenol	ug/L	<1.02 [3]	<0.962 [5]	<0.952 [4]	ug/L	<0.952 [4]	<1.02 [3]
2,4,6-Trichlorophenol	ug/L	<1.02 [3]	<0.962 [5]	<0.952 [4]	ug/L	<0.952 [4]	<1.02 [3]
Pentachlorophenol (PCP)	ug/L	<1.02 [3]	<0.962 [5]	<0.952 [4]	ug/L	<0.952 [4]	<1.02 [3]
Phenol	ug/L	<1.02 [3]	<0.962 [5]	<0.952 [4]	ug/L	<0.952 [4]	<1.02 [3]
METALS							
Hexavalent Chromium	mg/L	<0.0100	<0.0100	<0.0100 [6] [5]	mg/L	<0.0100	<0.0100
Silver	ug/L	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Arsenic	ug/L	3.73	4.83 [2] [1]	5.99	ug/L	3.73	5.99
Cadmium	ug/L	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Chromium	ug/L	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Copper	ug/L	<5.00	<5.00	<5.00	ug/L	<5.00	<5.00
Iron	ug/L	644	463	378	ug/L	378	644
Mercury	ug/L	<0.0100	0.0136	<0.0100	ug/L	<0.0100	0.0136
Manganese	ug/L	75.9	45.9	56.2	ug/L	45.9	75.9
Nickel	ug/L	2.66	2.99	4.81	ug/L	2.66	4.81
Lead	ug/L	<1.00	<1.00	<1.00	ug/L	<1.00	<1.00
Selenium	ug/L	2.54	2.73	2.1	ug/L	2.1	2.73
Zinc	ug/L	5.4	5.27	4.92	ug/L	4.92	5.4
Calcium	ug/L	5830	3310	3230	ug/L	3230	5830
Hardness (Calc by 6020)	mg CaCO3/L	150	131	135	mg CaCO3/L	131	150
Magnesium	ug/L	32800	29900	30700	ug/L	29900	32800
Trivalent Chromium	ug/L	<11.0	<11.0	<11.0	ug/L	<11.0	<11.0
VOLATILE ORGANICS							
Acetone	ug/L	<20.0	<20.0	<20.0 [15]	ug/L	<20.0 [15]	<20.0 [15]
Benzene	ug/L	<0.250	<0.250	<0.250 [15]	ug/L	<0.250	<0.250
2-Butanone (MEK)	ug/L	<10.0	<10.0	<10.0 [15]	ug/L	<10.0	<10.0
1,1-Dichloroethene	ug/L	<0.500	<0.500	<0.500 [15]	ug/L	<0.500	<0.500
cis-1,2-Dichloroethene	ug/L	<0.500	<0.500	<0.500 [15]	ug/L	<0.500	<0.500
trans-1,2-Dichloroethene	ug/L	<0.500	<0.500	<0.500 [15]	ug/L	<0.500	<0.500
Ethylbenzene	ug/L	<0.500	<0.500	<0.500 [15]	ug/L	<0.500	<0.500
Tetrachloroethene (PCE)	ug/L	<0.500	<0.500	<0.500 [15]	ug/L	<0.500	<0.500
Toluene	ug/L	<0.500	<0.500	<0.500 [15]	ug/L	<0.500	<0.500
Trichloroethene (TCE)	ug/L	<0.500	<0.500	<0.500 [15]	ug/L	<0.500	<0.500
Vinyl chloride	ug/L	<0.500	<0.500	<0.500 [15]	ug/L	<0.500	<0.500
m,p-Xylene	ug/L	<1.00	<1.00	<1.00 [15]	ug/L	<1.00 [15]	<1.00 [15]
o-Xylene	ug/L	<0.500	<0.500	<0.500 [15]	ug/L	<0.500 [15]	<0.500 [15]

FootNumber	Qualifier	TextBody
1	B	Analyte detected in the associated extraction blank.
2	B-01	Analyte detected in the extraction blank at a level greater than the MRL. All associated samples contain the same analyte at a level that is greate
3	C-05	Extract has undergone a GPC (Gel-Permeation Chromotography) cleanup per EPA 3640A.
4	FILT	Sample was lab filtered and acid preserved prior to analysis. See sample preparation section of report for date and time of filtration.
5	H-01	This sample was analyzed outside the EPA recommended holding time.
6	Q-23	Recovery of Continuing Calibration Verification sample above upper control limit for this analyte. Data is likely biased high.
7	R-01	The Reporting Limit for this analyte has been raised to account for matrix interference.
8	S-04	Surrogate recovery is outside of established control limits due to a sample matrix effect.
9	X	See Case Narrative.

Attachment H: NW Natural Bench-Scale Air Stripping Results

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MW-1 Treatment Results

METALS GROUNDWATER DATA - ASP00 METHODS 6010/6020/7470/7471							
MW-1							
	Initial	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
	9H21003-02	9H21003-03	9H21003-05	9H21003-04	9H21017-01	9H21003-01	9H21017-02
Units	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Iron - Total	1.77	0.232	0.194	0.213	0.178	0.194	0.262
Manganese - Total	7.72	0.118	0.292	0.115	0.103	0.292	0.192
Conventional Chemistry Parameters by EPA Methods							
MW-1							
	Initial	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
	9H21003-02	9H21003-03	9H21003-05	9H21003-04	9H21017-01	9H21003-01	9H21017-02
Units	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Cyanide (total)	0.449	0.446	0.229	0.43	0.404	0.419	0.486
Cyanide (amenable)	0.036	0.033	0.559	0.027	0.033	0.015	0.082
VOC GROUNDWATER DATA - SW846 METHOD 8260B							
MW-1							
	Initial	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
	9H21003-02	9H21003-03	9H21003-05	9H21003-04	9H21017-01	9H21003-01	9H21017-02
Units	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Acetone	<10	<10	<10	<10	11	<10	13
Methylene chloride	<2	3	3	4	3	3	4
Toluene	1	<1	<1	<1	<1	<1	<1
Naphthalene	<1	<1	<1	<1	<1	<1	1
SVOC GROUNDWATER DATA - SW846 METHOD 8270C							
MW-1							
	Initial	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
	9H21003-02	9H21003-03	9H21003-05	9H21003-04	9H21017-01	9H21003-01	9H21017-02
Units	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
bis(2-Ethylhexyl)phthalate	<2	<2	<2	<2	<2	<2	2

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PW-1 Treatment Results

METALS GROUNDWATER DATA - ASP00 METHODS 6010/6020/7470/7471							
PW-1							
	Initial	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
	9H21017-03	9H21017-04	9H24002-01	9H21017-05	9H21017-06	9H21017-07	9H21017-08
Units	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Iron - Total	2.08	0.375	0.392	0.377	0.301	0.312	0.302
Manganese - Total	3.05	<0.005	0.026	0.016	0.049	<0.005	0.074
Conventional Chemistry Parameters by EPA Methods							
PW-1							
	Initial	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
	9H21017-03	9H21017-04	9H24002-01	9H21017-05	9H21017-06	9H21017-07	9H21017-08
Units	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Cyanide (total)	0.91	0.918	0.861	0.986	1.34	0.886	0.854
Cyanide (amenable)	<0.010	0.033	<0.010	0.147	0.699	0.123	0.164
VOC GROUNDWATER DATA - SW846 METHOD 8260B							
PW-1							
	Initial	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
	9H21017-03	9H21017-04	9H24002-01	9H21017-05	9H21017-06	9H21017-07	9H21017-08
Units	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Methylene chloride	25	26	28	23	28	22	22
Benzene	3580	145	133	63	100	16	24
Toluene	46	<10	<10	<10	<10	<10	<10
Ethylbenzene	66	<10	<10	<10	<10	<10	<10
m,p-xylene	31	<20	<20	<20	<20	<20	<20
o-xylene	28	<10	<10	<10	<10	<10	<10
Naphthalene	773	208	55	226	250	174	178
SVOC GROUNDWATER DATA - SW846 METHOD 8270C							
PW-1							
	Initial	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
	9H21017-03	9H21017-04	9H24002-01	9H21017-05	9H21017-06	9H21017-07	9H21017-08
Units	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Phenol	21	26	36	26	33	29	33
2,4-Dimethylphenol	<4	4	6	4	5	5	5
Naphthalene	184	46	40	51	132	124	118
2-Methylnaphthalene	6	<2	4	<2	5	4	4
Acenaphthylene	4	<2	4	<2	4	3	4
Acenaphthene	3	<2	4	<2	4	3	4
Phenanthrene	2	<2	4	<2	3	<2	3
Carbazole	25	32	4	26	24	31	26

Attachment I: Siltronic Bench-Scale Air Stripping Results

Siltronic
Rec'd 8/24/09

Treatment Results

METALS GROUNDWATER DATA - ASP00 METHODS 6010/6020/7470/7471							
	Initial	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
	9H25009-01	9H25009-05	9H25015-01	9H25009-02	9H25015-02	9H25009-03	9H25009-04
Units	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Iron - Total	25.2	0.241	0.190	0.158	0.172	0.16	0.149
Manganese - Total	1.40	0.011	0.040	<0.005	0.009	<0.005	0.033
Conventional Chemistry Parameters by EPA Methods							
	Initial	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
	9H25009-01	9H25009-05	9H25015-01	9H25009-02	9H25015-02	9H25009-03	9H25009-04
Units	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Cyanide (total)	0.349	0.413	0.403	0.413	0.398	0.398	0.41
Cyanide (amenable)	0.141	0.043	<0.010	0.043	0.028	0.273	0.410
VOC GROUNDWATER DATA - SW846 METHOD 8260B							
	Initial	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
	9H25009-01	9H25009-05	9H25015-01	9H25009-02	9H25015-02	9H25009-03	9H25009-04
Units	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Vinyl chloride	166	<10	<10	<10	<10	<10	<10
Methylene chloride	10	10	10	14	15	11	11
cis-1,2-dichloroethene	739	71	9	10	<5	<5	<5
Benzene	23	<5	<5	<5	<5	<5	<5
Trichloroethene	56	<5	<5	<5	<5	<5	<5
Naphthalene	25	14	6	6	5	<5	6
SVOC GROUNDWATER DATA - SW846 METHOD 8270C							
	Initial	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
	9H25009-01	9H25009-05	9H25015-01	9H25009-02	9H25015-02	9H25009-03	9H25009-04
Units	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
3 & 4-methylphenol	<4	59	11	51	17	52	56
Naphthalene	19	9	7	7	8	5	4
bis (2-Ethylhexyl)phthalate	<3	<3	4	<3	2	<3	<3

Attachment J: Pilot Plant PowerPoint Site Presentation

NW Natural and Siltronic Groundwater Treatment Pilot Plants

Sevenson Environmental Services, Inc.

1

Pilot Issues

- Verify process treatment effectiveness
- Optimize chemical dosages
- NW Natural
  - Use initial oxidation step to remove iron, manganese, and cyanide (if possible)
- Siltronic
  - Use initial oxidation step to remove iron, manganese, and chlorinated organics (if possible).

Sevenson Environmental Services, Inc.

2

Pollutants of Concern

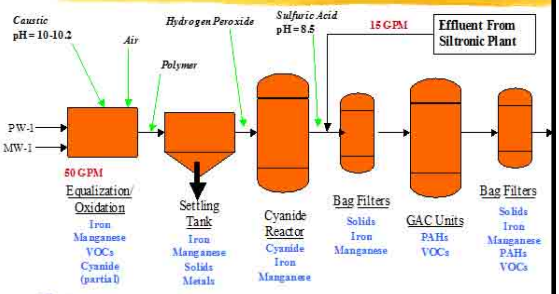
NW Natural
- DNAPL
- Iron and Manganese
- Cyanide
- Heavy Metals
- Volatile Organics
- Polyaromatic Hydrocarbons (PAHs)

Siltronic
- Iron and Manganese
- Heavy Metals
- Volatile Organics
- Chlorinated Organics
  - Vinyl chloride
  - TCE/DCE
- Polyaromatic Hydrocarbons (PAHs)

Sevenson Environmental Services, Inc.

3

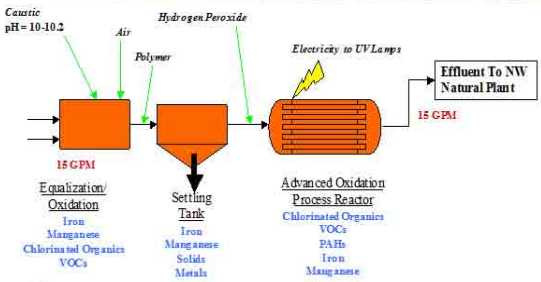
NW Natural Pilot Process Flow



Sevenson Environmental Services, Inc.

4

Siltronic Pilot Process Flow



Sevenson Environmental Services, Inc.

5

Pilot Plant Results & Schedule

- Pilot Startup
  - Started NW Natural July 23
  - Started Siltronic July 31
- Initial samples (not complete) show compliance with DEQ parameters
- Pilot Schedule
  - Run through approx. Aug 21
  - Depending upon results

Sevenson Environmental Services, Inc.

6

APPENDIX O
SAMPLING AND ANALYSIS PLAN

APPENDIX O
SAMPLING AND ANALYSIS PLAN
GROUNDWATER SOURCE CONTROL
DRAFT FINAL DESIGN REPORT
NW NATURAL GASCO SITE

Prepared for

NW Natural

Prepared by

Anchor QEA, LLC

April 2011

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Attachment O-1 Field Forms

1 INTRODUCTION

This Sampling and Analysis Plan (SAP) has been prepared as Appendix O to the *Groundwater Source Control Draft Final Design Report for the NW Natural Gasco Site* (Site) in Portland Oregon. This SAP covers monitoring of groundwater elevation and chemistry in select monitoring wells to aid in evaluation of the proposed source control measures for Segments 1 and 2 at the Site.

2 HYDROLOGY MONITORING

2.1 Manual Water Level Monitoring

Following the procedures described herein, manual water level measurements will be made in selected monitoring wells, pumping wells, observation wells, and piezometers before and after the water level transducers are in place. The manual measurements will be used as reference points for the data generated by the transducer equipment. Measurements will be taken with an electronic water level indicator. Levels will be measured to the nearest 0.01 foot from a surveyed notch or mark at the top of the polyvinyl chloride (PVC) casing or other reference point. Measurements will be recorded immediately on a water level record sheet with the date, time (on a 24-hour clock), reference point, and initials of the person who made the measurements. The manual measurements will be used to calibrate the pressure transducers and monitor for "drift" of the readings. The water level indicator will be decontaminated in between wells as specified below.

2.2 Transducer Water Level Monitoring

Accurate, time-coincident measurements will be used to evaluate the performance of the extraction well pumping system. Pressure transducers will be installed in selected wells and in the Willamette River to collect time-coincident water level data for several depth intervals. Data will be downloaded weekly and checked for accuracy. Manual water level measurements will also be made when the weekly transducer checks are made. If the manual measurement is off by more than 0.1 foot from the transducer reading, the transducer will be corrected and a new test will be started.

2.2.1 Pressure Transducer Installation

Pressure transducers (15 PSI, In-Situ mini-TROLL professional or In-Situ level TROLL) will be installed at the selected locations. The pressure transducers will be installed using cables that extend from the surface to the instrument that is submerged in the well or river water. The cables allow in situ calibration of depth-to-water measurements from the surface. The full-length cables also allow for venting to the atmosphere, eliminating the need for barometric data correction.

The following procedure will be used to install the transducers:

1. Each instrument will be connected to a communication/vent cable of the appropriate length.
2. The instrument and cable will be decontaminated before and after installation using the procedures described below.
3. The instrument will be calibrated to zero in ambient air conditions.
4. The instrument and cable will be slowly fed down into the well to a depth that will ensure submersion throughout the monitoring period.
5. The instrument cable will be securely attached to the well casing.
6. The instrument and cable will cause the displacement of water in the well casing; therefore, the water level in the well will be allowed to equilibrate for 30 to 60 minutes before depth-to-water reference measurements are entered into the instrument.
7. The installer will connect to the instrument cable with a portable personal computer.
8. The installer will use an electric water level indicator to measure the depth-to-water from the monitoring point and enter the result into the instrument as a real-time reference value.
9. The installer will program the instrument to collect one measurement of temperature and depth-to-water (pressure) every 15 minutes.
10. The above-ground connector on the cable will be protected by a desiccant filter that is designed specifically for this application.

3 WATER QUALITY MONITORING

Groundwater samples will be collected from select wells during the implementation of source control measures. Groundwater samples will be collected from extraction wells, monitoring wells, and piezometers along the shoreline of the Gasco site. The selected wells and frequency of sampling are described in Section 3.2.2.5.4 of the Draft Final Design Report. The Draft Final Design Report also describes the target analytes, including volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), weak acid dissociable (WAD) cyanide, and free cyanide.

3.1 Groundwater Sample Collection Procedures

Prior to groundwater sample collection, depth-to-water readings from the top of the well casing will be measured using a water level indicator. The water level indicator will be decontaminated between wells using the procedures outlined later in this section.

The wells will then be purged of at least three well casing volumes before groundwater is collected. Purging will be accomplished with one of the following methods: peristaltic pump with dedicated polyethylene tubing, Waterra inertial pump with dedicated Waterra tubing and check-valve, a disposable polyethylene bailer, or a submersible pump. After each well casing volume has been purged, water quality parameters (pH, specific conductance, temperature, and dissolved oxygen) will be recorded using a calibrated water quality meter. The well will be considered adequately purged when the water quality parameters have stabilized to within +/-10% of the previous measurement.

After the water quality parameters have stabilized, the sample will be collected directly from the dedicated tubing or disposable bailer into the sample container. The samples will then be stored on ice for shipment to an analytical laboratory.

4 EQUIPMENT CLEANING AND DECONTAMINATION PROCEDURES

Decontamination procedures are specified below. The objective for decontamination is to reduce the chance of cross-contaminating samples. All waters generated by cleaning and decontamination will be contained and disposed of. The water from sampling the Gasco wells will be treated in the on-site treatment system. The water from sampling wells on the Siltronic site will be evaluated to select the appropriate treatment/disposal option.

4.1 Groundwater Monitoring Equipment

Groundwater sampling equipment includes items used during groundwater sampling and water level monitoring. All equipment that contacts groundwater will be decontaminated before its first use and between sampling locations. Decontamination will proceed as follows:

- Distilled-water rinse
- Non-phosphatic detergent (e.g., Liquinox) and water wash
- Distilled water rinse
- Final distilled water rinse

5 QUALITY ASSURANCE PLAN

5.1 Data Quality Objectives and Criteria

The overall data quality objective (DQO) for this project is to ensure that the data collected are of known and acceptable quality so that the project objectives described in this document can be achieved. The quality of the laboratory data is assessed by precision, accuracy, representativeness, comparability, and completeness (the "PARCC" parameters). Definitions of these parameters and the applicable Quality Control (QC) procedures are given below. Applicable quantitative goals for these data quality parameters are listed or referenced in Table O-1.

5.1.1 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.

In the laboratory, "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.

Field precision will be evaluated by the collection of blind field duplicates for chemistry samples at a frequency of one in 10 samples. Field chemistry duplicate precision will be screened against a relative percent difference (RPD) of 50 percent for groundwater samples. However, no data will be qualified based solely on field duplicate precision.

Precision measurements can be affected by the nearness of a chemical concentration to the method detection limit (MDL), where the percent error (expressed as RPD) increases. The equation used to express precision is as follows:

$$RPD = \frac{(C_1 - C_2) \times 100\%}{(C_1 + C_2)/2}$$

Where:

RPD = relative percent difference

C1 = larger of the two observed values

C2 = smaller of the two observed values

5.1.2 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 (%R) of the measured value, relative to the true or expected value. If a measurement process produces results for which the 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). Analytical laboratories utilize several quality control (QC) 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.

Laboratory accuracy will be evaluated against quantitative matrix spike and surrogate spike recovery performance criteria provided by the laboratory. Accuracy can be expressed as a percentage of the true or reference value, or as a %R in those analyses where reference materials are not available and spiked samples are analyzed. The equation used to express accuracy is as follows:

$$\%R = 100\% \times (S-U)/C_{sa}$$

Where:

%R = percent recovery

S	=	measured concentration in the spiked aliquot
U	=	measured concentration in the unspiked aliquot
C_{sa}	=	actual concentration of spike added

Field accuracy will be controlled by adherence to sample collection procedures outlined in the SAP.

5.1.3 Bias

Bias is the systematic or persistent distortion of a measurement process that causes errors in one direction. Bias assessments for environmental measurements are made using personnel, equipment, and spiking materials or reference materials as independent as possible from those used in the calibration of the measurement system. When possible, bias assessments should be based on analysis of spiked samples rather than reference materials so that the effect of the matrix on recovery is incorporated into the assessment. A documented spiking protocol and consistency in following that protocol are important to obtaining meaningful data quality estimates.

5.1.4 Representativeness

Representativeness expresses the degree to which data accurately and precisely represent an environmental condition. For the Gasco site, the list of analytes has been identified to provide a comprehensive assessment of the known and potential contaminants at the site.

5.1.5 Comparability

Comparability expresses the confidence with which one data set can be evaluated in relation to another data set. For this program, comparability of data will be established through the use of standard analytical methodologies and reporting formats, as well as the use of common traceable calibration and reference materials.

5.1.6 Completeness

Completeness is a measure of the amount of data that is determined to be valid in proportion to the amount of data collected. Completeness will be calculated as follows:

$$C = \frac{\text{(Number of acceptable data points)} \times 100}{\text{(Total number of data points)}}$$

The DQO for completeness for all components of this project is 90 percent. Data that have been qualified as estimated because the QC criteria were not met will be considered valid for the purpose of assessing completeness. Data that have been qualified as rejected will not be considered valid for the purpose of assessing completeness.

5.1.7 Sensitivity

Analytical sensitivities must be consistent with or lower than the regulated criteria values in order to demonstrate compliance with this Quality Assurance Plan. When they are achievable, target detection limits specified will be at least a factor of 2 less than the analyte's corresponding regulated criteria value.

The MDL is defined as the minimum concentration at which a given target analyte can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. Laboratory practical quantitation limits (PQLs) or reporting limits (RLs) are defined as the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. Laboratory MDLs and RLs will be used to evaluate the method sensitivity and/or applicability prior to the acceptance of a method for this program.

The sample-specific MDL and RL will be reported by the laboratory and will take into account any factors relating to the sample analysis that might decrease or increase the reporting limit (e.g., dilution factor, percent moisture, sample volume, and sparge volume). In the event that the MDL and RL are elevated for a sample due to matrix interferences and subsequent dilution or reduction in the sample aliquot, the data will be evaluated by Anchor QEA and the laboratory to determine if an alternative course of action is required or possible. If this situation cannot be resolved readily (i.e., detection limits less than criteria are achieved), the Oregon Department of Environmental Quality (DEQ) will be contacted to discuss an acceptable resolution. The sample-specific RL will be the value provided in the project database and subsequent EQuIS deliverable.

5.1.8 Special Training Requirements/Certifications

The 29 CFR 1910.120 Occupational Safety and Health Administration (OSHA) regulations require training to provide employees with the knowledge and skills enabling them to perform

their jobs safely and with minimum risk to their personal health. All sampling personnel will have completed the 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) training course and 8-hour refresher courses, as necessary, to meet the OSHA regulations.

5.2 Documentation and Records

This project will require central project files to be maintained at Anchor QEA. Project records will be stored and maintained in a secure manner. Each project team member is responsible for filing all necessary project information or providing it to the person responsible for the filing system. Individual team members may maintain files for individual tasks, but must provide such files to the central project files upon completion of each task. A project-specific index of file contents is to be kept with the project files. Hard copy documents will be kept on file at Anchor QEA or at a document storage facility throughout the duration of the project, and all electronic data will be maintained in the database at Anchor QEA.

5.2.1 Field Records

All documents generated during the field effort are controlled documents that become part of the project file.

5.2.1.1 Field Forms

Field team members will keep a daily record of significant events, observations, and measurements on field forms. Copies of typical field forms are in Appendix O-1. All field activities will be recorded on forms specific to the collection activity and will be maintained by the Field Coordinator (FC). Field forms will be the main source of field documentation for all field activities. The on-site field representative will record on the field log form information pertinent to the investigation program. The sampling documentation will contain information on each sample collected, and will include at a minimum the following information:

- Project name
- Field personnel on site
- Facility visitors
- Weather conditions
- Field observations and any deviations from the SAP
- Maps and/or drawings

- Date and time sample collected
- Sampling method and description of activities
- Identification or serial numbers of instruments or equipment used
- Deviations from the QAPP and SAP
- Conferences associated with field sampling activities

The field forms will be on water-resistant, durable paper for adverse field conditions. Notes will be taken in indelible, waterproof blue or black ink. Errors will be corrected by crossing out with a single line, dating, and initialing. Each form will be marked with the project name, number, and date. The field forms will be scanned into Anchor QEA's project file directory as convenient during the sampling event or upon completion of each sampling event.

Sample collection tables will be prepared prior to each sampling program. The checklist will include proposed coordinates of each location, the sampling scheme, and whether any QC samples are to be collected.

5.2.2 Analytical and Chemistry Records

Analytical data records will be retained by the laboratory and in the Anchor QEA central project files. For all analyses, the data reporting requirements will include those items necessary to complete data validation, including copies of all raw data. The analytical laboratory will be required, where applicable, to report the following:

- **Project Narrative.** This summary, in the form of a cover letter, will discuss problems, if any, encountered during any aspect of analysis. This summary should discuss, but not be limited to, QC, sample shipment, sample storage, and analytical difficulties. Any problems encountered, actual or perceived, and their resolutions will be documented in as much detail as appropriate.
- **Chain-of-Custody (COC) Records.** Legible copies of the COC forms will be provided as part of the data package. This documentation will include the time of receipt and condition of each sample received by the laboratory. Additional internal tracking of sample custody by the laboratory will also be documented on a sample receipt form. The form must include all sample shipping container temperatures measured at the time of sample receipt.
- **Sample Results.** The data package will summarize the results for each sample analyzed. The summary will include the following information when applicable:

- Field sample identification code and the corresponding laboratory identification code
- Sample matrix
- Date of sample extraction
- Date and time of analysis
- Weight and/or volume used for analysis
- Final dilution volumes or concentration factor for the sample
- Identification of the instrument used for analysis
- MDLs
- Method reporting limits accounting for sample-specific factors (e.g., dilution, total solids)
- Analytical results with reporting units identified
- Data qualifiers and their definitions
- A computer disk with the data in a format specified in advance by Anchor QEA

- **Quality Assurance/Quality Control (QA/QC) Summaries.** This section will contain the results of the laboratory QA/QC procedures. Each QA/QC sample analysis will be documented with the same information required for the sample results (see above). No recovery or blank corrections will be made by the laboratory. The required summaries are listed below; additional information may be requested.
- **Calibration Data Summary.** This summary will report the concentrations of the initial calibration and daily calibration standards, and the date and time of analysis. The response factor, percent relative standard deviation, percent difference, and retention time for each analyte will be listed, as appropriate. Results for standards to indicate instrument sensitivity will be documented.
- **Internal Standard Area Summary.** The stability of internal standard areas will be reported.
- **Method Blank Analysis.** The method blank analyses associated with each sample and the concentration of all compounds of interest identified in these blanks will be reported.
- **Surrogate Spike Recovery.** This will include all surrogate spike recovery data for organic compounds. The name and concentration of all compounds added, percent recoveries, and range of recoveries will be listed.
- **Matrix Spike Recovery.** This will report all matrix spike recovery data for organic and metal compounds. The name and concentration of all compounds added, percent recoveries, and range of recoveries will be listed. The RPD for all duplicate analyses will be included.

- **Matrix Duplicate.** This will include the percent recovery and associated RPD for all matrix duplicate analyses.
- **Laboratory Control Sample.** All laboratory control sample recovery data for organic and metal compounds will be reported. The name and concentration of all compounds added, percent recoveries, and range of recoveries will be listed. The RPD for all duplicate analyses will be included.
- **Relative Retention Time.** This will include a report of the relative retention time of each analyte detected in the samples for both primary and conformational analyses.
- **Original Data.** Legible copies of the original data generated by the laboratory will include:
  - Sample extraction, preparation, identification of extraction method used, and cleanup logs
  - Instrument specifications and analysis logs for all instruments used on days of calibration and analysis
  - Calculation worksheets for inorganic analyses
  - Reconstructed ion chromatograms for all samples, standards, blanks, calibrations, spikes, replicates, and reference materials
  - Original printouts of full scan chromatograms and quantitation reports for all gas chromatography (GC) and/or GC/matrix spike (MS) samples, standards, blanks, calibrations, spikes, replicates, and reference materials
  - Enhanced spectra of detected compounds with associated best-match spectra for each sample

All instrument data shall be fully restorable at the laboratory from electronic backup. Laboratories will be required to maintain all records relevant to project analyses for a minimum of 7 years. Data validation reports will be maintained in the central project files with the analytical data reports.

5.2.3 Data Reduction

Data reduction is the process by which original data (analytical measurements) are converted or reduced to a specified format or unit to facilitate analysis of the data. Data reduction requires that all aspects of sample preparation that could affect the test result, such as sample volume analyzed or dilutions required, be taken into account in the final result. It is the laboratory analyst's responsibility to reduce the data, which are subjected to further review by the

Laboratory Manager, the Project Manager, the QA/QC Manager, and independent reviewers. Data reduction may be performed manually or electronically. If performed electronically, all software used must be demonstrated to be true and free from unacceptable error.

- Copies of complete laboratory data packages, as appendices or attachments.
- Copies of applicable sections of the field log, as appendices or attachments.
- Copies of validation reports and/or findings.

5.3 Overview of Data Generation and Acquisition

The rationale for the sampling design and design assumptions for locating and selecting environmental samples is detailed in the Draft Final Design Report. The methods and procedures for collection of field samples are also provided in the Draft Final Design Report.

5.3.1 Analytical Methods

This section summarizes the target chemical analyses for the samples. All sample analyses will be conducted in accordance with DEQ-approved methods. Prior to analysis, all samples will be maintained according to the appropriate holding times and temperatures for each analysis as defined in Table O-2. Table O-1 presents the proposed analytes, the analytical methods to be used, and the targeted reporting limits for the chemical testing. The analytical laboratory will prepare a detailed report in accordance with this Quality Assurance Plan, to be included as an appendix in the Data Report.

Prior to the analysis of the samples, the laboratory will calculate method detection limits for each analyte of interest, where applicable. Method reporting limits will be below the values specified in Table O-1, if technically feasible. To achieve the required detection limits, some modifications to the methods may be necessary. These modifications from the specified analytical methods will be provided by the laboratory at the time of establishing the laboratory contract, and must be approved by DEQ prior to implementation.

Chemical testing will be conducted at an accredited laboratory under the National Environmental Laboratories Accreditation Program (NELAP). In completing chemical analyses for this project, the contract laboratory is expected to meet the following minimum requirements:

- Adhere to the methods outlined in this Quality Assurance Plan, including methods

referenced for each analytical procedure (Table O-1)

- Deliver facsimile, hard copy, and electronic data as specified
- Meet reporting requirements for deliverables
- Meet turnaround times for deliverables
- Implement QA/QC procedures including data quality objectives, laboratory QC requirements, and performance evaluation testing requirements
- Notify the project QA/QC Manager of any QA/QC problems when they are identified to allow for quick resolution
- Allow laboratory and data audits to be performed, if deemed necessary

5.3.2 Quality Assurance and Quality Control

Field and laboratory activities must be conducted in such a manner that the results meet specified quality objectives and are fully defensible. Guidance for QA/QC is derived from the protocols developed for the EPA SW-846 (1986), the EPA Contract Laboratory Program (EPA 2008), and the cited methods.

5.3.2.1 Field Quality Control

Anchor QEA personnel will identify and label samples in a consistent manner to ensure that field samples are traceable and that labels provide all information necessary for the laboratory to conduct required analyses properly. Samples will be placed in appropriate containers and preserved for shipment to the laboratory.

5.3.2.1.1 Sample Containers

Sample containers and preservatives will be provided by the laboratory. The laboratory will maintain documentation certifying the cleanliness of bottles and the purity of preservatives provided. Specific container requirements will be subject to the sample design as described in this Quality Assurance Plan.

5.3.2.1.2 Sample Identification and Labels

Each sample will have an adhesive plastic or waterproof paper label affixed to the container and will be labeled at the time of collection. The following information will be recorded on the container label at the time of collection:

- Project name
- Sample identification
- Date and time of sample collection
- Preservative type (if applicable)
- Analysis to be performed

Samples will be uniquely identified with a sample identification that at a minimum specifies sample matrix, sample number, sample location, and type of sample.

5.3.2.1.3 Sample Custody and Shipping Requirements

Samples are considered to be in one's 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).

COC procedures will be followed for all samples throughout the collection, handling, and analysis process. The principal document used to track possession and transfer of samples is the COC form. Each sample will be represented on a COC form the day it is collected. All data entries will be made using indelible ink pen. Corrections will be made by drawing a single line through the error, writing in the correct information, then dating and initialing the change. Blank lines/spaces on the COC form will be lined-out, dated, and initialed by the individual maintaining custody.

A COC form will accompany each cooler of samples to the analytical laboratories. Each person who has custody of the samples will sign the COC form and ensure that the samples are not left unattended unless properly secured. Copies of all COC forms will be retained in the project files.

All samples will be shipped to the analytical laboratory no later than the day after collection. Samples collected on Friday may be held until the following Monday for shipment provided that this does not jeopardize any hold time requirements. Specific sample shipping procedures are as follows:

- Each cooler or container containing the samples for analysis will be hand-delivered by courier or shipped via overnight delivery to the appropriate analytical laboratory. In the

event that Saturday delivery is required, the FC will contact the analytical laboratory before 3 p.m. on Friday to ensure that the laboratory is aware of the number of coolers shipped and the airbill tracking numbers for those coolers. Following each shipment, the FC will call the laboratory and verify the shipment from the day before has been received and is in good condition.

- Coolant ice will be placed in the shipping containers.
- Individual sample containers will be packed to prevent breakage, and transported in a sealed ice chest or other suitable container.
- Glass jars will be separated in the shipping container by shock absorbent material (e.g., bubble wrap) to prevent breakage.
- The shipping containers will be clearly labeled with sufficient information (name of project, time and date container was sealed, person sealing the container, and consultant's office name and address) to enable positive identification.
- A sealed envelope containing COC forms will be enclosed in a plastic bag and taped to the inside lid of the cooler.
- A minimum of two signed and dated COC seals will be placed on adjacent sides of each cooler prior to shipping.
- Each cooler will be wrapped securely with strapping tape and will be clearly labeled with the laboratory's shipping address and the consultant's return address.
- Upon transfer of sample possession to the analytical laboratory, the persons transferring custody of the sample container will sign the COC form. Upon receipt of samples at the laboratory, the shipping container seal will be broken and the receiver will record the condition of the samples on a sample receipt form. COC forms will be used internally in the lab to track sample handling and final disposition.

5.3.2.1.4 Field Quality Assurance Sampling

Field QA procedures will consist of following procedures for acceptable practices for collecting and handling of samples. Adherence to these procedures will be complemented by periodic and routine equipment inspection.

Field QA samples will be collected along with the environmental samples. Field QA samples are useful in identifying possible problems resulting from sample collection or sample processing in the field. The collection of field QA samples includes one field blank and one duplicate sample. The field blank will be analyzed for the identical chemical list as the

groundwater samples. In addition, a trip blank will be included in each shipping container that includes samples for volatiles analysis. The trip blank samples will be analyzed for VOCs.

Field QA samples will also include the collection of additional sample volume, to ensure that the laboratory has sufficient sample volume to run the program-required analytical QA/QC (MS/matrix spike duplicate [MSD]) samples for analysis as specified in Table O-4. Additional sample volume to meet this requirement will be collected at a frequency of one per sampling event or one in 20 samples processed, whichever is more frequent. The samples designated for MS/MSD analyses should be clearly marked on the COC.

All field QA samples will be documented on the field forms and verified by the QA/QC Manager or designee.

5.3.2.2 Laboratory Quality Control

Laboratory QC procedures, where applicable, include initial and continuing instrument calibrations, standard reference materials, laboratory control samples, matrix replicates, matrix spikes, surrogate spikes (for organic analyses), and method blanks. Table O-4 lists the frequency of analysis for laboratory QA/QC samples, and Table O-3 summarizes the DQOs of sample testing for precision, accuracy, and completeness.

Results of the QC samples from each sample group will be reviewed by the analyst immediately after a sample group has been analyzed. The QC sample results will then be evaluated to determine if control limits have been exceeded. If control limits are exceeded in the sample group, the QA/QC Manager will be contacted immediately, and corrective action (e.g., method modifications followed by reprocessing the affected samples) will be initiated prior to processing a subsequent group of samples.

5.3.2.2.1 Laboratory Instrument Calibration and Frequency

An initial calibration will be performed on each laboratory instrument to be used at the start of the project, after each major interruption to the analytical instrument, and when any ongoing calibration does not meet method control criteria. A calibration verification will be analyzed following each initial calibration and will meet method criteria prior to analysis of samples. Continuing calibration verifications (CCV) will be performed daily prior to any sample analysis to track instrument performance. The frequency of CCVs varies with method. For GC/MS

methods, one will be analyzed every 12 hours. For GC, metals, and inorganic methods, one will be analyzed for every 10 field samples, or daily, whichever is more frequent. If the ongoing continuing calibration is out of control, the analysis must come to a halt until the source of the control failure is eliminated or reduced to meet control specifications. All project samples analyzed while instrument calibration was out of control will be reanalyzed.

Instrument blanks or continuing calibration blanks provide information on the stability of the baseline established. Continuing calibration blanks will be analyzed immediately prior to continuing calibration verification at the instrument for each type of applicable analysis.

5.3.2.2.2 Laboratory Duplicates/Replicates

Analytical duplicates provide information on the precision of the analysis and are useful in assessing potential sample heterogeneity and matrix effects. Analytical duplicates and replicates are subsamples of the original sample that are prepared and analyzed as a separate sample.

5.3.2.2.3 MS and MSDs

Analysis of MS samples provides information on the extraction efficiency of the method on the sample matrix. By performing duplicate MS analyses, information on the precision of the method is also provided for organic analyses.

5.3.2.2.4 Method Blanks

Method blanks are analyzed to assess possible laboratory contamination at all stages of sample preparation and analysis. The method blank for all analyses must be less than the method reporting limit of any single target analyte/compound. If a laboratory method blank exceeds this criterion for any analyte/compound, and the concentration of the analyte/compound in any of the samples is less than five times the concentration found in the blank (10 times for common contaminants), analyses must stop and the source of contamination must be eliminated or reduced.

5.3.2.2.5 Laboratory Control Samples

Laboratory control samples are analyzed to assess possible laboratory bias at all stages of sample preparation and analysis. The laboratory control sample is a matrix-dependent spiked

sample prepared at the time of sample extraction along with the preparation of sample and MSs. The laboratory control sample will provide information on the precision of the analytical process, and when analyzed in duplicate, will provide accuracy information as well.

5.3.2.2.6 Laboratory Deliverables

Data packages will be checked for completeness immediately upon receipt from the laboratory to ensure that data and QA/QC information requested are present. Data quality will be assessed by considering the following:

- Holding times
- All compounds of interest reported
- Reporting limits
- Surrogate spike results
- MS/MSD results
- Blank spikes
- Laboratory control samples/laboratory control sample duplicates
- Standard reference material results
- Method blanks
- Detection limits

5.3.3 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

This section describes procedures for testing, inspection, and maintenance of field and laboratory equipment.

5.3.3.1 Field Instruments/Equipment

In accordance with the QA program, Anchor QEA shall maintain an inventory of field instruments and equipment. The frequency and types of maintenance will be based on the manufacturer's recommendations and/or previous experience with the equipment.

The frequency of maintenance is dependent on the type and stability of the equipment, the methods used, the intended use of the equipment, and the recommendations of the

manufacturer. Detailed information regarding the calibration and frequency of equipment calibration is provided in specific manufacturer's instruction manuals.

All maintenance records will be verified prior to each sampling event. The FC will be responsible for verifying that required maintenance has been performed prior to using the equipment in the field.

5.3.3.2 Laboratory Instruments/Equipment

In accordance with the QA program, the laboratory shall maintain an inventory of instruments and equipment and the frequency of maintenance will be based on the manufacturer's recommendations and/or previous experience with the equipment.

The laboratory preventative maintenance program, as detailed in their QA Plan, is organized to maintain proper instrument and equipment performance, and to prevent instrument and equipment failure during use. The program considers instrumentation, equipment, and parts that are subject to wear, deterioration, or other changes in operational characteristics, the availability of spare parts, and the frequency at which maintenance is required. Any equipment that has been overloaded, mishandled, gives suspect results, or has been determined to be defective will be taken out of service, tagged with the discrepancy noted, and stored in a designated area until the equipment has been repaired. After repair, the equipment will be tested to ensure that it is in proper operational condition. The client will be promptly notified in writing if defective equipment casts doubt on the validity of analytical data. The client will also be notified immediately regarding any delays due to instrument malfunctions that could impact holding times.

Laboratories will be responsible for the preparation, documentation, and implementation of the preventative maintenance program. All maintenance records will be checked according to the schedule on an annual basis and recorded by the responsible individual. The Laboratory QA/QC Manager, or designee, shall be responsible for verifying compliance.

5.3.4 Instrument Calibration

Proper calibration of equipment and instrumentation is an integral part of the process that provides quality data. Instrumentation and equipment used to generate data must be calibrated at a frequency that ensures sufficient and consistent accuracy and reproducibility.

5.3.4.1 Field Instrument/Equipment Calibration

Field equipment will be calibrated prior to each sampling event according to manufacturer's recommendations using manufacturer's standards. The equipment, calibration, and maintenance information will be documented. The frequency of calibration is dependent on the type and stability of the equipment, the methods used, the intended use of the equipment, and the recommendations of the manufacturer. Detailed information regarding the calibration and frequency of equipment calibration is provided in specific manufacturer's instruction manuals.

Equipment that fails calibration or becomes inoperable during use will be removed from service and tagged (time and date of action) to prevent inadvertent use. Such equipment will be satisfactorily recalibrated or repaired and tagged (date and time of return to service) prior to use.

5.3.4.2 Laboratory Instrument/Equipment Calibration

As part of their QC program, laboratories perform two types of calibrations. A periodic calibration is performed at prescribed intervals (i.e., balances, drying ovens, refrigerators, and thermometers), and operational calibrations are performed daily, at a specified frequency, or prior to analysis (i.e., initial calibrations) according to method requirements. Calibration procedures and frequency are discussed in the laboratory QA Plan. Calibrations are discussed in the laboratory standard operating procedures (SOPs) for analyses.

The Laboratory QA/QC Manager will be responsible for ensuring that the laboratory instrumentation is calibrated in accordance with specifications. Implementation of the calibration program shall be the responsibility of the respective laboratory Group Supervisors. Recognized procedures (EPA, ASTM, or manufacturer's instructions) shall be used when available.

Physical standards (i.e., weights or certified thermometers) shall be traceable to nationally recognized standards such as the National Institute of Standards and Technology (NIST). Chemical reference standards shall be NIST Standard Reference Materials (SRMs) or vendor-certified materials traceable to these standards.

The calibration requirements for each method and respective corrective actions shall be accessible, either in the laboratory SOPs or the laboratory's QA Plan for each instrument or analytical method in use. All calibrations shall be preserved on electronic media.

5.3.5 Inspection/Acceptance Requirements for Supplies and Consumables

Inspection and acceptance of field supplies, including laboratory-prepared sampling bottles, will be performed by the FC. All primary chemical standards and standard solutions used in this project either in the field or laboratory will be traceable to documented, reliable, commercial sources. Standards will be validated to determine their accuracy by comparison with an independent standard. Any impurities found in the standard will be documented.

6 REFERENCES

USEPA. 1986. Test methods for Evaluating Solid Waste: Physical/Chemical Methods. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. EPA 530/SW-846.

USEPA. 2008. USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review. U.S. Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation. USEPA 540-R-08-01. June.

TABLES

Table O-1
Sampling Parameters and Analytical Methods for Groundwater

Parameter	Analytical Method	Unit	Reporting Limit
Volatile Organic Compounds			
1,1,1,2-Tetrachloroethane	8260B	µg/L	0.5
1,1,1-Trichloroethane (TCA)	8260B	µg/L	0.5
1,1,2,2-Tetrachloroethane	8260B	µg/L	0.5
1,1,2-Trichloroethane	8260B	µg/L	0.5
1,1-Dichloroethane	8260B	µg/L	0.5
1,1-Dichloroethene	8260B	µg/L	0.5
1,2,3-Trichloropropane	8260B	µg/L	0.5
1,2,4-Trichlorobenzene	8260B	µg/L	2
1,2,4-Tricmethylbenzene	8260B	µg/L	2
1,2-Dibromoethane (EDB)	8260B	µg/L	2
1,2-Dichlorobenzene	8260B	µg/L	0.5
1,2-Dichloroethane (EDC)	8260B	µg/L	0.5
1,2-Dichloropropane	8260B	µg/L	0.5
1,3-Dichlorobenzene	8260B	µg/L	0.5
1,3,5-Tricmethylbenzene	8260B	µg/L	2
1,4-Dichlorobenzene	8260B	µg/L	0.5
2-Butanone (MEK)	8260B	µg/L	20
2-Chloroethyl Vinyl Ether	8260B	µg/L	5
2-Hexanone	8260B	µg/L	20
4-Methyl-2-pentanone (MIBK)	8260B	µg/L	20
Acetone	8260B	µg/L	20
Acrolein	8260B	µg/L	20
Acrylonitrile	8260B	µg/L	5
Benzene	8260B	µg/L	0.5
Bromochloromethane	8260B	µg/L	0.5
Bromodichloromethane	8260B	µg/L	0.5
Bromoform	8260B	µg/L	0.5
Bromomethane	8260B	µg/L	0.5
Carbon Disulfide	8260B	µg/L	0.5
Carbon Tetrachloride	8260B	µg/L	0.5
Chlorobenzene	8260B	µg/L	0.5
Chloroethane	8260B	µg/L	0.5
Chloroform	8260B	µg/L	0.5
Chloromethane	8260B	µg/L	0.5
cis-1,2-Dichloroethene	8260B	µg/L	0.5
cis-1,3-Dichloropropene	8260B	µg/L	0.5
Dibromochloromethane	8260B	µg/L	0.5
Dibromomethane	8260B	µg/L	0.5
Dichlorodifluoromethane	8260B	µg/L	0.5
Ethylbenzene	8260B	µg/L	0.5
Hexachlorobutadiene	8260B	µg/L	2
Iodomethane	8260B	µg/L	5
Isopropylbenzene	8260B	µg/L	2
m,p-Xylenes	8260B	µg/L	0.5
Methyl tert-Butyl Ether	8260B	µg/L	0.5
Methylene Chloride	8260B	µg/L	2
Naphthalene	8260B	µg/L	2

Table O-1
Sampling Parameters and Analytical Methods for Groundwater

Parameter	Analytical Method	Unit	Reporting Limit
o-Xylene	8260B	µg/L	0.5
Styrene	8260B	µg/L	0.5
Tetrachloroethene (PCE)	8260B	µg/L	0.5
Toluene	8260B	µg/L	0.5
trans-1,2-Dichloroethene	8260B	µg/L	0.5
trans-1,3-Dichloropropene	8260B	µg/L	0.5
trans-1,4-Dichloro-2-butene	8260B	µg/L	10
Trichloroethene (TCE)	8260B	µg/L	0.5
Trichlorofluoromethane	8260B	µg/L	0.5
Vinyl Acetate	8260B	µg/L	5
Vinyl Chloride	8260B	µg/L	0.5
PAHs/SVOCs (µg/L)			
Acenaphthene	8270C-SIM	µg/L	0.02
Acenapthylene	8270C-SIM	µg/L	0.02
Anthracene	8270C-SIM	µg/L	0.02
Benzo(a)anthracene	8270C-SIM	µg/L	0.02
Benzo(a)pyrene	8270C-SIM	µg/L	0.02
Benzo(b)fluoranthene	8270C-SIM	µg/L	0.02
Benzo(k)fluoranthene	8270C-SIM	µg/L	0.02
Chrysene	8270C-SIM	µg/L	0.02
Dibenzo(a,h)anthracene	8270C-SIM	µg/L	0.02
Fluoranthene	8270C-SIM	µg/L	0.02
Fluorene	8270C-SIM	µg/L	0.02
Indeno(1,2,3-cd)pyrene	8270C-SIM	µg/L	0.02
1-Methylnaphthalene	8270C-SIM	µg/L	0.02
2-Methylnaphthalene	8270C-SIM	µg/L	0.02
Naphthalene	8270C-SIM	µg/L	0.02
Phenanthrene	8270C-SIM	µg/L	0.02
Pyrene	8270C-SIM	µg/L	0.02
Benzo(g,h,i)perylene	8270C-SIM	µg/L	0.02
Dibenzofuran	8270C-SIM	µg/L	0.02
Carbazole	8270C-SIM	µg/L	0.02
Inorganics			
WAD Cyanide	SM4500-CN (I/E)	mg/L	0.005
Free Cyanide	ASTM D4282	mg/L	0.005

Notes:

µg/L= micrograms per Liter

mg/L= milligrams per Liter

PAH= Polycylic Aromatic Hydrocarbons

SVOC= Semi-Volatile Organic Compounds

Table O-2
Container Requirements, Holding Times, and Preservation Methods for Groundwater

Parameter	Method	Sample Size	Container Size and Type	Holding Time	Sample Preservation Technique
PAHs	EPA 8270D SIM	2 x 1 L	1-L Amber glass	7 days to extraction, 40 days to analysis	Cool/4° C
VOCs	EPA 8260B	3 x 40 mL	40 mL glass VOA vials, Teflon-lined septum cap	14 days	Zero head space/ pH < 2 with HCl
					Cool/4° C
WAD Cyanide	SM4500-CN (I/E)	250 mL	250-mL HDPE	14 days	NaOH, pH>12, Cool, 4°
Free Cyanide	D4282	250 mL	250-mL HDPE	24 hours	NaOH, pH>12, Cool, 4°

Notes:

HCl = hydrochloric acid
L = liter
mL = milliliter
VOA = volatile organic analysis
VOCs = volatile organic compounds
SVOCs = semivolatile organic compounds
SIM = Selected Ion Monitoring
HDPE = high density polyethylene

Table O-3
Data Quality Objectives for Groundwater

Parameter	Precision (Duplicates)	Accuracy (Spike Recoveries)	Completeness
Volatile organic compounds	+/- 30% RPD	70-130% R	90%
PAHs/ SVOC	+/- 30% RPD	50-140% R	90%
Cyanide (total and WAD)	+/- 20% RPD	75-125% R	90%

Notes:
RPD = Relative percent difference
R = Recovery

Table O-4
Laboratory Quality Control Sample Analysis Frequency for Groundwater

Analysis Type	Initial Calibration	Ongoing Calibration	Replicates	Matrix Spikes	LCS	Matrix Spike Duplicates	Method Blanks	Surrogate Spikes
Cyanide	Daily or each batch	1 per 10 samples	1 per 20 samples	1 per 20 samples	1 per 20 samples	NA	1 per 20 samples	NA
SVOCs/PAHs	As needed [a]	Every 12 hours	NA	1 per 20 samples	1 per 20 samples	1 per 20 samples	1 per 20 samples	Every sample
Volatile organics	As needed [a]	Every 12 hours	NA	1 per 20 samples	1 per 20 samples	1 per 20 samples	1 per 20 samples	Every sample

Notes:

a = Initial calibrations are considered valid until the ongoing continuing calibration no longer meets method specifications. At that point, a new initial calibration is performed.

APPENDIX O-1
FIELD FORMS

Daily Log

Anchor QEA, LLC
6650 SW Redwood Lane, Suite 333
Portland, OR 97224
Phone 503.670.1108 Fax 503.670.1128

PROJECT NAME: **DATE:**

SITE ADDRESS: **PERSONNEL:**

WEATHER:	**WIND FROM:**	N	NE	E	SE	S	SW	W	NW	LIGHT	MEDIUM	HEAVY
		SUNNY		CLOUDY		RAIN		?		**TEMPERATURE:**	° F	° C

[Circle appropriate units]

TIME	COMMENTS

Signature: ______________________

ANCHOR QEA

LOG OF EXPLORATORY BORING

CLIENT/PROJECT NAME_____ BORING #_____

PROJECT NUMBER_____ DATE BEGAN_____

GEOLOGIST/ENGINEER_____ DATE COMPLETED_____

DRILLING CONTRACTOR_____ TOTAL DEPTH_____

DRILLING METHOD_____ SHEET_____OF_____

HOLE DIAMETER_____

OTHER*	WELL OR PIEZOMETER DETAILS	SAMPLING DATA						DEPTH IN FEET	SOIL GROUP SYMBOL (USCS)	Field location of boring LITHOLOGIC DESCRIPTION
		SAMPLING METHOD	SAMPLE NUMBER	FID / PID (ppm)	RECOVERY (feet)	BLOWS / 6 INCHES	DEPTH SAMPLED			
								1		
								2		
								3		
								4		
								5		
								6		
								7		
								8		
								9		
								0		
								1		
								2		
								3		
								4		
								5		
								6		
								7		
								8		
								9		
								0		

Remarks:

WELL DETAILS

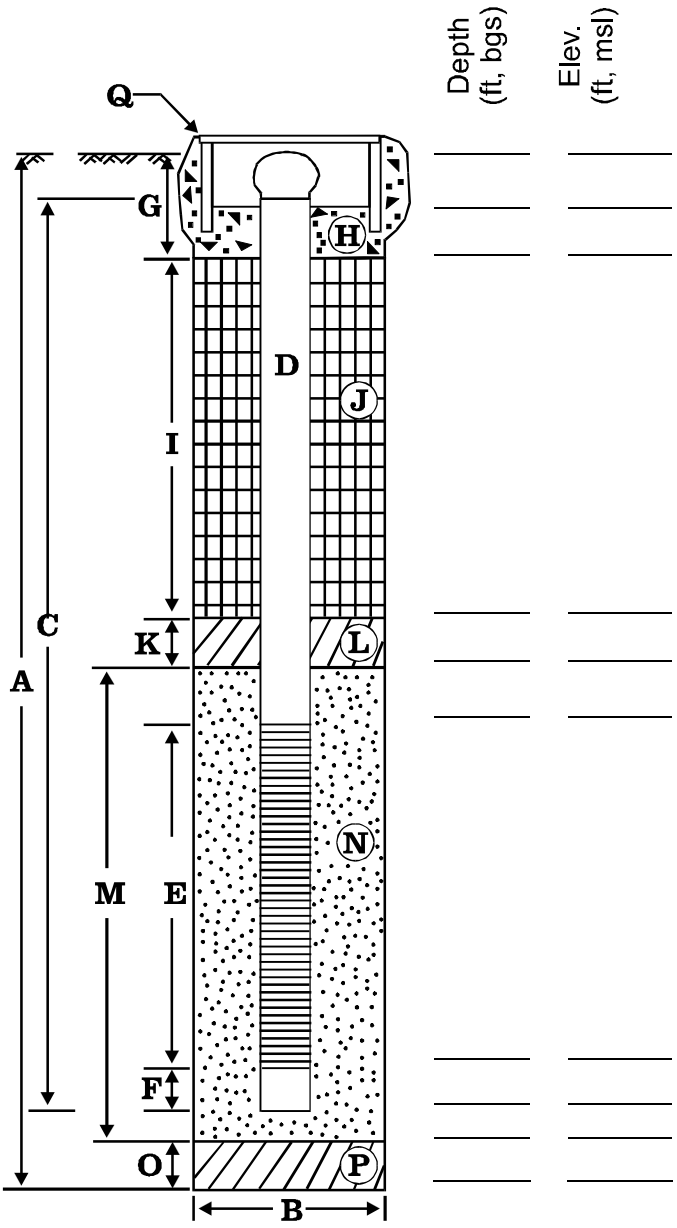
Project Number: _____ Boring/Well No.: _____

Client Name: _____ Top of Casing Elev.: _____

Project Name: _____ Ground Surface Elev.: _____

Location: _____ Installation Date: _____

Driller: _____ Permit/Start Card No.: _____



EXPLORATORY BORING

A. Total depth: _____ **ft.**

B. Diameter _____ **in.**

Drilling method: _____

WELL CONSTRUCTION

C. Well casing length: _____ **ft.**

Well casing material: _____

D. Well casing diameter: _____ **in.**

E. Well screen length: _____ **ft.**

Well screen type: _____

Well screen slot size: _____ **in.**

F. Well sump/end cap length: _____ **ft.**

G. Surface seal thickness: _____ **ft.**

H. Surface seal material: _____

I. Annular seal thickness: _____ **ft.**

J. Annular seal material: _____

K. Filter pack seal thickness: _____ **ft.**

L. Filter pack seal material: _____

M. Sand pack thickness: _____ **ft.**

N. Sand pack material: _____

O. Bottom material thickness: _____ **ft.**

P. Bottom material: _____

Q. Vault box type: _____

Well centralizer depths: _____ **ft.**

NOTES:

Installed by: _____

Reviewed by: _____

Date: _____

WELL DEVELOPMENT FORM

ANCHOR QEA

Project No.	Date:	Well:
Site Location:	Initial DTB:	Final DTB:
Name:	Initial DTW:	Final DTW:
Development Method:	Casing Volume:	
Total Water Removed:	Casing Diameter:	
Water Contained ?	Meter #:	
Estimate of specific capacity or recharge to well:		

Time	Cum. Vol. Removed	Sand/Silt (ml/1000ml)	Temp.	EC	pH	DTW (TOC)	Appearance/Comments

FIELD SAMPLING DATA SHEET

ANCHOR QEA

6650 SW Redwood Lane, Suite 333
Portland, OR 97224
Office: (503) 670-1108 Fax: (503) 670-1128

PROJECT NAME: **WELL ID:**

SITE ADDRESS: **BLIND ID:**

DUP ID: **NA**

WIND FROM:	N	NE	E	SE	S	SW	W	NW	LIGHT	MEDIUM	HEAVY

WEATHER:	SUNNY	CLOUDY	RAIN	?	**TEMPERATURE:**	° F . ° C

[Circle appropriate units]

HYDROLOGY/LEVEL MEASUREMENTS (Nearest 0.01 ft)

Date	Time	DT-Bottom	DT-Product	DT-Water	DTP-DTW [Product Thickness]	DTB-DTW [Water Column]		Volume (gal) [Water Column x Gal/ft]
/ /	:	.	.	.	.	.	X 1	.
/ /	:	.	.	.	.		X 3	.

Gal/ft = (dia./2)^2 x 0.163	1" = 0.041	2" = 0.163	3" = 0.367	4" = 0.653	6" = 1.469	10" = 4.080	12" = 5.875

§ METHODS: (A) Submersible Pump (B) Peristaltic Pump (C) Disposable Bailer (D) PVC/Teflon Bailer (E) Dedicated Bailer (F) Dedicated Pump (G) Other =

GROUNDWATER SAMPLING DATA (if product is detected, do NOT sample) Sample Depth: [√ if used]

Bottle Type	Date	Time	Method §	Amount & Volume mL		Preservative [circle]	Ice	Filter	pH	√
VOA Glass	/ /	:		3	40 ml	HCl	YES	NO		
Amber Glass	/ /	:			250, 500, 1L	(None) (HCl) (H_2SO_4)	YES	NO		
White Poly	/ /	:			250, 500, 1L	None	YES	NO	NA	
Yellow Poly	/ /	:			250, 500, 1L	H_2SO_4	YES	NO		
Green Poly	/ /	:			250, 500, 1L	NaOH	YES	NO		
Red Total Poly	/ /	:			250, 500, 1L	HNO_3	YES	NO		
Red Diss. Poly	/ /	:			250, 500, 1L	HNO_3	YES	YES		
	/ /	:			250, 500, 1L		YES			
Total Bottles (include duplicate count):										

Analysis Allowed per Bottle Type	BOTTLE TYPE	TYPICAL ANALYSIS ALLOWED PER BOTTLE TYPE (Circle applicable or write non-standard analysis below)
	VOA - Glass	(8021) (8260B) (BTEX) (NWTPH-Gx)
	AMBER - Glass	(PAH) (TPH-HCID) (NWTPH-Dx) (TPH-418.1) (Oil &Grease) (8081A)
	WHITE - Poly	(pH) (Conductivity) (TDS) (TSS) (BOD) (Turbidity) (Alkalinity) (HCO_3/CO_3) (Cl) (SO_4) (NO_3) (NO_2) (F)
	YELLOW - Poly	(COD) (TOC) (Total PO_4) (Total Keldahl Nitrogen) (NH_3) (NO_3/NO_2)
	GREEN - Poly	(Cyanide)
	RED TOTAL - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na)
	RED DISSOLVED - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na) (Hardness) (Silica)

WATER QUALITY DATA Purge Start Time: : Pump/Bailer Inlet Depth:

Meas.	Method §	Purged (gal)	pH	E Cond (µS)	°F Temp °C	Other	Diss O_2 (mg/l)	Water Quality
4		.	.		.		.	
3		.	.		.		.	
2		.	.		.		.	
1		.	.		.		.	
0		**0.00**	.		.		.	

[Casing] [Select A-G] [Cumulative Totals] [Circle units] [Clarity, Color]

SAMPLER: _____ _____

(PRINTED NAME) (SIGNATURE)

1423 Third Avenue, Suite 300
Seattle, Washington 98101
Phone 206.287.9130
Fax 206.287.9131
www.anchorqea.com

MEMORANDUM

To:	Dana Bayuk and Henning Larsen, Oregon Department of Environmental Quality	**Date:**	August 17, 2010
From:	Joy Dunay, Anchor QEA	**Project:**	000029-02
Cc:	Bob Wyatt, NW Natural; Patty Dost, Pearl Legal Group; Ben Hung, John Edwards and Carl Stivers, Anchor QEA		
Re:	Recommendations for Cyanide Testing at the Gasco Site		

At the request of the Oregon Department of Environmental Quality (DEQ), NW Natural assessed cyanide analytical methods and associated potential method interferences in groundwater at the NW Natural "Gasco" Site in Portland, Oregon (Site). Results of this assessment were summarized in a July 3, 2008, memorandum to DEQ (Anchor 2008), and cyanide methods were chosen for use in groundwater source control treatability tests performed in July and August 2008. In a July 15, 2008, email from Dana Bayuk of DEQ to John Edwards of Anchor QEA, LLC, DEQ agreed that the results of the 2008 assessment indicated that potentially interfering compounds are not present at concentrations of concern for most compounds that are currently identified as interferences in the determinative analytical step (with some uncertainty regarding thiocyanate effects). DEQ has now requested that NW Natural propose cyanide methods to be used for future site groundwater monitoring purposes.

NW Natural has evaluated five different cyanide methods at the Site:

1. Total cyanide by U.S. Environmental Protection Agency (EPA) method 335.4
2. Weak acid dissociable (WAD) cyanide by method Standard Method (SM) 4500-CN-I (with SM4500-CN-E determinative step)
3. Cyanide amenable to chlorination (CATC) by EPA method 335.1
4. Available cyanide by method OIA-1677
5. Free cyanide by method American Society for Testing and Materials (ASTM) D4282-02

It has been determined that the free cyanide method will provide an accurate measure of the toxic form of hydrogen cyanide (HCN); however, DEQ has expressed concern that in specific environmental conditions, cyanide complexes could convert to HCN and the free cyanide

analytical method could thus underestimate the concentration of toxic cyanide. NW Natural believes that the free cyanide method accurately measures free cyanide at the time of sample collection; however, NW Natural also acknowledges DEQ's concern that concentrations of samples taken in unidentified areas or specific environmental conditions could vary if such a conversion occurs. The objective of this memorandum is to propose a cyanide method in addition to free cyanide that provides a conservative measurement for monitoring potentially bioavailable cyanide at the Site.

The results of the treatability study conducted in June 2008 are presented in Table 1 and the results of the 2009 Third Quarter groundwater monitoring event are presented in Table 2.

Total cyanide analysis involves a strong acid distillation preparation with a colorimetric finishing step (EPA 1993). This analysis will measure free cyanide plus metal-complexed (strong and weak acid dissociable) forms of cyanide that are unlikely to convert to free cyanide under normal groundwater and many types of surface water conditions and are several orders of magnitude less toxic than free cyanide. This measurement would result in the most conservative value and could greatly overestimate the potential toxicity. Because of this, NW Natural recommends eliminating this method from the monitoring program.

WAD cyanide analysis involves a mild acid distillation preparation with a colorimetric finishing step (APHA 2005). This analysis will measure free cyanide and weak acid dissociable forms of cyanide and includes all species that the CATC method would measure. Many states, including Washington use this method for compliance monitoring since it provides a conservative measurement but eliminates less toxic and less convertible forms of cyanide. Additionally it has been observed to be less prone to interferences than the CATC method (Dzombak et al. 2006). NW Natural recommends using the WAD cyanide method in the monitoring program.

CATC cyanide analysis involves measuring total cyanide in two portions of the same sample (one chlorinated) and subtracting the difference (EPA 1974). This method is prone to interferences in the chlorination step that may lead to higher total cyanide results after chlorination, thus negative values for the calculated CATC (Dzombak et al. 2006). CATC was not analyzed in the treatability study but has been used for several other tasks at the Site. For these reasons, NW Natural recommends eliminating the CATC method from the monitoring program.

Available cyanide analysis involves a ligand exchange preparation step and amperometric finishing step which measures WAD cyanide plus mercury-cyanide complexes (EPA 2004). This method was analyzed along with total, WAD, and free cyanide in the treatability testing and the Hahn and Associates, Inc. (Hahn), groundwater testing (Tables 1 and 2, respectively). Theoretically the available cyanide concentrations should have been greater than the WAD concentrations and less than the total concentrations. In most results, however, the WAD concentration was higher. The laboratory that conducted this test performed all interference testing prior to analysis and found no interferences present. Because of the inconsistent results and lack of labs that commonly do the available cyanide test, NW Natural recommends eliminating this method from the monitoring program.

In conclusion, NW Natural recommends the analysis of Free and WAD cyanide for future groundwater monitoring. These two analyses will provide both an accurate measurement of bioavailable cyanide (free) and a conservative measurement of potentially available cyanide (WAD). Total cyanide testing should be removed from the groundwater monitoring program because it overestimates potentially available cyanide. CATC and available cyanide testing should be removed from the program because these methods may possibly underestimate potentially available cyanide.

This recommendation does not apply to future performance monitoring of the Gasco groundwater treatment system. The cyanide test methods that will be used for treatment system performance monitoring will be developed through the NPDES permit process.

ATTACHMENTS

Table 1 Gasco Treatability Study Cyanide Results

Table 2 Summary of Historical Analytical Results for Groundwater Samples

REFERENCES

APHA/AWWA/WEF (Standard Method; SM), 2005. Method 4500-CN Cyanide, in Standard Methods for the Examination of Water and Wastewater, 21st ed., Clesceri, L.S., Greenberg, A. E., Eaton, A.D., Rice, E.W., Franson, M.A.H., American Public Health Assoc., American Water Works Assoc., and Water Environment Federation, Washington DC. 2005.

Anchor Environmental (Anchor), 2008. Report of Findings From Cyanide Testing Evaluation at NW Natural Gasco Site. Memorandum to Dana Bayuk of DEQ from Joy Dunay and Amy Nelson. July 3, 2008.

Dzombak, D.A., R.S. Ghosh, and G.M. Wong-Chong, 2006. Cyanide in Water and Soil. Chemistry, Risk and Management. CRC Press/Taylor & Francis, Boca Raton, FL.

U.S. Enivronmental Protection Agency (EPA), 1974. Method 335.1: Cyanide amenable to chlorination, United States Environmental Protection Agency.

EPA, 1993. Method 335.4: Determination of Total Cyanide by Semi-automated Colorimetry. United States Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Office of Research and Development, Cincinnati, OH. Revision 1.0 August 1993.

EPA, 2004. Method OIA 1677: DW, Available Cyanide by Flow Injection, Ligand Exchange and Amperometry. United States Environmental Protection Agency, Office of Water. January 2004.

Table 1
Gasco Treatability Study Cyanide Results

Sample and SDG name	Total (mg/L)	Available (mg/L)	WAD (mg/L)	Free (mg/L)
Reporting Limit	***0.01***	***0.002***	***0.01***	***0.01***
K0806643				
MW-1-55-072108	0.92	0.041 J	0.38	0.017 UJ
PW-1-80-072108	1.46	0.056 J	0.27	0.012 UJ
K0806860-pre treat exp#4				
GS-WG-E41-0	0.94	0.026	0.43 J	0.011 UJ
GS-WG-E41-40	0.68	0.011	0.44 J	0.012 UJ
K0806861				
GS-COMP-E5-0	1.2	0.005 U	0.61	0.011 UJ
GS-COMP-E5-20	0.94	0.008	0.28	0.008 UJ
GS-COMP-E5-90	0.04	0.005 U	0.02	0.008 UJ
GS-COMP-E5-90F	0.004 J	0.002 U	0.01 U	0.005 UJ
GS-COMP-E6-20	0.85	0.006 U	0.39	0.004 UJ
GS-COMP-E6-90	0.02	0.013	0.02	0.019 UJ
GS-COMP-E6-90F	0.002 J	0.01 U	0.01 U	0.006 UJ
K0806909				
MW-1-55-072808	0.94	0.09 J	0.32	0.017 U
PW-1-80-072808	1.56	0.2 J	0.19	0.006 U
K0807074				
GS-WG-E42-0	0.92	0.07 J	0.44	0.01 UJ
GS-WG-E42-40	0.6	0.056 J	0.52	0.01 UJ
GS-WG-C-E7-0	1.24	0.012 J	0.59	0.01 UJ
GS-WG-C-E7-20	1.29	0.01 J	0.42	0.01 UJ
GS-WG-C-E7-60	0.32	0.019 J	0.16	0.065 J
GS-WG-C-E7-90	0.01	0.013 J	0.006 J	0.01 UJ
GS-WG-C-E8-0	1.3	0.01 J	0.53	0.01 U
GS-WG-C-E8-20	1.31	0.011 J	0.46	0.01 U
GS-WG-C-E8-60	0.47	0.263 J	0.31	0.258 J
GS-WG-C-E8-90	0.01	0.018 J	0.01	0.01 U
K0807174				
MW-1-55-080408	0.99	0.223 J	0.48	0.042 J
PW-1-80-080408	1.39	0.235 J	0.4	0.01 UJ
K0807396				
GS-WG-E43-0	0.96	0.439	0.48	0.011 J
GS-WG-E43-40	0.65	0.041	0.45	0.004 J
GS-C-E9-0	1.26	0.027	0.57	0.005 J
GS-C-E9-20	1.25	0.026	0.61	0.008 J
GS-C-E9-60	0.44	0.296	0.19	0.079 J
GS-C-E9-90	0.01	0.04 J	0.01	0.008 J
GS-C-E10-0	1.2	0.02	0.48	0.007 J
GS-C-E10-20	1.13	0.035	0.49	0.018 J
GS-C-E10-60	0.14	0.08	0.09	0.072 J
GS-C-E10-90	0.02	0.043	0.01	0.005 J

Notes:

mg/L	milligrams per liter	J	Estimated value
	Low MS/MSD bias for Available Cyanide	U	Compound analyzed, but not detected above detection limit
	High MS/MSD bias for Available Cyanide		
SDG	Standard Delivery Group	UJ	Compound analyzed, but not detected above estimated detection limit
WAD	Weak Acid Dissociable		

Table 2
Summary of Historical Analytical Results for Groundwater Samples

Gasco Property Well Number	HAI Sample Number[1]	Sample Date	Screen Interval (feet bgs)	EPA Method 9012A, 9010A, D4282-95M, 335.4, SM-4500-CN[+], or OIA-1677[++] (mg/l [ppm])					EPA Method 8270 SIM or 8270C (ug/l [ppb])	
				Total Cyanide	Amenable Cyanide	Free Cyanide	WAD Cyanide[+]	Available Cyanide[++]	Carcinogenic PAHs	Total PAHs
MW-01-22	951207-MW1-22-01	7-Dec-95	11 - 21 (fill WBZ)	1.08	-	-	-	-	93.4	465.3
	960319-MW1-22-01	19-Mar-96		0.86	-	-	-	-	4.71	140.45
	960618-MW1-22-01	18-Jun-96		1.91	-	-	-	-	2.2	112.
	961001-MW1-22-01	1-Oct-96		5.7	-	-	-	-	6.2	720.17
	970225-MW1-22-01	25-Feb-97		1.24	-	-	-	-	0.91	67.
	970225-MW1-22-02	25-Feb-97		-	-	-	-	-	2.2	64.
	970827-MW1-22-01	27-Aug-97		11.	-	-	-	-	20.	988.2
	970827-MW1-22-02	27-Aug-97		10.	-	-	-	-	28.1	737.5
	980217-MW1-22-01	17-Feb-98		0.34	0.01 U	-	-	-	4.45	23.23
	980602-MW1-32-11	2-Jun-98		0.46	0.045	-	-	-	93.	209.
	980826-MW1-22-10	26-Aug-98		6.7	0.6	-	-	-	517.	1,137.5
	981118-MW1-22-15	18-Nov-98		3.4	-	-	-	-	3.4	569.
	990216-MW1-22-012	16-Feb-99		0.22	0.02 U	-	-	-	3.53	11.27
	990513-MW1-22-11	13-May-99		-	-	-	-	-	3.17	17.33
	990824-MW1-22-15	24-Aug-99		6.5	0.02 U	-	-	-	68.19	816.91
	991028-MW1-22-16	28-Oct-99		6.7	0.02 U	-	-	-	8.69	424.98
	000330-MW1-22-116	30-Mar-00		1.7	0.02 U	-	-	-	0.42	62.35
	010329-MW1-22-115	29-Mar-01		0.192	0.186	-	-	-	13.36	51.06
	040825-MW1-22-019 [7]	25-Aug-04		4.31	1.89	-	-	-	0.26	589.51
	050401-014	1-Apr-05		-	0.0844	-	-	-	0.95	11.47
	050928-MW1-22-120	28-Sep-05		17.8	1.54	-	-	-	0.33	471.09
	060403-MW-1-22-117	3-Apr-06		4.13	0.165	0.185	-	-	ND	243.59
	061030-MW-1-22-123	30-Oct-06		8.7	0.5	0.113	-	-	1.26	733.15
	2708-070720-MW-1-22-131	20-Jul-07		5.66	0.5 U	0.482	-	-	1.2207	488.0307
	2708-080512-MW1-22-105	12-May-08		2.92	0.22	0.135	-	-	0.7276	121.9726
	NS (Dry)	16-Sep-08		-	-	-	-	-	-	-
	2708-090402-MW1-22-132	2-Apr-09		0.97	0.26 J	0.06 J	-	-	3.739	69.779
	2708-090820-MW-1-22-163	20-Aug-09		5.84	0.158	0.15	0.333	0.13	64.89	1,094.62
MW-01-55	2708-070719-MW-1-55-127	19-Jul-07	45 - 55	0.398	0.005 U	0.0104	-	-	ND	ND
	2708-080512-MW1-55-104	12-May-08		0.9	0.21	0.008 J	-	-	0.003	0.0627
	2708-080915-MW-1-55-121	15-Sep-08		0.86	0.33	0.01	-	-	ND	0.056
	2708-081208-MW-1-55-002	8-Dec-08		0.84	0.18	0.009 U	-	-	ND	0.0408
	2708-090401-MW1-55-130	1-Apr-09		0.82	0.003 UJ	0.003 UJ	-	-	ND	0.0586
	2708-090820-MW-1-55-164	20-Aug-09		0.952	0.154	0.00915 J	0.121	0.012	ND	0.2361
MW-01-82	2708-070719-MW-1-82-126	19-Jul-07	72 - 82	0.0095	0.0053	0.003 U	-	-	ND	0.142
	2708-080512-MW1-82-103	12-May-08		0.003 J	0.002 U	0.002 J	-	-	0.0104	0.0606
	2708-080915-MW-1-82-119	15-Sep-08		0.002 U	0.002 U	0.003 U	-	-	0.0045	0.0912
	2708-081208-MW-1-82-001	8-Dec-08		0.003 J	0.002 U	0.005 U	-	-	0.0134	0.0428
	2708-090401-MW1-82-128	1-Apr-09		0.003 U	0.003 UJ	0.003 UJ	-	-	0.0033	0.0291
	2708-090820-MW-1-82-161	20-Aug-09		0.0094	0.01 U	0.01 U	-	-	ND	0.0604
	2708-090820-MW-1-82-162	20-Aug-09		0.0125	0.0125	0.01 U	-	-	ND	0.144
MW-02-32	951206-MW2-32-01	6-Dec-95	21.5 - 31.5 (fill WBZ)	0.353	-	-	-	-	ND	51.55
	960318-MW2-32-01	18-Mar-96		0.26	-	-	-	-	ND	4.54
	960618-MW2-32-01	18-Jun-96		0.44	-	-	-	-	ND	2.6
	961001-MW2-32-01	1-Oct-96		0.22	-	-	-	-	ND	10.43
	970225-MW2-32-01	25-Feb-97		0.16	-	-	-	-	ND	1.62
	970827-MW2-32-01	27-Aug-97		0.28	-	-	-	-	0.1	17.94
	980217-MW2-32-01	17-Feb-98		0.16	0.01 U	-	-	-	ND	5.02
	980601-MW2-32-05	1-Jun-98		0.26	0.01 U	-	-	-	ND	3.21
	980825-MW2-32-04	25-Aug-98		0.28	0.09	-	-	-	1.39	7.1
	981117-MW2-32-10	17-Nov-98		0.08	0.02	-	-	-	ND	ND
	990216-MW2-32-008	16-Feb-99		0.12	0.03	-	-	-	ND	18.35
	990513-MW2-32-10	13-May-99		0.11	-	-	-	-	0.1	9.12
	990824-MW2-32-10	24-Aug-99		0.16	0.02 U	-	-	-	0.11	6.29
	991027-MW2-32-12	27-Oct-99		0.13	0.02 U	-	-	-	ND	ND
	000329-MW2-32-112	29-Mar-00		0.08	0.02 U	-	-	-	ND	2.23
	010328-MW2-32-111	28-Mar-01		0.039	0.02 U	-	-	-	ND	ND
	040816-MW2-32-009 [7]	16-Aug-04		0.0835	0.0285	-	-	-	ND	ND
	050331-009	31-Mar-05		-	0.3	-	-	-	ND	3.1333
	050927-MW-2-32-118	27-Sep-05		0.082	0.01 U	-	-	-	ND	0.2128
	060328-MW-2-32-102	28-Mar-06		0.198	0.043	0.0089	-	-	0.00943	0.75743
	061016-MW-2-32-107	16-Oct-06		0.2	0.002 U	0.005 U	-	-	ND	0.2622
	2708-070712-MW-2-32-120	12-Jul-07		0.181 J	0.158 J	0.0074 J	-	-	0.15172	11.34372
	2708-080512-MW2-32-101	12-May-08		0.05	0.05	0.007 J	-	-	0.0285	2.0838
	2708-080915-MW-2-32-120	15-Sep-08		0.15	0.03 J	0.006 J	-	-	0.2099	0.7299
	2708-090401-MW2-32-127	1-Apr-09		0.25	0.06 J	0.003 UJ	-	-	0.074	1.03
	2708-090812-MW-2-32-113	12-Aug-09		0.0781	0.005 U	0.01 U	-	-	0.085	2.7901

Table 2
Summary of Historical Analytical Results for Groundwater Samples

Gasco Property Well Number	HAI Sample Number[1]	Sample Date	Screen Interval (feet bgs)	EPA Method 9012A, 9010A, D4282-95M, 335.4, SM-4500-CN[+], or OIA-1677[++] (mg/l [ppm])					EPA Method 8270 SIM or 8270C (ug/l [ppb])	
				Total Cyanide	Amenable Cyanide	Free Cyanide	WAD Cyanide[+]	Available Cyanide[++]	Carcinogenic PAHs	Total PAHs
MW-02-61	981116-MW2-61-04	16-Nov-98	50 - 60 (alluvial WBZ)	1.3	1.3	-	-	-	ND	0.33
	990216-MW2-61-006	16-Feb-99		1.6	0.04 U	-	-	-	ND	0.37
	990512-MW2-61-05	12-May-99		1.1	0.02 U	-	-	-	ND	0.54
	990823-MW2-61-07	23-Aug-99		1.4	0.2	-	-	-	ND	ND
	991026-MW2-61-04	26-Oct-99		1.3	0.34	-	-	-	ND	ND
	000328-MW2-61-104	28-Mar-00		1.2	0.58	-	-	-	ND	ND
	001004-MW2-61-04	4-Oct-00		-	0.43	-	-	-	ND	ND
	010328-MW2-61-104	28-Mar-01		0.251	0.02 U	-	-	-	ND	ND
	011009-MW2-61-104	9-Oct-01		0.83	-	-	-	-	ND	ND
	020403-MW2-61-103	3-Apr-02		2.38	0.4 U	-	-	-	ND	ND
	020924-MW2-61-103	24-Sep-02		0.97	-	-	-	-	ND	ND
	030318-MW2-61-104	18-Mar-03		1.3	0.04 U	-	-	-	ND	ND
	030930-MW2-61-103 [7]	30-Sep-03		-	0.02 U	-	-	-	ND	ND
	040813-MW2-61-002 [7]	13-Aug-04		0.819	0.085	-	-	-	ND	ND
	050926-MW-2-61-111	26-Sep-05		0.803	0.017	-	-	-	ND	0.0424
	060329-MW-2-61-104	29-Mar-06		0.884	0.0714	0.0157	-	-	ND	0.0937
	061011-MW-2-61-101	11-Oct-06		1.1	0.09	0.005 U	-	-	ND	0.0887
	2708-070719-MW-2-61-128	19-Jul-07		0.779	0.172	0.0043	-	-	ND	ND
	2708-080512-MW2-61-100	12-May-08		0.92	0.11	0.027	-	-	0.0172	ND
	2708-080915-MW-2-61-118	15-Sep-08		0.74	0.04 U	0.059	-	-	0.1984	0.7534
	2708-090401-MW2-61-125	1-Apr-09		0.74	0.19 J	0.003 UJ	-	-	ND	0.043
	2708-090812-MW-2-61-115	12-Aug-09		0.738 J	0.415	0.01 U	0.056	0.0055	ND	0.165
MW-02-104	2708-070712-MW-2-104-	12-Jul-07	94 - 104	0.173 J	0.163 J	0.0039 J	-	-	ND	0.248
	2708-080512-MW2-104-	12-May-08		0.44	0.18	0.02	-	-	ND	0.1356
	2708-080915-MW-2-104-	15-Sep-08		0.24	0.01 U	0.003 J	-	-	ND	0.0908
	2708-080915-MW-2-104-	15-Sep-08		0.23	0.04 J	0.006 J	-	-	ND	0.0987
	2708-081208-MW-2-104-	8-Dec-08		0.24	0.002 U	0.007 U	-	-	ND	0.1153
	2708-090401-MW2-104-	1-Apr-09		0.5	0.003 UJ	0.003 UJ	-	-	ND	0.0618
	2708-090812-MW-2-104-	12-Aug-09		0.535 U	0.01 U	0.01 U	-	-	ND	0.284
MW-03-26	951206-MW3-26-01	6-Dec-95	15 - 25 (fill WBZ)	-	-	-	-	-	21.04	85.24
	960318-MW3-26-02	18-Mar-96		0.27	-	-	-	-	1.71	42.39
	960618-MW3-26-01	18-Jun-96		0.25	-	-	-	-	2.55	47.86
	961001-MW3-26-01	1-Oct-96		0.34	-	-	-	-	182.	334.1
	970225-MW3-26-01	25-Feb-97		0.28	-	-	-	-	4.94	11.89
	970827-MW3-26-01	27-Aug-97		2.3	-	-	-	-	27.6	53.2
	980217-MW3-26-01	17-Feb-98		0.5	0.01 U	-	-	-	7.06	13.44
	980602-MW3-26-09	2-Jun-98		0.76	0.01 U	-	-	-	99.8	204.27
	980826-MW3-26-08	26-Aug-98		1.3	0.72	-	-	-	576.	982.
	981117-MW3-26-12	17-Nov-98		2.1	0.1	-	-	-	32.23	58.83
	990216-MW3-26-010	16-Feb-99		0.33	0.02 U	-	-	-	0.97	3.56
	990514-MW3-26-23	14-May-99		0.3	-	-	-	-	4.42	13.21
	990824-MW3-26-12	24-Aug-99		0.57	0.02 U	-	-	-	1.67	4.69
	991027-MW3-26-14	27-Oct-99		0.79	0.02 U	-	-	-	7.23	12.56
	000330-MW3-26-113	30-Mar-00		0.36	0.21	-	-	-	2.44	6.32
	001005-MW3-26-11	5-Oct-00		-	0.04	-	-	-	2.96	6.15
	010328-MW3-26-113	28-Mar-01		0.221	0.209	-	-	-	5.42	11.9
	048023-MW3-26-010 [7]	23-Aug-04		0.184	0.184	-	-	-	ND	0.2121
	050330-004	30-Mar-05		-	0.384	-	-	-	0.7177	1.4491
	050922-MW-3-26-105	22-Sep-05		0.502	0.295	-	-	-	3.412	8.0986
	060330-MW-3-26-110	30-Mar-06		0.3	0.0756	0.0157	-	-	0.1554	1.482
	061017-MW-3-26-110	17-Oct-06		4.2	0.53	0.005 U	-	-	0.3799	1.3539
	2708-070629-MW-3-26-119	29-Jun-07		0.0423 J	0.0246 J	0.003 UJ	-	-	15.709	102.579
	2708-080512-MW3-26-107	12-May-08		0.38	0.21	0.004 J	-	-	1.496	4.066
	2708-080911-MW-3-26-115	11-Sep-08		7.5	4.03	0.029	-	-	1.986	5.
	2708-090331-MW3-26-123	31-Mar-09		0.41 J	0.11 J	0.003 U	-	-	0.776	1.8863
	2708-090817-MW-3-26-139	17-Aug-09		0.371	0.005 U	0.01 UJ	0.0587	0.003	1.139	3.1544

Table 2
Summary of Historical Analytical Results for Groundwater Samples

Gasco Property Well Number	HAI Sample Number[1]	Sample Date	Screen Interval (feet bgs)	EPA Method 9012A, 9010A, D4282-95M, 335.4, SM-4500-CN[+], or OIA-1677[++] (mg/l [ppm])					EPA Method 8270 SIM or 8270C (ug/l [ppb])	
				Total Cyanide	Amenable Cyanide	Free Cyanide	WAD Cyanide[+]	Available Cyanide[++]	Carcinogenic PAHs	Total PAHs
MW-03-56	951206-MW3-56-01	6-Dec-95	45 - 55 (alluvial WBZ)	-	-	-	-	-	2.69	1,384.75
	960319-MW3-56-01	19-Mar-96		0.19	-	-	-	-	2.34	1,926.62
	960620-MW3-56-01	20-Jun-96		0.08	-	-	-	-	1.59	1,491.1
	961002-MW3-56-01	2-Oct-96		0.094	-	-	-	-	0.54	937.84
	970226-MW3-56-01	26-Feb-97		0.13	-	-	-	-	0.62	618.32
	970828-MW3-56-01	28-Aug-97		0.11	-	-	-	-	0.82	195.52
	980218-MW3-56-01	18-Feb-98		0.16	0.01 U	-	-	-	0.58	129.58
	980218-MW3-56-02	18-Feb-98		-	-	-	-	-	0.46	155.56
	980602-MW3-56-14	2-Jun-98		0.15	0.01 U	-	-	-	24.5	315.8
	980602-MW3-56-15	2-Jun-98		-	-	-	-	-	24.3	305.6
	980826-MW3-56-12	26-Aug-98		0.15	0.04	-	-	-	3.34	101.58
	981118-MW3-56-16	18-Nov-98		0.13	0.01 U	-	-	-	0.97	118.97
	981118-MW3-56-17	18-Nov-98		-	-	-	-	-	0.77	121.47
	990217-MW3-56-015	17-Feb-99		0.076	0.02 U	-	-	-	12.53	163.45
	990514-MW3-56-24	14-May-99		0.11	-	-	-	-	3.24	157.21
	990824-MW3-56-16	24-Aug-99		0.12	0.022	-	-	-	0.6	99.66
	991028-MW3-56-17	28-Oct-99		0.1	0.02 U	-	-	-	0.59	98.98
	000330-MW3-56-117	30-Mar-00		0.07	0.02 U	-	-	-	3.84	166.08
	001005-MW3-56-13	5-Oct-00		-	0.02 U	-	-	-	12.63	135.58
	010329-MW3-56-116	29-Mar-01		0.055	0.047	-	-	-	10.35	107.75
	020404-MW3-56-111	4-Apr-02		0.146	0.046	-	-	-	2.62	98.13
	030319-MW3-56-112	19-Mar-03		0.1	0.04 U	-	-	-	1.52	94.38
	040823-MW3-56-011 [7]	23-Aug-04		0.0324	0.0324	-	-	-	ND	56.164
MW-03-56	050330-003	30-Mar-05	45 - 55 (alluvial WBZ)	-	0.0198	-	-	-	0.6607	66.2207
	050922-MW-3-56-106	22-Sep-05		0.0418	0.0175	-	-	-	0.632	52.212
	060330-MW-3-56-111	30-Mar-06		0.0402	0.0274	0.0013 U	-	-	1.466	95.269
	061024-MW-3-56-116	24-Oct-06		0.05	0.002	0.005 U	-	-	8.81	85.21
	2708-070626-MW-3-56-108	26-Jun-07		0.0339	0.0169	0.006 UJ	-	-	21.195	193.875
	2708-080512-MW3-56-106	12-May-08		0.05	0.002 U	0.003 J	-	-	22.84	119.33
	2708-080911-MW-3-56-116	11-Sep-08		0.03	0.02	0.004 J	-	-	40.52	186.12
	2708-090326-MW3-56-105	26-Mar-09		0.04	0.01 J	0.004 J	-	-	18.57	107.07
	2708-090811-MW-3-56-107	11-Aug-09		0.0295	0.005 U	0.01 U	-	-	62.11	215.24
MW-04-35	951206-MW4-35-01	6-Dec-95	24 - 34	0.079	-	-	-	-	0.69	54.49
	960318-MW4-35-01	18-Mar-96		0.35	-	-	-	-	3.18	84.4
	960318-MW4-35-02	18-Mar-96		-	-	-	-	-	2.41	79.1
	960618-MW4-35-01	18-Jun-96		0.46	-	-	-	-	2.51	61.4
	961001-MW4-35-01	1-Oct-96		0.75	-	-	-	-	1.7	42.33
	970225-MW4-35-01	25-Feb-97		0.39	-	-	-	-	0.41	45.65
	980827-MW4-57-01 [4]	27-Aug-97		0.8	-	-	-	-	0.53	36.26
	980217-MW4-35-01	17-Feb-98		0.36	0.01 U	-	-	-	0.25	31.85
	980601-MW4-35-06	1-Jun-98		0.29	0.017	-	-	-	0.48	43.63
	980826-MW4-35-06	26-Aug-98		0.63	0.03	-	-	-	3.02	60.85
	980826-MW4-35-07	26-Aug-98		0.81	0.17	-	-	-	4.37	64.65
	981117-MW4-35-11	17-Nov-98		0.83	0.53	-	-	-	5.32	50.83
	990216-MW4-35-009	16-Feb-99		0.22	0.02 U	-	-	-	0.4	23.41
	990514-MW4-35-21	14-May-99		0.26	-	-	-	-	0.32	24.83
	990824-MW4-35-11	24-Aug-99		0.86	0.1	-	-	-	1.101	33.261
	991027-MW4-35-13	27-Oct-99		0.98	0.02 U	-	-	-	5.75	97.39
	000330-MW4-35-114	30-Mar-00		0.61	0.04	-	-	-	0.42	45.26
	001005-MW4-35-10	5-Oct-00		-	0.02 U	-	-	-	21.72	162.5
	010328-MW4-35-112	28-Mar-01		-	0.005 U	-	-	-	0.4	25.55
	040823-MW4-35-012	23-Aug-04		0.178	0.098	-	-	-	ND	65.33
	050331-005	31-Mar-05		-	0.0499	-	-	-	0.21	11.9331
	050928-MW4-35-123	28-Sep-05		0.247	0.01 U	-	-	-	0.301	37.936
	060331-MW-4-35-113	31-Mar-06		0.14	0.0389	0.0029	-	-	0.4361	31.9876
	061018-MW-4-35-113	18-Oct-06		0.17	0.002 U	0.005 U	-	-	1.66	65.37
	2708-070726-MW-4-35-137	26-Jul-07		0.28	0.262	0.0043 J	-	-	0.4281	20.4801
	2708-080513-MW4-35-112	13-May-08		0.16	0.01	0.003 U	-	-	1.686	57.916
	2708-080513-MW4-35-113	13-May-08		0.15	0.01	0.003 U	-	-	1.432	52.262
	2708-080911-MW-4-35-109	11-Sep-08		0.17	0.01 U	0.007 J	-	-	1.045	92.955
	2708-090331-MW4-35-119	31-Mar-09		0.21 J	0.003 U	0.003 U	-	-	0.6944	43.9514
	2708-090813-MW-4-35-121	13-Aug-09		0.202 J	0.005 U	0.01 U	0.0297	0.002 U	ND	48.309

Table 2
Summary of Historical Analytical Results for Groundwater Samples

Gasco Property Well Number	HAI Sample Number[1]	Sample Date	Screen Interval (feet bgs)	EPA Method 9012A, 9010A, D4282-95M, 335.4, SM-4500-CN[+], or OIA-1677[++] (mg/l [ppm])					EPA Method 8270 SIM or 8270C (ug/l [ppb])	
				Total Cyanide	Amenable Cyanide	Free Cyanide	WAD Cyanide[+]	Available Cyanide[++]	Carcinogenic PAHs	Total PAHs
MW-04-57	951205-MW4-57-01	5-Dec-95	46 - 56 (alluvial WBZ)	1.18	-	-	-	-	1.73	1,328.27
	960321-MW4-57-01	21-Mar-96		0.03	-	-	-	-	2.29	1,097.76
	960620-MW4-57-01	20-Jun-96		0.88	-	-	-	-	1.42	646.47
	961002-MW4-57-01	2-Oct-96		1.	-	-	-	-	0.64	1,706.84
	970226-MW4-57-01	26-Feb-97		1.52	-	-	-	-	0.52	1,688.42
	970828-MW4-35-01 [4]	28-Aug-97		2.	-	-	-	-	0.44	1,691.74
	980218-MW4-57-01	18-Feb-98		2.	0.05 U	-	-	-	0.28	2,357.88
	980603-MW4-57-18[5]	3-Jun-98		1.9		-	-	-	0.67	2,298.87
	980826-MW4-57-13	26-Aug-98		1.4	0.1	-	-	-	0.44	2,471.24
	981119-MW4-57-20	19-Nov-98		1.8	0.5	-	-	-	0.34	1,967.94
	990217-MW4-57-016	17-Feb-99		1.4	0.02 U	-	-	-	0.32	1,575.28
	990514-MW4-57-22	14-May-99		1.8	-	-	-	-	0.39	1,684.32
	990825-MW4-57-17	25-Aug-99		1.7	0.02 U	-	-	-	0.4	2,305.4
	991028-MW4-57-21	28-Oct-99		0.65	0.02 U	-	-	-	ND	1,692.
	000403-MW4-57-121	3-Apr-00		0.74	0.17	-	-	-	0.47	2,765.74
	001006-MW4-57-19	6-Oct-00		-	0.02 U	-	-	-	0.38	2,498.11
	010329-MW4-57-120	29-Mar-01		0.696	0.08 U	-	-	-	0.43	3,063.35
	020405-MW4-57-117	5-Apr-02		3.43	0.4 U	-	-	-	0.21	2,249.96
	030320-MW4-57-117	20-Mar-03		1.3	0.04 U	-	-	-	ND	2,233.4
	040824-MW4-57-016	24-Aug-04		1.76	0.261	-	-	-	1.205	3,823.305
	050331-008	31-Mar-05		-	0.175	-	-	-	ND	2,909.039
	051003-MW-4-57-133	3-Oct-05		2.7	0.55	-	-	-	ND	271.63
	060331-MW-4-57-114	31-Mar-06		2.24	0.044	0.0374	-	-	0.536	551.64
	060331-MW-4-57-115	31-Mar-06		2.12	0.016	0.0353	-	-	-	-
	061030-MW-4-57-122	30-Oct-06		2.6	0.13	0.0282	-	-	0.72	806.12
	2708-070622-MW-4-57-101	22-Jun-07		-	0.005 U	-	-	-	0.6619	33.6919
	2708-070723-MW-4-57-135	23-Jul-07		2.89 J	0.5 UJ	0.003 UJ	-	-	-	-
	2708-080513-MW4-57-111	13-May-08		3.01	0.19	0.008 J	-	-	4.94	930.81
	2708-080911-MW-4-57-108	11-Sep-08		3.4	0.52	0.073	-	-	6.96	302.26
	2708-090331-MW4-57-121	31-Mar-09		2.66 J	0.05 J	0.003 U	-	-	1.538	397.388
MW-04-101	981117-MW4-101-09	17-Nov-98	89.5 -99.5 (alluvial WBZ)	0.62	0.2	-	-	-	ND	20.
	990216-MW4-101-007	16-Feb-99		0.64	0.03	-	-	-	ND	8.3
	990514-MW4-101-19	14-May-99		0.47	0.12	-	-	-	ND	68.31
	990514-MW4-101-20	14-May-99		0.48	-	-	-	-	ND	62.5
	990824-MW4-101-09	24-Aug-99		0.56	0.03	-	-	-	ND	190.64
	991027-MW4-101-11	27-Oct-99		0.36	0.02 U	-	-	-	ND	166.65
	000329-MW4-101-111	29-Mar-00		0.52	0.11	-	-	-	ND	21.57
	001005-MW4-101-09	5-Oct-00		-	0.08	-	-	-	ND	1.36
	010328-MW4-101-110	28-Mar-01		0.203	0.02 U	-	-	-	ND	1.14
	011009-MW4-101-103	9-Oct-01		0.66	-	-	-	-	ND	1.18
	020404-MW4-101-110	4-Apr-02		0.432	0.04 U	-	-	-	ND	5.97
	020924-MW4-101-102	24-Sep-02		0.49	-	-	-	-	ND	12.63
	030318-MW4-101-109	18-Mar-03		0.51	0.04 U	-	-	-	ND	15.63
	030930-MW4-101-105 [7]	30-Sep-03		-	0.28	-	-	-	ND	14.59
	040816-MW4-101-007 [7]	16-Aug-04		0.005 U	0.005 U	-	-	-	ND	26.741
	050330-002	30-Mar-05		-	0.131	-	-	-	ND	16.676
	050928-MW4-101-122	28-Sep-05		0.587	0.022	-	-	-	ND	7.3298
	060329-MW-4-101-106	29-Mar-06		0.636	0.0604	0.0134	-	-	ND	10.5918
	061018-MW-4-101-112	18-Oct-06		0.8	0.002 U	0.008 J	-	-	0.0092	6.3155
	2708-070625-MW-4-101-	25-Jun-07		0.671 J	0.083	0.0035	-	-	0.03383	1.42483
	2708-080513-MW4-101-	13-May-08		0.87	0.08	0.006 J	-	-	0.0031	3.2401
	2708-080910-MW-4-101-	10-Sep-08		0.7	0.002 UJ	0.032	-	-	ND	2.2108
	2708-090331-MW4-101-	31-Mar-09		0.7 J	0.003 U	0.003 U	-	-	ND U	2.8741
	2708-090331-MW4-101-	31-Mar-09		0.68 J	-	0.003 U	-	-	ND U	2.7484
	2708-090813-MW-4-101-	13-Aug-09		0.759 U	0.0194	0.01 U	-	-	0.04	3.2696
MW-05-32	951205-MW5-32-01	5-Dec-95	21 - 31 (fill/alluvial WBZ)	0.101	-	-	-	-	7.59	207.69
	960319-MW5-32-01	19-Mar-96		0.11	-	-	-	-	29.81	268.91
	960319-MW5-32-01	19-Mar-96		-	-	-	-	-	ND	44.97
	960620-MW5-32-01	20-Jun-96		0.05	-	-	-	-	13.67	82.79
	961001-MW5-32-01	1-Oct-96		0.14	-	-	-	-	277.	773.
	970225-MW5-32-01	25-Feb-97		0.11	-	-	-	-	1.	9.71
	970827-MW5-32-01	27-Aug-97		0.14	-	-	-	-	10.4	24.3
	980217-MW5-32-01	17-Feb-98		0.17	0.01 U	-	-	-	3.23	7.57
	980602-MW5-32-10	2-Jun-98		0.18	0.038	-	-	-	35.71	94.72
	980826-MW5-32-09	26-Aug-98		0.23	0.01	-	-	-	258.8	540.4
	981118-MW5-32-13	18-Nov-98		0.25	0.05	-	-	-	1.42	4.73
	990216-MW5-32-011	16-Feb-99		0.13	0.02 U	-	-	-	2.57	6.89
	990514-MW5-32-17	14-May-99		0.15	-	-	-	-	0.8	2.38
	990824-MW5-32-13	24-Aug-99		0.18	0.028	-	-	-	8.82	21.15
	991027-MW5-32-15	27-Oct-99		0.19	0.02 U	-	-	-	6.68	16.16
	000330-MW5-32-115	30-Mar-00		0.02 U	0.02 U	-	-	-	4.45	8.97
	001005-MW5-32-12	5-Oct-00		-	0.04	-	-	-	1.66	3.3
	010329-MW5-32-114	29-Mar-01		0.178	0.17	-	-	-	10.12	19.65

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Gasco Property Well Number	HAI Sample Number[1]	Sample Date	Screen Interval (feet bgs)	EPA Method 9012A, 9010A, D4282-95M, 335.4, SM-4500-CN[+], or OIA-1677[++] (mg/l [ppm])					EPA Method 8270 SIM or 8270C (ug/l [ppb])	
				Total Cyanide	Amenable Cyanide	Free Cyanide	WAD Cyanide[+]	Available Cyanide[++]	Carcinogenic PAHs	Total PAHs
MW-05-32	040816-MW5-32-008 [7]	16-Aug-04	21 - 31 (fill/alluvial WBZ)	0.521	0.175	-	-	-	ND	0.269
	050401-011	1-Apr-05		-	0.0281	-	-	-	1.59	4.463
	050937-MW-5-32-117	27-Sep-05		0.09	0.01 U	-	-	-	11.113	26.855
	060329-MW-5-32-107	29-Mar-06		0.106	0.101	0.0031	-	-	5.376	11.937
	061018-MW-5-32-114	18-Oct-06		0.09	0.01	0.005 J	-	-	1.196	5.337
	2708-070625-MW-5-32-104	25-Jun-07		-	0.0907	-	-	-	6.239	17.209
	2708-070730-MW-5-32-142	30-Jul-07		0.106	0.0941	0.003 U	-	-		-
	2708-080514-MW5-32-118	14-May-08		0.11	0.03	0.006 J	-	-	5.57	11.5909
	2708-080910-MW-5-32-102	10-Sep-08		0.09	0.05	0.007 J	-	-	3.628	7.706
	2708-090330-MW5-32-111	30-Mar-09		0.11 J	0.04 J	0.003 U	-	-	6.9	14.035
	2708-090812-MW-5-32-114	12-Aug-09		0.108	0.005 U	0.01 U	0.0234	0.0023	3.4891	7.6181
MW-05-100	981118-MW5-100-14	18-Nov-98	88 - 98 (alluvial WBZ)	0.66	0.01 U	-	-	-	ND	7,126.7
	990217-MW5-100-018	17-Feb-99		0.66	0.06	-	-	-	ND	5,032.73
	990514-MW5-100-18	14-May-99		0.44	0.02 U	-	-	-	ND	7,482.13
	990825-MW5-100-18	25-Aug-99		0.84	0.02 U	-	-	-	ND	13,330.3
	991028-MW5-100-19	28-Oct-99		0.69	0.02 U	-	-	-	ND	7,471.79
	000330-MW5-100-119	30-Mar-00		0.56	0.02 U	-	-	-	0.1	9,825.06
	001006-MW5-100-15	6-Oct-00		-	0.08	-	-	-	ND	10,104.03
	001006-MW5-100-16	6-Oct-00		-	0.09	-	-	-	ND	9,218.41
	010329-MW5-100-118	29-Mar-01		0.142	0.135	-	-	-	ND	9,619.8
	020405-MW5-100-114	5-Apr-02		1.8	0.4 U	-	-	-	1.1	82,318.6
	020405-MW5-100-115	5-Apr-02		1.54	0.08 U	-	-	-	0.25	4,321.28
	030319-MW5-100-114	19-Mar-03		0.56	0.04 U	-	-	-	ND	5,614.
	040824-MW5-100-015 [7]	24-Aug-04		0.816	0.298	-	-	-	ND	11,921.9
	050401-012	1-Apr-05		-	0.109	-	-	-	ND	8,753.8
	050921-MW-5-100-102	21-Sep-05		0.869	0.248	-	-	-	0.0369	6,549.2297
	060404-MW-5-100-121	4-Apr-06		0.814	0.106	0.0283	-	-	ND	8,408.6
	061027-MW-5-100-120	27-Oct-06		1.06	0.17	0.005 J	-	-	ND	7,117.
	2708-070625-MW-5-100-	25-Jun-07		-	0.056	-	-	-	ND	7,320.
	2708-070730-MW-5-100-	30-Jul-07		0.747	0.287	0.0074 J	-	-	-	-
	2708-080514-MW5-100-	14-May-08		0.99	0.11	0.041	-	-	0.0323	7,816.7353
	2708-080910-MW-5-100-	10-Sep-08		0.91	0.12	0.036	-	-	0.011	9,927.507
	2708-090330-MW5-100-	30-Mar-09		0.94 J	0.2 J	0.063	-	-	0.0444	9,630.7738
	2708-090812-MW-5-100-	12-Aug-09		0.924 U	0.05 U	0.0124	0.109	0.015	ND U	19,500.
MW-05-175	981116-MW5-175-07	16-Nov-98	163 - 173 (alluvial WBZ)	0.02 U	0.01 U	-	-	-	ND	ND
	990215-MW5-175-003	15-Feb-99		0.02 U	0.02 U	-	-	-	ND	ND
	990512-MW5-175-07	12-May-99		0.02 U	0.02 U	-	-	-	ND	ND
	990823-MW5-175-03	23-Aug-99		0.02 U	0.02 U	-	-	-	ND	0.2
	991026-MW5-175-06	26-Oct-99		0.02 U	0.02 U	-	-	-	ND	ND
	000329-MW5-175-106	29-Mar-00		0.02 U	0.02 U	-	-	-	ND	ND
	001004-MW5-175-05	4-Oct-00		-	0.02 U	-	-	-	ND	ND
	010328-MW5-175-105	28-Mar-01		0.02 U	0.02 U	-	-	-	ND	ND
	011009-MW5-175-102	9-Oct-01		0.02 U	-	-	-	-	ND	ND
	020404-MW5-175-105	4-Apr-02		0.04 U	0.04 U	-	-	-	ND	ND
	020924-MW5-175-101	24-Sep-02		-	-	-	-	-	ND	ND
	030318-MW5-175-105	18-Mar-03		0.04 U	0.04 U	-	-	-	ND	ND
	030929-MW5-175-101	29-Sep-03		-	0.02 U	-	-	-	ND	ND
	040824-MW5-175-013	24-Aug-04		0.0069	0.0069	-	-	-	ND	0.0883
	050921-MW5-175-101	21-Sep-05		0.0156	0.0052	-	-	-	ND	0.0894
	060329-MW-5-175-105	29-Mar-06		0.018	0.0054	0.0013 U	-	-	ND	0.0796
	061016-MW-5-175-05	16-Oct-06		0.04	0.002 U	0.005 U	-	-	ND	0.047
	2708-070625-MW-5-175-	25-Jun-07		0.0145 J	0.0064	0.0022 J	-	-	0.03018	0.14418
	2708-080514-MW5-175-	14-May-08		0.02	0.002 U	0.005 J	-	-	0.0185	0.1241
	2708-080910-MW-5-175-	10-Sep-08		0.01	0.01	0.004 J	-	-	0.0236	0.1416
	2708-090330-MW5-175-	30-Mar-09		0.01 J	0.003 U	0.003 U	-	-	0.0108	0.0481
	2708-090812-MW-5-175-	12-Aug-09		0.0186	0.005 U	0.01 U	-	-	ND U	0.119
MW-06-32	951207-MW6-32-01	7-Dec-95	21 - 31 (fill WBZ)	0.091	-	-	-	-	7,470.	199,570.
	960319-MW6-32-01	19-Mar-96		0.21	-	-	-	-	6.56	2,346.46
	960319-MW6-32-01	19-Mar-96		-	-	-	-	-	ND	1,940.1
	960617-MW6-32-01	17-Jun-96		0.23	-	-	-	-	16.24	1,877.54
	960930-MW6-32-01	30-Sep-96		0.02	-	-	-	-	203.5	4,757.7
	970225-MW6-32-01	25-Feb-97		0.22	-	-	-	-	ND	1,308.2
	970826-MW6-32-01	26-Aug-97		0.15	-	-	-	-	15.	2,069.65
	980216-MW6-32-01	16-Feb-98		0.18	0.01 U	-	-	-	161.9	3,554.2
	980601-MW6-32-04	1-Jun-98		0.1	0.01 U	-	-	-	19.98	2,244.96
MW-06-61	951206-MW6-61-01	6-Dec-95	50 - 60 (alluvial WBZ)	0.228	-	-	-	-	8.17	744.89
	960319-MW6-61-01	19-Mar-96		0.28	-	-	-	-	3.29	196.96
	960620-MW6-61-01	20-Jun-96		0.27	-	-	-	-	4.27	139.28
	961001-MW6-61-01	1-Oct-96		0.3	-	-	-	-	3.8	152.9
	970225-MW6-61-01	25-Feb-97		0.35	-	-	-	-	ND	365.1
	970828-MW6-61-01	28-Aug-97		0.41	-	-	-	-	4.88	1,451.5

Table 2
Summary of Historical Analytical Results for Groundwater Samples

Gasco Property Well Number	HAI Sample Number[1]	Sample Date	Screen Interval (feet bgs)	EPA Method 9012A, 9010A, D4282-95M, 335.4, SM-4500-CN[+], or OIA-1677[++] (mg/l [ppm])					EPA Method 8270 SIM or 8270C (ug/l [ppb])	
				Total Cyanide	Amenable Cyanide	Free Cyanide	WAD Cyanide[+]	Available Cyanide[++]	Carcinogenic PAHs	Total PAHs
MW-08-29	951207-MW8-29-01	7-Dec-95	18 - 28 (fill WBZ)	3.11	-	-	-	-	315.	7,688.
	960321-MW8-29-01	21-Mar-96		2.4	-	-	-	-	143.7	7,879.7
	960620-MW8-29-01	20-Jun-96		-	-	-	-	-	5.41	2,087.29
	960620-MW8-29-02	20-Jun-96		-	-	-	-	-	13.32	2,166.12
	961002-MW8-29-01	2-Oct-96		0.524	-	-	-	-	25.9	6,086.4
	970226-MW8-29-01	26-Feb-97		1.46	-	-	-	-	9.9	6,203.9
	970828-MW8-29-01	28-Aug-97		3.4	-	-	-	-	171.7	11,712.7
	980218-MW8-29-01	18-Feb-98		2.6	0.01 U	-	-	-	22.19	11,760.19
	980603-MW8-29-19	3-Jun-98		4.9	0.022	-	-	-	195.8	12,406.8
	981119-MW8-29-22	19-Nov-98		2.5	-	-	-	-	11.11	5,376.91
	990513-MW8-29-14	13-May-99		2.6	-	-	-	-	10.73	6,444.82
	991029-MW8-29-23	29-Oct-99		60.	2.	-	-	-	ND	3,302.
	000403-MW8-29-123	3-Apr-00		0.61	0.03	-	-	-	7.42	7,158.23
	010330-MW8-29-123	30-Mar-01		0.92	0.042	-	-	-	49.12	2,291.24
	040825-MW8-29-022	25-Aug-04		2.69	0.138	-	-	-	38.52	3,072.45
	05-0929-MW-29-27	29-Sep-05		5.92	0.01 U	-	-	-	28.643	5,592.863
	061031-MW-8-29-124	31-Oct-06		3.8	0.28	0.005 U	-	-	8.7	2,265.4
	2708-080603-MW8-29-100	3-Jun-08		3.44	0.48	0.015	-	-	21.22	2,623.82
	2708-080911-MW-8-27-113	11-Sep-08		2.59	0.04 U	0.028	-	-	19.15	2,685.35
	2708-090331-MW8-29-118	31-Mar-09		4.57 J	0.45 J	0.003 U	-	-	5.027	3,690.297
	2708-090811-MW-8-29-106	11-Aug-09		2.36	0.05 U	0.01 U	-	-	8.36	3,172.8
MW-08-56	951207-MW8-56-01	7-Dec-95	45 - 55 (alluvial WBZ)	0.582	-	-	-	-	156.	21,200.
	960321-MW8-56-01	21-Mar-96		0.54	-	-	-	-	361.1	15,501.1
	960620-MW8-56-01 [6]	20-Jun-96		0.31	-	-	-	-	34.81	1,768.61
	961002-MW8-56-01	2-Oct-96		-	-	-	-	-	114.	11,742.
	970226-MW8-56-01	26-Feb-97		0.7	-	-	-	-	ND	13,692.
	970828-MW8-56-01	28-Aug-97		0.66	-	-	-	-	20.	18,141.
	980218-MW8-56-01	18-Feb-98		0.74	0.01 U	-	-	-	11.18	12,944.88
	980603-MW8-56-21[5]	3-Jun-98		0.77	0.018 [5]	-	-	-	67.8	17,719.8
	981119-MW8-56-23	19-Nov-98		0.36	-	-	-	-	ND	11,024.
	990513-MW8-56-15	13-May-99		0.57	-	-	-	-	ND	11,965.8
	991029-MW8-56-24	29-Oct-99		2.1	0.08 U	-	-	-	4.23	12,537.17
	000403-MW8-56-124	3-Apr-00		0.58	0.02 U	-	-	-	42.1	14,027.8
	010330-MW8-56-122	30-Mar-01		0.272	0.02 U	-	-	-	40.42	14,953.54
	020405-MW8-56-118	5-Apr-02		1.13	0.08 U	-	-	-	1.94	7,143.
	030320-MW8-56-120	20-Mar-03		0.51	0.04 U	-	-	-	4.2	7,712.2
	040825-MW8-56-021	25-Aug-04		0.474	0.153	-	-	-	ND	10,832.7
	05-0929-MW-8-56-128	29-Sep-05		0.538	0.017	-	-	-	26.97	8,759.88
	061031-MW-8-56-125	31-Oct-06		0.3	0.002 U	0.005 U	-	-	22.1	10,483.7
	061031-MW-8-56-126	31-Oct-06		0.6	0.002 U	0.005 U	-	-	20.9	20,492.8
	2708-080603-MW8-56-101	3-Jun-08		0.63	0.03	0.003 J	-	-	126.	12,165.
	2708-080915-MW-8-56-117	15-Sep-08		0.59	0.03 J	0.015	-	-	174.4	8,698.4
	2708-090331-MW8-56-116	31-Mar-09		0.54 J	0.07 J	0.003 U	-	-	41.22	8,175.02
	2708-090811-MW-8-56-104	11-Aug-09		0.455	0.02 U	0.01 U	-	-	110.3	10,539.2
MW-09-29	951205-MW9-29-01	5-Dec-95	18 - 28 (fill WBZ)	-	-	-	-	-	ND	1.19
	960318-MW9-29-01	18-Mar-96		0.01 U	-	-	-	-	ND	1.6
	960618-MW9-29-01	18-Jun-96		0.01 U	-	-	-	-	ND	0.15
	961001-MW9-29-01	1-Oct-96		0.018	-	-	-	-	ND	0.4
	970225-MW9-29-01	25-Feb-97		0.01	-	-	-	-	ND	ND
	970827-MW9-29-01	27-Aug-97		0.02 U	-	-	-	-	ND	ND
	980217-MW9-29-01	17-Feb-98		0.02 U	-	-	-	-	ND	ND
	980602-MW9-29-07	2-Jun-98		0.02 U	-	-	-	-	ND	ND
	981116-MW9-29-02	16-Nov-98		0.03	-	-	-	-	ND	ND
	990511-MW9-29-03	11-May-99		0.02 U	-	-	-	-	ND	ND
	991026-MW9-29-02	26-Oct-99		0.02 U	0.02 U	-	-	-	ND	ND
	000328-MW9-29-102	28-Mar-00		0.02 U	0.02 U	-	-	-	ND	ND
	010327-MW9-29-102	27-Mar-01		0.026	0.02 U	-	-	-	ND	ND
	020403-MW9-29-101	3-Apr-02		0.04 U	0.04 U	-	-	-	ND	ND
	030318-MW9-29-103	18-Mar-03		0.042	0.04 U	-	-	-	ND	ND
	040812-MW9-29-001 [7]	12-Aug-04		0.01	0.01	-	-	-	ND	ND
	05096-MW-9-29-109	26-Sep-05		0.017	0.01 U	-	-	-	ND	0.1193
	061013-MW-9-103	13-Oct-06		0.04	0.04	0.005 U	-	-	0.1747	0.4097
	2708-080604-MW9-29-109	4-Jun-08		0.01	0.005 J	0.004 J	-	-	0.1146	0.4818
	2708-080604-MW9-29-110	4-Jun-08		0.01	0.01 J	0.004 J	-	-	0.1022	0.4914
	2708-080916-MW-9-29-132	16-Sep-08		0.01	0.01	0.004 J	-	-	0.1822	0.4423
	2708-090326-MW9-29-102	26-Mar-09		0.02	0.003 U	0.005 J	-	-	0.0591	0.1871
	2708-090813-MW-9-29-120	13-Aug-09		0.201 J	0.005 U	0.01 U	-	-	0.0475	0.2236

Table 2
Summary of Historical Analytical Results for Groundwater Samples

Gasco Property Well Number	HAI Sample Number[1]	Sample Date	Screen Interval (feet bgs)	EPA Method 9012A, 9010A, D4282-95M, 335.4, SM-4500-CN[+], or OIA-1677[++] (mg/l [ppm])					EPA Method 8270 SIM or 8270C (ug/l [ppb])	
				Total Cyanide	Amenable Cyanide	Free Cyanide	WAD Cyanide[+]	Available Cyanide[++]	Carcinogenic PAHs	Total PAHs
MW-10-25	951207-MW10-25-01	7-Dec-95	14 - 24 (fill WBZ)	-	-	-	-	-	18.	13,316.5
	960320-MW10-25-01	20-Mar-96		0.07	-	-	-	-	5.9	9,126.31
	960617-MW10-25-01	17-Jun-96		0.01 U	-	-	-	-	6.79	10,266.09
	960930-MW10-25-01	30-Sep-96		0.204	-	-	-	-	78.6	10,529.5
	970225-MW10-25-01	25-Feb-97		0.01	-	-	-	-	74.3	9,841.3
	970827-MW10-25-01	27-Aug-97		-	-	-	-	-	19.6	7,047.1
	980216-MW10-25-01	16-Feb-98		0.02 U	-	-	-	-	58.1	9,165.2
	980601-MW10-25-02	1-Jun-98		0.21	-	-	-	-	35.1	12,161.9
	061213-MW-10-25-131	13-Dec-06		0.07	0.002 U	0.006 J	-	-	212.	14,463.
	2708-080604-MW10-25-	4-Jun-08		0.04	0.002 UJ	0.005 J	-	-	7.84	9,435.84
	2708-080917-MW-10-25-	17-Sep-08		0.07	0.002 U	0.005 J	-	-	1,017.	19,257.
	2708-090326-MW10-25-	26-Mar-09		0.07	0.003 U	0.008 J	-	-	791.	11,761.
	2708-090813-MW-10-25-	13-Aug-09		0.0612 J	0.005 U	0.01 U	-	-	442.97	4,188.47
MW-10-61	951206-MW10-61-01	6-Dec-95	50 - 60 (alluvial WBZ)	-	-	-	-	-	0.72	829.72
	960321-MW10-61-01	21-Mar-96		0.01 U	-	-	-	-	2.55	102.43
	960620-MW10-61-01	20-Jun-96		0.01 U	-	-	-	-	2.	45.52
	961002-MW10-61-01	2-Oct-96		0.01 U	-	-	-	-	1.5	25.15
	970226-MW10-61-01	26-Feb-97		0.01 U	-	-	-	-	1.04	18.02
	970828-MW10-61-01	28-Aug-97		0.02 U	-	-	-	-	0.39	7.76
	980218-MW10-61-01	18-Feb-98		0.02 U	-	-	-	-	0.4	3.76
	980603-MW10-61-16	3-Jun-98		0.02 U	-	-	-	-	1.55	6.18
	981117-MW10-61-08	17-Nov-98		0.02 U	-	-	-	-	3.06	5.85
	990512-MW10-61-06	12-May-99		0.02 U	-	-	-	-	0.57	1.3
	991026-MW10-61-05	26-Oct-99		0.02 U	0.02 U	-	-	-	0.24	1.36
	000329-MW10-61-105	29-Mar-00		0.02 U	0.02 U	-	-	-	0.24	1.09
	011010-MW10-61-109	10-Oct-01		0.02 U	-	-	-	-	ND	0.61
	020404-MW10-61-109	4-Apr-02		0.04 U	0.04 U	-	-	-	0.11	0.84
	020924-MW10-61-104	24-Sep-02		0.04 U	-	-	-	-	0.25	1.38
	030319-MW10-61-111	19-Mar-03		0.04 U	0.04 U	-	-	-	ND	0.95
	031003-MW10-61-108 [7]	3-Oct-03		-	0.02 U	-	-	-	ND	ND
	040813-MW10-61-005 [7]	13-Aug-04		0.0614	0.0321	-	-	-	0.104	0.527
	050928-MW10-61-121	28-Sep-05		0.01 U	0.01 U	-	-	-	1.43	2.5692
	061017-MW-10-61-108	17-Oct-06		0.002 J	0.002 U	0.005 U	-	-	1.255	2.433
	2708-080604-MW10-61-	4-Jun-08		0.003	0.002 UJ	0.003 J	-	-	0.3251	0.7281
	2708-080917-MW-10-61-	17-Sep-08		0.003 J	0.003 J	0.003 U	-	-	5.3	10.004
	2708-090326-MW10-61-	26-Mar-09		0.003 U	0.003 U	0.004 J	-	-	1.792	2.9
	2708-090813-MW-10-61-	13-Aug-09		0.0059 J	0.005 U	0.01 U	-	-	2.1816	5.759
MW-11-32	951207-MW11-32-01	7-Dec-95	21 - 31 (fill WBZ)	-	-	-	-	-	20.	22,365.2
	960320-MW11-32-01	20-Mar-96		0.24	-	-	-	-	6.33	14,676.08
	960617-MW11-32-01	17-Jun-96		0.19	-	-	-	-	13.51	11,608.31
	960930-MW11-32-01	30-Sep-96		0.249	-	-	-	-	131.9	17,603.9
	960930-MW11-32-02	30-Sep-96		-	-	-	-	-	189.	18,894.
	970225-MW11-32-01	25-Feb-97		0.22	-	-	-	-	10.7	11,536.1
	970826-MW11-32-01	26-Aug-97		0.17	-	-	-	-	20.5	17,075.8
	980216-MW11-32-01	16-Feb-98		0.2	0.01 U	-	-	-	15.9	9,759.2
	980601-MW11-32-03	1-Jun-98		0.21	0.01 U	-	-	-	112.	32,376.
	061212-MW-11-32-130	12-Dec-06		0.25	0.01 U	0.005 U	-	-	67.	19,026.
	2708-080604-MW11-32-	4-Jun-08		0.13	0.002 UJ	0.005	-	-	77.4	16,029.4
	2708-080917-MW-11-32-	17-Sep-08		0.17	0.002 U	0.007 J	-	-	########	207,160.
	2708-090402-MW11-32-	2-Apr-09		0.25	0.03 J	0.003 UJ	-	-	820.	27,508.
	2708-090811-MW-11-32-	11-Aug-09		0.0826	0.05 U	0.01 U	-	-	842.	24,574.
MW-12-36	951207-MW12-36-01	7-Dec-95	25 - 35 (fill/alluvial WBZ)	-	-	-	-	-	3.65	3,377.55
	960321-MW12-36-01	21-Mar-96		0.01 U	-	-	-	-	0.73	2,010.03
	960620-MW12-36-01	20-Jun-96		0.01 U	-	-	-	-	0.8	1,621.2
	961002-MW12-36-01	2-Oct-96		0.01 U	-	-	-	-	0.8	1,374.8
	970226-MW12-36-01	26-Feb-97		0.01 U	-	-	-	-	0.94	1,032.64
	970828-MW12-36-01	28-Aug-97		0.02 U	-	-	-	-	0.67	839.77
	980218-MW12-36-01	18-Feb-98		0.02 U	-	-	-	-	0.69	708.27
	980603-MW12-36-17	3-Jun-98		0.02 U	-	-	-	-	ND	697.
	981119-MW12-36-18	19-Nov-98		0.02 U	-	-	-	-	0.79	487.13
	990513-MW12-36-12	13-May-99		1.1	-	-	-	-	0.53	491.4
	991028-MW12-36-18	28-Oct-99		0.02 U	0.02 U	-	-	-	0.7	546.03
	000330-MW12-36-118	30-Mar-00		0.02 U	0.02 U	-	-	-	1.74	648.98
	010329-MW12-36-117	29-Mar-01		0.02 U	0.02 U	-	-	-	0.69	415.04
	020404-MW12-36-112	4-Apr-02		0.04 U	0.04 U	-	-	-	0.5	375.88
	030319-MW12-36-113	19-Mar-03		0.04 U	0.04 U	-	-	-	0.31	369.18
	040825-MW12-36-017 [7]	25-Aug-04		0.005 U	0.005 U	-	-	-	ND	696.31
	050927-MW-12-36-116	27-Sep-05		0.01 U	0.01 U	-	-	-	0.2529	371.9952
	061024-MW-12-36-115	24-Oct-06		0.004 J	0.002 J	0.005 U	-	-	0.1223	591.2071
	2708-080604-MW12-36-	4-Jun-08		0.004	0.002 UJ	0.004 J	-	-	0.4662	226.8522
	2708-080916-MW-12-36-	16-Sep-08		0.002 U	0.002 J	0.003 U	-	-	0.2359	739.9925
	2708-090402-MW12-36-	2-Apr-09		0.003 U	0.003 UJ	0.003 UJ	-	-	0.2798	193.279
	2708-090817-MW-12-36-	17-Aug-09		0.0025 U	0.005 U	0.01 UJ	-	-	ND U	1,035.6

Table 2
Summary of Historical Analytical Results for Groundwater Samples

Gasco Property Well Number	HAI Sample Number[1]	Sample Date	Screen Interval (feet bgs)	EPA Method 9012A, 9010A, D4282-95M, 335.4, SM-4500-CN[+], or OIA-1677[++] (mg/l [ppm])					EPA Method 8270 SIM or 8270C (ug/l [ppb])	
				Total Cyanide	Amenable Cyanide	Free Cyanide	WAD Cyanide[+]	Available Cyanide[++]	Carcinogenic PAHs	Total PAHs
MW-13-30	980217-MW13-30-01	17-Feb-98	19 - 29 (fill WBZ)	0.28	0.01 U	-	-	-	ND	426.1
	980602-MW13-30-12	2-Jun-98		0.28	0.01 U	-	-	-	ND	1,180.9
	980826-MW13-30-11	26-Aug-98		0.42	0.42	-	-	-	ND	742.3
	981119-MW13-30-19	19-Nov-98		0.28	0.02	-	-	-	ND	399.
	990217-MW13-30-014	17-Feb-99		0.095	0.02 U	-	-	-	ND	770.59
	990513-MW13-30-13	13-May-99		0.12	-	-	-	-	ND	1,035.62
	991028-MW13-30-20	28-Oct-99		0.02	0.02 U	-	-	-	ND	820.
	000403-MW13-30-120	3-Apr-00		0.14	0.02 U	-	-	-	ND	720.84
	001005-MW13-30-18	5-Oct-00		-	0.02 U	-	-	-	ND	410.3
	010329-MW13-30-119	29-Mar-01		0.046	0.037	-	-	-	ND	522.96
	020405-MW13-30-116	5-Apr-02		0.04 U	0.04 U	-	-	-	ND	451.65
	030319-MW13-30-115	19-Mar-03		0.1	0.04 U	-	-	-	ND	1,008.4
	040825-MW13-30-018 [7]	25-Aug-04		0.1	0.0552	-	-	-	ND	354.41
	051003-MW-13-30-132	3-Oct-05		0.0889	0.0703	-	-	-	ND	568.47
	060404-MW-13-30-122	4-Apr-06		0.112	0.0751	0.0013 U	-	-	ND	931.34
	061027-MW-13-30-121	27-Oct-06		0.13	0.02	0.005 U	-	-	ND	477.2
	2708-080604-MW13-30-	4-Jun-08		0.1	0.002 UJ	0.004	-	-	########	##########
MW-13-61	980218-MW13-61-01	18-Feb-98	50 - 60 (alluvial WBZ)	0.14	0.01 U	-	-	-	ND	ND
	980602-MW13-61-13	2-Jun-98		0.13	0.01 U	-	-	-	ND	ND
	980825-MW13-61-03	25-Aug-98		0.15	0.09	-	-	-	ND	ND
	981116-MW13-61-03	16-Nov-98		0.15	0.15	-	-	-	ND	0.2
	990512-MW13-61-04	12-May-99		0.069	-	-	-	-	ND	0.26
	991026-MW13-61-03	26-Oct-99		0.11	0.02 U	-	-	-	ND	0.62
	000328-MW13-61-104	28-Mar-00		0.087	0.04	-	-	-	ND	ND
	001004-MW13-61-03	4-Oct-00		-	0.02 U	-	-	-	ND	0.68
	010327-MW13-61-103	27-Mar-01		0.088	0.02 U	-	-	-	ND	ND
	011009-MW13-61-106	9-Oct-01		0.19	-	-	-	-	ND	0.28
	020403-MW13-61-102	3-Apr-02		0.206	0.04 U	-	-	-	ND	ND
	020924-MW13-61-106	24-Sep-02		-	-	-	-	-	ND	ND
	030317-MW13-61-101	17-Mar-03		0.13	0.04 U	-	-	-	ND	ND
	031003-MW13-61-109 [7]	3-Oct-03		-	0.02 U	-	-	-	ND	ND
	040813-MW13-61-003 [7]	13-Aug-04		0.125	0.0423	-	-	-	ND	0.283
	050927-MW-13-61-114	27-Sep-05		0.089	0.01 U	-	-	-	1.263	14.927
	060404-MW-13-61-123	4-Apr-06		0.106	0.0399	0.0013 U	-	-	3.435	24.141
MW-14-110	981116-MW14-110-06	16-Nov-98	98 - 108 (alluvial WBZ)	0.05	-	-	-	-	ND	ND
	990216-MW14-110-005	16-Feb-99		0.04	0.02 U	-	-	-	ND	0.11
	990512-MW14-110-09	12-May-99		0.029	0.029	-	-	-	ND	0.28
	990823-MW14-110-06	23-Aug-99		0.045	0.02 U	-	-	-	ND	0.41
	991027-MW14-110-09	27-Oct-99		0.035	0.02 U	-	-	-	ND	0.26
	991027-MW14-110-10	27-Oct-99		0.028	0.02 U	-	-	-	ND	0.26
	000329-MW14-110-109	29-Mar-00		0.03	0.02 U	-	-	-	ND	0.42
	000329-MW14-110-110	29-Mar-00		0.034	0.02 U	-	-	-	ND	0.42
	000615-MW14-110-102	15-Jun-00		-	0.02 U	-	-	-	ND	0.18
	001005-MW14-110-06	5-Oct-00		-	0.02 U	-	-	-	ND	ND
	001220-MW14-110-102	20-Dec-00		-	0.02 U	-	-	-	ND	0.14
	010328-MW14-110-108	28-Mar-01		0.02 U	0.02 U	-	-	-	ND	0.23
	010628-MW14-110-102	28-Jun-01		-	0.025	-	-	-	-	-
	011009-MW14-110-105	9-Oct-01		0.05	-	-	-	-	ND	ND
	011213-MW14-110-101	13-Dec-01		-	0.02 U	-	-	-	ND	ND
	020404-MW14-110-108	4-Apr-02		0.04 U	0.04 U	-	-	-	ND	ND
	020711MW14-110-101	11-Jul-02		0.04 U	0.04 U	-	-	-	ND	ND
	020924-MW14-110-105	24-Sep-02		-	-	-	-	-	ND	ND
	021217-MW14-110-102	17-Dec-02		-	0.04 U	-	-	-	ND	ND
	030318-MW14-110-108	18-Mar-03		0.04 U	0.04 U	-	-	-	ND	ND
	030602-MW14-110-101	2-Jun-03		-	0.04 U	-	-	-	ND	ND
	031003-MW14-110-110 [7]	3-Oct-03		-	0.02 U	-	-	-	ND	ND
	030112-MW-14-110-101 [7]	12-Jan-04		-	0.02 U	-	-	-	ND	ND
	040824-MW14-110-014 [7]	24-Aug-04		0.0154	0.0154	-	-	-	ND	0.0828
	050922-MW-14-110-104	22-Sep-05		0.0208	0.005 U	-	-	-	ND	0.2008
	061013-MW-14-110-104	13-Oct-06		-	0.04	0.005 U	-	-	0.158	0.5584
	2708-080603-MW14-110-	3-Jun-08		0.02	0.002 U	0.003 J	-	-	0.1749	0.4602
	2708-080916-MW-14-110-	16-Sep-08		0.002 U	0.002 U	0.003 J	-	-	0.897	1.668
	2708-090326-MW14-110-	26-Mar-09		0.03	0.003 U	0.004 J	-	-	0.14	0.699
	2708-090812-MW-14-110-	12-Aug-09		0.0223	0.005 U	0.01 U	-	-	ND U	0.341

Table 2
Summary of Historical Analytical Results for Groundwater Samples

Gasco Property Well Number	HAI Sample Number[1]	Sample Date	Screen Interval (feet bgs)	EPA Method 9012A, 9010A, D4282-95M, 335.4, SM-4500-CN[+], or OIA-1677[++] (mg/l [ppm])					EPA Method 8270 SIM or 8270C (ug/l [ppb])	
				Total Cyanide	Amenable Cyanide	Free Cyanide	WAD Cyanide[+]	Available Cyanide[++]	Carcinogenic PAHs	Total PAHs
MW-15-50	990728-MW15-50-04	28-Jul-99	40 - 50 (silt unit/alluvial WBZ)	0.02 U	0.02 U	-	-	-	ND	18,460.
	991029-MW15-50-25	29-Oct-99		0.15	0.02 U	-	-	-	ND	762.
	000403-MW15-50-125	3-Apr-00		0.065	0.02 U	-	-	-	3.31	5,610.74
	000615-MW15-50-105	15-Jun-00		-	0.02 U	-	-	-	267.65	474.75
	000615-MW15-50-106	15-Jun-00		-	0.02 U	-	-	-	253.67	450.94
	001005-MW15-50-14	5-Oct-00		-	0.02 U	-	-	-	74.38	128.96
	001221-MW15-50-105	21-Dec-00		-	0.028	-	-	-	158.93	9,661.17
	001221-MW15-50-106	21-Dec-00		-	0.062	-	-	-	199.16	8,730.64
	010330-MW15-50-124	30-Mar-01		0.151	0.089	-	-	-	87.5	7,233.48
	010628-MW15-50-105	28-Jun-01		-	0.089	-	-	-	-	-
	010628-MW15-50-106	28-Jun-01		-	0.105	-	-	-	-	-
	011010-MW15-50-111	10-Oct-01		0.11	-	-	-	-	14.52	3,839.07
	011010-MW15-50-112	10-Oct-01		0.07	-	-	-	-	48.2	59,423.3
	011214-MW15-50-104	14-Dec-01		-	0.02 U	-	-	-	0.98	4,667.24
	011214-MW15-50-105	14-Dec-01		-	0.02 U	-	-	-	1.27	6,035.38
	020405-MW15-50-119	5-Apr-02		0.102	0.04 U	-	-	-	9.76	4,353.97
	020711-MW15-50-104	11-Jul-02		0.04 U	0.04 U	-	-	-	15.5	3,795.9
	020711-MW15-50-105	11-Jul-02		0.04 U	0.04 U	-	-	-	24.8	5,788.
	020925-MW15-50-110	25-Sep-02		0.072	-	-	-	-	65.3	8,044.4
	020925-MW15-50-111	25-Sep-02		0.076	-	-	-	-	17.2	7,971.3
	021218-MW15-50-107	18-Dec-02		-	0.04 U	-	-	-	42.	7,494.
	030321-MW15-50-122	21-Mar-03		0.07	0.04 U	-	-	-	ND	5,042.
	030603-MW15-50-105	3-Jun-03		-	0.15	-	-	-	ND	3,405.
	031006-MW15-50-113 [7]	6-Oct-03		-	0.02	-	-	-	ND	4,804.3
	030113-MW-15-50-105 [7]	13-Jan-04		-	0.02 U	-	-	-	ND	4,765.
	030113-MW-15-50-106 [7]	13-Jan-04		-	0.02 U	-	-	-	ND	3,650.
	040825-MW15-50-020 [7]	25-Aug-04		0.46	0.418	-	-	-	ND	6,359.5
	050929-MW-15-50-126	29-Sep-05		0.488	0.39	-	-	-	46.23	2,300.08
	061031-MW-15-50-127	31-Oct-06		0.52	0.41	0.005 U	-	-	89.6	3,883.
	2708-080603-MW15-50-	3-Jun-08		0.11	0.02	0.003 U	-	-	54.6	6,878.3
	2708-080916-MW-15-50-	16-Sep-08		0.35	0.23	0.004 J	-	-	80.3	4,827.3
	2708-090402-MW15-50-	2-Apr-09		0.16	0.09 J	0.003 UJ	-	-	34.36	6,356.86
	2708-090817-MW-15-50-	17-Aug-09		0.308	0.21	0.01 UJ	-	-	18.77	6,424.87
MW-15-66	990728-MW15-66-03	28-Jul-99	60.5 - 66.5 (alluvial WBZ)	0.02 U	0.02 U	-	-	-	0.83	2.46
	990823-MW15-66-04	23-Aug-99		-	-	-	-	-	-	-
	991026-MW15-66-07	26-Oct-99		0.02 U	0.02 U	-	-	-	ND	ND
	000329-MW15-66-108	29-Mar-00		0.02 U	0.02 U	-	-	-	3.91	6.93
	000615-MW15-66-104	15-Jun-00		-	0.02 U	-	-	-	12.17	22.05
	001005-MW15-66-08	5-Oct-00		-	0.02 U	-	-	-	1.36	2.34
	001221-MW15-66-104	21-Dec-00		-	0.02 U	-	-	-	0.7	1.24
	010328-MW15-66-107	28-Mar-01		0.02 U	0.02 U	-	-	-	0.61	1.1
	010628-MW15-66-104	28-Jun-01		-	0.02 U	-	-	-	-	-
	011010-MW15-66-110	10-Oct-01		0.02 U	-	-	-	-	ND	ND
	011213-MW15-66-103	13-Dec-01		-	0.02 U	-	-	-	ND	ND
	020404-MW15-66-107	4-Apr-02		0.04 U	0.04 U	-	-	-	ND	0.12
	020711-MW15-66-103	11-Jul-02		0.04 U	0.04 U	-	-	-	ND	ND
	020925-MW15-66-109	25-Sep-02		0.04 U	-	-	-	-	ND	ND
	021218-MW15-66-105	18-Dec-02		-	0.04 U	-	-	-	ND	ND
	021218-MW15-66-106	18-Dec-02		-	0.04 U	-	-	-	ND	ND
	030318-MW15-66-107	18-Mar-03		0.04 U	0.08 U	-	-	-	ND	0.1
	030603-MW15-66-104	3-Jun-03		-	0.04 U	-	-	-	4.	7.41
	031006-MW15-66-112 [7]	6-Oct-03		-	0.02 U	-	-	-	ND	ND
	030113-MW-15-66-104 [7]	13-Jan-04		-	0.02 U	-	-	-	1.33	1.82
	040813-MW15-66-006 [7]	13-Aug-04		0.005 U	0.005 U	-	-	-	ND	ND
	050929-MW-15-66-125	29-Sep-05		0.01 U	0.01 U	-	-	-	0.2032	0.4482
	061017-MW-15-66-109	17-Oct-06		0.002 U	-	0.005 U	-	-	50.	83.41
	2708-080603-MW15-66-	3-Jun-08		0.002 U	0.002 U	0.003 U	-	-	0.781	1.3539
	2708-080916-MW-15-66-	16-Sep-08		0.002 U	0.002 U	0.003 U	-	-	0.3672	21.8502
	2708-090402-MW15-66-	2-Apr-09		0.003 U	0.003 UJ	0.003 UJ	-	-	0.0522	0.2811
	2708-090817-MW-15-66-	17-Aug-09		0.0075 U	0.015 U	0.01 UJ	-	-	0.0529	0.6072
MW-16-45	040826-MW16-45-028 [7]	26-Aug-04	30 - 45 (alluvial WBZ)	0.138	0.0725	-	-	-	10.77	7,946.17
	041222-MW16-45-103 [7]	22-Dec-04		-	0.154	-	-	-	16.08	8,492.11
	050401-013	1-Apr-05		-	0.0663	-	-	-	6.892	6,353.179
	0506-22-05	21-Jun-05		-	0.1	-	-	-	44.95	10,997.45
	051003-MW-16-45-136	3-Oct-05		0.131	0.0528	-	-	-	236.8	9,774.9
	060403-MW-16-45-118	3-Apr-06		0.117	0.0188	0.0013 U	-	-	3,028.5	53,847.5
	061212-MW-16-45-129	12-Dec-06		0.14	0.01 U	0.005 U	-	-	21.3	11,429.3
	2708-070731-MW-16-45-	31-Jul-07		0.412	0.276	0.003 U	-	-	########	145,371.
	2708-080521-MW16-45-	21-May-08		0.51	0.002 U	0.005	-	-	256.5	6,538.5
	2708-080917-MW-16-45-	17-Sep-08		0.67	0.06 J	0.006 J	-	-	968.	19,038.
	2708-090402-MW16-45-	2-Apr-09		0.38	0.12 J	0.003 UJ	-	-	6,170.	82,240.
	2708-090814-MW-16-45-	14-Aug-09		0.306 J	0.005 U	0.01 U	-	-	ND	11,158.

Table 2
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Gasco Property Well Number	HAI Sample Number[1]	Sample Date	Screen Interval (feet bgs)	EPA Method 9012A, 9010A, D4282-95M, 335.4, SM-4500-CN[+], or OIA-1677[++] (mg/l [ppm])					EPA Method 8270 SIM or 8270C (ug/l [ppb])	
				Total Cyanide	Amenable Cyanide	Free Cyanide	WAD Cyanide[+]	Available Cyanide[++]	Carcinogenic PAHs	Total PAHs
MW-16-65	040826-MW16-65-026 [7]	26-Aug-04	55 - 65 (alluvial WBZ)	0.402	0.186	-	-	-	0.541	3,838.121
	040826-MW16-65-027 [7]	26-Aug-04		-	-	-	-	-	0.756	4,098.676
	041222-MW16-65-102 [7]	22-Dec-04		-	0.201	-	-	-	ND	0.1
	050331-006	31-Mar-05		-	0.175	-	-	-	0.664	5,058.574
	0506-21-04	21-Jun-05		-	0.219	-	-	-	ND	5,928.06
	051003-MW-16-65-134	3-Oct-05		0.25	0.0854	-	-	-	ND	3,060.92
	060403-MW-16-65-119	3-Apr-06		0.301	0.127	0.0149	-	-	ND	3,321.77
	061023-MW-16-65-114	23-Oct-06		0.31	0.002 U	0.005 U	-	-	0.3531	2,623.4741
	2708-070628-MW-16-65-	28-Jun-07		0.18 J	0.18 J	0.003 UJ	-	-	3.319	903.849
	2708-080513-MW16-65-	13-May-08		0.42	0.1	0.009 J	-	-	2.685	2,710.295
	2708-080911-MW-16-65-	11-Sep-08		0.28	0.01 U	0.007 J	-	-	2.941	1,308.491
	2708-090330-MW16-65-	30-Mar-09		0.24 J	0.02 J	0.003 U	-	-	1.536	1,792.016
	2708-090813-MW-16-65-	13-Aug-09		0.27 J	0.005 U	0.01 U	0.0321	0.0027	ND U	4,948.2
	2708-090813-MW-16-65-	13-Aug-09		0.248 J	0.005 U	0.01 U	0.0377	0.0033	ND U	5,188.7
MW-16-125	040826-MW16-125-025 [7]	26-Aug-04	115-125 (alluvial WBZ)	0.0943	0.0747	-	-	-	ND	36.883
	041221-MW16-125-100 [7]	21-Dec-04		-	0.0598	-	-	-	ND	10.216
	050330-001	30-Mar-05		-	0.0554	-	-	-	ND	10.65
	0506-21-03	21-Jun-05		-	0.0455	-	-	-	ND	4.67
	050930-MW-16-125-130	30-Sep-05		0.0775	0.0702	-	-	-	0.0328	5.0428
	060330-MW-16-125-109	30-Mar-06		0.0777	0.0272	0.0016	-	-	0.0755	7.5515
	061016-MW-16-125-106	16-Oct-06		0.13	0.01	0.005 U	-	-	0.059	2.737
	2708-070628-MW-16-125-	28-Jun-07		0.114 J	0.108 J	0.003 UJ	-	-	0.04765	0.82765
	2708-080515-MW16-125-	15-May-08		0.16	0.002 U	0.006 J	-	-	25.96	1,502.26
MW-17-79	050926-MW-17-79-110	26-Sep-05	38.5 - 78.5 (alluvial WBZ)	0.814	0.045	-	-	-	ND	49.531
	061026-MW-17-79-119	26-Oct-06		1.	0.15	0.005 U	-	-	0.23	6.916
	2708-070627-MW-17-79-	27-Jun-07		0.831	0.433	0.0178	-	-	0.1139	2.0109
	2708-080514-MW17-79-	14-May-08		0.81	0.02	0.008 J	-	-	0.1976	7.4686
	2708-080911-MW-17-79-	11-Sep-08		0.81	0.04 J	0.011	-	-	0.2338	7.4838
	2708-081209-MW-17-79-	9-Dec-08		0.89	0.03	0.024	-	-	0.1937	8.1177
	2708-090326-MW17-79-	26-Mar-09		0.79	0.08 J	0.023	-	-	0.1173	7.4559
	2708-090817-MW-17-79-	17-Aug-09		0.82	0.01 U	0.01 UJ	-	-	0.6253	10.2231
MW-18-30	2708-070731-MW-18-30-	31-Jul-07	19 - 29	1.65	0.895	0.003	-	-	-	-
	2708-080514-MW18-30-	14-May-08		2.22	0.002 U	0.006 J	-	-	########	##########
	NS (Dry)	17-Sep-08		-	-	-	-	-	-	-
	NS (Dry)	9-Dec-08		-	-	-	-	-	-	-
	2708-090402-MW18-30-	2-Apr-09		1.69	0.2 J	0.003 UJ	-	-	######## J	169,310. J
	2708-090812-MW-18-30-	12-Aug-09		1.48 U	0.005 U	0.01 U	-	-	ND J	14,395. J
MW-18-180	2708-070628-MW-18-180-	28-Jun-07	170 - 180	0.0242 J	0.0201 J	0.003 UJ	-	-	ND	0.575
	2708-080513-MW18-180-	13-May-08		0.03	0.02	0.003 J	-	-	0.0032	0.1692
	2708-080911-MW-18-180-	11-Sep-08		0.04	0.02	0.006 J	-	-	0.012	0.2981
	2708-081209-MW-18-180-	9-Dec-08		0.03	0.002 U	0.01	-	-	0.0075	0.1188
	2708-090326-MW18-180-	26-Mar-09		0.03	0.003 U	0.007 J	-	-	0.0033	0.1296
	2708-090817-MW-18-180-	17-Aug-09		0.0412	0.005 U	0.01 UJ	-	-	ND U	2.1915
MW-19-22	2708-070730-MW-19-22-	30-Jul-07	12 - 22	0.121	0.0777	0.003 U	-	-	5,473.	17,922.
	2708-080513-MW19-22-	13-May-08		0.12	0.01	0.004 J	-	-	1,896.	5,221.
	2708-080910-MW-19-22-	10-Sep-08		0.12	0.07 J	0.007 J	-	-	1,235.	3,883.
	2708-081209-MW-19-22-	9-Dec-08		0.14	0.002 U	0.013	-	-	625.	1,977.
	2708-090330-MW19-22-	30-Mar-09		0.07 J	0.01 J	0.003 U	-	-	225.9	871.5
	2708-090817-MW-19-22-	17-Aug-09		0.1	0.005 U	0.01 UJ	-	-	2,656.9	8,445.
MW-19-125	2708-070627-MW-19-125-	27-Jun-07	115 - 125	0.0755	0.0622	0.0087	-	-	0.0126	3.1226
	2708-080514-MW19-125-	14-May-08		0.23	0.01	0.007 J	-	-	0.011	49.207
	2708-080910-MW-19-125-	10-Sep-08		0.15	0.002 UJ	0.004 J	-	-	0.0088	27.1384
	2708-081209-MW-19-125-	9-Dec-08		0.1 J	0.005 J	0.011	-	-	0.0132	15.1788
	2708-090330-MW19-125-	30-Mar-09		0.08 J	0.08 J	0.003 U	-	-	0.0105	8.0432
	2708-090813-MW-19-125-	13-Aug-09		0.0827 J	0.005 U	0.01 U	-	-	ND U	9.05
MW-19-180	2708-070627-MW-19-180-	27-Jun-07	170 - 180	0.0172	0.0076	0.003 U	-	-	ND	0.0954
	2708-080513-MW19-180-	13-May-08		0.02	0.01	0.003 J	-	-	0.0035	0.1479
	2708-080910-MW-19-180-	10-Sep-08		0.02	0.02 J	0.005 J	-	-	ND	0.1219
	2708-081209-MW-19-180-	9-Dec-08		0.02	0.01	0.012	-	-	ND	0.031
	2708-090330-MW19-180-	30-Mar-09		0.02 J	0.003 U	0.003 U	-	-	ND U	0.014
	2708-090813-MW-19-180-	13-Aug-09		0.0255 J	0.005 U	0.01 U	-	-	ND U	0.755
MW-20-120	2708-070628-MW-20-120-	28-Jun-07	110 - 120	0.118	0.0548	0.003 UJ	-	-	ND	40.749
	2708-080515-MW20-120-	15-May-08		0.16	0.02	0.007 J	-	-	0.0276	120.4986
	2708-080910-MW-20-120-	10-Sep-08		0.14	0.002 U	0.005 J	-	-	0.0197	84.5787
	2708-081209-MW-20-120-	9-Dec-08		0.14	0.002 U	0.013	-	-	0.0153	51.5959
	2708-081209-MW-20-120-	9-Dec-08		0.14	0.002 U	0.014	-	-	0.0043	45.5743
	2708-090330-MW20-120-	30-Mar-09		0.15 J	0.003 U	0.006 U	-	-	ND U	86.3906
	2708-090812-MW-20-120-	12-Aug-09		0.119	0.005 U	0.01 U	-	-	ND U	59.

Table 2
Summary of Historical Analytical Results for Groundwater Samples

Gasco Property Well Number	HAI Sample Number[1]	Sample Date	Screen Interval (feet bgs)	EPA Method 9012A, 9010A, D4282-95M, 335.4, SM-4500-CN[+], or OIA-1677[++] (mg/l [ppm])					EPA Method 8270 SIM or 8270C (ug/l [ppb])	
				Total Cyanide	Amenable Cyanide	Free Cyanide	WAD Cyanide[+]	Available Cyanide[++]	Carcinogenic PAHs	Total PAHs
MW-21-12	2708-070719-MW-21-12-	19-Jul-07	7 - 12	0.0537	0.0211	0.0048	-	-	0.0921	12.7821
	2708-080514-MW21-12-	14-May-08		0.05	0.002 U	0.01 J	-	-	1.626	22.256
	NS (Dry)	15-Sep-08		-	-	-	-	-	-	-
	2708-081208-MW-21-12-	8-Dec-08		0.09	0.002 U	0.005 J	-	-	0.974	20.044
	2708-090401-MW21-12-	1-Apr-09		0.04	0.01 J	0.003 UJ	-	-	3.07	29.52
	2708-090811-MW-21-12-	11-Aug-09		0.0538	0.005 U	0.01 U	-	-	0.0431	12.0461
MW-21-75	2708-070718-MW-21-75-	18-Jul-07	65 - 75	0.0648 J	0.0537 J	0.0043 J	-	-	ND	0.135
	2708-080514-MW21-75-	14-May-08		0.12	0.02	0.009 J	-	-	0.0076	0.182
	2708-080915-MW-21-75-	15-Sep-08		0.09	0.01 U	0.012	-	-	ND	0.1527
	2708-081208-MW-21-75-	8-Dec-08		0.14	0.002 U	0.005 J	-	-	0.0038	0.1705
	2708-090331-MW21-75-	31-Mar-09		0.14 J	0.003 UJ	0.003 U	-	-	ND U	0.1343
	2708-090817-MW-21-75-	17-Aug-09		0.121	0.005 U	0.01 UJ	0.0187	0.002 U	ND U	0.844
MW-21-115	2708-070718-MW-21-115-	18-Jul-07	105 - 115	0.0123 J	0.0088 J	0.003 UJ	-	-	ND	0.0989
	2708-080515-MW21-115-	15-May-08		0.01	0.002 U	0.003 J	-	-	ND	0.0649
	2708-080915-MW-21-115-	15-Sep-08		0.02	0.002 U	0.003 U	-	-	0.0028	0.1259
	2708-081208-MW-21-115-	8-Dec-08		0.01	0.01	0.005 U	-	-	0.0067	0.0719
	2708-090331-MW21-115-	31-Mar-09		0.01 J	0.003 U	0.003 U	-	-	0.0534	0.2155
	2708-090811-MW-21-115-	11-Aug-09		0.0146	0.005 U	0.01 U	-	-	ND U	0.0722
MW-21-165	2708-070718-MW-21-165-	18-Jul-07	156 - 166	0.005 UJ	0.005 UJ	0.003 UJ	-	-	ND	0.0971
	2708-080514-MW21-166-	14-May-08		0.002 U	0.002 U	0.003 U	-	-	ND	0.1277
	2708-080915-MW-21-166-	15-Sep-08		0.02 U	0.002 U	0.003 U	-	-	ND	0.1061
	2708-081208-MW-21-166-	8-Dec-08		0.005 J	0.005 J	0.005 J	-	-	ND	0.0503
	2708-090331-MW21-165-	31-Mar-09		0.003 UJ	0.003 UJ	0.003 U	-	-	ND U	0.032
	2708-090811-MW-21-166-	11-Aug-09		0.0062	0.0062	0.01 U	-	-	ND U	0.181
PW-01	061012-PW-01-102	12-Oct-06	40 - 80	1.5	0.002 U	0.005 U	-	-	2.795	4,269.505
	2708-070731-PW-01-80-	31-Jul-07		1.31	0.75	0.0329	-	-	173.3	6,129.2
	2708-080604-PW01-80-107	4-Jun-08		1.45	0.002 UJ	0.019	-	-	11.72	3,239.62
	NS*	16-Sep-08		-	-	-	-	-	-	-
Temporary Well Point Samples 1995 (surficial fill WBZ)										
B-01	950921-BW1-01	21-Sep-95	20 - 23	7.8	-	-	-	-	0.09	175.71
B-05	950929-BW05-01	29-Sep-95	25 - 28	0.02 U	-	-	-	-	ND	34.78
B-08	950918-BW8-01	18-Sep-95	20.5 - 23.5	-	-	-	-	-	-	-
B-19	950920-BW19-01	20-Sep-95	10 - 13	-	-	-	-	-	-	-
B-19	950920-BW19-02	20-Sep-95	25 - 28	-	-	-	-	-	0.7	6,610.2
B-21	951003-BW21-01	3-Oct-95	15.5 - 19.5	-	-	-	-	-	2.93	726.25
B-31	950925-BW31-01	25-Sep-95	26 - 29	0.02 U	-	-	-	-	13.28	694.58
HydroPunch Samples 1998 (alluvial WBZ)										
MW-04-101	981014-BW4-01	14-Oct-98	86 - 86.5	-	-	-	-	-	-	-
	981015-BW4-02	15-Oct-98	110.5 - 111	-	-	-	-	-	-	-
MW-05-175	981020-BW5-03	20-Oct-98	52.5 - 53	-	-	-	-	-	-	-
	981020-BW5-04	20-Oct-98	52.5 - 53	-	-	-	-	-	-	-
	981020-BW5-05	20-Oct-98	72.5 - 73	-	-	-	-	-	-	-
	981020-BW5-06	20-Oct-98	94.5 - 95	-	-	-	-	-	-	-
MW-05-175	981021-BW5-07	21-Oct-98	122 - 122.5	-	-	-	-	-	-	-
	981021-BW5-08	21-Oct-98	152 - 152.5	-	-	-	-	-	-	-
Temporary Well Point Samples 2004										
B-56	040602-101	2-Jun-04	18 - 22	0.08	0.0343	-	-	-	45.52	317.6
	040603-102	3-Jun-04	40 - 44	0.517	0.105	-	-	-	0.1369	4.9419
	040603-103	3-Jun-04	60 - 64	0.406	0.0842	-	-	-	ND	63.903
	040603-104	3-Jun-04	80 - 84	0.506	0.107	-	-	-	0.16	358.961
	040603-105	3-Jun-04	80 - 84	-	-	-	-	-	ND	405.53
	040604-106	4-Jun-04	100 - 104	0.533	0.156	-	-	-	0.0895	0.939
	040614-115	14-Jun-04	136 - 140	0.006	0.005 U	-	-	-	0.521	9.56
	040614-116	14-Jun-04	174 - 178	0.0557	0.0319	-	-	-	ND	1.17
B-59	040611-108	11-Jun-04	46-50	-	-	-	-	-	-	-
	040611-109	11-Jun-04	76-80	-	-	-	-	-	-	-
	040611-110	11-Jun-04	96-100	-	-	-	-	-	-	-
	040611-112	11-Jun-04	116-120	-	-	-	-	-	-	-
	040611-113	11-Jun-04	144-148	-	-	-	-	-	-	-
	040614-114	14-Jun-04	171-175	-	-	-	-	-	-	-

Table 2
Summary of Historical Analytical Results for Groundwater Samples

Gasco Property Well Number	HAI Sample Number[1]	Sample Date	Screen Interval (feet bgs)	EPA Method 9012A, 9010A, D4282-95M, 335.4, SM-4500-CN[+], or OIA-1677[++] (mg/l [ppm])					EPA Method 8270 SIM or 8270C (ug/l [ppb])	
				Total Cyanide	Amenable Cyanide	Free Cyanide	WAD Cyanide[+]	Available Cyanide[++]	Carcinogenic PAHs	Total PAHs
Quality Control Samples (HAI)										
TB	2708-080512-TB1-37492	12-May-08		-	-	-	-	-	-	-
	2708-080513-TB2-37493	13-May-08		-	-	-	-	-	-	-
	2708-080514-TB3-37552	14-May-08		-	-	-	-	-	-	-
	2708-080515-TB4-37553	15-May-08		-	-	-	-	-	-	-
	TB5-37589	21-May-08		-	-	-	-	-	-	-
	2708-080603-TB-37649	3-Jun-08		-	-	-	-	-	-	-
	2708-080604-TB6-37648	4-Jun-08		-	-	-	-	-	-	-
	2708-080910-TB-38520	10-Sep-08		-	-	-	-	-	-	-
	2708-080911-TB-38519	11-Sep-08		-	-	-	-	-	-	-
	2708-080915-TB-38518	15-Sep-08		-	-	-	-	-	-	-
	2708-080916-TB 38517	16-Sep-08		-	-	-	-	-	-	-
	2708-080917-TB 38516	17-Sep-08		-	-	-	-	-	-	-
	2708-081208-TB-39353	8-Dec-08		-	-	-	-	-	-	-
	2708-081209-TB-39350	9-Dec-08		-	-	-	-	-	-	-
	2708-090326-TB39765	26-Mar-09		-	-	-	-	-	-	-
	2708-090330-TB-39763	30-Mar-09		-	-	-	-	-	-	-
	2708-090331-TB39825	31-Mar-09		-	-	-	-	-	-	-
	2708-090401-TB39764	1-Apr-09		-	-	-	-	-	-	-
	2708-090402-TB39827	2-Apr-09		-	-	-	-	-	-	-
	5237-090407-TB39828	7-Apr-09		-	-	-	-	-	-	-
	5237-090408-TB39826	8-Apr-09		-	-	-	-	-	-	-
	5237-090409-TB40002	9-Apr-09		-	-	-	-	-	-	-
	2708-081109-TB-108	11-Aug-09		-	-	-	-	-	-	-
	2708-090812-TB-109	12-Aug-09		-	-	-	-	-	-	-
	2708-090813-TB-118	13-Aug-09		-	-	-	-	-	-	-
	2708-090817-TB-131	17-Aug-09		-	-	-	-	-	-	-
	2708-090820-TB-160	20-Aug-09		-	-	-	-	-	-	-

Notes:

-	not analyzed	ppb	parts per billion
#	Reference Level not established	ppm	parts per million
A	this analysis was performed on a VOA sample containing headspace	SCV	Secondary Chronic Value
AWQC	Ambient Water Quality Criteria	U	Non-detect above reporting detection limit
BTEX	benzene, toluene, ethylbenzene, and xylenes	U*	Compound considered non-detect because it was also detected in associated blank at similar concentration levels.
DEQ	Oregon Department of Environmental Quality	UJ	Compound not detected, but the reporting limit is probably higher due to a low bias identified during the quality assurance review.
EPA	U.S. Environmental Protection Agency	ug/l	micrograms per liter
J	Estimated Concentration		

Reference Level is lowest of EPA AWQC for aquatic life protection, AWQC for human consumption of organisms only, or DEQ SLV for aquatic receptors

1. Sample number prefix: 2708-
2. Tier II values were taken from Suter II, G.W. and Tasco, C.L., 1996. Toxilogical Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. ORNL publication ES/ER/TM-96/R2
3. Screening Level Values are from Portland Harbor Joint Source Control Strategy, Final, December 2005
4. Due to mislabeling in the field or due to laboratory misidentification, the laboratory report transposed results for MW4-35 and MW-4-57 in August 1997. Tables attribute data to the correct well.
5. Sample Numbers (980603-) MW4-57-18 & MW8-56-21 were analyzed for Amenable Cyanide outside of recommended holding time.
6. AH results for sample 960620-MW8-56-01 should be considered qualitative due to an apparent error concerning sample identity.
7. Monitoring well purged & sampled with low-flow protocol as per EPA/540/S-95/504 (April 1996)
8. EPA, under CERCLA authority, has identified the Safe Drinking Water Acts MCLs and AWQCs (federal and state once approved) as potential ARARs under CERCLA. The final determination will be made in the EPA Portland Harbor Record of Decision (ROD). Decisions to implement source control, prior to The EPA Portland Harbor ROD, due to an exceedance of an SLV in upland stormwater will be evaluated and prioritized on a case by case basis.

* Location PW-01 was converted to an extraction well following 2nd quarter of 2008.

APPENDIX P
HEALTH AND SAFETY PLAN

HEALTH AND SAFETY PLAN
GROUNDWATER SOURCE CONTROL
DRAFT FINAL DESIGN REPORT

Prepared for

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May 2011

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LIST OF ACRONYMS AND ABBREVIATIONS

AIR	Project Area Identification Report
AED	Automated External Defibrillator
AOC	Administrative Settlement Agreement and Order on Consent
AST	Aboveground Storage Tank
BTEX	benzene, toluene, ethylbenzene, xylenes
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CPR	cardiopulmonary resuscitation
CRZ	contamination reduction zone
CSO	combined sewer overflow
DNAPL	dense non-aqueous phase liquid
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
FC	Field Coordinator
FID	flame ionization detector
FSP	Field Sampling Plan
HASP	Health and Safety Plan
MFA	Maul Foster & Alongi, Inc.
MSDS	Material Safety Data Sheets
OSHA	Occupational Safety and Health Administration
OVM	organic vapor monitor
PAH	polycyclic aromatic hydrocarbon
PBRA	probable benthic risk area
PEC	project emergency coordinator
PEL	permissible exposure limit
PFD	personal flotation device
PID	photoionization detector
Portland Harbor Site	Portland Harbor Superfund Site
PPE	personal protective equipment
PM	project manager
ppm	parts per million
QAPP	Data Gaps Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act

RM	river mile
Siltronic	Siltronic Corporation
SOW	Statement of Work
SS	Site Supervisor
SSHO	Site Safety and Health Officer
TCE	trichloroethene
TPH	total petroleum hydrocarbons
TSD	Treatment, storage, and disposal
TZW	transition zone water
USACE	U.S. Army Corps of Engineers
vibracore	vibratory core sampler
VOCs	volatile organic compounds

1 INTRODUCTION

As part of the Groundwater Source Control Draft Final Design, NW Natural will be installing pumping wells, monitoring wells, and piezometers associated with the hydraulic containment system. Ongoing activities will also include groundwater sampling and general maintenance. Field activities covered under this HASP include subsurface drilling and well installation conducted from a drill rig operated from both a barge and onshore, well development, and well pump test activities. Methods for drilling and installing extraction wells, observation wells, and piezometers are outlined in detail in the *Draft Final Design Report*.

2 SITE DESCRIPTION AND PROJECT SCOPE

The "Gasco site" is a former oil gasification plant located at 7900 NW St. Helens Road, Portland, Oregon, 97210, and is bounded on the northeast by the Willamette River at River Mile (RM) 6 and on the southwest by State Highway 30 (St. Helens Road). The site is within the initial study area of the Portland Harbor Superfund site. It is adjacent to Wacker Siltronics Corporation and the U.S. Army Corps of Engineers (USACE) U.S. Moorings facilities. The site is currently used as a storage facility for liquefied natural gas.

Prior to 1941, wastewater effluent and tar-stills from the gasification process and by-product refining at the site were discharged to a stream channel leading from the production area to the Willamette River, or to low-lying areas of the Gasco site. Previous investigations identified the approximate limits of the tar residue on the river sediments adjacent to the site, "tar body," and characterized sediment conditions along the rest of the shoreline of the site. The scope of the current investigation is to drill and install extraction wells, observation wells, and piezometers; install pump; collect groundwater samples; monitor the system; and maintain capture of site groundwater.

3 HAZARD EVALUATION AND CONTROL MEASURES

This section covers potential chemical and physical hazards that may be associated with the proposed field activities and presents control measures to address these potential hazards. Section 3.4 and Table 1 present the activity hazard analysis, which lists the potential hazards associated with each site activity and the recommended site control to be used to minimize each potential hazard. Confined space entry will not be necessary for this project; therefore, hazards associated with this activity are not discussed in this HASP.

3.1 Exposure Routes

Potential routes of exposure to chemicals include inhalation, dermal contact, and ingestion of dust, mist, gas, vapor, or liquid. Exposure will be minimized by using safe work practices and by wearing the appropriate personal protective equipment (PPE). Further discussion of PPE requirements is presented in Section 6.

3.1.1 Inhalation

Inhalation of particulates, dust, mist, gas, or vapor during the planned activities is possible. Whenever possible the coring equipment will be oriented so that personnel are upwind of the coring location. An organic vapor monitor (OVM), photoionization detector (PID), or flame ionization detector (FID) will be used to monitor ambient air in the breathing zone within the work area for organic compounds. Section 8.2 and Table 2 describe OVM action levels and response procedures. A daily air monitoring log form is presented in Attachment 2.

3.1.2 Dermal Contact

Dermal contact with potentially contaminated soil, sediment, or groundwater during shoreline and vessel-based coring operations is possible. Direct contact will be minimized through the use of appropriate PPE and decontamination procedures.

3.1.3 Ingestion

Ingestion of contaminants is a less likely route of exposure than inhalation or dermal contact for many of the contaminants of concern. Direct ingestion of contaminants can occur by inhaling airborne dust, mist, or vapors or swallowing contaminants trapped in the upper respiratory tract. Indirect ingestion can occur by introducing the contaminants into the mouth by way of food, tobacco, fingers, or other carriers. Although ingestion of contaminants can occur, proper

decontamination/contamination reduction procedures should eliminate the probability of this route of exposure.

3.2 Chemical Hazards

Metals, volatile organic compounds (VOCs), petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), and free product sourced from manufactured gas plants (MGP) have been detected in water, sediment, and soils within the initial project area during past site activities. The minimum, mean, and maximum concentrations that may be encountered during the field activities for each chemical of concern identified in the *Final Project AIR and Data Gaps QAPP* for each media (sediments, soil, surface water, and groundwater and transition zone water) are summarized in Tables3a to 3d. In addition, there is some potential for exposure to hydrogen sulfide gas from native soil and hexane, which in rare cases may be used as a decontamination liquid.

3.2.1 VOCs

VOCs known to be present at the site include chlorinated VOCs [vinyl chloride, trichloroethylene (TCE), and 1,2-dichloroethane (1,2-DCE)] and volatile components of gasoline [benzene, toluene, ethylbenzene, and xylenes (BTEX)]. The primary exposure routes for VOCs during the planned activities are inhalation, dermal contact, and ingestion of contaminated soil, sediment, dust, or water.

VOCs readily volatilize and are primarily an inhalation concern. The BTEX compounds are known or suspected human carcinogens. Chlorinated volatile compounds are known to cause cancer in animals and the target organs primarily affected by prolonged exposure to chlorinated volatiles compounds are the central nervous system, liver, eyes and skin.

An OVM equipped with a photo-ionization detector will be used to monitor ambient air and the breathing zone for VOCs. Respiratory protection will be employed if elevated levels of organic compounds are measured by the OVM, if odors are present, or other conditions warrant its use. Air monitoring action levels are presented in Table 2.

3.2.2 Metals

The primary exposure routes for metals during the planned activities are inhalation or ingestion of dust particles. Metals may also be indirectly ingested, as described in Section 3.1.3. A

secondary route of exposure to metals is dermal contact. The target organs primarily affected by prolonged exposure to metals are the respiratory tract, gastrointestinal tract, central nervous system, kidneys, and liver.

Prolonged exposure to metals through any of the potential routes of exposure is not expected. Skin will be washed immediately when exposed to soil, sediment, dust, or water potentially impacted by metals.

3.2.3 TPHs

Total petroleum hydrocarbons (TPHs) likely at the project site include tar and oil related materials in sediments and soils, which contain benzene and aromatic hydrocarbons. Gasoline, diesel, fuel, and waste oil, and heavier hydrocarbons such as grease may also be present associated with sampling equipment. The primary exposure routes for petroleum hydrocarbons during the planned activities are inhalation, dermal contact, and ingestion of contaminated soil, sediment, dust, or water. Lighter petroleum hydrocarbons such as gasoline and benzene readily volatilize and are primarily an inhalation concern (as described in Section 3.2.1), whereas the primary route of exposure to heavier petroleum hydrocarbons such as aromatic hydrocarbons, oil, and grease is dermal contact. The target organs primarily affected by prolonged exposure to petroleum hydrocarbons are the respiratory system, central nervous system, kidneys, liver, and skin. Prolonged dermal contact with petroleum hydrocarbons can cause irritation or dermatitis.

As described in Section 3.2.1, an OVM equipped with a photo-ionization detector will be used to monitor ambient air and the breathing zone for TPH compounds that have volatized. Respiratory protection will be employed if elevated levels of organic compounds are measured by the OVM, if odors are present, or other conditions warrant its use. Air monitoring action levels are presented in Table 2. Petroleum hydrocarbons such as gasoline are also flammable and can be a physical hazard when present in high concentrations. Physical hazards associated with flammable compounds are addressed in Section 3.3.10. Combustion of petroleum hydrocarbons can produce carbon dioxide, carbon monoxide, aldehydes, fumes, smoke (particulate matter), and other products of incomplete combustion. Intentional and inadvertent combustion of petroleum hydrocarbons is not expected during sampling activities; however, personnel will be removed from the area should a fire occur.

3.2.4 PAHs

PAHs are petroleum hydrocarbons that are relatively nonvolatile due to their large molecular structure and high molecular weight. Consequently, the primary route of exposure to PAHs is through dermal contact. PAHs may also be indirectly ingested as described in Section 3.1.3. Inhalation of PAHs is unlikely due to their nonvolatile nature. Dermal or eye contact with PAHs can cause irritation or burning.

3.2.5 Hydrogen Sulfide

Hydrogen sulfide is a naturally occurring gas often associated with organic clay and peat. Hydrogen sulfide gas is potentially toxic through inhalation, ingestion, and contact with the skin and eyes. Inhalation can result in respiratory irritation, rhinitis, and edema of the lungs. Inhalation of hydrogen sulfide gas can result in headache, dizziness, and agitation. Acute exposure at high concentrations may result in coma and death as a result of respiratory failure. Hydrogen sulfide gas has a distinct rotten egg odor, and will be noted if encountered in the field.

3.2.6 Hexane

If necessary to achieve adequate decontamination of equipment, a hexane rinse may be applied to remove hydrocarbon-type compounds. Exposure to high concentrations of hexane usually occurs by inhalation. Effects of inhalation may be slow and shallow breathing, possible tachycardia, vertigo or giddiness, nausea, and vomiting. Dermal exposure may result in dermatitis or conjunctival irritation. Eye exposure will cause irritation and requires irrigation.

3.3 Physical Hazards

3.3.1 Slips, Trips, and Falls

As with all fieldwork sites, personnel should exercise caution to prevent slips on slick surfaces. In particular, sampling from a floating platform requires careful attention to minimize the risk of falling down or falling overboard. The same care should be used in rainy conditions. Wearing boots with good tread, made of material that does not become overly slippery when wet, can minimize slips.

Trips are always a hazard on the uneven deck of a boat or in a cluttered work area. The deck of the vessel may have numerous stationary fittings and tie-downs that present potential tripping

hazards. Personnel will keep work areas as free as possible from items that interfere with walking and will be aware of stationary obstacles on deck.

Falls may be avoided by working as far away from exposed edges as possible. For this project, the potential for falling is associated primarily with deployment and recovery of sampling equipment over the bow of the vessel, boarding and disembarking the vessel at the dock, and while walking along the shoreline composed of loose rocks. Personnel will keep walkways and work areas clear when possible and use caution when walking along the shoreline and the riverbank slope.

3.3.2 Soil and Sediment Sampling Equipment

Subsurface soil samples will be collected using a drill rig operated onshore or from a barge. In-water subsurface sediment samples may be collected using a vibratory core sampler (vibracore) methods operated from a vessel. In-water surficial sediments may be collected using either a hydraulic or gravity driven Van Veen grab sampling device. Prior to initiation of sampling on the uplands or sampling vessel, there will be a training session for all field personnel pertaining to the equipment that will be used on the uplands or onboard the sampling vessel. The captain will review vessel-specific hazards and safety procedures and will point out the location and proper use of all safety equipment. For example, field personnel will be shown the locations of all fire extinguishers, flotation rings, and first aid kits and their appropriate uses.

3.3.3 Precautions When Working Around Heavy Equipment

The following precautions will be taken to minimize heavy equipment hazards:

- Personnel must make eye contact with the operator before approaching the equipment and remain safely outside the swing radius of the equipment
- Personnel must wear orange visibility vests in addition to standard Level D PPE
- Personnel must never stand on track-hoe tracks to communicate with the operator
- Operators must be aware of personnel in the area and use proper hand signals before maneuvering
- Operators must wear hard hats when operating machines and when going to and from their equipment
- Operators must use spotters and be cautious when maneuvering equipment within 15 feet of overhead power lines and utility pole guy wires, and maintain safe distances at all times (greater than 10 feet)

- Provisions will be made to prevent the unauthorized start-up of equipment when personnel leave the site at the end of the shift, such as battery ignition locks

3.3.4 Falling Overboard

As with any work from a floating platform, there is a chance of falling overboard. A U. S. Coast Guard-approved personal flotation device (PFD) for each crew person will be available in the boat at all times. PFDs will be worn and properly buckled and zipped as appropriate, by all personnel while working on or over water, regardless of work zone. PFDs will be checked daily and will be in good condition and of the proper size for the intended wearer. The use of hydrostatic life vests are not anticipated, however, if used they will be checked each day prior to donning to confirm that the carbon dioxide cartridge is ready for use.

3.3.5 Uneven Work Surfaces

Slips and trips on uneven surfaces such as a riprap slope can be particularly hazardous. Care will be taken when setting up drilling equipment to provide an area for field personnel working on or near the drilling equipment. Wearing boots with good tread that are made of material that does not become overly slippery when wet can minimize slips. Sturdy work gloves shall be worn to protect the hands against sharp or rough rocky surfaces.

3.3.6 Manual Lifting and Material Handling

Equipment and samples must be lifted and carried both aboard the vessel and along the shoreline. Back strain can result if lifting is done improperly. During any manual handling tasks, personnel should lift with the load supported by their legs and not their backs. For heavy loads, an adequate number of people will be used, or if possible, a mechanical lifting/handling device. Leather gloves will be worn when handling metal, wire rope, sharp debris, or transporting material (wood, piping, drums, etc.).

3.3.7 Heat Stress

For operations occurring in the summer, high temperatures may be encountered. The potential for heat stress may occur if impermeable PPE is worn or if strenuous work is performed under hot conditions with inadequate water. When the core body temperature rises above 100.4° F, the body cannot sweat to cool down, and heat stress can occur. Heat stress may be identified by the following symptoms: dizziness, profuse sweating, skin color change, vision problems,

confusion, nausea, fatigue, fainting, and clammy skin. Personnel exhibiting such symptoms will be removed to a cool shady area, given water, and allowed to rest. Fresh drinking water will be provided aboard the vessel. All field team members will monitor their own condition and that of their co-workers to detect signs of heat stress.

3.3.8 Hypothermia

Hypothermia is abnormal lowering of the core body temperature caused by exposure to a cold environment. Wind chill as well as wetness or water immersion can play a significant role. Typical signs of hypothermia include fatigue, weakness, lack of coordination, apathy, and drowsiness. Confusion is a key symptom of hypothermia. Shivering and pallor are usually absent, and the face may appear puffy and pink.

Body temperatures below 90° F require immediate treatment to restore the temperature to normal. Current medical practice recommends slow warming of the individual followed by professional medical care. Moving the person to a sheltered area and wrapping them in a blanket can accomplish this portion of the task. If possible, the person should be placed in a warm room. In emergencies where body temperature falls below 90° F and shelter is not available, a sleeping bag, blankets, and body heat from another individual can be used to help raise body temperature.

3.3.9 Weather

In general, field team members will be equipped for the normal range of weather conditions. The designated field coordinator (FC) will be aware of current weather conditions and of the potential for those conditions to pose a hazard to the field crew. Some conditions that might force work stoppage are electrical storms, high winds, or high waves resulting from winds.

3.3.10 Flammable Hazards

Petroleum hydrocarbons are flammable in moderate to high concentrations. Therefore smoking, open flames, and unprotected ignition sources will not be allowed in the work area. An OVM will be used to measure concentrations of organic vapors (i.e., benzene) in the work area. If elevated OVM measurements persist, work will be suspended until corrective measures are taken to ensure a safe work environment.

3.3.11 Biological Hazards

Direct contact with Willamette River water may be hazardous due to the potential for combined sewer overflow (CSO) contamination. All field crew will avoid contact with potential biological or infectious materials, wear PPE as appropriate, and wash hands and face as soon as possible after contact and before eating or drinking.

3.4 Activity Hazard Analysis

The activity hazard analysis summarizes the field activities to be performed during borehole drilling and sediment sampling activities, outlines the hazards associated with each activity, and presents controls that can reduce or eliminate the risk of the hazard occurring.

Table 1 presents the activity hazard analysis for the following activities:

- Drilling activities including soil and sediment sample collection
- Sample handling, packaging, processing, and shipping
- Equipment decontamination

4 WORK ZONES AND ACCESS CONTROL

The vessel captain, onshore boring operator, and the FC will delineate the boundaries of the work zones aboard the vessel and shoreline and will inform the field crews of the arrangement. The purpose of the zones is to limit the migration of sample material out of the zones and to restrict access to active work areas by defining work zone boundaries.

4.1 Vessel Sediment Sampling Work Zones

The following zones are vessel sediment sampling work zones:

- **Exclusion zone:** The exclusion zone encompasses the sampling vessel where **s**ediment sampling and processing will occur. This area will be considered the exclusion zone only when samples are being handled on the vessel. The exclusion zone will be clearly communicated to all field personnel and adequately demarcated.
- **Contamination reduction zone (CRZ):** The CRZ during sediment handling is the entire vessel deck, except as noted in the preceding paragraph. Decontamination of both personnel and equipment will occur in this zone to prevent the transfer of chemicals of concern to the support zone. For surface sediment and core processing, the CRZ will consist of an area surrounding the exclusion zone where decontamination of both personnel and equipment will occur.
- **Support zone:** On the sampling vessel, the support zone will be located in the cabin of the vessel or on the vessel deck when contaminated sediments are not on deck.

Sampling staff will instruct people to stay outside the exclusion zone while sample processing is occurring. Only staff required to enter the exclusion zone should be in the exclusion zone to avoid tracking contaminants into the contaminant reduction and support zones. Only personnel that are current with HAZWOPER compliance and Occupational Safety and Health Administration (OSHA) medical monitoring standards will be present on the vessel.

4.2 Onshore Soil Sampling Work Zones

The following zones are onshore soil sampling work zones:

- **Exclusion zone:** The exclusion zone will enclose the entire perimeter of the track-rig and will include the area where sampling is taking place. The exclusion zone will encompass an area 1.5-times the height of the drill rig tower around the drill rig where practical. Where topography and structures preclude this area, adjustments will be

made in the field. Only the coring crew may enter this zone unless assistance is required by other personnel. The exclusion zone will also include a nearby core processing area along the shoreline or on top of the bank area. Cores will likely be processed under fold-up canopies and the exclusion zone will encompass the entire area under the canopy where cores will be processed or where contact to contaminated soil and sediments is possible. The drill contractor coring crew will transport the sediment core tubes to this zone. Entry and exit to this zone will be through a designated access point.

- **CRZ:** The CRZ during sediment handling will encompass the area surrounding the Exclusion zone. Decontamination of both personnel and equipment will occur in this zone to prevent the transfer of chemicals of concern to the support zone. Entry and exit between zones will be through a designated access point.
- **Support zone:** On-shore, the support zone will be located in the on-site trailer or outside the CRZ.

Sampling staff will instruct people to stay outside the exclusion zone where samples are collected and where sample processing is occurring.

4.3 Decontamination Area

All contaminated materials will be properly captured and disposed. A station within the CRZ will be set up for decontaminating sample processing equipment and personnel gear such as boots or PPE. The station will have the buckets, brushes, soapy water, rinse water, or wipes necessary to perform decontamination operations. Plastic bags will be provided for expendable and disposable materials. The decontamination fluids will be stored in sealable containers and will be disposed of in accordance with the procedures presented in Section 9.3.

4.4 Access Control

Security and control of access to the sampling vessel and onshore area will be the responsibility of the captain, site supervisor (SS), and/or site safety and health officer (SSHO). Additional security measures may be placed into affect by NW Natural, as required by national security threat levels determined by the federal government. Access to the vessel and onshore areas will only be granted to necessary project personnel and authorized visitors. Any security or access control problems will be reported to the client or appropriate authorities.

5 SAFE WORK PRACTICES

Following common sense rules will minimize the risk of exposure or accidents at a work site. These general safety rules will be followed on site:

- Be aware of overhead and underfoot hazards at all times
- Do not eat, drink, smoke, or perform other hand-to-mouth transfers in the work zones
- Get immediate first aid for all cuts, scratches, abrasions, or other minor injuries
- Report all accidents and close calls, no matter how minor, to the FC
- Be alert to your own and other workers' physical condition
- Do not climb over or under obstacles of questionable stability
- Make eye contact with equipment operators before moving into the range of their equipment
- Work during daylight hours

6 PERSONAL PROTECTIVE EQUIPMENT AND SAFETY EQUIPMENT

Appropriate PPE will be worn for all tasks as protection against potential hazards. In addition, a PFD will be required when working on the vessel. Prior to donning PPE, the workers will inspect their equipment for any defects that might render the equipment ineffective.

All fieldwork for all tasks will be conducted in Level D, modified Level D, or Level C PPE as discussed below in Sections 6.1, 6.2, and 6.3, respectively. Situations requiring PPE beyond Level C are not anticipated for this project. Should the FC determine that PPE beyond Level C is necessary at a given sampling station, the FC will notify the SSHO to select an appropriate corrective action.

6.1 Level D Personal Protective Equipment

Workers performing general activities in which skin contact with contaminated materials is unlikely and in which inhalation risks are not expected will wear Level D PPE. Level D PPE includes the following:

- Chemical-resistant, steel-toed boots
- Leather, cotton, or chemical-resistant gloves, as the type of work requires
- Safety glasses
- Hard hat (if overhead hazard exists)
- Hearing protection, if necessary

6.2 Modified Level D Personal Protective Equipment

Workers performing activities where skin contact with contaminated materials is possible will wear chemical-resistant outer gloves and an impermeable outer suit. The type of outerwear will be chosen according to the types of chemical contaminants that might be encountered. Modified Level D PPE includes the following:

- Outer garb such as rain gear or rubber or vinyl aprons
- Chemical-resistant steel-toed boots
- Surgical rubber inner gloves
- Chemical-resistant outer gloves
- Safety glasses (or face shield, if significant splash hazard exists)
- Hard hat (if overhead hazard exists)
- Hearing protection, if necessary

6.3 Level C Personal Protective Equipment

If elevated concentrations of vapors are measured with the OVM (see Section 8.2 and Table 2), significant contaminant odors are noted, or significant amounts of airborne particulate matter are generated, health and safety requirements may be upgraded to Level C if implementation of engineering controls (i.e., fans) do not decrease the airborne concentrations to acceptable levels. Level C PPE includes the equipment listed under modified Level D plus the following:

- Half-face or full face respirator
- Organic vapor/acid gas cartridges, if appropriate
- Particulate filter cartridge, if appropriate

6.4 Safety Equipment

In addition to PPE that will be worn by shipboard personnel, basic emergency and first aid equipment will also be provided and easily accessible in an unlocked location known to all field personnel prior to the start of any activities. Equipment will include:

- A copy of this HASP
- PFD
- First aid kit adequate for the number of personnel
- Emergency eyewash

Anchor QEA and/or subconsultants will provide this equipment, which must be at the location(s) where field activities are being performed. Equipment will be checked daily to ensure its readiness for use. PFDs will be inspected daily and will be in good condition and of the proper size for the intended wearer. PFDs will be worn and properly buckled and zipped as appropriate, by all personnel on or over water, regardless of work zone. In addition to the safety equipment listed above, an Automated External Defibrillator (AED) will be located in the on-site trailer or other unlocked location or in a locked "break glass" type container, which will be located in the Support Zone. The location of the AED will be discussed as part of the morning safety meetings. All field crew will be trained on the procedures for proper use of the AED and the user manual will be kept with the AED at all times. The AED will be inspected to confirm readiness for use on a daily basis.

7 MEDICAL SURVEILLANCE PROGRAM

All Anchor QEA field personnel that complete the field investigations will be will be enrolled in a medical surveillance program in compliance with OSHA standards (29 CFR 1910.120(f). These employees will have medical examinations and consultations made available to them by Anchor QEA on the following schedule:

- Prior to assignment
- At least once every 12 months, unless the attending physician believes a longer interval (not greater than biennially) is appropriate
- At termination of employment or reassignment to an area where the employee would not be covered if the employee has not had an examination within the last 6 months
- As soon as possible upon notification that the employee has developed signs or symptoms indicating possible overexposure to hazardous substances or health hazards, or that the employee has been injured or exposed above the permissible exposure limit (PEL) or published exposure levels in an emergency situation
- At more frequent times, if the examining physician determines that an increased frequency of examination is medically necessary

The content of medical examinations or consultations made available to employees shall be determined by the attending physician but shall include, at a minimum, a medical and work history with special emphasis on symptoms related to the handling of hazardous substances and health hazards, and to fitness for duty including the ability to wear any required PPE under conditions (i.e., temperature extremes) that may be expected at the work site.

The attending physician shall provide Anchor QEA with a written opinion for each examined employee that contains the following information:

- Whether the employee has any detected medical conditions that would place the employee at an increased risk of impairment of the employee's health from hazardous waste operations work, emergency response, or respirator use
- Any recommended limitations on the employee's assigned work
- A statement that the employee has been informed of the results of the medical examination and any medical conditions that require further examination or treatment

The written opinion obtained by Anchor QEA shall not reveal specific findings or diagnoses unrelated to occupational exposures. Medical surveillance and other employee-related medical records shall be retained for at least the duration of employment plus 30 years.

8 MONITORING PROCEDURES FOR SITE ACTIVITIES

A monitoring program that addresses the potential site hazards will be maintained. The monitoring program includes self-monitoring by the field crew and monitoring with instruments.

8.1 Crew Self Monitoring

All personnel will be instructed to look for and inform each other of any deleterious changes in their physical or mental condition during the performance of all field activities. Examples of such changes are as follows:

- Headaches
- Dizziness
- Nausea
- Blurred vision
- Cramps
- Irritation of eyes, skin, or respiratory system
- Changes in complexion or skin color
- Changes in apparent motor coordination
- Increased frequency of minor mistakes
- Excessive salivation or changes in papillary response
- Changes in speech ability or speech pattern
- Symptoms of heat stress or heat exhaustion (Section 3.3.7)
- Symptoms of hypothermia (Section 3.3.8)

If any of these conditions develop, the affected person(s) will be moved from the immediate work location and evaluated. If further assistance is needed, personnel at the local hospital will be notified, and an ambulance will be summoned if the condition is thought to be serious. If the condition is the result of sample collection or processing activities, procedures and/or PPE will be modified to address the problem.

8.2 Real-time Air Monitoring Equipment

Organic vapor concentrations shall be monitored in the field using an organic vapor monitor such as a PID or FID. During soil boring and sediment sample collection and processing, organic vapor measurements shall be taken in the breathing zone of workers while additional

area monitoring may be conducted at the well head, auger point, etc. to gather background and environmental impact information.

Other real-time air monitoring equipment, such as a hydrogen cyanide meter, may be utilized depending upon the scope of work and compounds of concern. Air monitoring results shall be documented on the air monitoring log form presented in Attachment 2.

8.2.1 Equipment Calibration and Maintenance

Calibration and maintenance of air monitoring equipment shall follow manufacturer specifications and must be documented. Re-calibration and adjustment of air monitoring equipment shall be completed daily and as site conditions and equipment operation warrant. Records of air monitoring equipment calibration and adjustment information will be recorded in the field logbook or daily log form.

8.2.2 Air Monitoring Action Levels

Air monitoring action levels have been developed for this project and are listed in Table 2. The table stipulates the chemical concentrations in the worker's breathing zone that require an upgrade in level of PPE.

9 DECONTAMINATION

Decontamination is necessary to prevent the migration of contaminants from the work zone(s) into the surrounding environment and to minimize the risk of exposure of personnel to contaminated materials that might adhere to PPE. The following sections discuss personnel and equipment decontamination. The following supplies will be available to perform decontamination activities:

- Wash and rinse buckets
- Tap water and phosphate-free detergent (i.e., Alconox)
- Hexane (or similar type solution) for more robust equipment decontamination
- Scrub brushes
- Distilled/deionized water
- Deck pump with pressurized freshwater hose (aboard the vessel)
- Paper towels and plastic garbage bags

9.1 Minimization of Contamination

The following measures will be observed to prevent or minimize exposure to potentially contaminated materials:

Personnel:

- Do not walk through spilled sediment or soil
- Do not handle, touch, or smell sediment or soil directly
- Make sure PPE has no cuts or tears prior to use
- Protect and cover any skin injuries
- Stay upwind of airborne dusts and vapors
- Do not eat, drink, chew tobacco, or smoke in the work zones

Sampling Equipment and Vessel/Drill Rig:

- Use care to avoid getting sampled media on the outside of sample containers
- If necessary, bag sample containers before filling with sampled media
- Place clean equipment on a plastic sheet to avoid direct contact with contaminated media
- Keep contaminated equipment and tools separate from clean equipment and tools

- Fill sample containers over a plastic tub to contain spillage
- Clean up spilled material immediately to avoid tracking around the vessel or drill rig

9.2 Personal Decontamination

The FC will ensure that all site personnel are familiar with personnel decontamination procedures. Personnel will perform decontamination procedures, as appropriate, when exiting work areas. Following is a description of the procedure:

Decontamination Procedure:

- Wash and rinse outer gloves and boots in portable buckets
- If suit is heavily soiled, rinse it off
- Remove outer gloves, inspect and discard if damaged, leave inner gloves on
- Remove inner gloves and wash hands if taking a break
- Don necessary PPE before returning to work
- Dispose of soiled PPE before leaving for the day

9.3 Handling of Investigation-Derived Waste

All remaining sediment, fluids used for decontamination of sampling equipment, and core collection disposable wastes (e.g., gloves, paper towels, foil, etc.) will be placed into appropriate containers and staged on-site for characterization and eventual disposal.

Investigation-derived waste (IDW) will be placed into sealable containers and temporarily staged on site. Representative (composite) samples of the IDW will be collected and analyzed.

All disposable wastes will be placed into two heavy duty plastic bags (that is, double-bagged) and stored in sealable containers until the IDW generated from the investigation has been characterized. If the IDW is characterized as non-hazardous, the waste will be removed from the sealable container and transported to a Subtitle D landfill for disposal. If the sediment or soil IDW is characterized as either a listed or characteristic RCRA waste, the sealed container(s) of disposable wastes will be transported to and disposed of at the facility selected for disposal of the sediment IDW.

10 TRAINING REQUIREMENTS

Individuals performing work at locations where potentially hazardous materials and conditions may be encountered must meet specific training requirements. It is not anticipated that personnel will encounter hazardous concentrations of contaminants in sampled material, so training will consist of site-specific instruction for all personnel and oversight of inexperienced personnel for one working day. The following sections describe the training requirements for work at this site.

10.1 Project Specific Training

All Anchor QEA personnel must read this HASP and be familiar with its contents before beginning work. They shall acknowledge reading the HASP by signing the field team HASP review form contained in Attachment 1. The form will be kept in the project files.

The FC or a designee will provide and document project-specific training during the project kickoff meeting and whenever new Anchor QEA workers arrive for fieldwork. Anchor QEA personnel will not be allowed to begin work until project-specific training is completed and documented by the FC. Training will address the HASP and all health and safety issues and procedures pertinent to field operations. Training will include, but will not be limited to, the following topics:

- Activities with the potential for chemical exposure
- Activities that pose physical hazards, and actions to control the hazards
- Ship access control and procedures
- Use and limitations of PPE
- Decontamination procedures
- Emergency procedures
- Use and hazards of sampling equipment
- Location of emergency equipment on the vessel
- Vessel safety practices

In addition, since field activities are occurring within the Portland Harbor Superfund Site, all workers in the exclusion zone or CRZ must have 40-hour HAZWOPER training in accordance with OSHA. An updated 8-hour HAZWOPER refresher training is required for all workers in the exclusion zone or CRZ whose 40-hour HAZWOPER training certificate is more than one year old.

10.2 Daily Safety Briefings

The FC or a designee will present tailgate safety briefings before the start of each day's activities. These tailgate safety briefings will outline the activities expected for the day, update work practices and hazards, and address any specific concerns associated with the work location, and review emergency procedures and routes. The tailgate safety briefings will be documented in the logbook. A checklist of daily safety briefing topics will be conducted and supplemented with the following topics:

- Hazard Exposure Routes
- Chemical Hazards
- Physical Hazards
- Biological Hazards (by direct contact with river water)
- Mitigation Procedures
- Vessel Safety
- Safety Communication
- Lines of Authority
- Description of first aid kit and AED locations, including a discussion of usage (initial comprehensive training session and a brief daily overview
- Over water safety and PFD usage

A daily safety briefing log form is presented in Attachment 2.

11 RECORDING AND RECORD KEEPING

The FC or a designee will record health- and safety-related details of the project in the field logbook. The logbook must be bound and the pages must be numbered consecutively. Entries will be made with indelible ink. At a minimum, each day's entries must include the following information:

- Project name or location
- Names of all personnel
- Level of PPE worn and any other specifics regarding PPE
- Weather conditions
- Type of fieldwork being performed

The person maintaining the entries will initial and date the bottom of each completed page. Blank space at the bottom of an incompletely filled page will be lined out. Each day's entries will begin on the first blank page after the previous workday's entries.

As necessary, other documentation will be obtained or initiated by the FC. Other documentation may include field change requests, medical and training records, exposure records, accident/incident report forms, OSHA Form 200s, and material safety data sheets. Attachment 2 contains copies of key health and safety forms.

12 EMERGENCY RESPONSE PLAN

As a result of the health and safety hazards associated with the field sampling and sample handling activities, the potential exists for an emergency situation to occur. Emergencies may include personal injury, exposure to hazardous substances, fire, explosion, or release of toxic or non-toxic substances (spills). OSHA regulations require that an emergency response plan be available for use onboard to guide actions in emergency situations.

Onshore organizations will be relied upon to provide response in emergency situations. The local fire department and ambulance service can provide timely response. Anchor QEA personnel and subcontractors will be responsible for identifying an emergency situation, providing first aid if applicable, notifying the appropriate personnel or agency, and evacuating any hazardous area. Shipboard personnel will attempt to control only very minor hazards that could present an emergency situation, such as a small fire, and will otherwise rely on outside emergency response resources.

The following sections address key safety personnel, authority and responsibilities of key personnel, pre-emergency preparation, identify individual(s) who should be notified in case of emergency, provide a list of emergency telephone numbers, offer guidance for particular types of emergencies, and provide directions and a map for getting from any sampling location to a hospital.

12.1 Authority and Responsibilities of Key Personnel

This section describes the authority and responsibilities of key Anchor QEA project personnel. Key personnel will be selected at the beginning of each field task. The emergency phone number for the site is **911**, and should be used first for all medical, fire, and police emergencies.

12.1.1 Project Manager

The project manager (PM) provides overall direction for the project. The PM is responsible for ensuring that the project meets the client's objectives in a safe and timely manner. The PM is responsible for providing qualified staff for the project and adequate resources and budget for the health and safety staff to carry out their responsibilities during the field work. The PM is in regular contact with the FC and SSHO to ensure that appropriate health and safety procedures are implemented into each project task.

The PM has authority to direct response operations; the PM assumes total control over project activities but may assign responsibility for aspects of the project to others. In addition, the PM:

- Oversees the preparation and organization of background review of the project, the work plan, and the field team.
- Ensures that the team obtains permission for site access and coordinates activities with appropriate officials.
- Briefs the FC and field personnel on specific assignments.
- Together with the FC, sees that health and safety requirements are met.
- Consults with the SSHO regarding unsafe conditions, incidents, or changes in site conditions or the Scope of Work.

12.1.2 Field Coordinator

The FC reports to the PM and has authority to direct response operations and assumes control over on-site activities. The FC will direct field activities, coordinate the technical and health and safety components of the field program, and is responsible in general for enforcing the HASP and Corporate HASP. The FC will be the primary point of contact for all field personnel and visitors and has direct responsibility for implementation and administration of this HASP. The FC and any other member of the field crew have the authority to stop or suspend work in the event of an emergency, if conditions arise that pose an unacceptable health and safety risk to the field crew or environment, or if conditions arise that warrant revision or amendment of this HASP.

The functions of the FC related to this HASP include but are not necessarily limited to the following:

- Conduct and document daily safety meetings, or designate an alternate FC in his or her absence
- Execute the work plan and schedule
- Periodic field health and safety inspections to ensure compliance with this HASP
- Oversee implementation of safety procedures
- Implement worker protection levels
- Enforce site control measures to ensure that only authorized personnel are allowed on site
- Notify, when necessary, local public emergency officials (all personnel on site may conduct this task as needed)

- Follow-up on incident reports to the PM
- Periodically inspect protective clothing and equipment for adequacy and safety compliance
- See that protective clothing and equipment are properly stored and maintained
- Perform or oversee air monitoring in accordance with this HASP
- Maintain and oversee operation of monitoring equipment and interpretation of data from the monitoring equipment
- Monitor workers for signs of stress, including heat stress, cold exposure, and fatigue.
- Require participants to use the "buddy" system
- Provide (via implementation of this HASP) emergency procedures, evacuation routes, and telephone numbers of the local hospital, poison control center, fire department, and police department
- Communicate incidents promptly to the PM
- Maintain communication with the SSHO on site activities
- If applicable, ensure decontamination and disposal procedures are followed
- Maintain the availability of required safety equipment
- Advise appropriate health services and medical personnel of potential exposures.
- Notify emergency response personnel in the event of an emergency. Coordinate emergency medical care

The FC will record health-and-safety-related details of the project in the field logbook. At a minimum, each day's entries must include the following information:

- Project name or location
- Names of all on-site personnel
- Level of PPE worn and any other specifics regarding PPE
- Weather conditions
- Type of field work being performed

The FC will have completed the required OSHA 40-hour HAZWOPER training and annual updates, the 8-hour Supervisor training, current first aid and cardiopulmonary resuscitation (CPR) training, and medical monitoring clearance, if applicable. Other certifications or training may be stipulated based on client or site requirements.

12.1.3 Site Safety and Health Officer

Anchor QEA's SSHO will be responsible for managing on-site health and safety activities and will provide support to the PM and FC on health and safety issues. The specific duties of the SSHO are to:

- Provide technical input into the design and implementation of this HASP.
- Advise on the potential for occupational exposure to project hazards, along with appropriate methods and/or controls to eliminate site hazards.
- Ensure that a hazard assessment has been performed and that the adequacy of the PPE selected was evaluated as required by 29 CFR 1910.132(d), 1910.134, 1926.25, and 1926.55, and is duly noted by the signatures and date appearing on the Certification Page of this document.
- Consult with the FC on matters relating to suspending site activities in the event of an emergency.
- Verify that all on-site Anchor QEA personnel and subcontractors have read and signed the HASP Acknowledgement Form.
- Review daily the on-site health and safety activities for effectiveness and modify as needed.
- Verify that corrective actions resulting from deficiencies identified by daily health and safety reviews and observations are implemented and effective.

The SSHO will have completed the required OSHA 40-hour HAZWOPER training and annual updates, the 8-hour Supervisor training, and have medical monitoring clearance, if applicable. In addition, the SSHO will have current training in first aid and CPR.

12.1.4 Corporate Health and Safety Officer

Anchor QEA's corporate health and safety officer will be responsible for managing Anchor QEA's corporate health and safety program and will provide support to the SSHO, PM, and FC on health and safety issues.

12.1.5 Field Personnel

All project field personnel will attend a project-specific meeting conducted by the FC concerning safety issues and project work task review before beginning work. All field crew must be familiar with and comply with this HASP. Subcontractors will be responsible for

developing and complying with their own company HASP. The field crew has the responsibility to immediately report any potentially unsafe or hazardous conditions to the FC, and all members of the field crew have the authority to stop or suspend work if conditions arise that pose an unacceptable health and safety risk to the field crew or environment or if conditions arise that warrant revision or amendment of this HASP.

The field team reports to the FC for on-site activities and is responsible for

- Reviewing and maintaining a working knowledge of this HASP
- Safe completion of on-site tasks required to fulfill the work plan
- Compliance with the HASP
- Attendance and participation in daily safety meetings
- Notification to the FC of existing or potential safety conditions at the site
- Reporting all incidents to the FC
- Demonstrating safety and health conscious conduct

12.2 Pre-Emergency Preparation

Before the start of field activities, the FC will ensure that preparation has been made in anticipation of emergencies. Preparatory actions include the following:

- All field personnel meeting with the FC (if working on land) or the captain (if on vessel) and equipment handlers concerning the emergency procedures in the event that a person is injured. Appropriate actions for specific scenarios will be reviewed. These scenarios will be discussed and responses determined before the sampling event commences.
- A training session given by the FC and captain informing all field personnel of emergency procedures, locations of emergency equipment and their use, and proper evacuation procedures.
- A training session given by senior staff operating field equipment, to apprise field personnel of operating procedures and specific risks associated with that equipment.
- Ensuring that field personnel are aware of the existence of the emergency response plan, its location, and ensuring that a copy of the HASP accompanies the field team(s).

12.3 Project Emergency Coordinator

The FC will serve as the Project Emergency Coordinator (PEC) in the event of an emergency. The FC will designate a replacement for times when he is not onboard or is not serving as the PEC. The designation will be noted in the logbook. The PEC will be notified immediately when an emergency is recognized. The PEC will be responsible for evaluating the emergency situation, notifying the appropriate emergency response units, coordinating access with those units, and directing interim actions onboard before the arrival of emergency response units. The PEC will notify the SSHO and the PM as soon as possible after initiating an emergency response action. The PM will have responsibility for notifying the client.

12.4 Emergency Response Contacts

All personnel must know whom to notify in the event of an emergency situation, even though the FC has primary responsibility for notification.

12.5 Emergency Response and Alerting Procedures

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 FC or any other site personnel recognizing the condition will blow the air horn three times. When the horn sounds, all personnel will meet at the emergency meeting location (the site entrance near the guard shack when on the upland portion of the site, Figure 1, and either the site entrance near the guard shack or the Cathedral Park boat ramp if working in the river, depending on the circumstances). All other emergency notifications that do not require evacuation (e.g., a person falling overboard) will be conducted using a cell phone. Emergency phone numbers are listed in Table 4.

In the event of an emergency, immediate action must be taken by the first person to recognize the event. The following steps will be used as a guideline:

- Survey the situation to ensure that it is safe for you and the victim. Do not endanger your own life. Do not enter an area to rescue someone who has been overcome unless properly equipped and trained. Ensure that all protocols are followed. If applicable, review Material Safety Data Sheets (MSDS) to evaluate response actions for chemical exposures.

- Call the appropriate emergency number (**911**) or direct someone else to do this immediately. Explain the physical injury, chemical exposure, fire, or release and location of the incident.
- Have someone retrieve the nearest first aid kit and AED, if available.
  - **Note:** Only use an AED if you have been properly trained.
- Decontaminate the victim without delaying life-saving procedures (see Section 12.8).
- Administer first aid and CPR, if properly trained, until emergency responders arrive.
- Notify the PM and the FC.
- Complete the appropriate incident investigation reports.

12.6 Recognition and Prevention of Emergency Situations

Everyone on site is responsible to monitor the environment for conditions that could lead to a release or an injury. Emergency situations will generally be recognizable by observation. The site team must take steps needed to respond to such observations. An injury or illness will be considered an emergency if it requires treatment by a medical professional and cannot be treated with simple first-aid techniques.

12.7 Decontamination

In the case of evacuation, decontamination procedures will be performed only if doing so does not further jeopardize the welfare of site workers. If an injured individual is also heavily contaminated and must be transported by emergency vehicle, the emergency response team will be told of the type of contamination. To the extent possible, contaminated PPE will be removed, but only if doing so does not exacerbate the injury. Plastic sheeting will be used to reduce the potential for spreading contamination to the inside of the emergency vehicle.

12.8 Fire

Personnel will attempt to control only small fires, should they occur. If an explosion appears likely, personnel will follow evacuation procedures specified by the captain or FC in the training session. If a fire cannot be controlled with a fire extinguisher that is part of the required safety equipment, personnel will either withdraw from the vicinity of the fire or use additional firefighting equipment, or evacuate the boat or upland area as specified by the captain or FC in the training session.

12.9 Personal Injury

In the event of serious personal injury, including unconsciousness, possibility of broken bones, severe bleeding or blood loss, burns, shock, or trauma, the first responder will immediately do the following:

- Administer first aid, if qualified
- If not qualified, seek out an individual who is qualified to administer first aid, if time and conditions permit
- Notify the PEC of the incident, the name of the individual, the location, and the nature of the injury

The PEC will immediately do the following:

- Notify the captain and the appropriate emergency response organization
- Assist the injured individual
- Follow the emergency procedures for retrieving or disposing equipment reviewed in the training session, and leave the site en route to the predetermined land-based emergency pick-up
- Designate someone to accompany the injured individual to the hospital
- If an emergency situation (i.e., broken bones or injury where death is imminent without immediate treatment) occurs, the FC or captain will call 911 and arrange to meet the response unit at the nearest accessible dock
- Notify the SSHO and the PM

If the PEC determines that emergency response is not necessary, he may direct someone to decontaminate and transport the individual by vehicle to the nearest hospital. Directions and a map showing the route to the hospital are in Section 12.13 and Figures 2 and 3.

If a worker leaves the ship or the upland work site to seek medical attention, another worker should accompany him or her to the hospital. When in doubt about the severity of an injury or exposure, always seek medical attention as a conservative approach and notify the PEC.
The PEC will have responsibility for completing all accident/incident field reports, OSHA form 200s, and other required follow-up forms.

12.10 Overt Personal Exposure or Injury

If an overt exposure to toxic materials occurs, the first responder to the victim will initiate actions to address the situation. The following actions should be taken, depending on the type of exposure:

Skin Contact:

- Wash/rinse the affected area thoroughly with copious amounts of soap and water
- If eye contact has occurred, eyes should be rinsed for at least 15 minutes using the eyewash that is part of the emergency equipment onboard and in the lab
- After initial response actions have been taken, seek appropriate medical attention

Inhalation:

- Move victim to fresh air
- Seek appropriate medical attention

Ingestion:

- Seek appropriate medical attention

Puncture Wound or Laceration:

- Seek appropriate medical attention

12.11 Spills and Spill Containment

As necessary, spill control measures will be used to contain contaminated materials that may enter into clean areas. Plastic sheeting, sorbent pads, sorbent booms, or a spill control system will be used to prevent spills and contain contaminated material.

If a spill occurs, the SSHO will immediately discuss the event with EPA or its oversight contractor to evaluate the need for reporting. Any spill will be reported consistent with state and federal law. In the case of a reportable spill, the National Response Center (800-424-8802) and Oregon Emergency Response System (800-452-0311) will be notified by the SSHO or the PM.

12.12 Emergency Route to the Hospital

The name, address, and telephone number of the hospital that will be used to provide medical care is as follows:

Legacy Good Samaritan Hospital and Medical Center
1015 NW 22ndAvenue
Portland, Oregon 97210
(503) 413-7711

Figure 2 is a map of the route from the uplands project site (7900 NW St. Helens Road, Portland, Oregon, 97210) to the Legacy Good Samaritan Hospital and Medical Center. Directions are as follows (travel time is approximately 11 minutes):

1. Start out going Southeast on NW ST HELENS RD. Continue to follow NW ST HELENS RD/US-30.
2. Continue onto US -30 NW YEON AVE.
3. Turn RIGHT onto NW NICOLAI ST.
4. Turn LEFT onto NW 24th ST.
5. Turn LEFT onto NW LOVEJOY ST.
6. End at 1015 NW 22nd Ave. Portland, Oregon

Figure 3 is a map of the route from the boat launch area at Cathedral Park, St. Johns, Oregon to the Legacy Good Samaritan Hospital and Medical Center. Directions are as follows (travel time is approximately 15 minutes):

1. Depart the Cathedral Park parking lot and proceed up the hill on N. BALTIMORE AVE.
2. Turn RIGHT at the light onto N. IVANHOE ST.
3. Turn RIGHT onto N. PHILADELPHIA ST. and cross over the St. Johns Bridge.
4. Turn LEFT onto NW BRIDGE AVE.
5. Merge onto NW ST. HELENS RD, U.S HWY-30
6. Continue on US -30, NW YEON AVE.
7. Turn RIGHT onto NW NICOLAI ST.
8. Turn LEFT onto NW 24th ST.
9. Turn LEFT onto NW LOVEJOY ST.
10. End at 1015 NW 22nd Ave. Portland, Oregon

13 HEALTH AND SAFETY PLAN APPROVAL RECORD

By their signature, the undersigned certify that this HASP is approved and that it will be used to govern health and safety aspects of fieldwork conducted by Anchor QEA personnel to investigate areas associated within the Removal Action Area.

Anchor QEA Project Manager Date

Anchor QEA Site Supervisor Date

Anchor QEA Site and Safety Health Officer Date

TABLES

Table 1
Activity Hazard Analysis

Activity	Hazard	Control
Drilling activities including soil sample collection on land, subsurface core collection and processing and van Veen grab activities on a vessel	Falling overboard	Avoid working near the edge of the vessel, if possible. Stay away from edge of barge deck. Wear PFD during sample collection.
	Cuts, amputations	Use locking pins to secure the grab sampler prior to deployment, and keep fingers clear of the open jaws at all times. When coring, never hold the core barrel with the fingers inside the core. Use care when using circular saw during core processing.
	Back or muscle strain	Use appropriate lifting technique when handling heavy equipment and lifting heavy sample containers. Enlist help if necessary.
	Ear Protection	Wear ear plugs or ear muffs when operating loud machinery or cutting cores open with a power saw.
	Skin or eye contact with potentially contaminated sediments or liquids	Wear modified Level D PPE, including eye protection.
	Slipping/tripping on slick or uneven deck and on uneven surfaces on the riverbank	Wear steel-toed boots with gripping tread. Be aware of obstacles and wet patches on deck and select a path to avoid them. Keep ropes and lines coiled and stowed to eliminate trip hazards. Maintain 3 point contact on vessel while underway.
	Injury from equipment falling or swinging	Wear a hard hat and steel-toed boots at all times; be in the appropriate position on deck when equipment is in operation.
	Electric Shock	Use ground fault-indicator extension cord, and seal plug connections with electrical tape.
	Fire	Avoid fueling operations near hot engines. Mop up any spilled flammable liquids and dispose of absorbent. No smoking or flame sources on the vessel. Evacuate the vessel according to procedures outlined in the training session given by the captain.
	Rotating or percussive drilling equipment	Stay clear of area around borehole while drilling activities are underway. Do not wear loose fitting clothing or exposed long hair.
	Injury from winch line snapping	Ensure that winch line is not frayed.

Table 1
Activity Hazard Analysis

Activity	Hazard	Control
Handling, packaging, and shipping samples	Skin or eye contact with potentially contaminated liquids	Wear modified Level D PPE, including eye protection.
	Back or muscle strain	Use appropriate lifting technique when handling heavy equipment and lifting heavy sample containers. Enlist help if necessary.
	Inhalation of or eye contact with airborne mists or vapors	Wear safety glasses. Perform decontamination activities outdoors or in a well-ventilated area. Stay upwind when spray-rinsing equipment.
Decontaminating equipment	Inhalation of, or eye contact with, airborne mists or vapors	Wear safety glasses. Perform decontamination activities outdoors or in a well-ventilated area. Stay upwind when spray-rinsing equipment.
	Skin contact with potentially contaminated materials	Wear modified Level D PPE.
	Ingestion of contaminated materials	Decontaminate clothing and skin prior to eating, drinking, smoking, or other hand-to-mouth activities. Follow the decontamination procedure for personal decontamination.

Table 2
Air Monitoring Action Levels

Instrument*	Job Task/Functions	Measurement	Monitoring Schedule[3]	Actions[1]
FID and/or PID (10.6*eV lamp) - Measures Total Organic Vapors	Conduct continuous air monitoring for volatile organic compounds during activities where contaminated media are present. Make sure that a background reading is taken before the start up of activities and periodically thereafter.	0 to 1 ppm above background in breathing zone	Continuous (logging periodically every 15 to 30 minutes)	Continue work
		Greater than 1 to 10 ppm above background	Continuous (logging periodically every 15 minutes)	Stop work if sustained readings for longer than 2 minutes.[2] Institute engineering controls. If concentrations decrease to below 1 ppm above background, continue work. If concentrations above 1 ppm persist, upgrade to Level C protection. Monitor for benzene and vinyl chloride using colorimetric detector tubes. Continue working with respiratory protection if colorimetric detector tubes indicate less than 1 ppm for benzene and/or vinyl chloride. Leave the work area if colorimetric tubes indicate > 1 ppm in the employee's breathing zone; contact PM for further guidance.
		Greater than 10 ppm above background in breathing zone	Continuous (logging periodically every 15-30 minutes)	Stop work required.[2] Leave work area, contact PM for guidance
Hydrogen Cyanide Monitor	Conduct air monitoring for HCN during activities where contaminated media are present. Monitor in the workers' breathing zone.	Detectable up to 4 ppm hydrogen cyanide	Continuous (logging periodically every 15 minutes)	Continue work
		Greater than 4 ppm hydrogen cyanide		Stop work required.[2] Leave work area, contact PM for guidance

Notes:

* Instruments must be calibrated according to manufacturer's recommendations.

ppm = parts per million

1 - For VOCs, sustained reading for greater than 2 minutes in excess of the action level will trigger a protective measure.

2 - Contact with the PM must be made prior to continuance of work. A hazard review must be conducted before proceeding with work.

3 - Monitoring frequency is at beginning of each task and continuously thereafter (logging periodically every 15 minutes), or when detectable soil contamination is encountered (as indicated by strong, sustained odor, visual evidence of product or

4 - Contact the PM for respiratory protection fit testing and air purifying cartridge change-out requirements.

Table 3a
Minimum, Mean, and Maximum COC Exposure Concentrations – Soil

Chemical Name	Target Unit	Minimum Detected Result	Maximum Detected Result	Average Detect Result
2-Methylnaphthalene	µg/kg	25100	683000	420366.6667
Acenaphthene	µg/kg	1.3	9210000	607011.4294
Acenaphthylene	µg/kg	0.37	77600	13287.68722
Anthracene	µg/kg	1.2	1650000	139881.8353
Benzo(a)anthracene	µg/kg	2.6	1540000	101879.8167
Benzo(a)pyrene	µg/kg	2.8	571000	72916.712
Benzo(b)fluoranthene	µg/kg	2.3	758000	70360.6
Benzo(g,h,i)perylene	µg/kg	2.7	230000	51705.5087
Benzo(k)fluoranthene	µg/kg	1.8	308000	34881.61304
Chrysene	µg/kg	3.5	1810000	109051.2885
Dibenzo(a,h)anthracene	µg/kg	62	46100	10971.77778
Fluoranthene	µg/kg	6.9	8480000	441135.236
Fluorene	µg/kg	0.84	4530000	306609.5788
Indeno(1,2,3-c,d)pyrene	µg/kg	2.2	181000	33858.74783
LWG RA Total 10 of 17 HPAH (Calculated U = 1/2)	µg/kg	35	20000000	1243819.038
LWG RA Total 17 PAH (Calculated U = 1/2)	µg/kg	52	59000000	3021244.889
LWG RA Total 7 of 17 LPAH (Calculated U = 1/2)	µg/kg	16	38000000	2093742
LWG RA Total cPAH TEQ (EPA 1993) (Calculated U = 1/2)	µg/kg	6	870000	97589.84615
Naphthalene	µg/kg	88	7400000	634337.375
Phenanthrene	µg/kg	6.4	15500000	861253.0182
Pyrene	µg/kg	7.8	6530000	376538.35
Cyanide	mg/kg	0.58	13900	2656.778182
Zinc	mg/kg	38.7	105	64.8875
Carbazole	µg/kg	2100	68700	38266.66667
Dibenzofuran	µg/kg	0.36	49300	23200.09
Diesel Range Hydrocarbons	mg/kg	37.4	14000	3082.54
1,1-Dichloroethene	µg/kg	Non detects	Non detects	Non detects
1,2-Dichloroethene, cis-	µg/kg	Non detects	Non detects	Non detects
1,2-Dichloroethene, trans-	µg/kg	Non detects	Non detects	Non detects
Benzene	µg/kg	26.4	150000	75013.2
Ethylbenzene	µg/kg	200	35000	9290
LWG RA Total Xylene (Calculated U = 1/2)	µg/kg	5740	5740	5740
Naphthalene	µg/kg	64200	1210000	637100
o-Xylene	µg/kg	5740	5740	5740
Toluene	µg/kg	150	140000	70075
Total Xylene (reported, not calculated)	µg/kg	400	110000	30187.5
Trichloroethene (TCE)	µg/kg	Non detects	Non detects	Non detects
Vinyl chloride	µg/kg	Non detects	Non detects	Non detects

Notes:

µg/kg microgram per kilogram

mg/kg milligram per kilogram

Table 3b
Minimum, Mean, and Maximum COC Exposure Concentrations – Surface Water

Chemical Name	Target Unit	Minimum Detected Result	Maximum Detected Result	Average Detect Result
2-Methylnaphthalene	µg/L	0.0025	0.62	0.030110811
Acenaphthene	µg/L	0.002	0.39	0.046438889
Acenaphthylene	µg/L	0.0019	0.1	0.013885714
Anthracene	µg/L	0.0011	0.48	0.046696344
Benzo(a)anthracene	µg/L	0.0028	0.27	0.031336581
Benzo(a)pyrene	µg/L	0.0048	0.475	0.070219417
Benzo(b)fluoranthene	µg/L	0.0025	0.13	0.018797826
Benzo(g,h,i)perylene	µg/L	0.0034	0.14	0.024458824
Benzo(k)fluoranthene	µg/L	0.0027	0.13	0.018625926
Chrysene	µg/L	0.0014	0.37	0.031474
Dibenzo(a,h)anthracene	µg/L	0.0026	0.024	0.007233333
Fluoranthene	µg/L	0.0024	0.9	0.091652903
Fluorene	µg/L	0.0038	0.31	0.051715465
Indeno(1,2,3-c,d)pyrene	µg/L	0.0031	0.12	0.017531707
LWG RA Total 10 of 17 HPAH (Calculated U = 1/2)	µg/L	0.062	3.5	0.249212048
LWG RA Total 17 PAH (Calculated U = 1/2)	µg/L	0.087	7.4	0.5251
LWG RA Total 7 of 17 LPAH (Calculated U = 1/2)	µg/L	0.024	3.9	0.385431111
LWG RA Total cPAH TEQ (EPA 1993) (Calculated U = 1/2)	µg/L	0.0074	0.488	0.064669118
Naphthalene	µg/L	0.0056	2.1	0.26922439
Phenanthrene	µg/L	0.0033	2.2	0.119938699
Pyrene	µg/L	0.0027	1.3	0.070669231
Cyanide	mg/L	0.002	0.14	0.01894359
Cyanide, free	mg/L	0.003	0.008	0.004944444
Zinc	µg/L	1.5	8.4	3.466666667
Aroclor 1016	µg/L	Non detects	Non detects	Non detects
Aroclor 1221	µg/L	Non detects	Non detects	Non detects
Aroclor 1232	µg/L	Non detects	Non detects	Non detects
Aroclor 1242	µg/L	Non detects	Non detects	Non detects
Aroclor 1248	µg/L	Non detects	Non detects	Non detects
Aroclor 1254	µg/L	Non detects	Non detects	Non detects
Aroclor 1260	µg/L	Non detects	Non detects	Non detects
LWG RA Total PCB Aroclors (Calculated U = 1/2)	µg/L	Non detects	Non detects	Non detects
LWG RA Total PCB Congener (Calculated U = 1/2)	ng/L	0.091	2.2	0.4101
PCB-077	ng/L	0.000146	0.000568	0.00037
PCB-081	ng/L	Non detects	Non detects	Non detects
PCB-105	ng/L	0.000455	0.005	0.002086

Table 3b
Minimum, Mean, and Maximum COC Exposure Concentrations – Surface Water

Chemical Name	Target Unit	Minimum Detected Result	Maximum Detected Result	Average Detect Result
PCB-114	ng/L	0.000047	0.00029	0.0001366
PCB-118	ng/L	0.00133	0.0116	0.004975556
PCB-123	ng/L	0.000056	0.000154	9.16666E-05
PCB-126	ng/L	0.000034	0.000057	0.0000455
PCB-156	ng/L	Non detects	Non detects	Non detects
PCB-157	ng/L	Non detects	Non detects	Non detects
PCB-167	ng/L	0.000068	0.000854	0.000365
PCB-169	ng/L	Non detects	Non detects	Non detects
PCB-189	ng/L	0.000083	0.00032	0.00020125
2,4'-DDD (o,p'-DDD)	µg/L	0.0000177	0.000102	4.90333E-05
2,4'-DDT (o,p'-DDT)	µg/L	0.00000532	0.0000488	0.00002573
4,4'-DDD (p,p'-DDD)	µg/L	0.0000495	0.000839	0.00019493
4,4'-DDE (p,p'-DDE)	µg/L	0.0000344	0.00022	9.52444E-05
4,4'-DDT (p,p'-DDT)	µg/L	0.0000144	0.0029	0.00035906
alpha-Hexachlorocyclohexane	µg/L	0.0000204	0.000099	3.45142E-05
beta-Hexachlorocyclohexane	µg/L	0.0000021	0.00000891	0.000005505
delta-Hexachlorocyclohexane	µg/L	0.00000356	0.00000388	0.00000372
Endrin ketone	µg/L	0.00000403	0.00000414	0.000004085
gamma-Hexachlorocyclohexane (Lindane)	µg/L	0.000000364	0.0000292	0.000017893
LWG RA Sum DDD (Calculated U = 1/2)	µg/L	0.0000672	0.00108	0.00026325
LWG RA Sum DDE (Calculated U = 1/2)	µg/L	0.0000369	0.000242	0.000103689
LWG RA Sum DDT (Calculated U = 1/2)	µg/L	0.0000173	0.0031	0.00040007
LWG RA Total DDx (Calculated U = 1/2)	µg/L	0.000145	0.0043	0.000883182
Carbazole	µg/L	0.024	0.16	0.081333333
Dibenzofuran	µg/L	0.0214	0.0731	0.042266667
Diesel Range Hydrocarbons	mg/L	Non detects	Non detects	Non detects
1,1-Dichloroethene	µg/L	0.51	0.51	0.51
1,2-Dichloroethene, cis-	µg/L	1.24	279	83.644
1,2-Dichloroethene, trans-	µg/L	1.46	1.46	1.46
Benzene	µg/L	0.05	31.4	1.011875
Ethylbenzene	µg/L	0.14	11.4	2.758888889
LWG RA Total Xylene (Calculated U = 1/2)	µg/L	0.34	5.9	1.446666667
Naphthalene	µg/L	2.46	605	152.174375
o-Xylene	µg/L	0.11	1.97	0.655
Toluene	µg/L	0.06	4.12	0.36627451
Trichloroethene (TCE)	µg/L	0.61	194	97.305
Vinyl chloride	µg/L	0.32	73.2	6.026666667

Notes:

µg/L microgram per liter

ng/L nanogram per liter

Table 3c
Minimum, Mean, and Maximum COC Exposure Concentrations – Sediment

Chemical Name	Target Unit	Minimum Detected Result	Maximum Detected Result	Average Detect Result
2-Methylnaphthalene	µg/kg	0.51	3800000	82120.09101
Acenaphthene	µg/kg	0.23	3900000	70980.46361
Acenaphthylene	µg/kg	0.29	1500000	17153.94993
Anthracene	µg/kg	0.3	1300000	36310.38585
Benzo(a)anthracene	µg/kg	0.21	760000	24603.34155
Benzo(a)pyrene	µg/kg	0.25	940000	29283.96868
Benzo(b)fluoranthene	µg/kg	0.42	590000	22690.52241
Benzo(g,h,i)perylene	µg/kg	0.34	730000	20638.06108
Benzo(k)fluoranthene	µg/kg	0.22	540000	12550.23843
Chrysene	µg/kg	0.61	980000	30222.79154
Dibenzo(a,h)anthracene	µg/kg	0.38	67000	2699.164152
Fluoranthene	µg/kg	0.51	3500000	94294.0164
Fluorene	µg/kg	0.23	1500000	35013.0998
Indeno(1,2,3-c,d)pyrene	µg/kg	0.4	610000	19594.8087
LWG RA Total 10 of 17 HPAH (Calculated U = 1/2)	µg/kg	2.2	13000000	361481.1753
LWG RA Total 17 PAH (Calculated U = 1/2)	µg/kg	3.7	53000000	988789.0077
LWG RA Total 7 of 17 LPAH (Calculated U = 1/2)	µg/kg	2.1	40000000	632992.6726
LWG RA Total cPAH TEQ (EPA 1993) (Calculated U = 1/2)	µg/kg	0.45	1200000	37980.2216
Naphthalene	µg/kg	0.5	20000000	307000.7434
Phenanthrene	µg/kg	0.46	8500000	197247.0275
Pyrene	µg/kg	0.49	4700000	120574.5105
Cyanide	mg/kg	0.03	26.9	1.15553719
Zinc	mg/kg	16.3	891	95.25571429
Zinc	µg/L	9	9	9
Aroclor 1016	µg/kg	Non detects	Non detects	Non detects
Aroclor 1221	µg/kg	Non detects	Non detects	Non detects
Aroclor 1232	µg/kg	Non detects	Non detects	Non detects
Aroclor 1242	µg/kg	23	93	53.25
Aroclor 1248	µg/kg	5.8	130	41.33675676
Aroclor 1254	µg/kg	6.1	180	61.91764706
Aroclor 1260	µg/kg	2.03	290	52.3980597
LWG RA Total PCB Aroclors (Calculated U = 1/2)	µg/kg	8.56	640	134.6978788
LWG RA Total PCB Congener (Calculated U = 1/2)	ng/kg	12000	230000	99181.81818
PCB-077	ng/kg	36.2	602	210.5181818
PCB-081	ng/kg	1.64	85.3	25.995
PCB-105	ng/kg	124	2140	827.0909091
PCB-114	ng/kg	11.3	167	71.3625
PCB-123	ng/kg	6.13	115	45.78111111
PCB-126	ng/kg	2.63	70.4	26.64333333

Table 3c
Minimum, Mean, and Maximum COC Exposure Concentrations – Sediment

Chemical Name	Target Unit	Minimum Detected Result	Maximum Detected Result	Average Detect Result
PCB-156	ng/kg	46.6	811	352.5454545
PCB-157	ng/kg	11.3	136	70.4
PCB-167	ng/kg	21.9	311	146.6
PCB-169	ng/kg	1.46	1.67	1.565
PCB-189	ng/kg	7.27	165	68.75222222
2,4'-DDD (o,p'-DDD)	µg/kg	0.098	1340	59.86122449
2,4'-DDT (o,p'-DDT)	µg/kg	0.463	815	32.01627941
4,4'-DDD (p,p'-DDD)	µg/kg	0.129	4750	141.6293434
4,4'-DDE (p,p'-DDE)	µg/kg	0.054	500	21.26015966
4,4'-DDT (p,p'-DDT)	µg/kg	0.094	1060	67.945925
alpha-Hexachlorocyclohexane	µg/kg	0.116	38	4.7186
beta-Hexachlorocyclohexane	µg/kg	0.099	318	10.27518841
delta-Hexachlorocyclohexane	µg/kg	0.0175	45.4	6.824106061
Endrin ketone	µg/kg	0.16	263	26.03258824
gamma-Hexachlorocyclohexane (Lindane)	µg/kg	0.492	9.6	2.8225
LWG RA Sum DDD (Calculated U = 1/2)	µg/kg	0.145	6090	177.5919583
LWG RA Sum DDE (Calculated U = 1/2)	µg/kg	0.063	530	26.85177344
LWG RA Sum DDT (Calculated U = 1/2)	µg/kg	0.11	1870	82.33732283
LWG RA Total DDx (Calculated U = 1/2)	µg/kg	0.22	6700	254.8043277
gamma-Hexachlorocyclohexane (Lindane)	µg/L	Non detects	Non detects	Non detects
Carbazole	µg/kg	1.7	520000	16628.32308
Dibenzofuran	µg/kg	0.24	230000	6426.767797
Diesel Range Hydrocarbons	mg/kg	2.1	190000	5626.504819
Residual Range Hydrocarbons	mg/kg	3.1	110000	3413.427439
1,1-Dichloroethene	µg/kg	Non detects	Non detects	Non detects
1,2-Dichloroethene, cis-	µg/kg	6.1	2200	751.525
1,2-Dichloroethene, trans-	µg/kg	Non detects	Non detects	Non detects
Benzene	µg/kg	0.03	270000	7753.164296
Ethylbenzene	µg/kg	0.05	140000	7825.926527
LWG RA Total Xylene (Calculated U = 1/2)	µg/kg	0.055	280000	7777.94428
Naphthalene	µg/kg	0.89	18000000	1148565.585
o-Xylene	µg/kg	0.04	80000	2681.387222
Toluene	µg/kg	0.03	190000	4792.043929
Total Xylene (reported, not calculated)	µg/kg	330	330	330
Trichloroethene (TCE)	µg/kg	0.23	1900000	115874.2205
Vinyl chloride	µg/kg	0.57	4000	695.1766667
1,1-Dichloroethene	µg/L	Non detects	Non detects	Non detects
Benzene	µg/L	13	2900	1456.5
Trichloroethene (TCE)	µg/L	Non detects	Non detects	Non detects
Vinyl chloride	µg/L	Non detects	Non detects	Non detects

Notes:

µg/L microgram per liter

µg/kg microgram per kilogram

ng/kg nanogram per kilogram

Table 3d
Minimum, Mean, and Maximum COC Exposure Concentrations – Groundwater and TZW

Chemical Name	Target Unit	Minimum Detected Result	Maximum Detected Result	Average Detect Result
2-Methylnaphthalene	µg/kg	23	53000	7787.9
Acenaphthene	µg/kg	95	120000	20167.5
Acenaphthylene	µg/kg	47	12000	2393.9
Anthracene	µg/kg	94	73000	13387.4
Benzo(a)anthracene	µg/kg	350	120000	21929
Benzo(a)pyrene	µg/kg	560	160000	31594
Benzo(b)fluoranthene	µg/kg	340	110000	19938
Benzo(g,h,i)perylene	µg/kg	450	130000	24767
Benzo(k)fluoranthene	µg/kg	290	89000	17117
Chrysene	µg/kg	440	130000	24395
Dibenzo(a,h)anthracene	µg/kg	59	15000	2650.3
Fluoranthene	µg/kg	670	350000	63954
Fluorene	µg/kg	61	58000	10105
Indeno(1,2,3-c,d)pyrene	µg/kg	450	130000	24511
LWG RA Total 10 of 17 HPAH (Calculated U = 1/2)	µg/kg	4400	1700000	314700
LWG RA Total 17 PAH (Calculated U = 1/2)	µg/kg	5100	2400000	432120
LWG RA Total 7 of 17 LPAH (Calculated U = 1/2)	µg/kg	690	760000	128149
LWG RA Total cPAH TEQ (EPA 1993) (Calculated U = 1/2)	µg/kg	740	210000	41144
Naphthalene	µg/kg	61	55000	7887.1
Phenanthrene	µg/kg	310	390000	66454
Pyrene	µg/kg	840	450000	82634
2-Methylnaphthalene	µg/L	0.0026	5700	72.19993136
Acenaphthene	µg/L	0.0038	2400	62.05515293
Acenaphthylene	µg/L	0.0023	250	7.766737849
Anthracene	µg/L	0.0042	1500	13.62432178
Benzo(a)anthracene	µg/L	0.0028	1000	9.442801015
Benzo(a)pyrene	µg/L	0.0036	990	13.3871956
Benzo(b)fluoranthene	µg/L	0.0028	530	8.76771215
Benzo(g,h,i)perylene	µg/L	0.003	650	9.873031761
Benzo(k)fluoranthene	µg/L	0.0021	520	6.788756989
Chrysene	µg/L	0.0029	1200	11.81355556
Dibenzo(a,h)anthracene	µg/L	0.0024	81	1.631630531
Fluoranthene	µg/L	0.0055	3700	30.76889773
Fluorene	µg/L	0.0039	1400	20.90292292
Indeno(1,2,3-c,d)pyrene	µg/L	0.0034	550	8.754909841
LWG RA Total 10 of 17 HPAH (Calculated U = 1/2)	µg/L	0.031	13000	109.9778755

Table 3d

Minimum, Mean, and Maximum COC Exposure Concentrations – Groundwater and TZW

Chemical Name	Target Unit	Minimum Detected Result	Maximum Detected Result	Average Detect Result
LWG RA Total 17 PAH (Calculated U = 1/2)	µg/L	0.11	47000	1135.273217
LWG RA Total 7 of 17 LPAH (Calculated U = 1/2)	µg/L	0.024	34000	1020.049129
LWG RA Total cPAH TEQ (EPA 1993) (Calculated U = 1/2)	µg/L	0.0026	1300	12.98274606
Naphthalene	µg/L	0.0067	16000	1126.377986
Phenanthrene	µg/L	0.0045	8700	77.85272414
Pyrene	µg/L	0.0048	4300	34.49300561
Cyanide	mg/kg	0.14	7.3	1.398333333
Cyanide	mg/L	0.002	23.1	0.520231707
Cyanide, free	mg/L	0.005	0.026	0.00975
Zinc	mg/kg	96.2	237	122.44
Zinc	µg/L	1.3	19200	390.2438562
Carbazole	µg/kg	13	880	225.5
Dibenzofuran	µg/kg	12	7300	1205.4
Carbazole	µg/L	1.18	219	37.06446809
Dibenzofuran	µg/L	0.0038	220	4.574626183
Diesel Range Hydrocarbons	mg/kg	98	10000	2454.8
Residual Range Hydrocarbons	mg/kg	250	13000	3102
Diesel Range Hydrocarbons	mg/L	0.24	6.1	1.618043478
Residual Range Hydrocarbons	mg/L	0.13	1.2	0.482
1,1-Dichloroethene	µg/kg	Non detects	Non detects	Non detects
1,2-Dichloroethene, cis-	µg/kg	0.21	0.21	0.21
1,2-Dichloroethene, trans-	µg/kg	Non detects	Non detects	Non detects
Benzene	µg/kg	0.26	64	17.368
Ethylbenzene	µg/kg	0.15	710	186.104
LWG RA Total Xylene (Calculated U = 1/2)	µg/kg	0.81	670	155.7183333
o-Xylene	µg/kg	0.5	500	112.0883333
Toluene	µg/kg	52	52	52
Trichloroethene (TCE)	µg/kg	Non detects	Non detects	Non detects
Vinyl chloride	µg/kg	0.34	0.34	0.34
1,1-Dichloroethene	µg/L	0.19	283	16.65735849
1,2-Dichloroethene, cis-	µg/L	0.12	574000	5101.851548
1,2-Dichloroethene, trans-	µg/L	0.19	1760	46.82677966
Benzene	µg/L	0.14	24000	1296.856769
Ethylbenzene	µg/L	0.14	905	100.5652921
LWG RA Total Xylene (Calculated U = 1/2)	µg/L	0.22	670	59.30108225
Naphthalene	µg/L	0.29	19700	2200.069234
o-Xylene	µg/L	0.11	240	26.51955556

Table 3d
Minimum, Mean, and Maximum COC Exposure Concentrations – Groundwater and TZW

Chemical Name	Target Unit	Minimum Detected Result	Maximum Detected Result	Average Detect Result
Toluene	µg/L	0.11	821	28.18587896
Total Xylene (reported, not calculated)	µg/L	0.24	1433	106.2025287
Trichloroethene (TCE)	µg/L	0.14	585000	6734.175381
Vinyl chloride	µg/L	0.05	28900	531.6960221

Notes:

µg/kg microgram per kilogram
mg/kg milligram per kilogram
µg/L microgram per liter
ng/L nanogram per liter

FIGURES

LEGEND:

- Property Boundary
- Evacuation Route
- Emergency Assembly Area
- Upland Processing Area

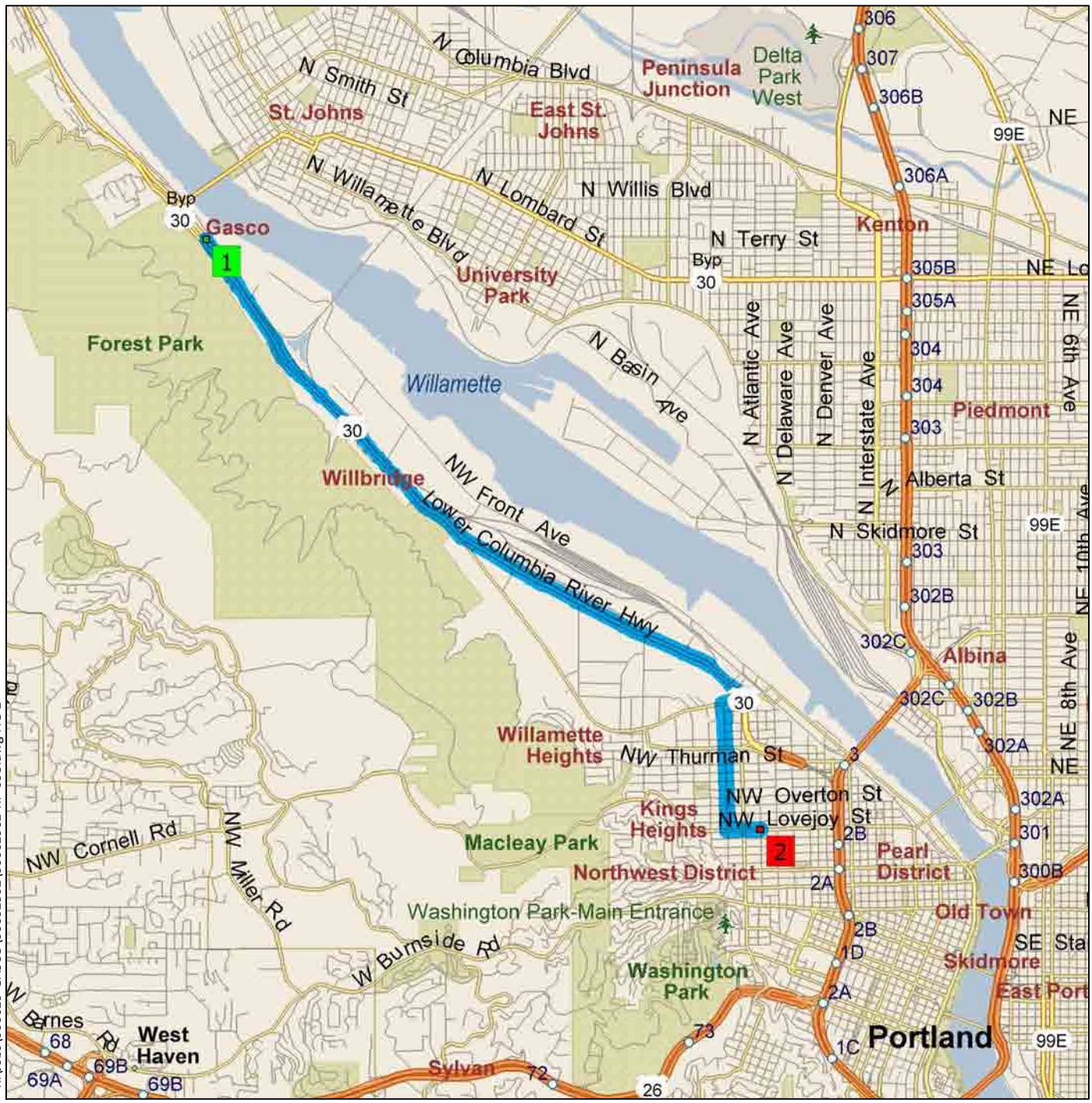
0 300
Scale in Feet

K:\Jobs\000029-GASCO\00002902\00002902-RP-092.dwg FIG 1

May 05, 2011 1:17pm dholmer

ANCHOR QEA

Figure 1
Emergency Evacuation Route Map and Emergency Assembly Area
Anchor QEA Health and Safety Plan
Gasco Sediments Cleanup Action



K:\Jobs\000029-GASCO\00002902\00002902-RP-093.dwg FIG 2

May 05, 2011 1:17pm dholmer

1 UPLAND SITE ADDRESS
7900 NW St. Helens Road
Portland, OR 97210

2 HOSPITAL ADDRESS
Legacy Good Samaritan Hospital
and Medical Center
1015 NW 22nd Ave.
Portland, OR 97210

DIRECTIONS

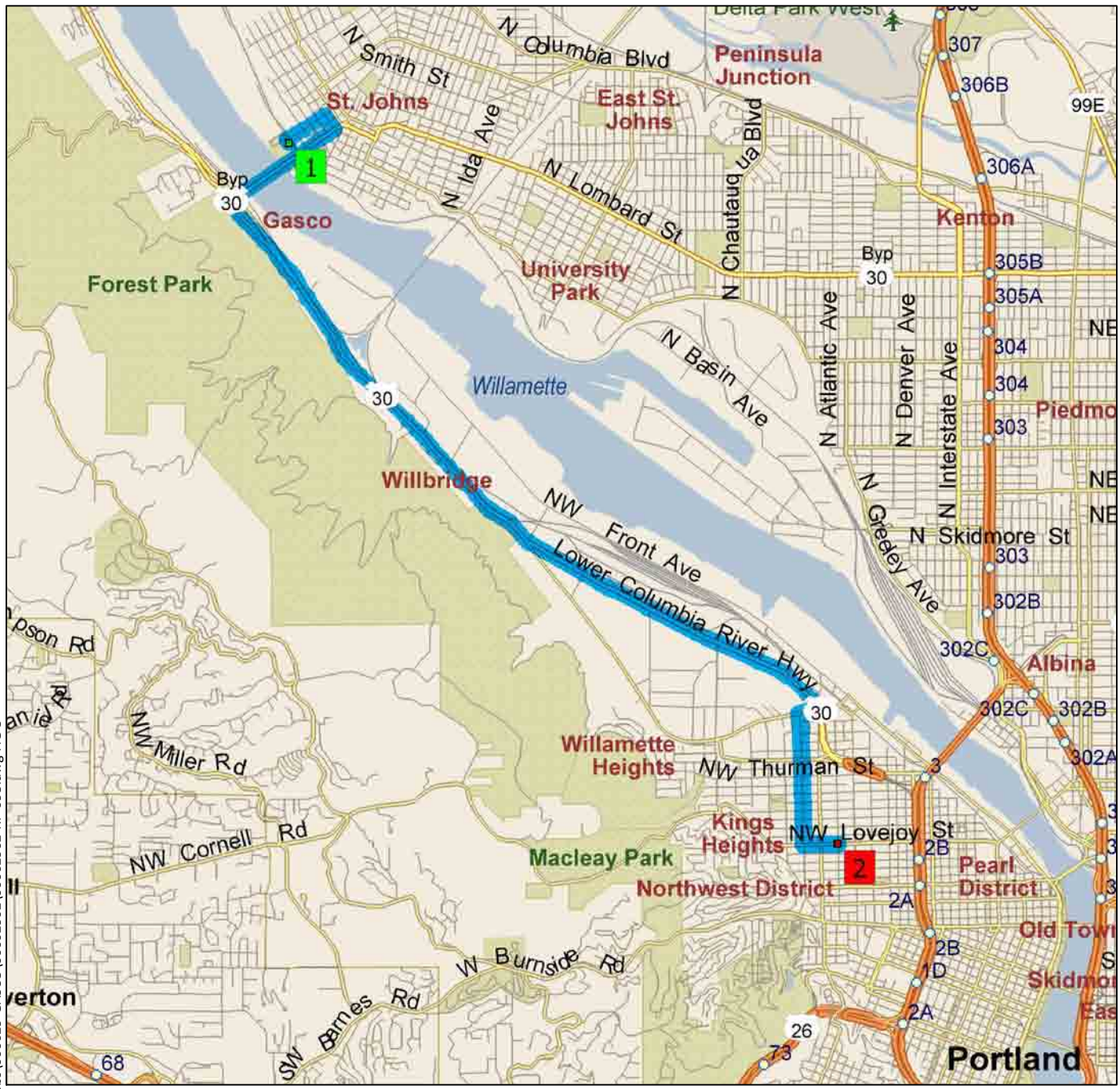
- Depart 7900 NW St. Helens Road towards NW Bridge Ave. (go 2.2 miles)
- Continue on US-30 E/NW Yeon Ave. (go 1.9 miles)
- Turn right toward NW Nicolai Street (go 131 feet)
- Turn right at NW Nicolai Street (go 0.1 mile)
- Turn left at NW 24th Ave. (go 0.8 mile)
- Turn left at NE Lovejoy Street (go 0.2 mile)
- Turn left at the 2nd cross street onto NW 22nd Ave. (go 144 feet)
- Legacy Good Samaritan Hospital will be on the left

0 4600
Scale in Feet

SOURCE: Map from Microsoft Streets & Trips, 2010.

Figure 2
Map to the Nearest Hospital, Uplands Work Area
Anchor QEA Health and Safety Plan
Gasco Sediments Cleanup Action

ANCHOR QEA



K:\Jobs\000029-GASCO\00002902\00002902-RP-093.dwg FIG 3

May 05, 2011 1:17pm dholmer

1 **ON-WATER SITE ADDRESS**
Cathedral Park

2 **HOSPITAL ADDRESS**
Legacy Good Samaritan Hospital
and Medical Center
1015 NW 22nd Ave.
Portland, OR 97210

SOURCE: Map from Microsoft Streets & Trips, 2010.

DIRECTIONS

- Depart near Untied Junction
- Turn right (East) onto North Baltimore Ave. (go 0.3 mile)
- Turn right (Southeast) onto North Syracuse Street (go 174 yards)
- Turn right (Southwest) onto US-30 (St. Johns Bridge) (go 1.3 miles)
- Bear right (South) onto US-30 (Lower Columbia River Highway) (go 4.0 miles)
- Turn right toward NW Nicolai Street (go 131 feet)
- Turn right at NW Nicolai Street (go 0.1 mile)
- Turn left at NW 24th Ave. (go 0.8 mile)
- Turn left at NE Lovejoy Street (go 0.2 mile)
- Turn left at the 2nd cross street onto NW 22nd Ave. (go 144 feet)
- Legacy Good Samaritan Hospital will be on the left

0 4600
Scale in Feet

Figure 3
Map to the Nearest Hospital, On-water Work Area
Anchor QEA Health and Safety Plan
Gasco Sediments Cleanup Action

ANCHOR QEA

ATTACHMENT 1
SAFETY RECORD FORMS

FIELD TEAM HEALTH AND SAFETY PLAN REVIEW

ANCHOR QEA, LLC

NW NATURAL GASCO SITE

I have read a copy of the HASP, which covers field activities that will be conducted to investigate specified areas on and adjacent to the NW Natural Gasco Site, Portland, Oregon. I understand the health and safety requirements of the project, which are detailed in this HASP.

Signature Date

Signature Date

Signature Date

Signature Date

Signature Date

ATTACHMENT 2
HEALTH AND SAFETY LOGS AND FORMS

DAILY AIR MONITORING RECORD

PROJECT NAME: _____ **DATE:** _____

PROJECT NUMBER: _____ **LOCATION:** _____

TEMPERATURE: _____

CONDITIONS: _____

_____

_____

_____

COC	Instrument	S/N	Calibration Date	Calibration Gas/Method	Calibration by
Organic vapors					
Particulates					
O_2					
Other:					
Other:					
Other:	Draeger				

Time	Location/Description	Organic Vapor (ppm)	O_2%	CG %LEL	Other	Other

Notes:

Completed by:

_____ _____ _____

Printed Name Signature Date

ANCHOR QEA

DATE: _____

PROJECT NAME: _____

PROJECT NO: _____

DAILY SAFETY BRIEFING

PERSON CONDUCTING MEETING: _____ **HEALTH & SAFETY OFFICER:** _____ **PROJECT MANAGER:** _____

TOPICS COVERED:

- ☐ Emergency Procedures and Evacuation Route
- ☐ Directions to Hospital
- ☐ HASP Review and Location
- ☐ Safety Equipment Location
- ☐ Proper Safety Equipment Use
- ☐ Employee Right-to-Know/MSDS Location
- ☐ Fire Extinguisher Location
- ☐ Eye Wash Station Location
- ☐ Buddy System
- ☐ Self and Coworker Monitoring
- ☐ Lines of Authority
- ☐ Communication
- ☐ Site Security
- ☐ Vessel Safety Protocols
- ☐ Work Zones
- ☐ Vehicle Safety and Driving/Road Conditions
- ☐ Equipment Safety and Operation
- ☐ Proper Use of PPE
- ☐ Decontamination Procedures
- ☐ Other:
- ☐ Lifting Techniques
- ☐ Slips, Trips, and Falls
- ☐ Hazard Exposure Routes
- ☐ Heat and Cold Stress
- ☐ Overhead and Underfoot Hazards
- ☐ Chemical Hazards
- ☐ Flammable Hazards
- ☐ Biological Hazards
- ☐ Eating/Drinking/Smoking

WEATHER CONDITIONS: _____

DAILY WORK SCOPE: _____

SITE-SPECIFIC HAZARDS: _____

SAFETY COMMENTS: _____

ATTENDEES

PRINTED NAME	SIGNATURE