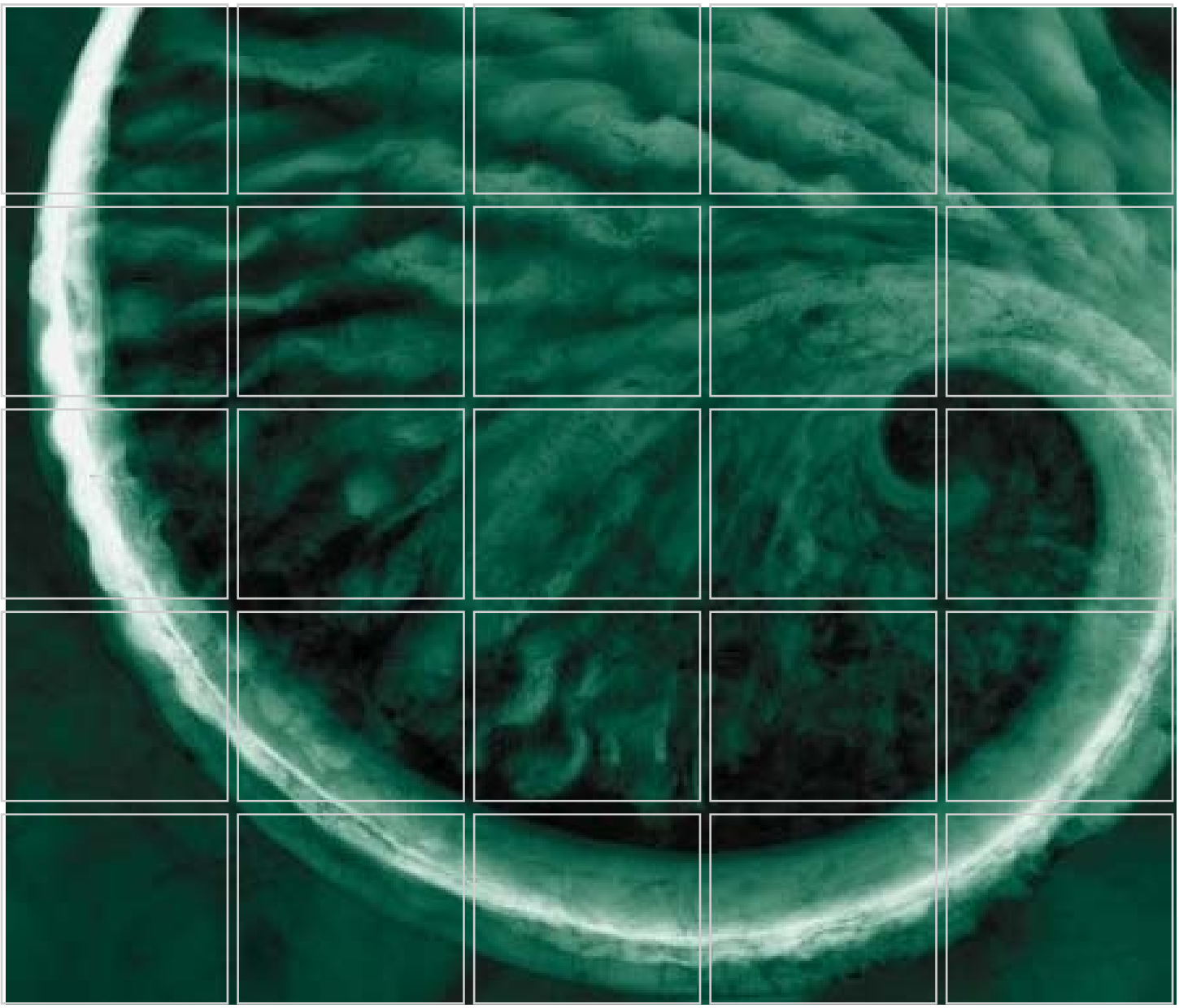

Revised Final Performance Monitoring Plan – Groundwater Source Control Measure

Arkema Inc. Facility
Portland, Oregon

July 2014

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ERM

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Arkema Inc. Facility, Portland, Oregon

July 2014

Project No. 0243285

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LIST OF ACRONYMS

COPC	Constituent of potential concern
DDT	Dichlorodiphenyltrichloroethane
ERM	ERM-West, Inc.
FBR	Fluidized bed reactor
FFS	Focused feasibility study
FS	Feasibility study
GWBW	Groundwater barrier wall
GWET	Groundwater extraction and treatment
GW SCM	Groundwater source control measure
JSCS	Joint Source Control Strategy
LSS	Legacy Site Services LLC
NPDES	National Pollutant Discharge Elimination System
NTCRA	Non-time-critical removal action
ODEQ	Oregon Department of Environmental Quality
PDR	Preliminary Design Report
PMP	Performance Monitoring Plan
PVC	Polyvinyl chloride
SCM	Source control measure
USEPA	United States Environmental Protection Agency

1.0 INTRODUCTION

On behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), ERM-West, Inc. (ERM) has prepared this Performance Monitoring Plan (PMP) for the former Arkema Portland Plant located at 6400 NW Front Avenue in Portland, Oregon (the site) (Figure 1-1). This PMP has been prepared pursuant to the Order on Consent requiring source control measures (SCMs) and a feasibility study (FS) issued by the Oregon Department of Environmental Quality (ODEQ), signed 31 October 2008 (DEQ No. LQVC-NWR-08-04) (Consent Order).

The purpose of this PMP is to present the monitoring requirements for the implementation of a groundwater source control measure (GW SCM). The PMP has been prepared in accordance with the following:

- *Scoping Technical Memorandum, Groundwater Source Control Interim Remedial Measure* (Scoping Memo) (ERM 2006);
- *Summary of Remedial Technology Alternatives Memorandum, Groundwater Source Control Interim Remedial Measure Focused Feasibility Study* (ERM 2008a);
- *Draft Focused Feasibility Study, Groundwater Source Control Interim Remedial Measure* (FFS) (ERM 2008b);
- *Draft Groundwater Source Control Measure Design and Implementation Work Plan* (Work Plan) (ERM 2009b);
- *Draft Preliminary Design Report – Groundwater Source Control Measure* (PDR) (ERM 2010b);
- *Groundwater Extraction and Treatment System Pre-Final Design* (ERM 2011b);
- *Groundwater Extraction and Treatment System Final Design* (Groundwater Extraction and Treatment [GWET] System Final Design) (ERM 2013); and
- Associated comments and approvals received from the ODEQ and United States Environmental Protection Agency (USEPA), included as Appendix E of this PMP.

1.1 BACKGROUND

The Site is located at 6400 NW Front Avenue in the Northwest Industrial Area of Portland, Oregon. The Site is located in the heart of the Guild's Lake Industrial Sanctuary, zoned and designated "IH" for heavy industrial use. The Site is bounded by Front Avenue on the north and west, the Willamette River on the east, and an asphalt roofing manufacturer on the south. The plant operated as a chemical manufacturing facility for over 50 years. Manufacturing activities at the facility were terminated in 2001, and the plant was decommissioned and dismantled in 2004. F

1.1.1 Site History

Starting in 1941, various chemicals were produced at the site, including: sodium chlorate, potassium chlorate, chlorine, sodium hydroxide, dichlorodiphenyltrichloroethane (DDT), sodium orthosilicate, sodium hydroxide, magnesium chloride hexahydrate, ammonia, ammonium perchlorate, sodium perchlorate, and hydrochloric acid. Most recently, the facility was an operating chlor-alkali plant until the plant shut down in 2001.

A detailed description of historical site activities and manufacturing processes was presented in the *Upland Remedial Investigation Report Lots 3 & 4 and Tract A – Revision 1* (RI Report) (ERM 2005).

Decommissioning and removal of the manufacturing infrastructure were completed in early 2005. The only remaining original structures are the office building located at the site entrance on Front Street and several concrete floor slabs left in place as environmental caps (Figure 1-2). Arkema maintains leases from the Oregon Department of State Lands for the docks in the Willamette River, which are not currently in use.

1.1.2 Regulatory Background

In 1998, Arkema entered into a Voluntary Agreement with the ODEQ under the Oregon Voluntary Cleanup Program to address impacts on environmental media associated with the manufacture of DDT in the Acid Plant Area and sediment in the Willamette River adjacent to the Site. The RI Report was conditionally approved by the ODEQ on 5 June 2006. Detailed information regarding environmental conditions at the Site is provided in the RI Report, which contains a site description, background

information, and discussion of the nature and extent of contamination at the Site.

In June 2005, Arkema entered into a non-time-critical removal action administrative settlement with the United States Environmental Protection Agency (USEPA) (Early Action)[1] to address impacts to near-shore sediment at the Site. The Statement of Work for the Early Action requires, among other things, the preparation and delivery of an Engineering Evaluation/Cost Analysis (EE/CA) Work Plan to identify and provide alternatives for addressing the primary chemicals of potential concern (COPCs) in the intertidal area and submerged lands on and adjacent to the Site. The draft EE/CA was submitted to the USEPA on 26 July 2012 (Integral 2012). Agency comments on the EE/CA were received on 11 February 2013. Responses were submitted on 28 March 2013.

In 2008, Arkema and the ODEQ entered into the Consent Order for the upland portion of the Site. The upland Consent Order requires submittal of various documents in support of upland source control (i.e., groundwater, stormwater, and erodible soil) and the upland FS (data gap investigation, risk assessment, hot spot evaluation, and FS Work Plan and FS).

A groundwater source control evaluation was submitted to the ODEQ in 2007 (Integral 2007a) and an addendum was submitted in 2008 (Integral 2008a). The source control screening evaluation concluded that implementation of the Groundwater SCM would prevent additional contaminant flux to the Willamette River, as required by the Joint Source Control Strategy (JSCS)[2]. In May 2008, LSS submitted the *Focused Feasibility Study, Groundwater Source Control Interim Remedial Measure* (FFS) in support of the Groundwater SCM at the Site (ERM 2008b). The FFS provided an evaluation of remedial alternatives and selected the preferred alternative for the Groundwater SCM.

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1 *Administrative Order on Consent for Removal Action*, USEPA Region 10, Docket No. CERCLA 10-20050191 (27 June 2005).

2 *The Portland Harbor Joint Source Control Strategy* prepared by the ODEQ and USEPA (ODEQ 2005) is a framework for making upland source control decisions at the Portland Harbor Superfund Site.

On 23 February 2009, the ODEQ approved the general approach for the Groundwater SCM. This approach included installation of a groundwater barrier wall and a GWET system, with treated water discharged to the Willamette River. The ODEQ approved the *Groundwater Barrier Wall Final Design* (ERM 2012b) on 7 August 2012. Construction of the groundwater barrier wall began in May 2012 and was completed in December 2012. The ODEQ approved the *Arkema Portland Groundwater Source Control Measure Groundwater Extraction and Treatment System Final Design* (ERM 2013) on 2 April 2013. Construction of the GWET system began in December 2012 and is anticipated to be completed in September 2013.

Between September 2000 and November 2006, several stormwater IRMs—including soil removal, temporary capping, and Best Management Practices [BMPs]—were implemented at the Site to address stormwater (Integral 2007b). However, because the planned Groundwater SCM was going to require a substantial modification and rerouting of the existing stormwater system, LSS agreed to further enhance the stormwater BMPs. LSS subsequently began preparing a Stormwater SCM FFS (SW FFS) (Integral 2008b) to evaluate additional stormwater IRMs. Following negotiation and response to comments on the SW FFS, LSS began designing the Stormwater SCM with preparation of the Design Work Plan (Integral 2009). Subsequent to this submittal, the ODEQ and Arkema entered into the Memorandum of Agreement and Order (MAO), which was executed on 4 August 2010.

The *Final Design Report Stormwater Source Control Measures* (Integral 2011) was submitted on 30 September 2011 and conditionally approved by the ODEQ on 21 December 2011. Construction of the Stormwater SCM began in April 2012 and was substantially complete at the time of this Work Plan. The design and implementation of the Stormwater SCM are summarized in Section 3.6.2. Stormwater SCM performance monitoring began in January 2013. A Performance Monitoring Report for the Stormwater SCMs at the Arkema Portland Facility was submitted on 1 June 2013. These design reports and performance monitoring report were prepared pursuant to the Order on Consent requiring SCMs, issued by the ODEQ, signed 31 October 2008 (ODEQ No. LQVC-NWR-08-04), and the storm water MAO, No. WQ/I-NWR-10-175 executed by ODEQ and LSS, as agent for Arkema, on 4 August 2010.

1.1.2 Groundwater Source Control Measure Development

The JSCS is a guidance document that was developed by the ODEQ and USEPA to identify, evaluate, and control potential sources of

contamination that may impact the Willamette River in a manner that is consistent with the objective and schedule for the Portland Harbor Superfund Site RI/FS (ODEQ 2005). LSS notes that, per statements from ODEQ and USEPA in the JSCS, screening levels are not intended to be cleanup levels or discharge limits. The goal of the JSCS is to achieve timely upland source control to prevent the risk of significant recontamination after the Portland Harbor cleanup is completed. The JSCS recommends that upland source control be substantially completed to the greatest extent practicable before or during any early removal actions, as well as none time-critical removal actions (NTCRAs), in order to reduce the potential for recontamination of river sediment.

Several innovative in situ interim remedial measures were implemented at the site between September 2000 and April 2006. Despite the success of those interim remedial measures, LSS did not believe an in situ remedial approach would be capable of meeting the source control objectives—many of which are not yet defined—in the USEPA-envisioned timeframe for the sediment NTCRA currently being planned at the site. Because of the NTCRA schedule, LSS has been required to pursue an alternative strategy of physical and hydraulic containment to achieve groundwater source control.

Following discussions with the ODEQ in September 2006, the Scoping Memo (ERM 2006) was prepared to identify and outline the general concepts necessary to complete a GW SCM. The ODEQ provided comments on this memo in January 2007, and these comments were addressed in a letter submitted by LSS in March 2007.

LSS subsequently commenced preparation of the FFS in April 2007 to evaluate the alternatives for a GW SCM to achieve the following remedial action objectives:

- Establish hydraulic control of groundwater constituents of potential concern (COPCs) at the site, and maintain an inward groundwater gradient toward the upland portion of the site, away from the Willamette River;
- Reduce the potential for recontamination of river sediments via the groundwater pathway following the Arkema NTCRA;
- Allow upland SCMs to proceed on an independent schedule from the NTCRA without impeding or compromising that work; and

- Implement a remedy, which, to the extent practicable, will complement and be compatible with potential final upland remedies for the site.

The GW SCM evaluated in the FFS consisted of the following primary components:

1. A containment barrier wall to physically separate the affected upland portions and in-water portions of the site.
2. Hydraulic control (GWET) to prevent groundwater containing unacceptable concentrations of COPCs from moving around, over, or under the containment barrier wall.
3. Management of treated groundwater from the ex situ treatment system, with treated effluent discharged to the Willamette River under a National Pollutant Discharge Elimination System (NPDES) Permit.

As requested by the ODEQ, LSS submitted the *Summary of Remedial Technology Alternatives Memorandum Groundwater Source Control Interim Remedial Measure Focused Feasibility Study* (ERM 2008a) in January 2008. This document provided a technology screening and summarized the range of remedial alternatives (i.e., proposed barrier wall alignments, treatment system options, and discharge options) being evaluated as part of the FFS (ERM 2008b).

Supporting studies and evaluations—including groundwater modeling, a GWBW geotechnical engineering analysis, slurry materials testing, and a groundwater treatability study—were completed between 2006 and 2008. Following the completion of this supporting work and the technology screening, a detailed evaluation and comparative analysis of the various remedial action alternatives was performed and presented in the FFS submitted to the ODEQ in May 2008.

The lateral and vertical extent of the GW SCM was primarily determined by the extent of four major COPCs in groundwater: hexavalent chromium, perchlorate, chlorobenzene, and DDT (and associated breakdown products DDD and DDE, collectively referred to as DDx). The historical interim remedial measures have focused on remediating one or more of these COPCs. Current and historical data indicate that the on-site sources of these compounds are limited to specific areas on Lots 3 and 4 (ERM 2005; ERM 2010a). Once an approved groundwater source control evaluation for the former Rhone Poulenc site and an upland feasibility study at the Arkema is available, the ODEQ and LSS will evaluate the

necessity, if any, to perform additional GW SCMs along Lots 1, 2, and the remainder of Lot 3.

The ODEQ conditionally approved the FFS and provided comments on the proposed GW SCM in a letter dated 29 July 2008. On 12 September 2008, LSS submitted responses to ODEQ comments on the FFS.

In a memorandum dated 20 February 2009, the ODEQ recommended alternatives for the primary components of the GW SCM. The layout of the GW SCM is presented as Figure 1-2. A conceptual cross section of the GW SCM is presented as Figure 1-3.

The recommended barrier wall component of the GW SCM required construction of a GWBW along the top of the river bank extending to the top of the basalt using conventional slurry wall technology. The GWBW construction was completed in December 2012. The recommended GWET system for the GW SCM consists of the following major components:

- Twenty-two groundwater recovery wells screened in the Shallow and Intermediate Zones;
- A chemical precipitation reactor with aeration and pH adjustment via sodium hydroxide;
- A solids handling system (i.e., clarifier with polymer feed, sludge holding tank, and associated equipment);
- A pH adjustment tank;
- An optional post-clarification solids filter, if required;
- A fluidized bed reactor (FBR) with a solids filter for biomass handling; and
- Two liquid-phase granular activated carbon vessels in series.

The recommended treated water discharge option consists of discharge to the Willamette River.

The ODEQ published a public notice on 9 March 2009 seeking public comments on the recommended remedial alternative. A public meeting was held on 14 April 2009 to present the GW SCM. The public comment period closed on 21 April 2009 and the ODEQ issued a response to public comments in a letter dated 21 May 2009. The Work Plan was prepared following the FFS, as required by the Consent Order.

The PDR was submitted to the ODEQ in May 2010. The *Groundwater Source Control Measure – Groundwater Barrier Wall Pre-Final Design* (ERM 2010b) was submitted to the ODEQ in October 2010. A recovery well and piezometer network design was submitted to the ODEQ in an email dated 11 December 2012. The final recovery well and piezometer network design was approved by ODEQ 14 March 2013. The GWET System Final Design was submitted to the ODEQ on 7 March 2013. The Final Design was approved by the ODEQ on 2 April 2013. This PMP is a document required under the Work Plan, the PDR, and the GWET System Final Design.

1.2 OBJECTIVES

The objectives of this PMP are to:

- Present the monitoring scope and rationale for evaluating the performance of the GW SCM in preventing the flux of contaminants in groundwater to the Willamette River; and
- Present an effluent discharge monitoring scope and rationale to evaluate compliance with as-yet-to-be-determined NPDES permit requirements.

1.3 REPORT ORGANIZATION

The remainder of the PMP is organized as follows:

- Section 2.0 presents the hydraulic containment system layout, target capture zone, water level monitoring locations, and evaluation of capture;
- Section 3.0 presents the groundwater treatment system summary, system performance monitoring scope, and proposed NPDES compliance monitoring scope;
- Section 4.0 presents the adaptive management process and reporting of performance monitoring results; and
- Section 5.0 lists the references cited in this PMP.

2.0 HYDRAULIC CONTAINMENT MONITORING

2.1 GROUNDWATER EXTRACTION SYSTEM MANAGEMENT

A key objective of the GW SCM is to achieve hydraulic containment of the alluvial sequence at the site, in order to prevent the flow of COPCs to the Willamette River. The alluvial sequence at the site consists of the Shallow Zone, Intermediate Zone, Shallow-Intermediate Silt, and the Deep Zone. The distribution of COPCs at the site is predominantly within the Shallow Zone, with decreasing impacts observed in the Intermediate and Deep Zones.

The layout of the GW SCM, including the Target Capture Zone, is presented on Figure 2-1. A numerical groundwater model was used to determine the distribution of recovery wells required to achieve hydraulic capture using conservative extraction rates developed from site-specific pumping tests (ERM 2010b).

The hydraulic conditions of the site are variable and subject to both seasonal and daily tidal fluctuations. As noted in the PDR, there is additional inherent uncertainty associated with the results of numerical groundwater modeling. Because of this inherent uncertainty, an adaptive management approach will be used to control the operation of the groundwater extraction system to meet the objectives of the GW SCM (i.e., hydraulic capture of the alluvial sequence and maintaining an inward hydraulic gradient across the GWBW).

The principle of adaptive management is a systematic, iterative process of decision-making. The proposed approach will consist of regular monitoring of the hydraulic conditions of the GW SCM. The monitoring results will then be used to evaluate the performance of the GW SCM. Appropriate changes can be made to the operation of the extraction system to optimize the performance of the GW SCM. Subsequent monitoring will be used to evaluate the effectiveness of these operational changes and determine the need for additional, or alternative, measures.

The primary method for evaluating the performance of the GW SCM will be through evaluating the capture zone of the extraction system. The USEPA has published the guidance document *A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems* (USEPA 2008) for the development of hydraulic containment performance monitoring programs; this guidance has been followed to develop the monitoring

program described in this PMP. The guidance identifies six steps for systematic evaluation of capture zones:

1. Review site data, site conceptual model, and remedy objectives;
2. Define site-specific Target Capture Zone;
3. Interpret water levels using potentiometric surface maps (horizontal), water level difference maps (vertical), and water level pairs (gradient control points);
4. Perform calculations, including flow rate, capture zone width, and numerical modeling (simulate water levels, particle tracking, and/or transport modeling);
5. Evaluate concentration trends; and
6. Interpret actual capture and compare to Target Capture Zone, and assess uncertainties and data gaps.

The steps outlined above encompass an adaptive management approach evaluating the performance of the GW SCM and incorporating changes in the operation of the system.

Steps 1 and 2 have been performed as part of the development of the GW SCM. The current site data and conceptual model for the purpose of GW SCM design were presented most recently in the ODEQ-approved PDR. The objective of the GW SCM is to establish hydraulic control of groundwater at the Arkema site, and maintain an inward groundwater gradient towards the upland portion of the site, away from the Willamette River. The approved SCM consists of constructing a conventional slurry barrier wall, and installing and operating a GWET system.

The lateral extent of the Target Capture Zone shown on Figure 2-1 was based on the historical and current (as of August 2009) distribution of COPCs at the site, as presented in the PDR. The vertical extent of the Target Capture Zone includes the alluvial sequence, which consists of the Shallow Zone, Shallow-Intermediate Silt, Intermediate Zone, and the Deep Zone. The Basalt Zone is not included in the Target Capture Zone. However, some flow of groundwater from the Basalt Zone upwards into the actual capture zone will occur. Particle tracking and modeled groundwater head solutions for hydraulic containment were presented in the PDR and are included in Appendix A of this PMP. A vertical profile of the recovery well and piezometers adjacent to the GWBW and cross-sections perpendicular to groundwater flow are presented in Appendix B.

Step 4 of the EPA guidance indicates that both simple horizontal analyses and modeling can be used as additional lines of evidence regarding the extent of actual capture when the system is operating. Simplified manual calculations of groundwater flux through individual hydrogeologic layers within the target capture zone have not been presented in previous submittals related to the design of the GW SCM.

Simple horizontal analyses may be performed to estimate the total groundwater flux into the target capture zone and as a line of evidence in the performance evaluation of the GWET System under normal operating conditions.

During the design of the extraction system, several methods were used to bound potential total groundwater pumping rates that may be required to achieve hydraulic capture. Due to significant complexity of the hydrogeologic conditions at the site, such as heterogeneity of multiple aquifers, influence of the barrier wall, horizontal and vertical recharge, and the complexity of the pumping system (22 extraction wells, and variable pumping rates), a modeling approach was used to estimate potential extraction rates required to achieve capture. A regional groundwater model was developed and used to simulate hydrogeologic conditions post-barrier wall construction and during GWET System operation.

The potentiometric surface maps, as well as the updated groundwater model in conjunction with particle tracking, will be used to evaluate flow paths and estimate overall groundwater flux through the individual hydrogeologic layers. Analysis of vertical upward gradients will be used as an additional line of evidence in support of the hydraulic containment evaluation.

The purpose of the monitoring described in this section is to provide sufficient data to perform Step 3, the interpretation of water levels, and Step 4, the calculation and numerical modeling for verification of target capture zone extent.

The purpose of treatment system sampling described in Section 3 is to meet the ODEQ-approved design treatment objectives and the as-yet-to-be-determined compliance monitoring requirements of the NPDES industrial discharge permit.

The reporting described in Section 4 includes the comparison of actual capture to the Target Capture Zone and evaluation of system performance (i.e., Step 6).

The development of potential contingency measures, ranging from adjustment of extraction rates to installation of additional recovery wells, will be generally based on this analysis and applied as part of the adaptive management process described in Section 4.

2.2 *CAPTURE ZONE EVALUATION*

The purpose of water level monitoring is to provide sufficient data to demonstrate an inward hydraulic gradient across the GWBW and evaluate the actual capture zone of the GW SCM (i.e. Steps 3 and 4 described above).

Water level data will be collected using a combination of transducer and manual measurements. The proposed potentiometric surface monitoring points and data collection objectives are listed in Table 2-2 and Table 2-3, respectively. Figures 2-2, 2-3, and 2-4 present the locations of the monitoring points in the Shallow, Intermediate, and Deep zones, respectively. The monitoring points consist of existing monitoring wells piezometers, and a river gauge installed between December 2012 and May 2014.

Select monitoring points will have water level transducers installed to allow real-time monitoring of groundwater elevations in designated locations at 15-minute intervals, as listed in Table 2-2. The groundwater elevations in these monitoring wells are likely to be influenced by seasonal and tidal fluctuations of the river.

The periodic manual water level measurements will be used evaluate the capture zone of the GW SCM and to confirm and recalibrate the transducers, as necessary.

Manual water level measurements will be completed monthly for the first year of operation to evaluate performance variability throughout the year and to make potential changes to optimize GW SCM performance. The appropriate long-term water level monitoring schedule will be determined based on this first year of system operation and optimization performance data. The long-term water level monitoring schedule will be presented in the Long-Term Operation and Maintenance Plan.

2.2.1 *Potentiometric Surface and Water Level Difference Maps*

Water level data will be used to prepare potentiometric surface maps (i.e., horizontal water level maps) of the Shallow, Intermediate, and Deep Zones. Flow lines can then be derived to determine the extent of horizontal capture of the GW SCM.

Vertical water level difference maps will be prepared by comparing the water levels in adjacent hydrogeological units. Specific clusters of monitoring points will be used to determine vertical gradient. This analysis will be used to determine areas of upward flow. The well clusters for calculation of vertical gradients are summarized in Table 2-2 and shown on Figure 2-5. The frequency of data collection is summarized in Table 2-3.

2.2.2 *Gradient Control Points*

One of the key measures of the performance of the GW SCM is the hydraulic gradient across the GWBW. By establishing an inward hydraulic gradient across the GWBW, a groundwater flux away from the Willamette River will be created.

Water level measurement and potentiometric surface mapping will be conducted periodically, as described in Section 2.2.1. The data collected as part of the potentiometric surface mapping will also be used to evaluate the hydraulic gradient across the GWBW within each hydrogeologic unit.

The hydraulic gradient across the GWBW will be continuously monitored in six areas (i.e., control point "clusters") along the GWBW alignment, as shown on Figure 2-5. The measured gradients will be used as the primary logic control for operation of the recovery wells (i.e., pump speed). Pump speeds for individual recovery wells will be adjusted in order to maintain a pre-determined target inward hydraulic gradient across the GWBW for each well pair. The methods used to develop the pre-determined target gradient for each well pair is discussed below. In addition to data comparisons already referenced, monthly hydrographs will be generated, based on Serfes method filtered water level data, of gradient cluster wells superimposed on hydrographs of their corresponding comparison point and river stage data.

As noted in the PDR, the recovery well layout and anticipated extraction rates were iteratively adjusted in the groundwater model until particle-tracking results indicated that full capture of the alluvial sequence was

achieved within the lateral extent of the Target Capture Zone. The particle tracking results and potentiometric surface maps are included as Appendix A.

The PDR presented the groundwater modeling design of the GW SCM and the steady-state results demonstrating hydraulic capture. The groundwater elevations estimated by the model at the compliance monitoring points were documented at this modeled steady state. The gradients were calculated as the difference in elevation between respective piezometer pairs divided by distance between the compliance cluster inside the wall and outside the wall. The model-predicted gradients between gradient control pairs are presented in Table 2-1.

There is inherent uncertainty and conservative assumptions used in the groundwater model to develop the recovery well system layout, including:

- 25-foot grid model resolution
- Complex interaction between the shallow and intermediate pumping well; and
- Rapid changes in the potentiometric surface adjacent to the GWBW and recovery wells.

These factors result in some of the modeled-predicted head differences and gradients being actually flat or outward across the barrier wall. Although there is an outward gradient observed across the GWBW in the individual aquifer zones, hydraulic control of the Target Capture Zone groundwater system was still achieved, as calculated by volumetric flow balance and particle tracking results. However, consistent with the conservative approach to GWET System design and operation, initial target gradient control set points will still be established at a minimum of 0.005 feet per feet inward across the GWBW. This will ensure that the conditions predicted by the model for achieving hydraulic control are met or exceeded during the initial operation of the GWET System. As described in Section 4, an adaptive management approach will be used to refine target gradient set points as GW SCM performance monitoring data is used to update the hydrogeologic model of the site.

2.2.2.1 *Real Time Water Level Data Filtering*

The water levels in the gradient control points outside of the GWBW are anticipated to fluctuate approximately 2 to 3 feet with the tides on a daily

basis (ERM 2010b). The water levels inside the GWBW are anticipated to fluctuate with a much lower amplitude and significant time lag compared to the points closer to the Willamette River. The Willamette River experiences a tidal influence from the Pacific Ocean, which produces a progressive pressure wave that propagates inland, causing groundwater levels, and therefore hydraulic gradients, to fluctuate.

In a system with tidal fluctuations of groundwater levels, mathematic filtering methods are used more accurately determine groundwater elevations by filtering tidal fluctuations using a moving average of a three day moving average (Serfes 1991). In order to provide an accurate value for the calculation of the long-term hydraulic gradient, the Serfes filtering method will be applied to all data from electronic monitoring locations. The Serfes filtering method applies the central limit theorem to groundwater elevation measurements collected on an hourly basis. Typically, diminishing return of accuracy is observed by increasing the number of points (i.e. shorter time intervals between measurements) included in a dataset. However, because groundwater level measurements of gradient control point pairs can be recorded by level transmitters and will be monitored remotely, readings will be taken every 15 minutes, on a real-time basis, via a network connection. These 15-minute interval readings will be used to calculate a mean hydraulic gradient. The Serfes filtering method, using a 3-day moving average, will be applied as follows:

1. Transmitters shall be calibrated to existing groundwater elevation conditions prior to beginning the 3-day moving average calculation.
2. The transmitters will be set to collect water level data every 15 minutes, at least 3 days prior to initiating the GW SCM system.
3. First moving average: A moving average will take an average of the first 24 hours of data collected (96 observation points).
4. Second moving average: A second moving average will take an average of 24 hours of the first running average (96 observation points).
5. Mean water level (third moving average): A third moving average will determine the mean water level. The third running average will take an average of 24 hours of the second running average. The first point of data will be at hour 36. The fourth point of data will be at hour 37.

The mean hydraulic gradient will be calculated between well pairs based on the calculated water levels, established by the moving average of a 3-day moving average and lateral distance between the well pairs.

The extraction rates from the individual recovery wells will be adjusted in order to maintain an inward hydraulic gradient, as measured within each of the six gradient control point clusters. The extraction pumps in the recovery wells are fitted with variable frequency drives and water level sensors connected to the networked computer on site. Flow adjustments at individual wells can be made manually and/or remotely through the on-site computer.

As noted in Section 2.2.1, unanticipated variations (i.e., too large or too small) in the real-time water level monitoring data will be confirmed by manual measurement of the water level. Spurious data, caused by water level sensor malfunction or calibration drift, will not be used for gradient evaluation. In these cases, the water level sensors will be replaced or repaired as necessary to monitoring the long-term hydraulic gradient.

The results of monthly potentiometric surface mapping and actual capture zone analysis will be used iteratively to develop specific target gradients and head differences for each well cluster during the first 12 months of operation, in accordance with the adaptive management plan presented in Section 4.1. These target gradients will be presented in the Long-Term Operation and Maintenance Plan that will be prepared following GWET system startup and optimization.

2.2.3 *Recovery Well Efficiency*

The groundwater extraction system will be operated to achieve a target head difference across the GWBW. Extraction rates from individual wells will be adjusted to maintain the inward hydraulic gradient.

As noted in the PDR, the well losses in recovery wells may be significant. Well losses are affected by well construction, well development, and long-term fouling of the screen. Excessive well losses can lead to insufficient available drawdown for proper pump operation or to meet the required extraction rate.

The water levels in the recovery wells will be monitored continuously using a water level sensor as part of the operation of the GWET system. Water level measurement data will be used to optimize operation of the pumps, to establish high/low shutoff switches on the extraction pump, and in coordination with feedback from piezometer water level measurements. This data will also be used to monitor the efficiencies of the individual recovery wells over time. Water level data from recovery wells will not be used in the evaluation of actual capture zone. If well

inefficiency is affecting the ability to achieve the target flow rate in a well, mitigation measures, such as well redevelopment, will be implemented, as discussed in Section 4.1.

2.3 *RECOVERY WELL PUMP TESTS AND GROUNDWATER MODEL UPDATE*

The performance monitoring program described above has been designed to provide sufficient data to evaluate whether the actual capture zone during GWET System operation encompasses the Target Capture Zone. The assessment of the capture zone will rely on the evaluation of potentiometric surface mapping and modeled particle tracking. This evaluation will require a sufficiently reliable groundwater model. As noted by the ODEQ, the current groundwater model includes assumed aquifer parameters (e.g. hydraulic conductivity) that are based on a series of localized pump tests. In order to improve the estimates of aquifer parameters along the length of the GWBW, a series of pump tests of individual recovery wells will be conducted prior to full operation of the GWET System. The empirical data collected during these tests will be applied to recalibrate the model. Recalibration of the model will include recalculation of vertical and horizontal hydraulic conductivity around each recovery well to improve the accuracy of model prediction and subsequent particle tracking results.

These individual recovery well pump tests will achieve the following objectives:

- Refinement of localized aquifer properties and hydrogeologic conditions, and subsequent recalibration and update of the groundwater model;
- Provide an indication of the maximum potential yield of each recovery well; and
- Provide an indication of groundwater quality in each recovery well and allow determination of likely effluent quality and treatment system operation parameters (e.g., dosing requirements) prior to system startup.

The pump tests will be conducted once the pumping and level monitoring systems are completed (anticipated late September). The centralized pump control, water level monitoring system, and recovery pipeline, will allow for efficient implementation of the pump test. It is anticipated that

multiple recovery well pump tests can be conducted simultaneously, and thus minimize any potential delays in full system start up. Samples of groundwater from selected individual wells will collected be analyzed for determine of system operation parameters. Purged groundwater generated during the pump test will be stored on site in frac-tanks for subsequent treatment in the GWET System.

Pump test procedures will generally follow the procedures used in previous pump tests described in the *Draft Data Gaps Assessment Work Plan* (ERM 2009). A specific pump test program work plan memorandum will be presented under separate cover.

3.0 GROUNDWATER TREATMENT SYSTEM PERFORMANCE MONITORING

The purpose of the groundwater treatment system is to treat the combined flow from the recovery wells and discharge the effluent to the Willamette River. The effluent discharge will be managed under an Individual NPDES Industrial Wastewater Permit.

3.1 GROUNDWATER TREATMENT SYSTEM

The recommended groundwater treatment system consists of the following components:

- A precipitation reactor with aeration and pH adjustment via sodium hydroxide to remove iron and other metals potentially present at concentrations exceeding their discharge limits in groundwater;
- A solids handling system (i.e., clarifier with polymer feed, sludge holding tank, filter press, and associated equipment) to dewater and prepare precipitated solids for off-site transportation and disposal;
- A pH adjustment tank to neutralize the groundwater pH prior to anaerobic biological treatment;
- An FBR to anaerobically biodegrade perchlorate and chlorate, and potentially biodegradable organics present in groundwater;
- A post-FBR sand filter to remove biomass potentially carried over into the FBR effluent;
- Two liquid-phase granular activated carbon units in series to remove remaining volatile organic compounds (e.g., chlorobenzene) and pesticides (e.g., DDT) from the effluent following treatment in the FBR, as a polishing step; and
- Discharges to the Willamette River through existing Outfall 4.

A general layout of the GWET system is shown on Figure 2-1. The process flow diagram of the treatment system is presented in Appendix C.

3.2 *COMPLIANCE MONITORING*

The purpose of compliance monitoring is to evaluate the performance of the treatment system in meeting the as-yet-to-be-determined discharge effluent limits required under the Individual NPDES Industrial Wastewater Permit. At the time of preparation of this PMP, the permit requirements have not been finalized; however, potential permit requirements for design purposes were presented in the PDR and include monthly sampling of the treatment system influent and effluent (Figure 3-1). The potential effluent quality objectives of the NPDES permit, based on discussions with the ODEQ, are presented in Table 3-1.

The composite flow samples will be collected using integrated flow samplers. These samplers will collect a composite sample proportional to the flow rate over a 24-hour period. The samples will be analyzed at an ODEQ-certified laboratory for the parameters listed in Table 3-1. Sample handling and labeling procedures will be performed in accordance with the most recent site Quality Assurance Project Plan, prepared as part of the *Draft Design Report Stormwater Source Control Measures* (Integral 2010). Data quality objectives for parameters not previously sampled at the site are provided in an addendum to the Quality Assurance Project Plan (Appendix D).

4.0 ADAPTIVE MANAGEMENT PROCESS AND REPORTING

LSS is committed to maintaining and documenting hydraulic containment of the alluvial sequence, and compliance with the NPDES permit requirements. This section describes the adaptive management process and performance monitoring reporting scope and schedule. The reporting phase is intended to fulfill Steps 5 and 6 of the evaluation of capture zones (see Section 2.1).

4.1 ADAPTIVE MANAGEMENT FLOW PROCESS

The GWET System component of the GW SCM will be operated and optimized to meet the remedial action objectives of the GW SCM. An adaptive management flow process has been established to verify the capture objectives are being achieved. The adaptive management flowchart is provided as Figure 4-1. The adaptive management flow chart distinguishes criteria for over- or underperformance of wells (maintaining hydraulic capture), design deficiencies, and maintenance issues (e.g. decreasing well efficiencies). Solutions to specific problems associated with equipment performance will be referred to in the Long Term Operation and Maintenance Plan

The adaptive management flow chart does not address issues with GWET System operation that are related to treatment system component operation and maintenance. These activities will be addressed in the Long Term Operation and Maintenance Plan.

4.2 PERFORMANCE MONITORING REPORTING

The results of GW SCM performance monitoring will be reported to the ODEQ monthly for the first 12 months of GWET system operation. These monthly reports will include water levels, potentiometric surface maps, head difference maps, capture zone evaluation, and recommendations for extraction system optimization. The results of monthly potentiometric surface mapping and actual capture zone analysis will be used iteratively to develop specific target gradients and head differences for each well cluster during the first 12 months of operation. The target gradients and long-term water level monitoring schedule will be presented in the Long-Term Operation and Maintenance Plan. Long-term monitoring requirements will be determined under an adaptive management

approach. LSS will request approval from the ODEQ before modifying the reporting frequency.

In the event that the GWET system is not operational for an extended period of time (e.g., greater than 1 month), manual water level monitoring will be conducted on a monthly basis to confirm/calibrate electronic real-time measurements until system operation resumes.

The longest anticipated operational downtime is expected to occur between GWBW installation and GWET system startup. LSS remains committed to working with the ODEQ to minimize this period through agency cooperation and a phased approach during construction of the GWBW and GWET system.

The Long-Term Operation and Maintenance Plan will identify procedures to limit system down time during scheduled maintenance. Measures such as phased shutdown of individual wells will be used to continue groundwater extraction during maintenance. Redundancy designed into the GWET System, such as dual carbon vessels, will allow maintenance of one piece of equipment without interrupting groundwater treatment. Maintenance of GWET System components requiring total system shutdown will be planned to minimize the shutdown time required.

5.0 REFERENCES

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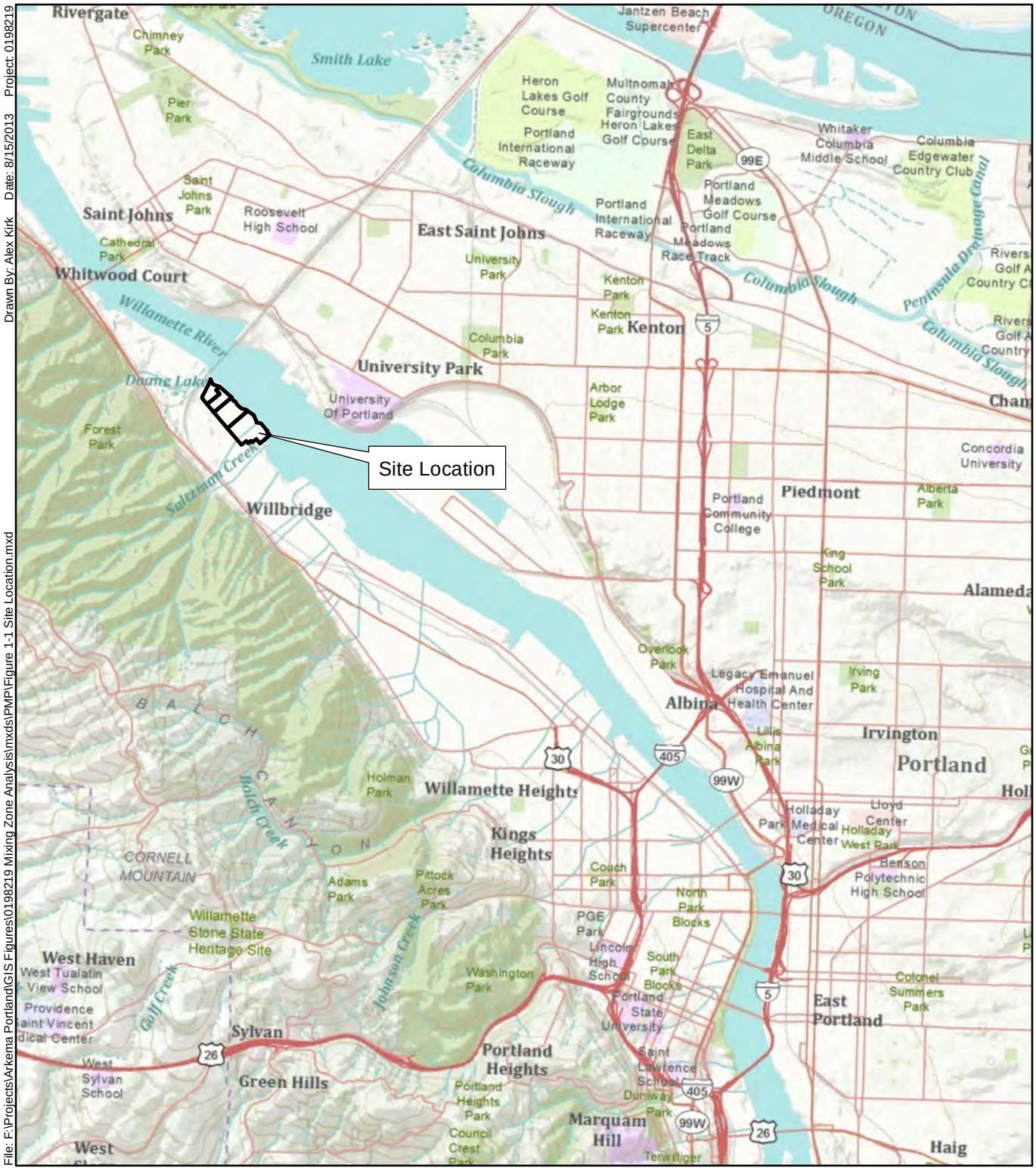
Figures



Drawn By: Alex Kirk Date: 8/15/2013 Project: 0198219

File: F:\Projects\Arkema Portland\GIS Figures\0198219 Mixing Zone Analysis\mxds\PMP\Figure 1-1 Site Location.mxd

Legend

Parcel and Property Boundaries

N

0 0.5 1 2 Miles

Figure 1-1
Site Location
Performance Monitoring Plan
Arkema Inc.
Portland, Oregon

Environmental Resources Management
1001 SW 5th St, Suite 1010
Portland, Oregon 97204
ERM.

Project: 0180382
Date: 8/26/2013
Drawn By: Alex Kirk
File: F:\Projects\Arkema Portland\GIS Figures\0198219 Mixing Zone Analysis\mxds\PMP\Figure 1-2 Site Layout.mxd

Legend

- Shallow Zone Recovery Well
- Intermediate Zone Recovery Well
- Top of Bank
- 100-yr Flood Plain (32.5 feet NAVD88)
- Barrier Wall Alignment
- Western Berm
- Southern Berm
- Eastern Berm
- Eastern Stormwater Swale
- Western Stormwater Swale
- Underground Water Conveyance Piping
- Pond Boundary
- Areas to be Filled
- Former Site Infrastructure
- Parcel Boundaries
- Property Boundaries

0 100 200 400 Feet

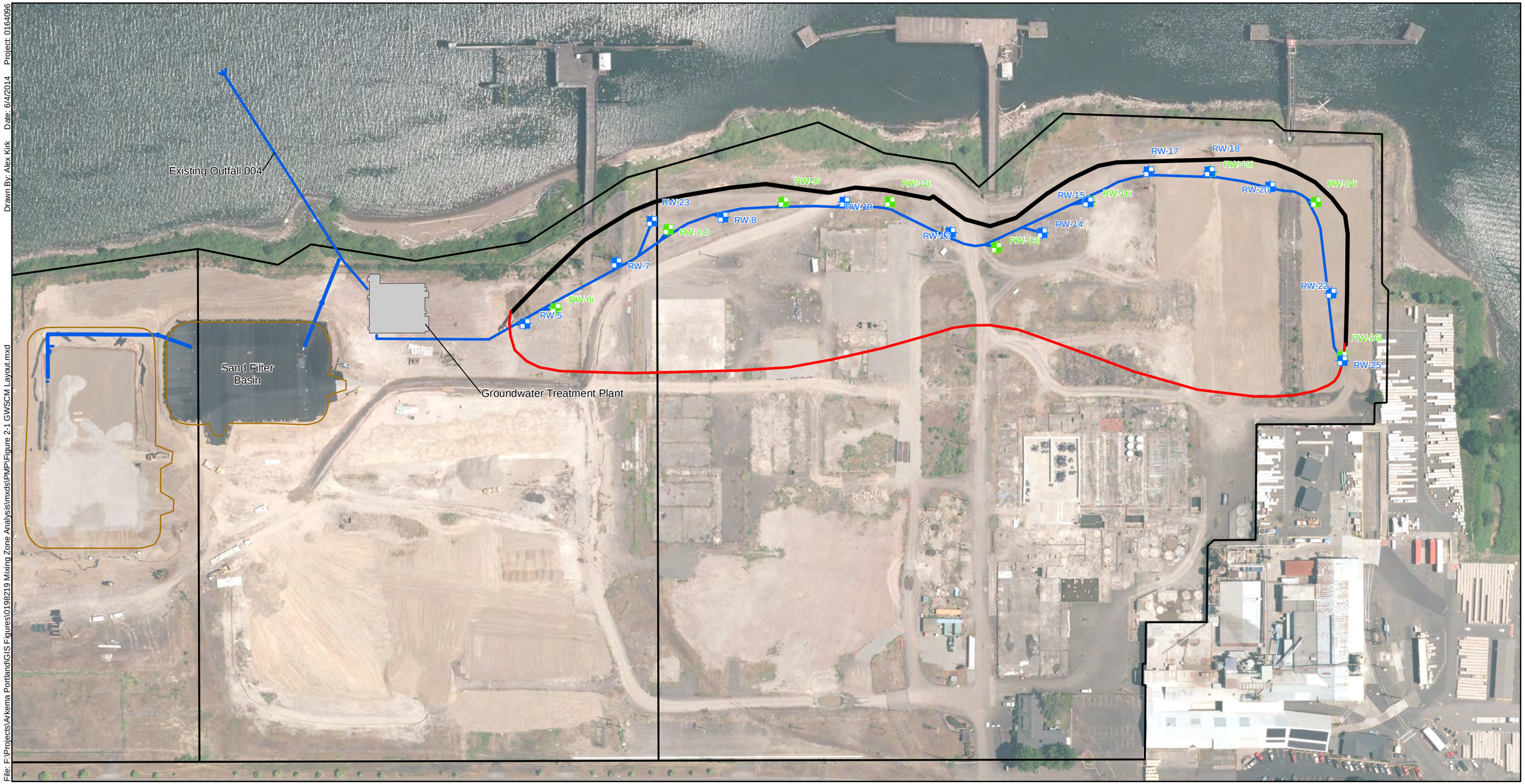
1 inch : 200 feet

Aerial Photo: City of Portland, July 8, 2012

Note:
A number of the buildings and structures noted on this diagram have been demolished and/or removed.

Figure 1-2
Site Layout
Performance Monitoring Plan
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
1001 SW 5th St, Suite 1010
Portland, Oregon 97204
ERM.



File: F:\Projects\Arkema Portland\GIS Figures\0198219 Mixing Zone Analysis\mxds\PMP\Figure 2-1 GWSCM Layout.mxd

Drawn By: Alex Kirk Date: 6/4/2014 Project: 0164096

Legend

- Shallow Zone Recovery Well
- Intermediate Zone Recovery Well
- Barrier Wall Alignment
- Target Capture Zone
- Underground Groundwater Conveyance Piping

0 80 160 320 Feet

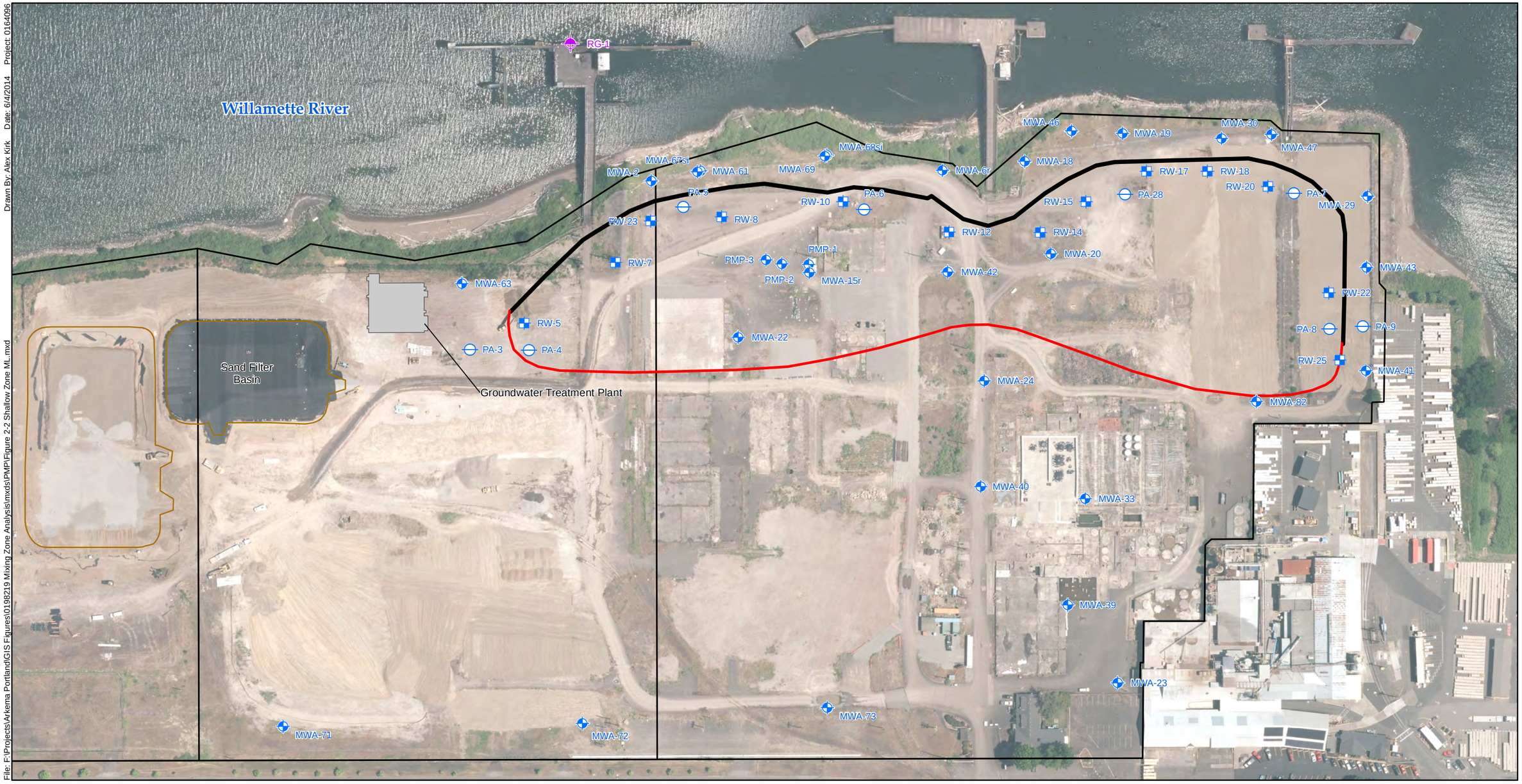
1 inch : 160 feet

Aerial Photo: City of Portland, July 8, 2012

Figure 2-1

Groundwater Source Control Measures Layout
Performance Monitoring Plan
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
1001 SW 5th St, Suite 1010
Portland, Oregon 97204
ERM.



File: F:\Projects\Arkema Portland\GIS Figures\0198219 Mixing Zone Analysis\mxds\PMP\Figure 2-2 Shallow Zone ML.mxd Drawn By: Alex Kirk Date: 6/4/2014 Project: 0164096

Legend

- Shallow Zone Piezometer
- Shallow Zone Recovery Well
- Shallow Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- River Gauge
- Barrier Wall Alignment
- Target Capture Zone
- Parcel and Property Boundaries

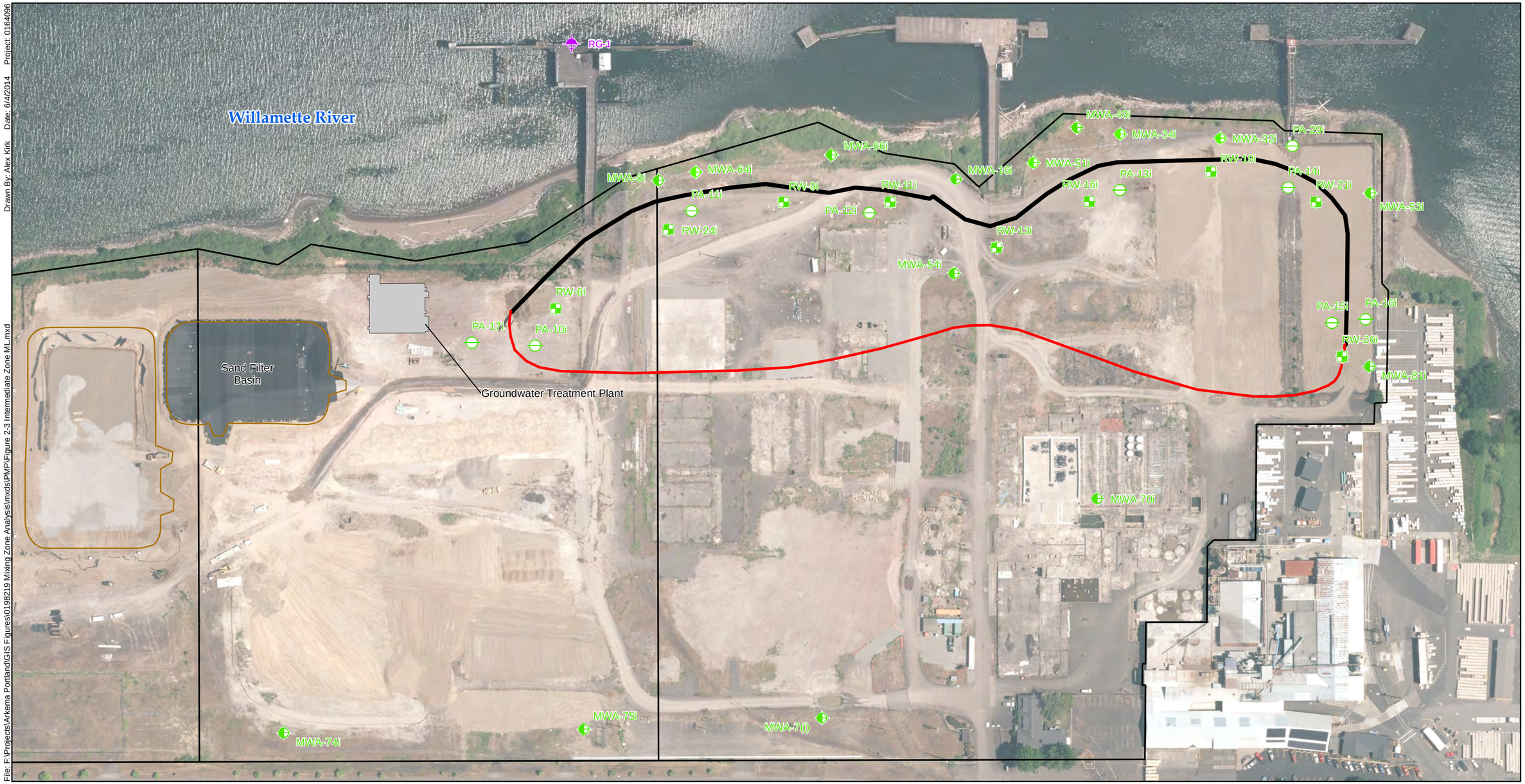
0 80 160 320 Feet

1 inch : 160 feet

Aerial Photo: City of Portland, July 8, 2012

Figure 2-2
Shallow Zone Water Level Monitoring Locations
Performance Monitoring Plan
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
1001 SW 5th St, Suite 1010
Portland, Oregon 97204
ERM.



File: F:\Projects\Arkema Portland\GIS Figures\0198219 Mixing Zone Analysis\mxds\PMP\Figure 2-3 Intermediate Zone ML.mxd Drawn By: Alex Kirk Date: 6/4/2014 Project: 0164096

Legend

- Intermediate Zone Piezometer
- Intermediate Zone Extraction Well
- Intermediate Monitoring Well
- River Gauge
- Barrier Wall Alignment
- Target Capture Zone
- Parcel and Property Boundaries

0 80 160 320 Feet

1 inch : 160 feet

Aerial Photo: City of Portland, July 8, 2012

Figure 2-3
Intermediate Zone Water Level Monitoring Locations
Performance Monitoring Plan
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
1001 SW 5th St, Suite 1010
Portland, Oregon 97204
ERM.

File: F:\Projects\Arkema Portland\GIS Figures\0198219 Mixing Zone Analysis\mxds\PMP\Figure 2-4 Deep Zone ML.mxd
Drawn By: Alex Kirk Date: 6/5/2014 Project: 0164096

Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- River Gauge
- Barrier Wall Alignment
- Target Capture Zone
- Parcel and Property Boundaries

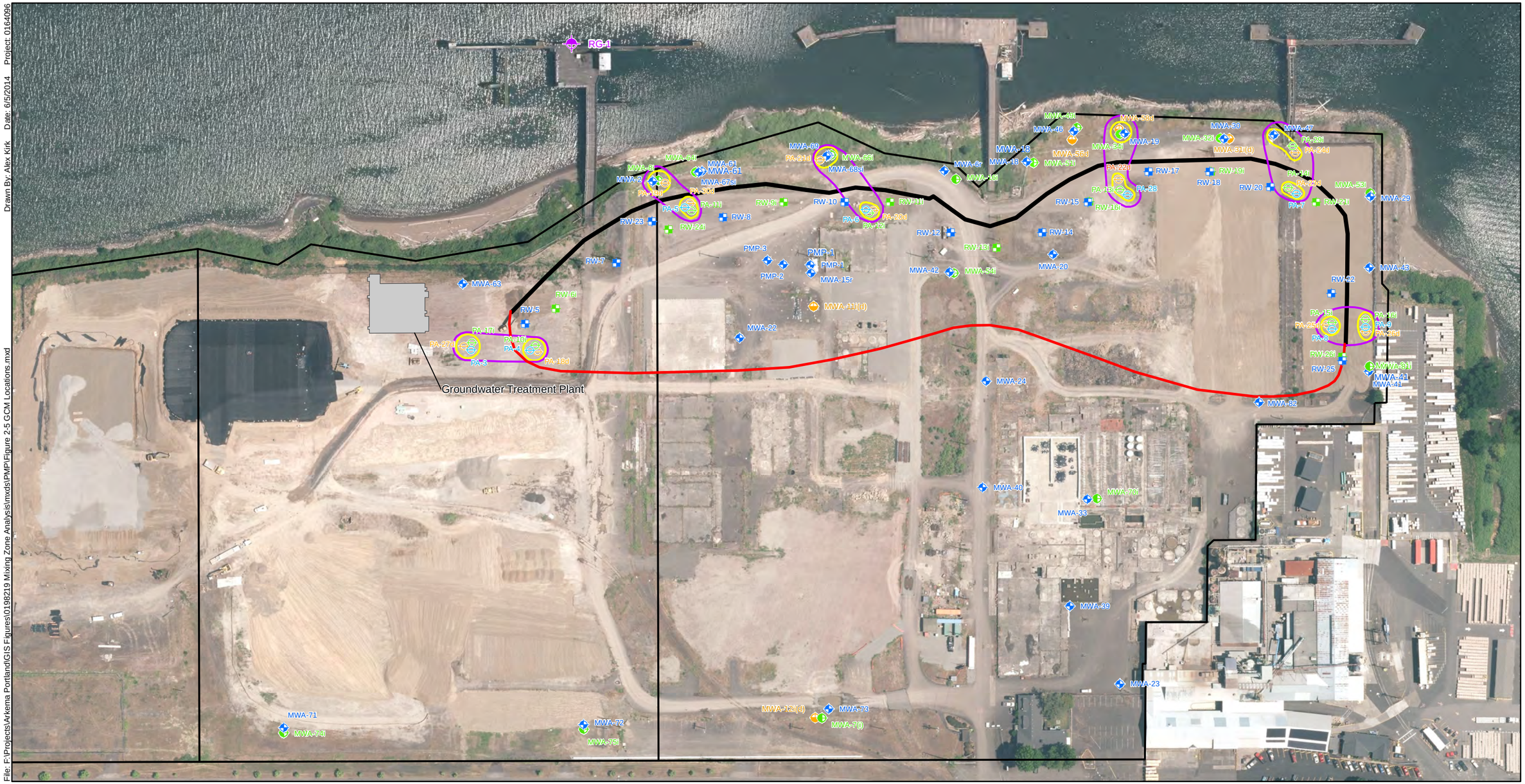
0 80 160 320 Feet

1 inch : 160 feet

Aerial Photo: City of Portland, July 8, 2012

Figure 2-4
Deep Zone Water Level Monitoring Locations
Performance Monitoring Plan
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
1001 SW 5th St, Suite 1010
Portland, Oregon 97204
ERM.



File: F:\Projects\Arkema Portland\GIS Figures\0198219 Mixing Zone Analysis\mxds\PMP\Figure 2-5 GCM Locations.mxd

Drawn By: Alex Kirk Date: 6/5/2014 Project: 0164096

Legend

- Shallow Zone Recovery Well
- Intermediate Zone Recovery Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Shallow Monitoring Well
- Shallow-Intermediate Monitoring Well
- Intermediate Monitoring Well
- Existing Deep Zone Monitoring Well
- River Gauge
- Barrier Wall Alignment
- Target Capture Zone
- Gradient Control Cluster
- Vertical Flow Cluster

0 80 160 320 Feet

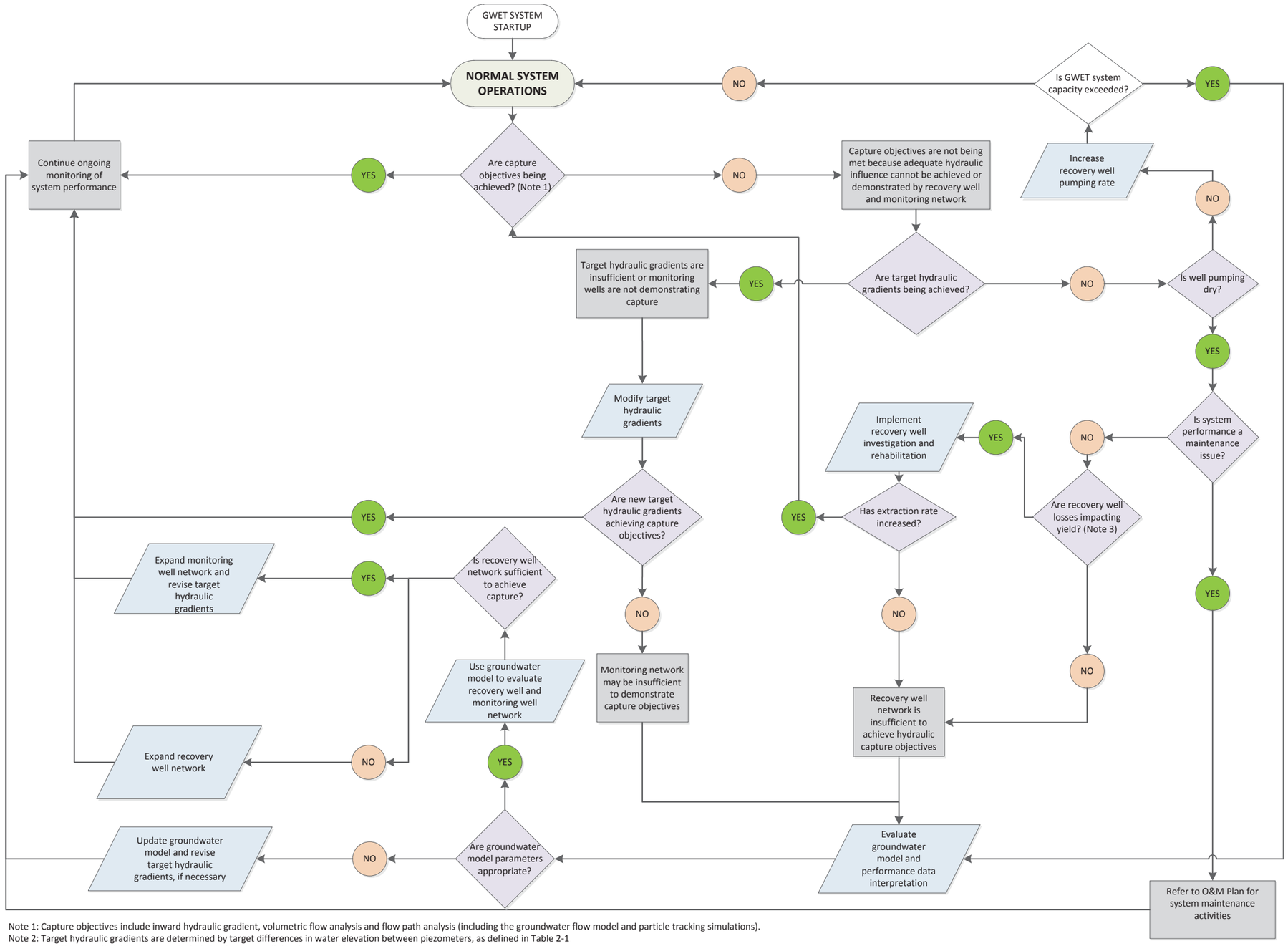
1 inch : 160 feet

Aerial Photo: City of Portland, July 8, 2012

Figure 2-5

Gradient Control Monitoring Locations
Performance Monitoring Plan
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
1001 SW 5th St, Suite 1010
Portland, Oregon 97204
ERM.



Note 1: Capture objectives include inward hydraulic gradient, volumetric flow analysis and flow path analysis (including the groundwater flow model and particle tracking simulations).
Note 2: Target hydraulic gradients are determined by target differences in water elevation between piezometers, as defined in Table 2-1
Note 3: Insufficient well yield factors can include inadequate well development, bio-fouling, well construction

Environmental Resources Management
1001 SW 5th St, Suite 1010
Portland, Oregon 97204

Figure 4-1
Adaptive Management Flow Process
Performance Monitoring Plan
Arkema Inc.
Portland, Oregon

Tables

Table 2-1
Well Construction and Monitoring Summary
Performance Monitoring Plan
Groundwater Source Control Measure
Arkema Inc. Facility
Portland, Oregon

Monitoring Point	Status	Northing	Easting	Aquifer Classification	Depth Drilled	Measuring Point Elevation	Ground Surface Elevation	Measuring Point Stickup	Well Depth	Screened Interval								Sandpack Interval					Performance Monitoring		Gradient Control						
										Screen Length	Screen Material	Screen Slot Size	Sump Length	Depth Below Surface		Elevation		Depth Below Surface		Elevation		Sandpack Thickness	Capture Zone Monitoring Point	Real-time Monitoring	Gradient Calculation Point	Comparison Point	Model Predicted Head Difference	Distance Between Observation Wells	Model Predicted Target Gradient	Selected Target Gradient	Target Head Difference
														Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top										
					(ft)	(ft)	(ft)	(ft)	(ft)	(ft)		(in)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)					(ft)	(ft)	(ft)	(ft)	(ft)
MWA-2	Active	702507.29	7627621.41	Shallow	32.3	36.20	36.52	-0.32	35.17	10.0	304 S.S.	0.010	0.5	31.5	21.5	5.0	15.0	32.3	18.5	4.2	18.0	13.8	Y	Y	Y	PA-5	-0.84	68.3	-0.012	-0.012	-0.84
MWA-6r	Active	702150.87	7627942.75	Shallow	34.0	36.46	36.75	-0.29	33.21	5.0	304 S.S.	0.010	0.3	33.2	28.2	3.6	8.6	33.5	25.5	3.3	11.3	8.0	Y	N	N						
MWA-7(i)	Active	701726.90	7627124.30	Intermediate	33.0	36.24	36.15	0.09	33.39	2.5	304 S.S.	0.010	0.3	33.0	30.5	3.2	5.7	33.3	28.0	2.9	8.2	5.3	N	N	N						
MWA-8i	Active	702500.54	7627628.33	Intermediate	47.3	36.25	36.53	-0.28	49.60	5.0	304 S.S	0.010	0.3	47.0	42.0	-10.5	-5.5	47.3	39.8	-10.8	-3.3	7.5	Y	Y	Y	PA-11i	-1.12	73.4	-0.015	-0.015	-1.12
MWA-	Active	702172.18	7627634.01	Deep	51.0	36.49	36.62	-0.13	51.00	4.5	304 S.S	0.010	0.3	50.8	46.2	-14.2	-9.6	51.0	44.0	-14.4	-7.4	7.0	Y	N	N						
MWA-	Active	701735.80	7627117.50	Deep	52.0	35.86	36.15	-0.30	51.76	10.0	304 S.S	0.010	0.3	51.8	42.0	-15.6	-5.9	52.0	40.0	-15.9	-3.9	12.0	Y	N	N						
MWA-15r	Active	702211.10	7627673.20	Shallow	32.5	36.06	36.39	-0.34	29.21	10.0	304 S.S.	0.10	0.1	32.5	22.5	3.9	13.9	32.5	22.5	3.9	13.9	10.0	N	N	N						
MWA-16i	Active	702127.25	7627944.39	Intermediate	45.3	36.58	36.99	-0.41	44.09	5.0	304 S.S	0.010	0.3	44.2	39.2	-7.2	-2.2	45.3	37.2	-8.3	-0.2	8.1	Y	N	N						
MWA-18	Active	702056.87	7628041.35	Shallow	29.5	39.43	36.44	2.99	32.49	10.0	304 S.S.	0.010	0.3	29.2	19.2	7.2	17.2	29.5	17.0	6.9	19.4	12.5	N	N	N						
MWA-19	Active	701963.23	7628180.37	Shallow	35.5	38.26	38.65	-0.39	29.11	10.0	304 S.S.	0.010	0.3	29.2	19.2	9.5	19.5	30.5	17.0	8.2	21.7	13.5	Y	Y	Y	PA-28	-0.74	101.6	-0.007	-0.007	-0.74
MWA-20	Active	701925.54	7627952.11	Shallow	35.5	40.95	38.46	2.49	37.49	10.0	304 S.S.	0.010	0.3	34.7	24.7	3.8	13.8	35.5	22.5	3.0	16.0	13.0	Y	N	N						
MWA-22	Active	702232.00	7627516.00	Shallow	36.0	36.59	36.91	-0.31	34.69	10.0	304 S.S.	0.010	0.3	34.7	24.7	2.2	12.2	36.0	23.0	0.9	13.9	13.0	Y	N	N						
MWA-23	Active	701387.76	7627481.85	Shallow	26.0	36.81	37.10	-0.30	25.12	10.0	304 S.S.	0.010	0.3	25.2	15.2	11.9	21.9	26.0	13.5	11.1	23.6	12.5	N	N	N						
MWA-24	Active	701875.73	7627721.74	Shallow	36.0	37.58	37.94	-0.36	33.48	10.0	304 S.S.	0.010	0.3	34.0	24.0	3.9	13.9	36.0	22.0	1.9	15.9	14.0	Y	N	N						
MWA-29	Active	701587.00	7628359.88	Shallow	35.2	37.23	37.51	-0.28	33.70h	10.0	304 S.S.	0.010	0.3	34.9	24.9	2.6	12.6	35.2	22.9	2.3	14.6	12.3	Y	N	N						
MWA-30	Active	701832.68	7628278.84	Shallow	30.0	38.34	38.75	-0.41	29.25	10.0	304 S.S.	0.010	0.3	29.1	19.1	9.7	19.7	29.4	17.4	9.4	21.4	12.0	N	N	N						
MWA-31i(d)	Active	701826.17	7628283.95	Deep	60.0	38.36	38.74	-0.38	59.80	5.0	304 S.S	0.010	0.2	59.8	54.8	-21.1	-16.1	60.0	54.0	-21.3	-15.3	6.0	N	N	N						
MWA-32i	Active	701837.47	7628275.46	Intermediate	44.0	38.70	38.92	-0.22	41.98	5.0	304 S.S	0.010	0.2	42.0	37.0	-3.1	1.9	42.0	35.0	-3.1	3.9	7.0	N	N	N						
MWA-33	Active	701623.46	7627679.75	Shallow	30.0	37.26	37.75	-0.49	29.71	10.0	Sch 40 PVC	0.010	0.2	30.0	20.0	7.7	17.7	30.0	19.0	7.7	18.7	11.0	Y	N	N						
MWA-34i	Active	701968.03	7628174.50	Intermediate	38.0	38.02	38.40	-0.38	36.82	5.0	304 S.S	0.010	0.2	37.0	32.0	1.4	6.4	37.5	31.5	0.9	6.9	6.0	Y	Y	Y	PA-13i	-1.61	91.4	-0.018	-0.018	-1.61
MWA-39	Active	701532.86	7627527.05	Shallow	26.5	37.06	37.23	-0.17	25.00	9.25	Sch 40 PVC	0.010	0.7	24.3	15.1	12.9	22.2	26.0	13.0	11.2	24.2	13.0	N	N	N						
MWA-40	Active	701767.86	7627584.45	Shallow	31.0	36.96	37.18	-0.21	30.20	9.25	Sch 40 PVC	0.010	0.7	29.5	20.3	7.7	16.9	29.5	18.0	7.7	19.2	11.5	N	N	N						
MWA-41	Active	701404.34	7628138.42	Shallow	35.0	37.77	38.01	-0.24	35.00	9.25	Sch 40 PVC	0.010	0.7	34.3	25.1	3.7	13.0	35.0	23.0	3.0	15.0	12.0	Y	N	N						
MWA-42	Active	702036.96	7627820.55	Shallow	33.5	37.24	37.62	-0.38	31.50	9.25	Sch 40 PVC	0.010	0.7	30.8	21.6	6.8	16.1	31.8	19.1	5.8	18.5	12.7	Y	N	N						
MWA-43	Active	701513.44	7628269.72	Shallow	35.0	37.22	37.46	-0.24	35.00	9.25	Sch 40 PVC	0.010	0.7	34.3	25.1	3.2	12.4	35.0	23.0	2.5	14.5	12.0	Y	N	N						
MWA-46	Active	702029.70	7628129.61	Shallow	30.5	36.67	36.68	-0.01	29.70	9.25	Sch 40 PVC	0.010	0.7	29.0	19.8	7.7	16.9	28.5	17.3	8.2	19.4	11.2	N	N	N						
MWA-47	Active	701773.75	7628336.57	Shallow	35.0	39.02	39.40	-0.38	35.00	9.25	Sch 40 PVC	0.010	0.7	34.3	25.1	5.1	14.4	35.0	23.0	4.4	16.4	12.0	Y	Y	Y	PA-07	1.58	103.7	0.015	-0.005	-0.52
MWA-49i	Active	702029.26	7628137.40	Intermediate	44.0	36.68	36.84	-0.16	44.00	4.45	Sch 40 PVC	0.010	0.7	43.3	38.9	-6.5	-2.0	43.0	36.6	-6.2	0.2	6.4	N	N	N						
MWA-51i	Active	702046.99	7628047.09	Intermediate	44.0	36.33	36.59	-0.26	42.50	4.45	Sch 40 PVC	0.010	0.7	41.8	37.4	-5.2	-0.8	42.5	35.2	-5.9	1.4	7.3	N	N	N						
MWA-53i	Active	701590.84	7628364.82	Intermediate	44.5	37.27	37.52	-0.25	44.40	4.45	Sch 40 PVC	0.010	0.7	43.7	39.3	-6.2	-1.7	43.5	36.3	-6.0	1.2	7.2	Y	N	N						
MWA-54i	Active	702030.36	7627823.95	Intermediate	41.5	37.31	37.72	-0.41	41.10	4.45	Sch 40 PVC	0.010	0.7	40.4	36.0	-2.7	1.8	41.1	35.3	-3.4	2.4	5.8	Y	N	N						
MWA-56d	Active	702022.47	7628117.01	Deep	61.0	36.68	36.82	-0.14	60.80	4.75	Sch 40 PVC	0.010	0.55	60.3	55.5	-23.4	-18.7	61.0	53.0	-24.2	-16.2	8.0	N	N	N						
MWA-58d	Active	701974.54	7628179.53	Deep	63.0	37.97	38.36	-0.39	60.50	4.75	Sch 40 PVC	0.010	0.55	60.0	55.2	-21.6	-16.8	61.5	52.8	-23.1	-14.4	8.7	Y	Y	Y	PA-22d	-1.14	90.3	-0.013	-0.013	-1.14
MWA-61	Active	702455.71	7627686.02	Shallow	33.5	36.21	36.15	0.06	32.50	10.0	Sch 40 PVC	0.010	0.0	32.1	22.3	4.1	13.9	32.5	21.0	3.7	15.2	11.5	N	N	N						
MWA-63	Active	702637.66	7627291.45	Shallow	30.5	36.29	36.38	-0.09	30.00	10.0	Sch 40 PVC	0.010	0.4	29.6	19.8	6.8	16.6	30.5	17.0	5.9	19.4	13.5	Y	N	N						
MWA-64i	Active	702462.46	7627678.56	Intermediate	49.0	35.84	36.17	-0.33	47.00	4.5	Sch 40 PVC	0.010	0.5	46.5	42.0	-10.3	-5.8	49.0	40.0	-12.8	-3.8	9.0	N	N	N						
MWA-66i	Active	702309.97	7627843.28	Intermediate	49.0	33.35	33.79	-0.44	42.50	4.5	Sch 40 PVC	0.010	0.1	42.4	37.6	-8.6	-3.8	43.5	35.8	-9.7	-2.0	7.7	Y	Y	Y	PA-12i	-0.86	114.1	-0.008	-0.008	-0.86
MWA-67si	Active	702458.92	7627681.48	Shallow	38.0	36.34	36.14	0.20	38.00	1.5	Sch 40 PVC	0.010	0.2	37.8	36.3	-1.7	-0.2	38.0	36.0	-1.9	0.1	2.0	N	N	N						
MWA-68si	Active	702312.58	7627839.61	Shallow	34.0	33.50	33.99	-0.49	34.00	1.5	Sch 40 PVC	0.010	0.2	33.8	32.3	0.2	1.7	34.0	32.0	0.0	2.0	2.0	N	N	N						
MWA-69	Active	702314.52	7627836.40	Shallow	30.0	33.73	34.08	-0.35	29.50	10.0	Sch 40 PVC	0.010	0.2	29.3	19.5	4.8	14.6	30.0	18.0	4.1	16.1	12.0	Y	Y	Y	PA-6	-1.05	109.1	-0.010	-0.010	-1.05
MWA-70i	Active	701611.69	7627691.20	Intermediate	46.5	37.62	37.84	-0.23	43.00	9.8	Sch 40 PVC	0.010	0.5	32.7	42.5	5.1	-4.7	32.5	43.0	5.3	-5.2	-10.5	N	N	N						
MWA-71	Active	702394.12	7626543.33	Shallow	23.0	34.82	35.23	-0.41	22.18	10.0	304 S.S	0.010	0.3	22.5	12.5	12.7	22.7	23.0	10.0	12.2	25.2	13.0	N	N	N						
MWA-72	Active	702019.73	7626864.10	Shallow	23.0	34.16	34.57	-0.41	22.34	10.0	304 S.S	0.010	0.3	22.0	12.0	12.6	22.6	23.0	10.0	11.6	24.6	13.0	N	N	N						
MWA-73	Active	701727.58	7627143.03	Shallow	22.0	36.01	36.37	-0.36	20.15	10.0	304 S.S	0.010	0.3	21.0	11.0	15.4	25.4	21.0	9.0	15.4	27.4	12.0	N	N	N						
MWA-74i	Active	702388.62	7626536.38	Intermediate	44.0	34.72	34.98	-0.26	72.78	5.0	304 S.S	0.010	0.3	43.0	38.0	-8.0	-3.0	43.0	35.5	-8.0	-0.5	7.5	N	N	N						
MWA-75i	Active	702014.68	7626858.37	Intermediate	48.0	34.09	34.43	-0.34	39.88	15.0	304 S.S	0.010	0.3	40.0	25.0	-5.6	9.4	41.0	23.5	-6.6	10.9	17.5	N	N	N						
MWA-76g	Active	702010.18	7626853.34	Gravel	94.0	34.96	35.23	-0.26	94.12	5.0	304 S.S	0.010	0.3	94.0	89.0	-58.8	-53.8	94.0	87.5	-58.8	-52.3	6.5	N	N	N						
MWA-77g	Active	702382.88	7626528.75	Gravel	91.0	34.03	34.40	-0.37	90.20	5.0	304 S.S	0.010	0.3	90.5	85.5	-56.1	-51.1	91.0	83.5	-56.6	-49.1	7.5	N	N	N						
MWA-81i	Active	701408.82	7628145.87	Intermediate	48.0	37.50	37.96	-0.46	44.00	5.0	Sch 40 PVC	0.010	0.3	44.0	39.0	-6.0	-1.0	45.0	37.5	-7.0	0.5	7.5	Y	N	N						
MWA-82	Active	701507.61	7627983.45	Shallow	32.0	37.74	37.89	-0.15	31.91	10.0	Sch 40 PVC	0.010	0.2	32.3	22.3	5.6	15.6	32.1	20.4	5.8	17.5	11.7	N	N	N						
NMP-1D	Active	702247.30	7627690.20	Shallow	36.0	35.82	36.18	-0.36	34.14	4.5	Sch 40 PVC	0.010	0.5	34.0	29.5	2.2	6.7	35.0	27.8	1.2	8.4	7.2	N	N	N						
NMP-1S	Active	702255.40	7627696.30	Shallow	30.5	35.90	36.11	-0.21	29.49	9.5	Sch 40 PVC	0.010	0.2	29.5	20.0	6.6	16.1	30.0	18.0	6.1	18.1	12.0	N	N	N						
NMP-2D	Active	702263.50	7627701.90	Shallow	37.0	35.56	35.97	-0.41	36.59	4.5	Sch 40 PVC	0.010	0.5	36.5	32.0	-0.5	4.0	37.0	30.0	-1.0	6.0	7.0	N	N	N						
NMP-2S	Active	702271.20	7627707.60	Shallow	30.5	35.75	35.88	-0.14	29.57	9.5	Sch 40 PVC	0.010	0.2	29.5	20.0	6.4	15.9	30.0	18.0	5.9	17.9	12.0	N	N	N						
NMP-3S	Active	702287.50	7627718.30	Shallow	30.5	35.68	36.02	-0.33	29.37	9.5	Sch 40 PVC	0.010	0.2	29.5	20.0	6.5	16.0	30.0	18.0	6.0	18.0	12.0	N	N	N						
NMP-4D	Active	702281.80	7627666.30	Shallow	36.0	35.63	35.91	-0.27	35.23	4.5	Sch 40 PVC	0.010	0.5	35.0	30.5	0.9	5.4	36.0	28.0	-0.1	7.9	8.0	N	N	N						
NMP-4S	Active	702290.70	7627672.40	Shallow	30.5	35.67	35.89	-0.22	29.48	9.5	Sch 40 PVC	0.010	0.2	29.5	20.0	6.4	15.9	30.0	18.0	5.9	17.9	12.0	N	N	N						
NMP-5D	Active	702273.20	7627684.40	Shallow	35.5	35.38	35.84	-0.47	33.54	4.5	Sch 40 PVC	0.010	0.5	33.5	29.0	2.3	6.8	34.5	27.0	1.3	8.8	7.5	N	N	N						
NMP-5S	Active	702281.50	7627689.70	Shallow	30.5	35.57	35.55	0.02	29.72	9.5	Sch 40 PVC	0.010	0.2	29.5	20.0	6.1	15.6	30.0	18.0	5.6	17.6	12.0	N	N	N						
NMP-6D	Active	702259.90	7627730.00	Shallow	36.0	36.08	36.27	-0.19	33.81	4.5	Sch 40 PVC	0.010	0.5	33.5	29.0	2.8	7.3	35.0	27.0	1.3	9.3	8.0	N	N	N						
NMP-6S	Active	702251.90	7627724.50	Shallow	30.5	35.94	36.23	-0.29	29.41	9.5	Sch 40 PVC	0.010	0.2	29.5	20.0	6.7	16.2	30.0	18.0	6.2	18.2	12.0	N	N	N						
PA-03	Proposed	7627216.44	702557.55	Shallow	29.2	37.10	37.72	-0.62	28.90	5.0	Sch 40 PVC	0.010	0.3	29.2	24.2	8.5	13.5	29.2	22.2	8.5	15.5	7.0	Y	Y	Y	PA-4	-1.57	97.2	-0.016	-0.016	-1.57
PA-04	Proposed	7627278.72	702482.87	Shallow	33.2	36.67	37.22	-0.55	32.97	5.0	Sch 40 PVC	0.010	0.3	33.2	28.2	4.0	9.0	33.2	26.2	4.0	11.0	7.0	Y	Y	Y	PA-3	--				
PA-05	Proposed	7627622.28	702439.04	Shallow	37.9	37.22	37.89	-0.67	37.52	5.0	Sch 40 PVC	0.010	0.3	37.9	32.9	0.0	5.0	37.9	30.9	0.0	7.0	7.0	Y	Y	Y	MWA-2	--				
PA-06	Proposed	7627810.48	702208.51	Shallow	38.6	38.03	38.56	-0.53	38.33	5.0	Sch 40 PVC	0.010	0.3	38.6	33.6	0.0	5.0	38.6	31.6	0.0	7.0	7.0	Y	Y	Y	MWA-69	--				
PA-07	Proposed	7628285.98	701683.25	Shallow	34.9	39.30	39.90	-0.60	34.60	5.0	Sch 40 PVC	0.010	0.3	34.9	29.9	5.0	10.0	34.9	27.9	5.0	12.0	7.0	Y	Y	Y	MWA-47	--				
PA-08	Proposed	7628152.67	701494.83	Shallow	36.9	40.47	40.86	-0.39	36.77	5.0	Sch 40 PVC	0.010	0.3	36.9	31.9	4.0	9.0	36.9	29.9	4.0	11.0	7.0	Y	Y	Y	PA-09	--				
PA-09	Proposed	7628190.77	701455.26	Shallow	36.7	40.24	40.73	-0.49	36.54	5.0	Sch 40 PVC	0.010	0.3	36.7	31.7	4.0	9.0	36.7	29.7	4.0	11.0	7.0	Y	Y	Y	PA-08	0.03	54.9	0.000	-0.005	-0.27
PA-10i	Proposed	7627290.20	702481.40	Intermediate	43.2	36.67	37.22	-0.55	42.97	5.0	Sch 40 PVC	0.010	0.3	43.2	38.2	-6.0	-1.0	43.2	36.2	-6.0	1.0	7.0	Y	Y	Y	PA-17i	--				
PA-11i	Proposed	7627625.25	702427.17	Intermediate	48.0	37.63	38.01	-0.38	47.93	5.0	Sch 40 PVC	0.010	0.3	48.0	43.0	-10.0	-5.0	48.0	41.0	-10.0	-3.0	7.0	Y	Y	Y	MWA-8i	--				
PA-12i	Proposed	7627810.14	702200.79	Intermediate	45.6	38.03	38.56	-0.53	45.33	5.0	Sch 40 PVC	0.010	0.3	45.6	40.6	-7.0	-2.0	45.6	38.6	-7.0	0.0	7.0	Y	Y	Y	MWA-66i	--				
PA-13i	Proposed	7628104.19	701909.50	Intermediate	47.1	38.48	39.08	-0.60	46.78	5.0	Sch 40 PVC	0.010	0.3	47.1	42.1	-8.0	-3.0	47.1	40.1	-8.0	-1.0	7.0	Y	Y	Y	MWA-34i	--				
PA-14i	Proposed	7628284.93	701700.25	Intermediate	47.9	39.30	39.93	-0.63	47.60	5.0	Sch 40 PVC	0.010	0.3	47.9	42.9	-8.0	-3.0	47.9	40.9	-8.0	-1.0	7.0	Y	Y	Y	PA-29i	--				
PA-15i	Proposed	7628161.26	701501.92	Intermediate	49.9	40.62	40.93	-0.31	49.92	5.0	Sch 40 PVC	0.010	0.3	49.9	44.9	-9.0	-4.0	49.9	42.9	-9.0	-2.0	7.0	Y	Y	Y	PA-16i	--				
PA-16i	Proposed	7628200.47	701463.79	Intermediate	50.1	40.30	41.06	-0.76	49.60	5.0	Sch 40 PVC	0.010	0.3	50.1	45.1	-9.0	-4.0	50.1	43.1	-9.0	-2.0	7.0	Y	Y	Y	PA-15i	-0.10	54.7	-0.002	-0.005	-0.27
PA-17i	Proposed	7627227.23	702563.89	Intermediate	43.8	37.22	37.81	-0.59	43.52	5.0	Sch 40 PVC	0.010	0.3	43.8	38.8	-6.0	-1.0	43.8	36.8	-6.0	1.0	7.0	Y	Y	Y	PA-10i	-0.96	103.8	-0.009	-0.009	-0.96
PA-18d	Proposed	7627285.10	702471.91	Deep	50.2	36.55	37.18	-0.63	49.85	5.0	Sch 40 PVC	0.010	0.3	50.2	45.2	-13.0	-8.0	50.2	43.2	-13.0	-6.0	7.0	Y	Y	Y	PA-27d	--				
PA-19d	Proposed	7627631.96	702489.77	Deep	51.2	36.65	37.18	-0.53	50.95	5.0	Sch 40 PVC	0.010	0.3	51.2	46.2	-14.0	-9.0	51.2	44.2	-14.0	-7.0	7.0	Y	Y	Y	PA-30d	-0.40	52.9	-0.007	-0.007	-0.40
PA-20d	Proposed	7627817.79	702198.24	Deep	63.6	37.91	38.62	-0.71	63.21	5.0	Sch 40 PVC	0.010	0.3	63.6	58.6	-25.0	-20.0	63.6	56.6	-25.0	-18.0	7.0	Y	Y	Y	PA-21d	--				
PA-21d	Proposed	7627824.81	702318.79	Deep	60.2	34.36	35.22	-0.86	59.66	5.0	Sch 40 PVC	0.010	0.3	60.2	55.2	-25.0	-20.0	60.2	53.2	-25.0	-18.0	7.0	Y	Y	Y	PA-20d	-0.16	120.8	-0.001	-0.005	-0.60
PA-22d	Proposed	7628115.97	701922.28	Deep	64.4	38.75	39.36	-0.61	64.05	5.0	Sch 40 PVC	0.010	0.3	64.4	59.4	-25.0	-20.0	64.4	57.4	-25.0	-18.0	7.0	Y	Y	Y	MWA-58d	--				
PA-23d	Proposed	7628285.33	701692.13	Deep	82.9	39.31	39.90	-0.59	82.61	5.0	Sch 40 PVC	0.010	0.3	82.9	77.9	-43.0	-38.0	82.9	75.9	-43.0	-36.0	7.0	Y	Y	Y	PA-24d	-1.47	62.3	-0.024	-0.024	-1.47
PA-24d	Proposed	7628335.03	701727.31	Deep	82.6	39.06	39.55	-0.49	82.36	5.0	Sch 40 PVC	0.010	0.3	82.6	77.6	-43.0	-38.0	82.6	75.6	-43.0	-36.0	7.0	Y	Y	Y	PA-23d	--				
PA-25d	Proposed	7628152.49	701506.80	Deep	81.9	40.44	40.86	-0.42	81.74	5.0	Sch 40 PVC	0.010	0.3	81.9	76.9	-41.0	-36.0	81.9	74.9	-41.0	-34.0	7.0	Y	Y	Y	PA-26d	--				

Table 2-1
Well Construction and Monitoring Summary
Performance Monitoring Plan
Groundwater Source Control Measure
Arkema Inc. Facility
Portland, Oregon

Monitoring Point	Status	Northing	Easting	Aquifer Classification	Depth Drilled	Measuring Point Elevation	Ground Surface Elevation	Measuring Point Stickup	Well Depth	Screened Interval								Sandpack Interval					Performance Monitoring		Gradient Control						
										Screen Length	Screen Material	Screen Slot Size	Sump Length	Depth Below Surface		Elevation		Depth Below Surface		Elevation		Sandpack Thickness	Capture Zone Monitoring Point	Real-time Monitoring	Gradient Calculation Point	Comparison Point	Model Predicted Head Difference	Distance Between Observation Wells	Model Predicted Target Gradient	Selected Target Gradient	Target Head Difference
														Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top										
					(ft)	(ft)	(ft)	(ft)	(ft)	(ft)		(in)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)					(ft)	(ft)	(ft)	(ft)	(ft)
PA-26d	Proposed	7628185.21	701450.16	Deep	81.8	40.33	40.82	-0.49	81.63	5.0	Sch 40 PVC	0.010	0.3	81.8	76.8	-41.0	-36.0	81.8	74.8	-41.0	-34.0	7.0	Y	Y	Y	PA-25d	-0.73	65.4	-0.011	-0.011	-0.73
PA-27d	Proposed	7627214.29	702570.40	Deep	49.6	37.10	37.56	-0.46	49.40	5.0	Sch 40 PVC	0.010	0.3	49.6	44.6	-12.0	-7.0	49.6	42.6	-12.0	-5.0	7.0	Y	Y	Y	PA-18d	-0.45	121.3	-0.004	-0.005	-0.61
PA-28	Proposed	7628105.84	701894.74	Shallow	34.2	38.58	39.22	-0.64	33.88	5.0	Sch 40 PVC	0.010	0.3	34.2	29.2	5.0	10.0	34.2	27.2	5.0	12.0	7.0	Y	Y	Y	MWA-19	--				
PA-29i	Proposed	7628341.94	701738.56	Intermediate	48.6	39.18	39.59	-0.41	48.48	5.0	Sch 40 PVC	0.010	0.3	48.6	43.6	-9.0	-4.0	48.6	41.6	-9.0	-2.0	7.0	Y	Y	Y	PA-14i	1.73	68.7	0.025	-0.005	-0.34
PA-30d	Proposed	7627633.26	702436.89	Deep	52.1	37.34	38.06	-0.72	51.64	5.0	Sch 40 PVC	0.010	0.3	52.1	47.1	-14.0	-9.0	52.1	45.1	-14.0	-7.0	7.0	Y	Y	Y	PA-19d	--				
PMP-1	Active	702220.30	7627682.50	Shallow	35.0	36.36	36.35	0.02	34.02	10.0	304 SS	0.010	0.0	34.0	24.0	2.3	12.3	35.0	22.5	1.3	13.8	12.5	N	N	N						
PMP-2	Active	702254.40	7627654.50	Shallow	35.0	36.36	36.32	0.05	33.85	10.0	304 SS	0.010	0.0	33.8	23.8	2.5	12.5	35.0	21.0	1.3	15.3	14.0	N	N	N						
PMP-3	Active	702279.20	7627643.20	Shallow	35.0	36.17	36.14	0.03	35.03	10.0	304 SS	0.010	0.0	35.0	25.0	1.1	11.1	35.0	22.8	1.1	13.3	12.2	N	N	N						
RW-05	Proposed	7627307.13	702516.89	Shallow	30.7	34.80	37.70	-2.90	28.10	10.0	304 SS	0.010	0.3	30.7	20.7	7.0	17.0	29.5	17.5	7.0	19.0	12.0	Y	Y	N						
RW-06i	Proposed	7627358.43	702494.65	Intermediate	42.8	34.98	37.78	-2.80	40.28	5.0	304 SS	0.010	0.3	42.8	37.8	-5.0	0.0	41.5	33.0	-5.0	3.5	8.5	Y	Y	N						
RW-07	Proposed	7627480.16	702466.26	Shallow	36.9	33.98	36.91	-2.93	34.28	10.0	304 SS	0.010	0.3	36.9	26.9	0.0	10.0	36.5	24.0	0.0	12.5	12.5	Y	Y	N						
RW-08	Proposed	7627650.10	702380.41	Shallow	37.1	34.21	37.08	-2.87	34.51	10.0	304 SS	0.010	0.3	37.1	27.1	0.0	10.0	39.0	26.4	0.0	12.6	12.6	Y	Y	N						
RW-09i	Proposed	7627733.53	702319.88	Intermediate	44.6	33.73	36.62	-2.89	42.03	5.0	304 SS	0.010	0.3	44.6	39.6	-8.0	-3.0	44.1	37.0	-8.0	-0.9	7.1	Y	Y	N						
RW-10	Proposed	7627796.06	702242.19	Shallow	37.2	34.33	37.17	-2.84	34.63	10.0	304 SS	0.010	0.3	37.2	27.2	0.0	10.0	37.0	24.2	0.0	12.8	12.8	Y	Y	N						
RW-11i	Proposed	7627840.09	702183.18	Intermediate	45.7	34.77	37.67	-2.90	43.07	5.0	304 SS	0.010	0.3	45.7	40.7	-8.0	-3.0	45.5	38.1	-8.0	-0.6	7.4	Y	Y	N						
RW-12	Proposed	7627871.99	702077.07	Shallow	34.4	35.58	38.43	-2.85	31.88	10.0	304 SS	0.010	0.3	34.4	24.4	4.0	14.0	31.0	18.0	4.0	17.0	13.0	Y	Y	N						
RW-13i	Proposed	7627901.05	702003.55	Intermediate	43.9	36.09	38.88	-2.79	41.39	5.0	304 SS	0.010	0.3	43.9	38.9	-5.0	0.0	42.0	33.5	-5.0	3.5	8.5	Y	Y	N						
RW-14	Proposed	7627968.41	701962.17	Shallow	33.9	36.08	38.87	-2.79	31.38	10.0	304 SS	0.010	0.3	33.9	23.9	5.0	15.0	32.5	20.0	5.0	17.5	12.5	Y	Y	N						
RW-15	Proposed	7628048.90	701930.66	Shallow	33.7	35.81	38.70	-2.89	31.11	10.0	304 SS	0.010	0.3	33.7	23.7	5.0	15.0	38.0	25.0	5.0	18.0	13.0	Y	Y	N						
RW-16i	Proposed	7628054.92	701936.85	Intermediate	44.7	35.77	38.66	-2.89	42.07	5.0	304 SS	0.010	0.3	44.7	39.7	-6.0	-1.0	49.0	36.0	-6.0	7.0	13.0	Y	Y	N						
RW-17	Proposed	7628150.24	701884.88	Shallow	34.5	36.55	39.50	-2.95	31.85	10.0	304 SS	0.010	0.3	34.5	24.5	5.0	15.0	34.0	21.0	5.0	18.0	13.0	Y	Y	N						
RW-18	Proposed	7628203.98	701810.54	Shallow	34.4	36.51	39.42	-2.91	31.81	10.0	304 SS	0.010	0.3	34.4	24.4	5.0	15.0	42.0	29.5	5.0	17.5	12.5	Y	Y	N						
RW-19i	Proposed	7628213.30	701818.09	Intermediate	47.5	36.56	39.46	-2.90	44.86	5.0	304 SS	0.010	0.3	47.5	42.5	-8.0	-3.0	50.0	42.7	-8.0	-0.7	7.3	Y	Y	N						
RW-20	Proposed	7628266.91	701723.11	Shallow	34.0	37.07	39.99	-2.92	31.37	10.0	304 SS	0.010	0.3	34.0	24.0	6.0	16.0	35.5	23.0	6.0	18.5	12.5	Y	Y	N						
RW-21i	Proposed	7628292.81	701650.87	Intermediate	48.4	37.38	40.42	-3.04	45.68	5.0	304 SS	0.010	0.3	48.4	43.4	-8.0	-3.0	53.0	36.1	-8.0	8.9	16.9	Y	Y	N						
RW-22	Proposed	7628197.13	701534.02	Shallow	33.9	38.02	40.90	-2.88	31.32	10.0	304 SS	0.010	0.3	33.9	23.9	7.0	17.0	33.0	20.0	7.0	20.0	13.0	Y	Y	N						
RW-23	Proposed	7627551.09	702466.07	Shallow	36.8	33.63	36.75	-3.12	33.93	10.0	304 SS	0.010	0.3	36.8	26.8	0.0	10.0	37.2	24.5	0.0		12.7	Y	Y	N						
RW-24i	Proposed	7627566.33	702443.43	Intermediate	43.8	34.03	36.79	-2.76	41.33	5.0	304 SS	0.010	0.3	43.8	38.8	-7.0	-2.0	45.0	37.5	-7.0	0.5	7.5	Y	Y	N						
RW-25	Proposed	7628122.95	701474.02	Shallow	38.0	38.06	40.96	-2.90	35.36	10.0	304 SS	0.010	0.3	38.0	28.0	3.0	13.0	38.5	25.0	3.0	16.5	13.5	Y	Y	N						
RW-26i	Proposed	7628130.55	701480.56	Intermediate	48.0	38.10	40.95	-2.85	45.40	5.0	304 SS	0.010	0.3	48.0	43.0	-7.0	-2.0	47.0	40.0	-7.0	0.0	7.0	Y	Y	N						

Notes:
Y = Yes
N = No
NA = Not applicable

Table 2-2
Vertical Head Difference Monitoring Locations
Performance Monitoring Plan
Groundwater Source Control Measure
Arkema Inc. Facility
Portland, Oregon

Aquifer Designation			Vertical Flow Calculation	
Shallow	**Intermediate**	**Deep**	**Shallow/Intermediate**	**Intermediate/Deep**
PA-3	PA-17i	PA-27d	X	X
PA-4	PA-10i	PA-18d	X	X
PA-5	PA-11i	PA-30d	X	X
MWA-2	MWA-8i	PA-19d	X	X
MWA-69	MWA-66i	PA-21d	X	X
PA-6	PA-12i	PA-20d	X	X
MWA-19	MWA-34i	MWA-58d	X	X
PA-28	PA-13i	PA-22d	X	X
PA-7	PA-14i	PA-23d	X	X
MWA-47	PA-29i	PA-24d	X	X
PA-8	PA-15i	PA-25d	X	X
PA-9	PA-16i	PA-26d	X	X

Table 2-3
Data Collection Objectives
Performance Monitoring Plan
Groundwater Source Control Measure
Arkema Inc. Facility
Portland, Oregon

Parameter	Minimium Measurement Frequency	Reporting Frequency
Monitoring Well Hydrograph[1]	15-Minutes	Monthly
River Stage Height[2]	15-Minutes	Monthly
Precipitation	Daily	Monthly
Potentiometric Surface[3]	Monthly	Monthly
System Flow Rate	15-Minutes	Monthly

Notes:
[1] = Hydrographs will consist of data sets corrected using the Serfes method.
[2] = River stage height collected from a transducer installed on Dock 2.
[3] = Potentiometric maps generated from a combination of electronic and monthly manual water level measurements

Table 3-1
NDPES Permit Effluent Discharge Limits
Performance Monitoring Plan
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Parameter	MQL	Effluent Quality Objective
VOCs (ug/L)[1]		
Benzene	0.5	<0.7
Chlorobenzene	0.5	<200
Chloroform	0.5	<30
SVOCs (ug/L)[1]		
2-Chlorophenol	1	<5
Pesticides (ug/L)[1]		
DDD	0.05	<0.05
DDE	0.05	<0.05
DDT	0.05	<0.05
Metals (ug/L)[2]		
Arsenic	0.05	<10
Chromium, hexavalent	0.9	<16
Inorganics (mg/L)[3]		
Chlorate	NA	<0.015
Perchlorate	0.004	<0.015
pH (s.u.)	NA	5.5 to 9.0
Other Parameters (mg/L)[3]		
Nitrate as N	0.1	<10
Nitrogen, Ammonium	1	
Nitrogen, Total Kjeldahl	NA	
Phosphate, Total as P	0.01	<1
Total Organic Carbon	NA	<10
Total Suspended Solids	NA	<25
Total Volatile Solids	NA	<25

Notes

(1) - Estimated effluent concentrations based on approximately 90% removal efficiency for liquid-phase granular activated carbon (LPGAC).

(2) - Estimated effluent concentrations assume iron co-precipitation with clarifier and optional solids filtration.

(3) - Estimated effluent concentrations based on documented performance of fluidized bed reactor.

MDL = Method Detection Limit
mg/L = milligrams per liter
ug/L = micrograms per liter
s.u. = standard units
NA = data not available
VOC = Volatile Organic Compounds
SVOC = Semi-Volatile Organic Compounds
ODEQ = Oregon Department of Environmental Qu
DDD = dichloro diphenyl dichloroethane
DDE = dichloro diphenyl dichloroethylene
DDT = dichloro diphenyl trichloroethane

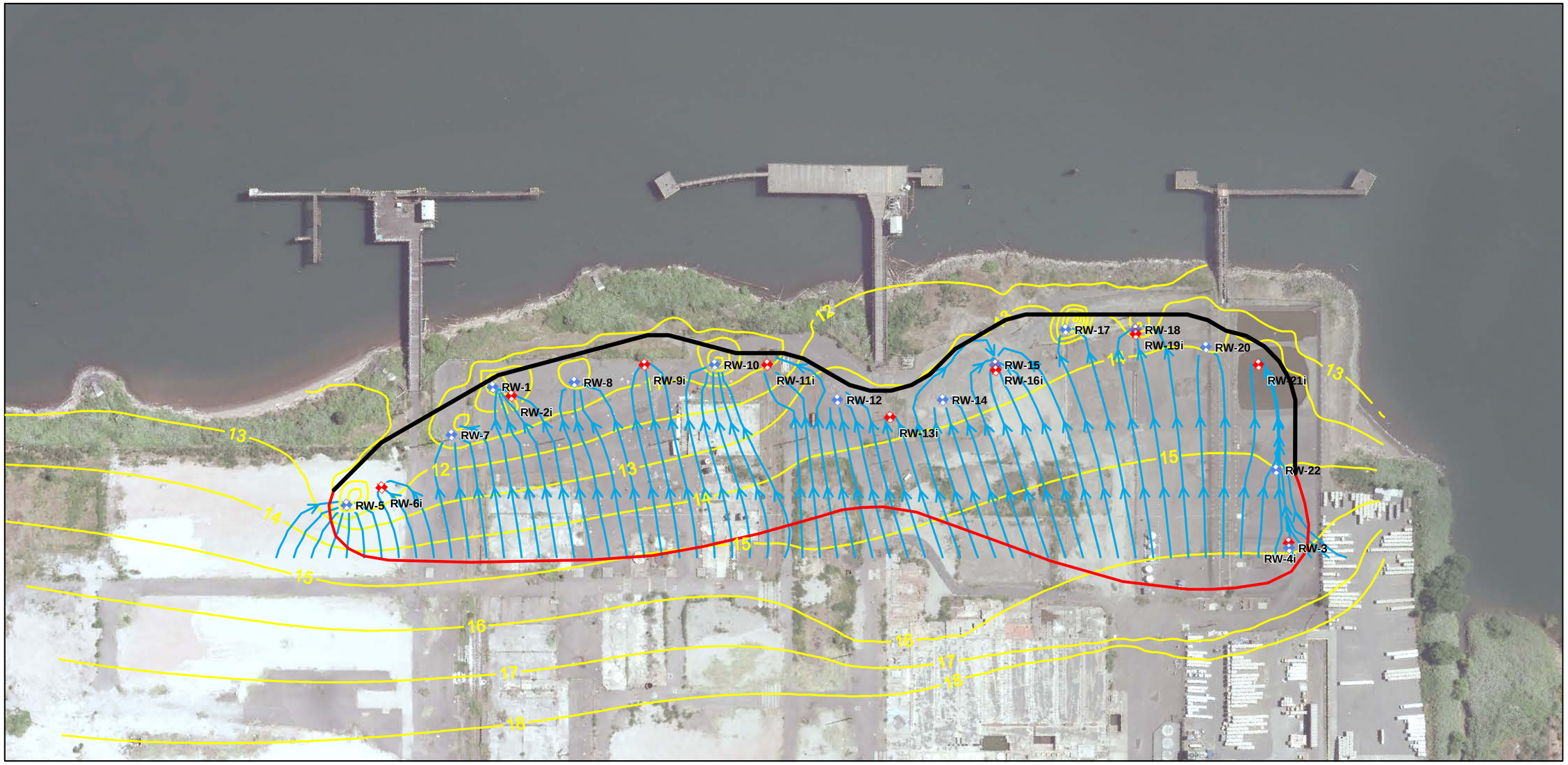
Appendix A
Potentiometric Surface and Particle Tracking Figures - Preliminary Design Report

Project: 0093634.05

Date: 05/02/2011

Drawn By: TFC

F:\RM106\A\Arkema\0057055 Groundwater Modeling\ArcGis\Arkema Preliminary Barrier Wall Design - Figure 3-1.mxd



Legend

- Shallow Zone Groundwater Flow Path
- Shallow Zone Head Solution (ft NAVD88)
- Shallow Zone Recovery Well
- Intermediate Zone Recovery Well
- Proposed Barrier Wall Alignment
- Target Capture Zone

N

0 150 300 Feet

Data Sources: Aerial Photo: City of Portland, June 2008

Figure 3-1

Shallow Zone Groundwater Flow Path and Head Solution
Preliminary Design Report
Groundwater Source Control Measure
Arkema, Inc.
Portland, Oregon

ERM 05/11

Project: 0093634.05

Date: 05/02/2011

Drawn By: TFC

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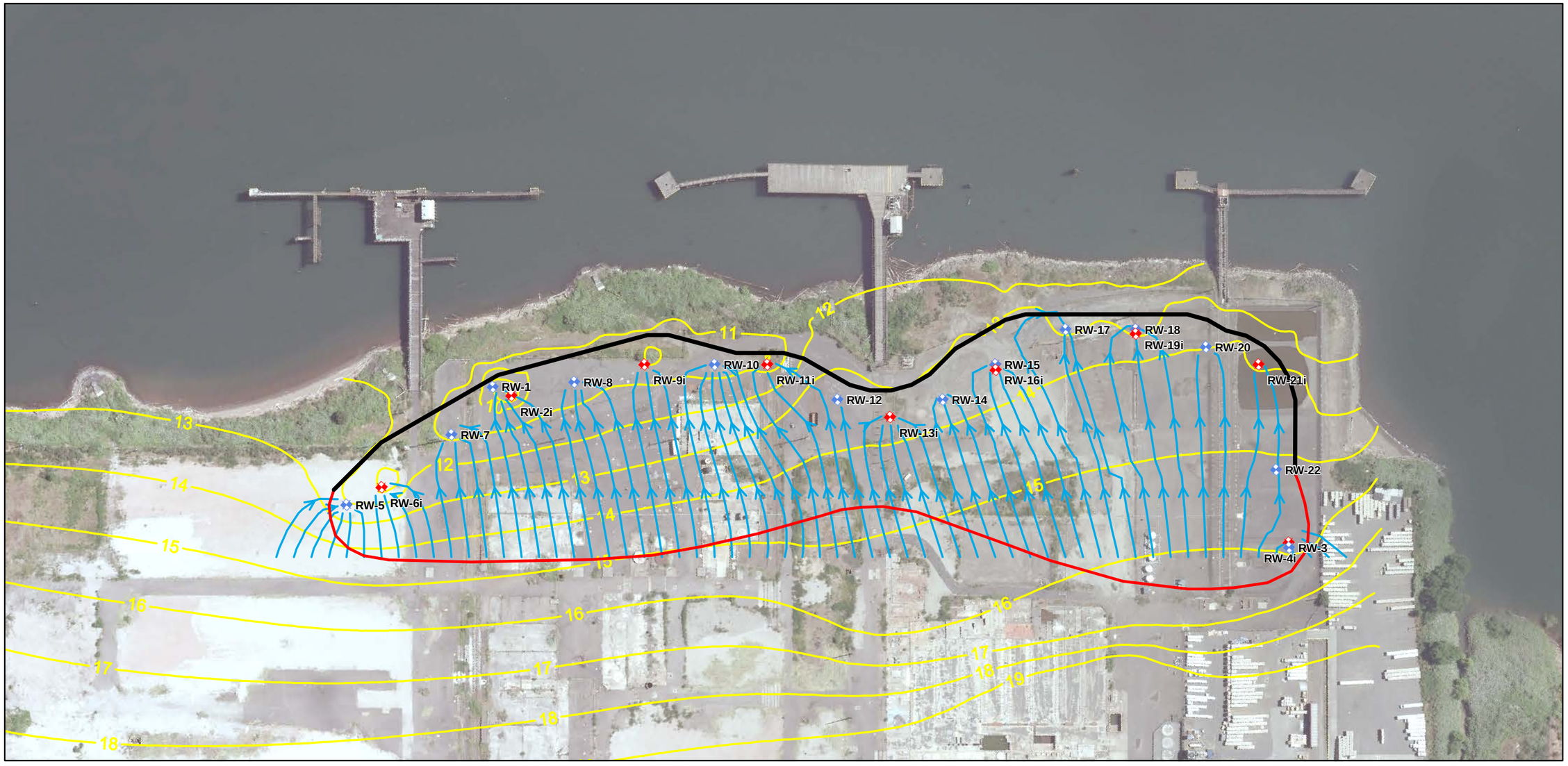

Legend

- Intermediate Zone Groundwater Flow Path
- Intermediate Zone Head Solution (ft NAVD88)
- Proposed Barrier Wall Alignment
- Target Capture Zone
- Shallow Zone Withdrawal Well
- Intermediate Zone Withdrawal Well

N

0 150 300 Feet

Data Sources: Aerial Photo: City of Portland, June 2008

Figure 3-2

Intermediate Zone Groundwater Flow Path and Head Solution
Preliminary Design Report
Groundwater Source Control Measure
Arkema, Inc.
Portland, Oregon

ERM 05/11

Project: 0093634.05

Date: 05/02/2011

Drawn By: TFC

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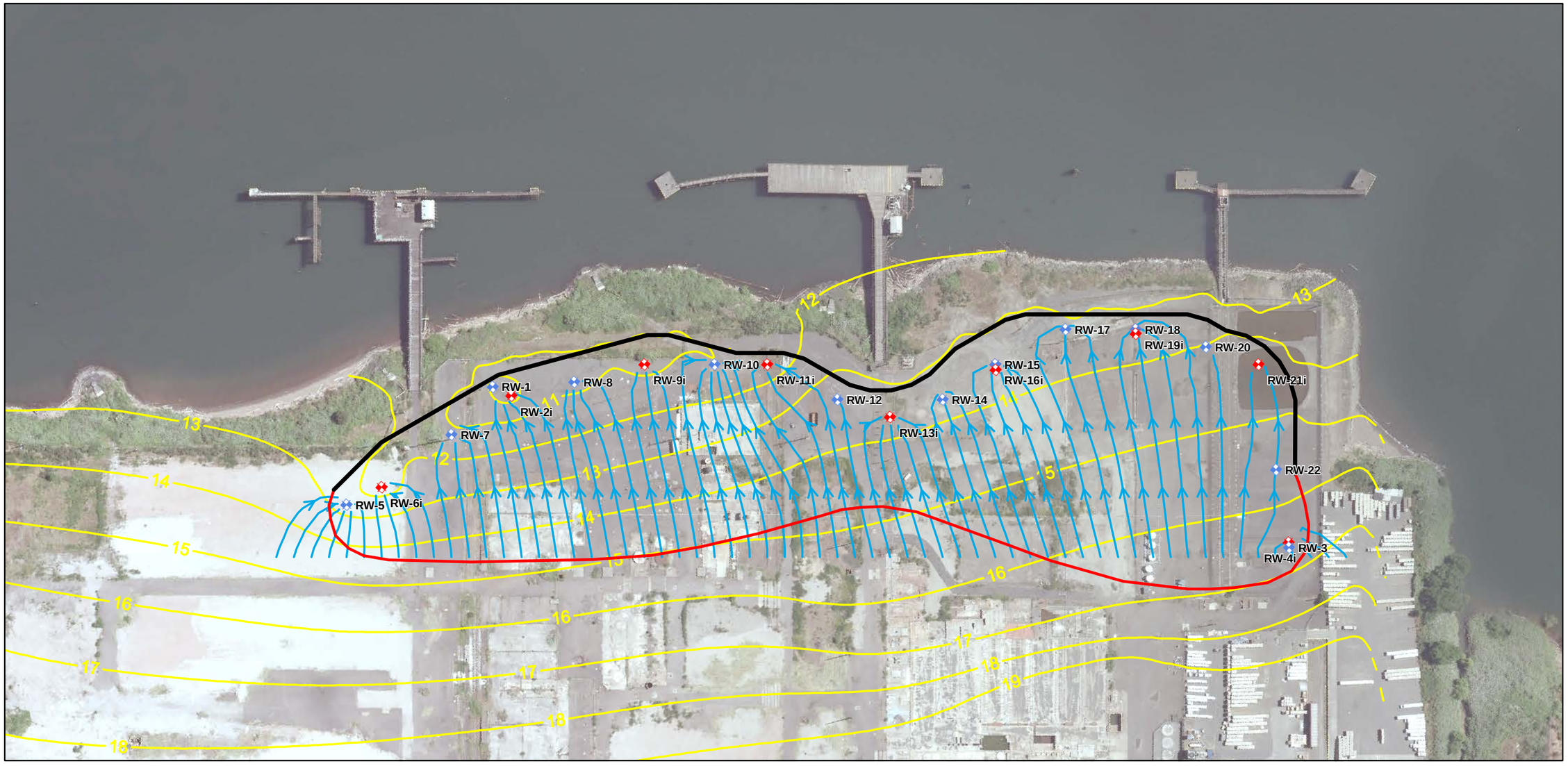

Legend

- Deep Zone Groundwater Flow Path
- Deep Zone Head Solution (ft NAVD88)
- Proposed Barrier Wall Alignment
- Target Capture Zone
- Shallow Zone Withdrawal Well
- Intermediate Zone Withdrawal Well

N

0 150 300 Feet

Data Sources: Aerial Photo: City of Portland, June 2008

Figure 3-3

Deep Zone Groundwater Flow Path and Head Solution
Preliminary Design Report
Groundwater Source Control Measure
Arkema, Inc.
Portland, Oregon

ERM 05/11

Project: 0093634.05

Date: 05/02/2011

Drawn By: TFC

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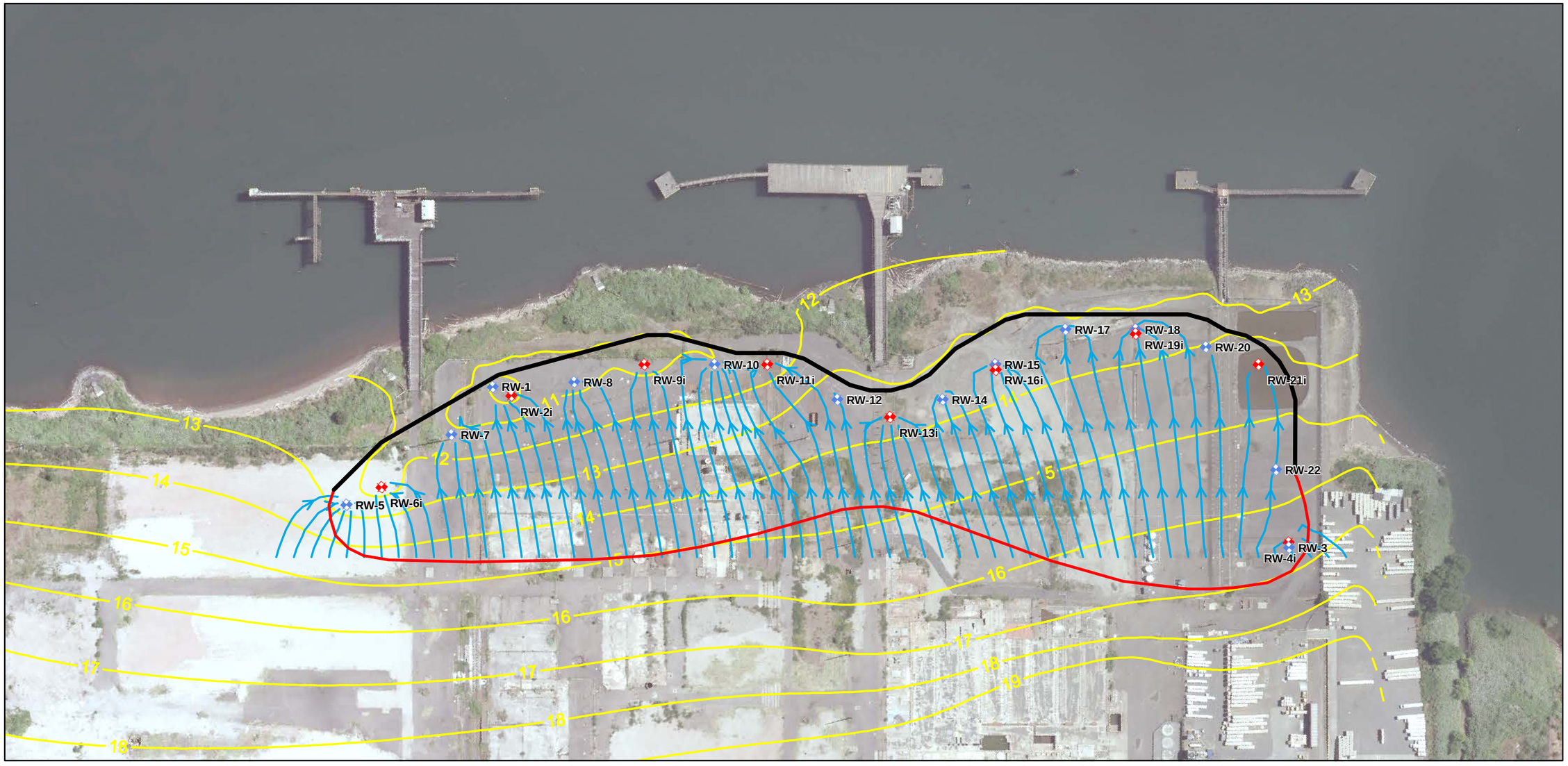


Legend

- Base Deep Zone Groundwater Flow Path
- Deep Zone Head Solution (ft NAVD88)
- Proposed Barrier Wall Alignment
- Target Capture Zone
- Shallow Zone Withdrawal Well
- Intermediate Zone Withdrawal Well

N

0 150 300 Feet

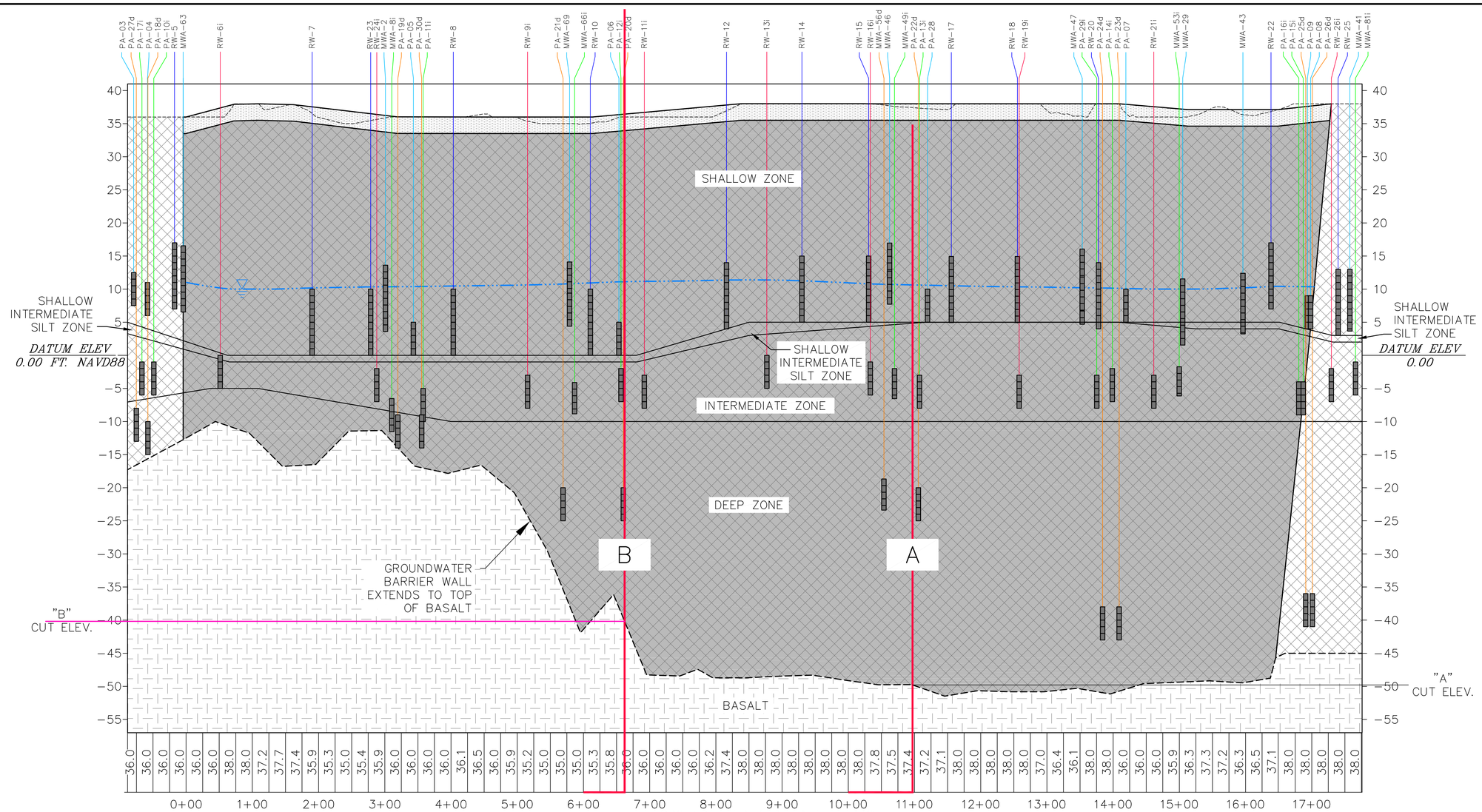
Data Sources: Aerial Photo: City of Portland, June 2008

Figure A-1

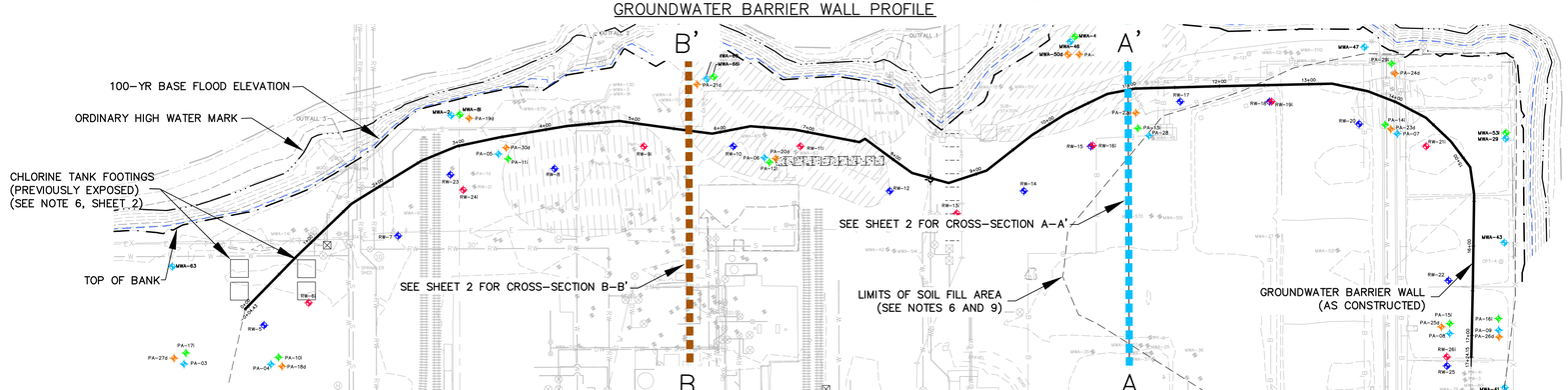
Base of Deep Zone Groundwater Flow Path and Head Solution
Preliminary Design Report
Groundwater Source Control Measure
Arkema, Inc.
Portland, Oregon

ERM 05/11

Appendix B
Hydraulic Gradient Control Point Cross Section



GROUNDWATER BARRIER WALL PROFILE



GROUNDWATER BARRIER WALL PLAN

ISSUED FOR AGENCY APPROVAL

REV.	DATE	DESCRIPTION	BY	CHK
1	2/5/13	ADDRESS AGENCY COMMENTS	RK	BR

DRAWN BY RMK | CADD Review FGB | CHECKED BY SL-ANN

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Environmental Resources Management, Inc.

REGISTERED PROFESSIONAL ENGINEER 78496PE OREGON DECEMBER 31, 2014 BRENDAN ANDREW ROBINSON 2012-7-13

EXP. 12/31/2014 P.E.

GROUNDWATER SOURCE CONTROL MEASURE PERFORMANCE MONITORING SYSTEM

ARKEMA INC.
PORTLAND, OREGON

HYDRAULIC GRADIENT CONTROL POINT CROSS SECTION

SCALE	PROJECT NUMBER	SHEET	REV.
AS NOTED	0180382	1	1
DATE 07/20/2010			

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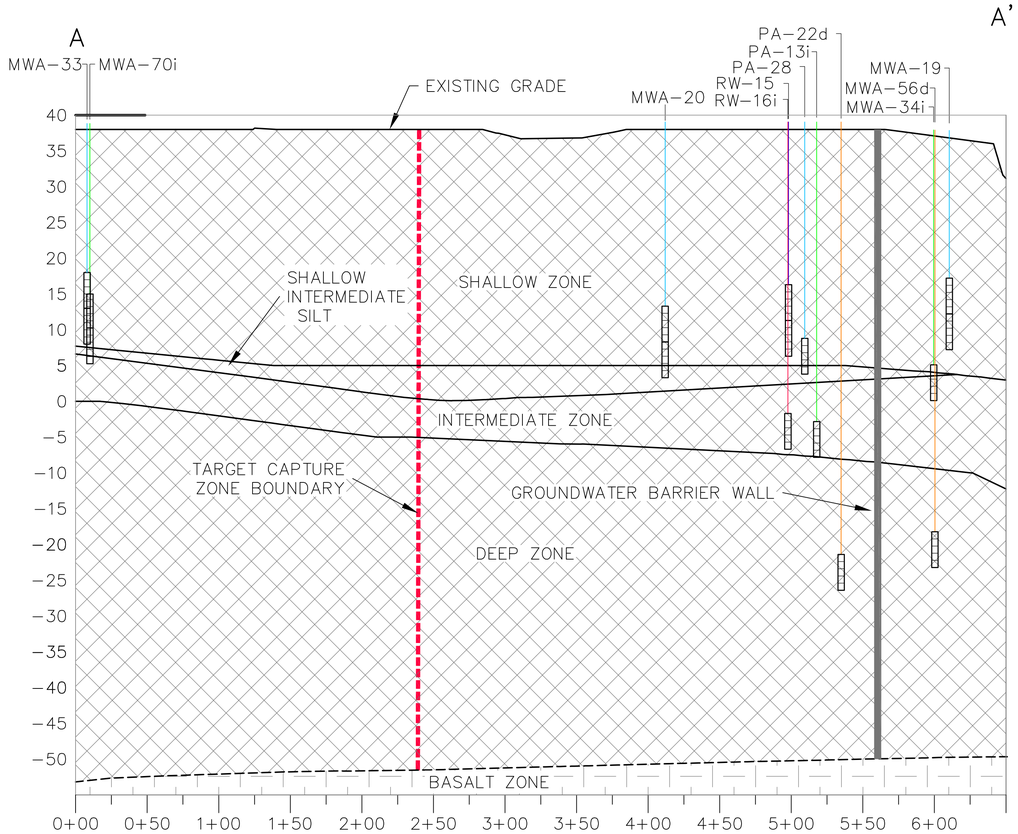
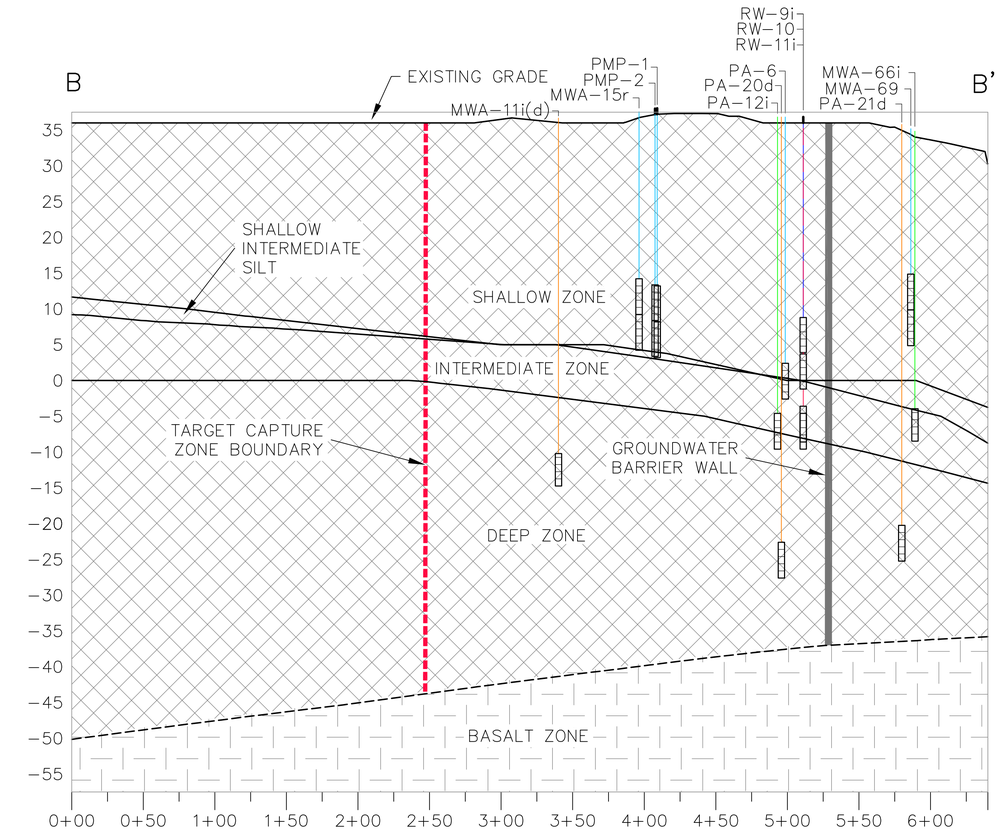


CROSS-SECTION A-A'



CROSS-SECTION B-B'

10
0
0
50
SCALE (IN FEET)

10
0
0
50
SCALE (IN FEET)

LEGEND

- EXISTING GRADE
- EXISTING GROUNDWATER ELEVATION
- TOP OF BASALT (BEDROCK)
- SHALLOW PA WELL
- INTERMEDIATE PA WELL
- DEEP PA WELL
- SHALLOW RW WELL
- INTERMEDIATE RW WELL
- SCREENED INTERVAL
- SUBSURFACE MATERAIL
- BASALT

REV.	DATE	DESCRIPTION	BY	CHK

DRAWN BY RMK | CADD Review FGB | CHECKED BY JD-POR

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SEAL

GROUNDWATER SOURCE CONTROL MEASURE
GWET SYSTEM
ARKEMA, INC.
PORTLAND, OREGON

CROSS-SECTIONS A-A' AND B-B'

SCALE	PROJECT NUMBER	SHEET	REV.
AS NOTED	0198219	2	
DATE 11/27/2013			

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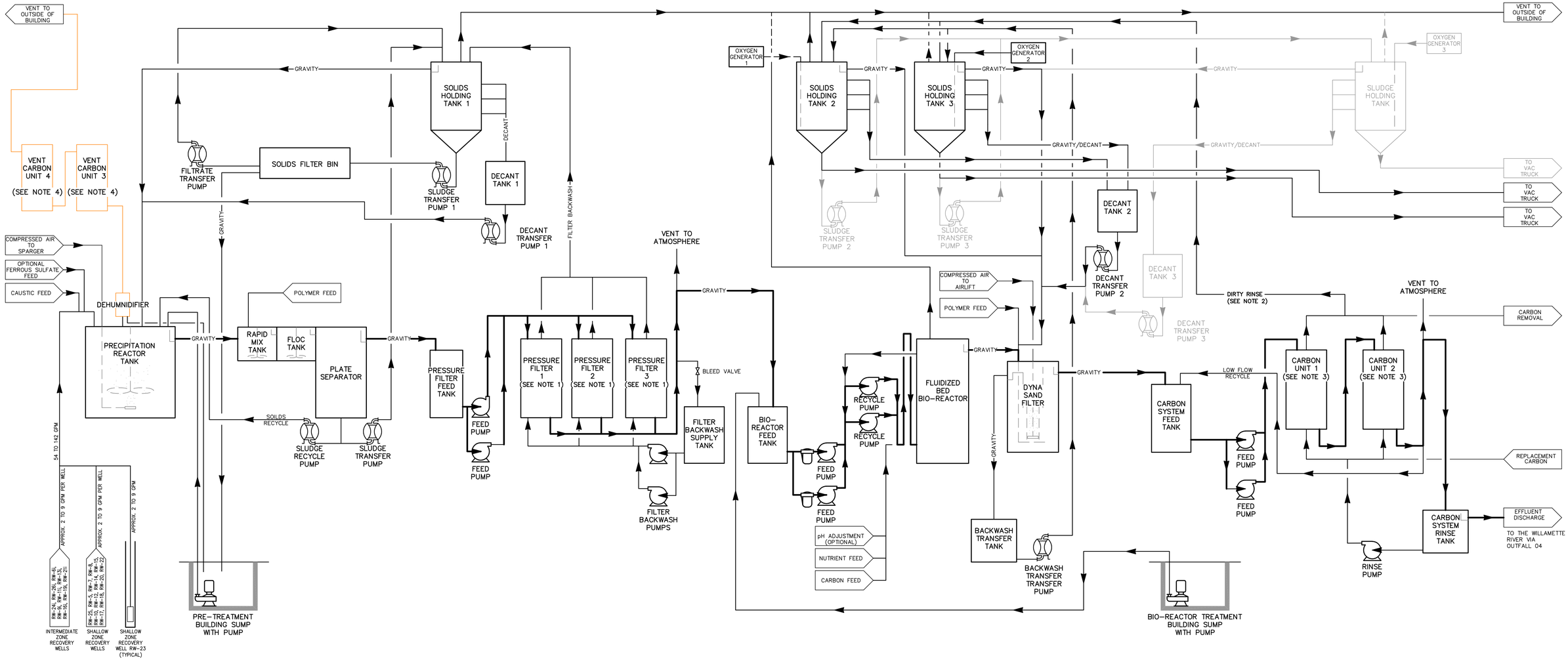
Appendix C
GWET System Process Flow Diagram



LEGEND

- AIR POWERED PUMP
- ELECTRICALLY POWERED CENTRIFUGLE PUMP
- SUMP PUMP
- INLINE STRAINER
- GRAY SHADE INDICATES POTENTIAL FUTURE EQUIPMENT AND ASSOCIATED PIPING

NOTES:

1. TWO FILTER UNITS IN OPERATION WITH ONE UNIT IN BACKWASH/STANDBY.
2. AFTER PLACEMENT OF NEW CARBON IN THE CARBON UNITS, THEY ARE RINSED TO REMOVE FINES
3. THE CARBON UNITS ARE OPERATED IN SERIES (PRIMARY UNIT DISCHARGING TO THE SECONDARY UNIT DISCHARGING TO THE OUTFALL)
4. THE CARBON UNITS ARE OPERATED IN SERIES (PRIMARY UNIT DISCHARGING TO THE SECONDARY UNIT DISCHARGING TO ATMOSPHERE.)

ISSUED FOR AGENCY APPROVAL

REV.	DATE	DESCRIPTION	BY	CHK
B	01/25/13	ISSUED FOR AGENCY APPROVAL	LAG	BR
A	05/14/12	ISSUED FOR BIDS	LAG	BR
0	02/07/11	ISSUED FOR AGENCY REVIEW	LAG	BR

DRAWN BY RMK | CADD Review FGB | CHECKED BY LG-Rol

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Environmental Resources Management, Inc.

REGISTERED PROFESSIONAL ENGINEER 78496PE OREGON DECEMBER 31, 2007 BRENDAN ANDREW ROBINSON

EXP. 12/31/2014

GROUNDWATER SOURCE CONTROL MEASURE

ARKEMA, INC.
PORTLAND, OREGON

GWET SYSTEM PROCESS FLOW DIAGRAM

SCALE	PROJECT NUMBER	SHEET	REV.
AS NOTED	0180382	PFD-01	B
DATE 11/10/2010			

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Appendix D
Quality Assurance Project Plan Addendum

Introduction

This attachment will serve as an addendum to most recent site Quality Assurance Project Plan (QAPP), prepared as part of the *Draft Design Report Stormwater Source Control Measures* (Integral 2010). This document has been prepared to include additional treatment system effluent monitoring analytical requirements in the project scope.

Data Quality Objectives

Effluent samples collected for reporting requirements will be analyzed by Columbia Analytical Services in Kelso, Oregon, following quantitative data quality objectives provided in Table 1. Internal monitoring of effluent will be accomplished using field test methods.

Field quality control samples, including duplicates and blanks will be collected as per the QAPP at a frequency of at least 1 set of quality control samples for every 20 field samples.

Table 1
Laboratory Quality Objectives
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Parameter	Analytial Method	MQL	Effluent Quality Objective
Organochlorine Pesticides (ug/L)			
DDD	USEPA 625	0.05	<0.05
DDE	USEPA 625	0.05	<0.05
DDT	USEPA 625	0.05	<0.05
Metals (ug/L)			
Arsenic (total)	USEPA 200.8	0.1	<10
Chromium, hexavalent	USEPA 7195/6010B	0.9	<16
Inorganics (mg/L)			
Chlorate	USEPA 300.1	NA	<0.015
Perchlorate	USEPA 314	0.004	<0.015
pH (s.u.)	SM 4500H+ B	NA	5.5 to 9.0
Other Parameters (mg/L)			
Nitrogen, Ammonium	USEPA 350.1	1	<10
Nitrogen, Total Kjeldahl	USEPA 351	NA	
Phosphate, Total as P	USEPA 365.1	0.01	<1
Total Suspended Solids	SM 2540D	NA	<130
Total Volatile Solids	USEPA 160.4	NA	<25

Notes
mg/L = milligrams per liter
ug/L = micrograms per liter
s.u. = standard units
NA = data not available
USEPA = United States Environmental Protection Agency
SM = Standard method

Appendix E
LSS Response to Agency Comments

10 December 2013

Mr. Matt McClincy
Oregon Department of Environmental Quality
Northwest Region
2020 Southwest 4th Avenue, Suite 400
Portland, Oregon 97201-4987

Subject: Former Arkema Portland Plant
Responses to DEQ Review Comments
Arkema Portland Performance Monitoring Plan
ECSI No. 398

Dear Matt:

This document provides responses to the comments received from the Oregon Department of Environmental Quality (ODEQ) on 29 October 2013 related to the *Final Performance Monitoring Plan* (PMP) – *Groundwater Source Control Measure - Arkema Inc.* (Arkema) *Portland Plant* and supporting documents. The PMP was prepared by ERM-West, Inc. (ERM), on behalf of Legacy Site Services, LLC (LSS), agent for Arkema, to memorialize monitoring requirements for the implementation of a groundwater source control measure (GW SCM) at the Arkema facility in Portland, Oregon (the "site"). LSS understands that the comment set received from the ODEQ incorporates comments received from United States Environmental Protection Agency (EPA) and the Five Tribes. Each of the ODEQ comments is provided below in italic font, followed by the LSS response.

LSS does not intend to submit a revised PMP, but will incorporate these responses and associated attachment as an addendum to the PMP.

General Comments

1. *It has been over 2 years since DEQ and partners generated comments related to this document (early 2011 timeframe). While there are notable improvements in the text explaining the process through which Legacy Site Services (LSS) plans to control contaminants present in site groundwater and monitor the effectiveness of the designed*

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source control measure, there remains a need to clarify some statements and present additional information before DEQ considers this document final. These clarifications and additional information are presented in the specific comments below. Verbatim

No response required.

2. *DEQ anticipates that effective hydraulic containment of upland groundwater plumes will be clearly demonstrable based on contouring of water elevation data (adjusted using the Serfes method) and calculation of gradients, and that the analyses of potentiometric maps and hydraulic gradients will be the first lines of evidence for evaluating hydraulic containment of upland groundwater. DEQ asks that LSS identify: 1) the various types of information that will be used to demonstrate containment, 2) the relative hierarchy of the various lines of evidence, and 3) the line of evidence and corresponding criteria that demonstrates successful containment.*

According to Step 3 of the EPA guidance document, *A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems* (EPA 2008), water level measurements will be used to develop potentiometric surface maps, to determine horizontal and vertical gradients and to evaluate flow directions. These will be used as the primary line of evidence for evaluating hydraulic containment. Inward horizontal gradients across the groundwater barrier wall (GWBW) and target capture zone boundary, and upward vertical gradients, will be considered indicative of successful containment.

A secondary line of evidence to demonstrate successful containment will consist of calculations of estimated flow rates. These analyses are described in Step 4 of the EPA guidance document. The potentiometric contour maps, as well as the updated groundwater model in conjunction with particle tracking, will be used to evaluate flow paths and estimate overall groundwater flux through the individual hydrogeologic layers. A net groundwater flux into the target capture zone (i.e., groundwater extraction rate greater than total recharge rate) will be indicative of successful containment.

3. *Data Collection – In addition to the filtered data comparisons inside and outside the wall, and/or shallow and deep well comparisons, it is not clear what other data will be collected and presented. A table should be included that lists data collection objectives for the performance monitoring plan. The table should indicate the locations and frequency with which the data will be collected, analyzed and submitted to DEQ. At a minimum, the data packages must include hydrographs based on the unfiltered data for each of the wells and for the river stage at the site. That type of raw data hydrograph, in addition to the filtered data comparisons should allow for better understanding of how the entire barrier wall system is working. Also, continuous data on individual well pumping rates and water level drawdown in addition to precipitation data should be presented in figures.*

The attached Table 2-3 presents a summary of the data collection objectives, water levels, hydrographs, potentiometric surface maps and the frequency of data recording and reporting.

LSS will provide unfiltered hydrographs of water levels and precipitation data on a monthly basis to the ODEQ. These hydrographs will be based on continuously monitored water levels reported at 15-minute intervals. Monthly potentiometric surface maps will be generated from water levels recorded by manual and electronic measurements (daily average) on, or around, the 15th day of each month.

Per the ODEQ's requirement that recovery well data not be used for evaluation of potentiometric surfaces, hydrographs of water levels in recovery wells and individual pumping rates will be presented in figures that are separate from the monitoring well hydrographs.

These data will be reported monthly and submitted in conjunction with the monthly monitoring report required under the National Pollutant Discharge Elimination System (NPDES) discharge permit.

4. *Modeling results described in the PMP were first presented in the 2010 Pre-Design Investigation document. In the 2010 document, the extraction rate for each well is listed in a table (typically 5 gpm with a total extraction rate of 109 gpm). The PMP should include a table identifying initial target pumping rates for each extraction well.*

Current estimates of average pumping rates have not changed since 2010. However, anticipated average pumping rates will be updated based on the analysis of the upcoming pumping test results and subsequent groundwater model update. These updated pumping rates will be used as the initial pumping rates when the groundwater extraction and treatment (GWET) system is started. LSS notes that these initial pumping rates are anticipated to immediately begin to vary from the estimated average, as the pumping rates are continuously adjusted to maintain the target gradient between individual control points.

Specific Comments

1. *Section 1.1.2 Groundwater Source Control Measure Development, Page 6, Sixth Paragraph. DEQ does not agree with the statement that data indicate that on-site sources are limited to specific areas on Lots 3 and 4. Additional source control measures for impacted groundwater outside of the influence of the Arkema groundwater extraction and treatment system on Lots 1, 2 and 3 will be evaluated in both the Rhone Poulenc and Arkema upland feasibility studies or additional interim remedial measure evaluations should the upland feasibility studies fail to move forward in a timely manner.*

LSS acknowledges the potential need for additional source control measures for impacted groundwater outside the influence of Arkema's GWET System on Lots 1, 2 and 3. LSS has previously submitted a Work Plan to perform pilot scale treatability in the area near MW-63 to address Arkema related sources at the fringe of the currently envisioned capture zone. LSS understands that DEQ will evaluate in both the Rhone Poulenc and Arkema feasibility studies the necessity, if any, of additional source control measures.

2. *Section 2.1 Groundwater Extraction System Management, Page 9. In addition to Figure 2-1, the PMP should include e a cross-section view (perpendicular to the groundwater flow direction) that depicts the vertical and horizontal extent of the "Target" capture zone.*

Additional cross-sections have been generated and are included as an Attachment.

3. *Section 2.1 Groundwater Extraction System Management, Page 9. Objectives of the GW SCM should include maintaining an vertical upward gradient to assure hydraulic containment.*

The remedial action objectives of the groundwater treatment system were previously established in the ODEQ-approved focused feasibility study (ERM 2008). The primary objective of the GW SCM is to "establish hydraulic control of groundwater contaminates of potential concern (COPCs) at the site, and maintain an inward groundwater gradient toward the upland portion of the site, away from the Willamette River". LSS notes that in accordance with the PMP and this addendum, analysis of vertical upward gradients will be used as an additional line of evidence in support of the hydraulic containment evaluation.

4. *Section 2.1 Groundwater Extraction System Management, Page 9. Consistent with EPA guidance, the PMP should provide details of manual calculations of groundwater flux through individual hydrogeologic layers within the target capture zone. This is a simple but important analysis that provides a line of evidence that supports/refutes a conclusion that modeled extraction rates will effectively contain the volume of groundwater flow through the target capture zone.*

Step 4 of the EPA guidance indicates that both simple horizontal analyses and modeling can be used as additional lines of evidence regarding the extent of actual capture when the system is operating. Simplified manual calculations of groundwater flux through individual hydrogeologic layers within the target capture zone have not been presented in previous submittals related to the design of the GW SCM.

Simple horizontal analyses may be performed to estimate the total groundwater flux into the target capture zone and as a line of evidence in the performance evaluation of the GWET System under normal operating conditions.

No post-construction data were available, and critical assumptions required to perform these simple horizontal analyses were violated, including:

- At the time of design, no real regional water level data, required for calculation of regional horizontal hydraulic gradients, were available for post-barrier wall construction conditions;
- The presence of the barrier wall results in a severe violation of the assumption of an isotropic aquifer of infinite extent;
- The thickness of the hydrogeologic layers varies significantly across the boundary of the target capture zone (e.g., deep zone thickness varies from approximately 5 to 40 feet across the 1800-long target capture zone boundary);
- Significant vertical gradients and some upward vertical flux are anticipated; and
- Significant recharge from the adjacent Willamette River is anticipated around the wings of the barrier wall.

During the design of the extraction system, several methods were used to bound potential total groundwater pumping rates that may be required to achieve hydraulic capture. Due to significant complexity of the hydrogeologic conditions at the site, such as heterogeneity of multiple aquifers, influence of the barrier wall, horizontal and vertical recharge, and the complexity of the pumping system (22 extraction wells, and variable pumping rates), a modeling approach was used to estimate potential extraction rates required to achieve capture. A regional groundwater model was developed and used to simulate hydrogeologic conditions post-barrier wall construction and during GWET System operation.

Using groundwater flux estimates presented in the *Portland Harbor RI/FS Draft Feasibility Study* (Lower Willamette Group, March 2012), the pre-barrier wall installation groundwater flux through the Lots 3 and 4 of the Arkema site to the Willamette River was estimated to be approximately 0.23 cubic feet per second (104 gpm). This estimate is approximately equal to the design flow rate of the GWET System (109 gpm). The post-barrier wall installation flux from the target capture zone, which covers only a portion of Lot 3 and all of Lot 4, is therefore anticipated to be less than 104 gpm. In accordance with the adaptive management approach used in the design and operation of the GWET System, it is capable of operating between 54 and 142 gpm.

5. *Section 2.2.1 Potentiometric Surface and Water Level Difference Maps, Page 12. The well clusters that will be used to evaluate vertical gradients need to be identified.*

The well clusters for calculation of vertical gradients that were identified in the draft PMP have been modified and are summarized in the attached revised Figure 2.5 and Table 2-2.

6. *Section 2.2.2 Gradient Control Points, Page 12, Third Paragraph. LSS needs to revise this paragraph for the following reason: As it currently reads, it implies the gradient control points will be used to confirm inward gradients are being maintained across the entire groundwater barrier wall (GWBW). To clarify, DEQ's understanding is that the gradient control pairs are used for establishing set points in the primary logic controls that will control the variable frequency pumps in the extraction wells to insure flow rates are creating a sufficient inward gradient across the GWBW. However, due to the close proximity of the gradient control points to the extraction wells, they cannot provide the sole source of evidence that hydraulic control is being maintained across the GWBW (e.g. in areas along the GWBW and between gradient control points). For this, all monitoring wells along the GWBW, between the control points, and completed in each stratigraphic layer should be evaluated with potentiometric surface maps developed from manual or temporary transducer monitoring data to verify capture. Table 2.1 should be updated accordingly.*

As stated in the response to the General Comment 2, water level measurements will be used to develop potentiometric surface maps, to determine horizontal and vertical gradients and to evaluate flow directions. These will be used as the primary line of evidence for evaluating hydraulic containment. Inward horizontal gradients across the groundwater barrier wall (GWBW) and target capture zone boundary, and upward vertical gradients, will be considered indicative of successful containment.

A secondary line of evidence to demonstrate successful containment will consist of calculations of estimated flow rates. The potentiometric contour maps, as well as the updated groundwater model in conjunction with particle tracking, will be used to evaluate flow paths and estimate overall groundwater flux through the individual hydrogeologic layers. A net groundwater flux into the target capture zone (i.e., groundwater extraction rate greater than total recharge rate) will be indicative of successful containment.

The original intent of the draft PMP was to collect manual water level measurements from all active monitoring wells as shown on the attached Figures 2-2 through 2-5 and Table 2-1.

7. *Section 2.2.2 Gradient Control Points, Page 13. The text describes what the constructed numerical model predicted for hydraulic capture between gradient control pairs. DEQ's*

expectations in use of the model for evaluating performance of the groundwater extraction and treatment (GWET) system, is a limited secondary line of evidence, due the inherent uncertainties presented in the text. Steady-state model scenarios cannot begin to replicate the complexities associated with tidal lag response resulting from tidal efficiency between various observation wells. To be clear, in order for the numerical model to be used in the evaluation process and considered a reliable line of evidence for performance monitoring, DEQ will need to see calibration results at a resolution that meets or exceeds performance evaluation targets for head and gradient conditions measured between wells. Until that is provided, the primary assessment of capture will need to evaluate gradient conditions, plotted spatially for each hydrostratigraphic layer, based on the water level data collected manually and electronically via water level transmitters.

See the response to General Comment 2 and Specific Comment 6. The groundwater model will be used as secondary line of evidence to evaluate hydraulic capture.

8. *Section 2.2.2 Gradient Control Points, Page 13. The text correctly notes that some of the modeled-predicted head differences are flat or consistent with outward flow across the barrier wall. It appears based on the groundwater model results shown in Appendix A that inward gradients across the barrier wall, as measured at the proposed monitoring well locations, are unattainable or can only be obtained at much higher pumping rates than proposed. Has the model been used to determine what pumping rates would be necessary in order for the well clusters to show a reverse gradient inward from the wall? If so, are these rates sustainable given the recovery well design?*

As noted in the comment and responses to General Comment 2 and Specific Comment 6, the primary method of determining hydraulic capture will be based on an evaluation of the potentiometric contour and flow path analysis. The same rationale was applied when using the groundwater model to design the extraction system to achieve hydraulic capture. The assessment of inward hydraulic gradient was based on the modeled potentiometric contours. The modeled head difference was calculated based on the modeled potentiometric head at the specific gradient control point monitoring well locations. Measured potentiometric head differences between the gradient control points that correspond to the target head differences will be indicative that the desired potentiometric surface is present. Additional manual measurements of water levels throughout the foot print of the GW SCM will be used to assist in the evaluation of the potentiometric surface that is present, and evaluate whether or not inward hydraulic gradients across the wall are be achieved.

The model predicted target gradients are function of where the specific monitoring wells are located in relation to the modeled potentiometric surface. A negative (outward) or flat head difference does not necessarily mean there is outward flow

across the wall. The entire potentiometric surface, and secondary lines of evidence, must be evaluated to make this determination.

To respond to the ODEQ concerns related to potentially insufficient inward gradients, a target gradient of 0.005 feet per feet was established as the minimum initial target inward gradient at system start up, regardless of the modeled head difference. In accordance with the adaptive management process presented in Figure 4-1, the potentiometric surface and flow path analysis will be used to update target head differences and pumping rates, as necessary, to achieve the desired potentiometric surface that is indicative of hydraulic capture.

LSS notes that the upcoming pump test will be used to update the groundwater model and improve estimates of the required head differences, sustainable pumping rates, and the potentiometric surfaces indicative of hydraulic capture.

9. *Section 2.2.2 and Section 2.2.2.1, Gradient Control Points, Page 13. LSS will need to clarify statements regarding predicted flat or outward gradients. Are these conditions anticipated to be transient such that the 3-day moving average elevations and corresponding gradients will demonstrate an average inward gradient? Note that inward and upward gradients must be clearly demonstrated after accounting for uncertainty associated with measurement errors (i.e. transducer error).*

See response to Specific Comment 8.

LSS notes that the 3-day moving average head differences are used to remove tidal fluctuations in water levels for the purpose logic control of the recovery well pump variable frequency drives.

10. *Section 2.2.1 Real Time Water Level Data Filtering, Page 14. DEQ would like LSS to elaborate on the presentation of moving average data. Will moving average elevation values be calculated for each day of the month? For long-term operation of the system, is it the objective that each calculated moving average value will demonstrate inward gradients relative to river stage?*

See response to Specific Comment 8. Water levels are measured using level sensors networked to the system control computer. Moving average elevation values will be re-calculated every 15 minutes for the purpose of logic control of the recovery well pumps. The calculated moving average value is intended to demonstrate that the system is achieving the target head difference relative to water levels in piezometers located outside of the GWBW, not river stage.

11. *Section 2.2.1 Real Time Water Level Data Filtering, Page 14, Last Paragraph. Please clarify what data will be used to prepare the monthly potentiometric surface figures.*

See response to General Comment 3. Monthly potentiometric surface maps will be created based on water levels recorded by manual and electronic measurements (daily average) on or around the 15th day of each month.

12. *Groundwater Model Update, Page 8. The text LSS infers calibration of the groundwater flow model will be based on transient flow simulations. DEQ requests that LSS provide additional detail describing how recalibration of the model will be performed.*

LSS notes this response was also presented in the 20 November 2013 response to agency comments on the pump test work plan.

The groundwater flow model calibration will be updated based on the results of the pumping tests. Transient calibration simulations of the pumping tests will be performed using the steady-state flow model, which was calibrated to site-wide and regional water levels measured in May 2007. For the simulation of each pumping test, the model grid spacing will be reduced to 1 foot around the pumping and observation wells to more accurately simulate the drawdown measured during the tests. A well node will be added to the model grid to represent the pumping well.

The model will then be calibrated to the observed pumping test water levels by using the estimated input parameters and head solution from the calibrated steady-state model, and solving the model for transient flow conditions with a total simulation time equal to the duration of the pumping test. The input parameters of the model will then be varied in successive simulations until the transient drawdown solutions of the model reasonably match the drawdown measured in the observation wells during the pumping tests. After the transient pumping test calibration is completed, the steady-state model calibration will be checked and the transient calibration will be repeated, if required, until the transient and steady-state model calibrations reasonably match the water level measurements.

13. *Section 4.0 Adaptive Management Process and Reporting. As presented in the DEQ's July 28, 2011 review of LSS' May 11, 2011 responses (see Specific Comment 16 related to Performance Monitoring Plan), "Procedures to minimize the duration of shutdown events still need to be included in plans". Procedures to minimize the duration of shutdown events were not noted in the updated plan.*

Per the LSS 11 May 2011 "Responses to DEQ Comments" letter, regarding the Arkema Portland GW SCM, GWET System Pre-Final Design, comment one of section "Summary of GWET Shut Down Hydraulic Response" LSS responded with the following:

"As previously noted by LSS in the Preliminary Design Report, the Performance Monitoring Plan, and in meetings with DEQ, the time between GWBW construction and GWET System startup will be minimized through phased concurrent construction of both components of the GW SCM.

The GWET System O&MP will identify procedures to limit system down time during scheduled maintenance. Measures such as phased shutdown of individual wells will be used to continue groundwater extraction during maintenance. Redundancy designed into the GWET System, such as dual carbon vessels, will allow maintenance of one piece of equipment without interrupting groundwater treatment. Maintenance of GWET System components requiring total system shutdown will be planned to minimize the shutdown time required.

As noted by DEQ, a 60- to 90-day shutdown is not anticipated to significantly exacerbate conditions at the site. Planned system maintenance activities typically require much less than 60 days to perform. Unanticipated system failures, such as power outages or emergency equipment shutdown can typically be resolved within days or weeks. In order to minimize unanticipated shutdown time, spare parts of critical components will be kept on hand, so that replacement/repair can be performed quickly."

14. *Include a figure that identifies all active monitoring wells present on Lots 3 and 4, so that the wells referenced in Table 2.1 can be located.*

A revised Figure 2-5 showing all active wells in Lots 3 and 4 is attached.

15. *Figure 1-3. Reference is made to a Figure 1-3 under Section 2.1 on page 9, but this Figure is not included in the document.*

The reference to Figure 1-3 was an error and will not be included.

16. *Figure 4-1. Is the execution of the groundwater flow model and particle tracking simulations considered to be part of the "flow path analysis" step? If so, Figure 4-1 and the PMP text should be modified to reflect this relationship.*

Groundwater modeling and particle tracking are considered applicable, but not necessarily exclusive, methods of evaluating flows in the "flow path analysis" step. A revised Figure 4-1 is attached.

17. *Figure 4-1. The following are comments on final steps shown on the adaptive management flow process diagram when capture objectives are not being achieved:*

a. *A final step is shown to "Expand monitoring well network and revise target hydraulic gradients" after a "YES" is given as the answer to "Is recovery well network sufficient to achieve capture?" LSS should explain why there would be a step needed to expand the well network and revised target hydraulic gradients if the current network is shown to be sufficient for achieving capture. Based on the information presented, it appears this step could be removed and an arrow directed to "Continue ongoing monitoring of system performance".*

The potential step of expanding the monitoring well network would be required in the unlikely event that future monitoring and observations during long-term operation of the GWET System indicate that there are unanticipated hydrogeologic conditions present, or additional recovery wells are required. If these potential future conditions occur, existing monitoring points may potentially be located in inappropriate locations to evaluate system performance, and the monitoring network may need to be revised.

b. *The step shown for a "NO" answer to the question "Is recovery well network sufficient to achieve capture?" should be expanded to include an evaluation and optimization of the well design prior to additional extraction wells. LSS should include this as a process step between the decision point that "NO" the recovery well network is not sufficient to achieve capture objectives and the process step to expand recovery well network.*

Evaluation and optimization of the recovery wells is noted in step "Implement recovery well investigation and rehabilitation" after completing the process to get to this step.

18. *Appendix A Figures 3.1 through 3.3. Why do potentiometric contours cross the barrier wall obliquely, appearing as if the barrier is not affecting groundwater flow or head distribution? Is this the flow field anticipated by LSS? How would a potentiometric map such as this be interpreted as demonstrating the system is achieving full containment?*

As noted in the PMP and previous design submittals, there are inherent limitations of the groundwater model, such as a model resolution based on 25-foot horizontal grid spacing. Modeled groundwater contours are based on a smooth line interpolation between these nodes, which may lead to small variations when compared to site features on a spacing of less than 25 feet, including crossing the barrier wall at slightly oblique angles.

LSS notes that GWBW is a low permeability wall, as opposed to a no-flow boundary. Potentiometric contours will reflect a continuous surface that crosses this low-permeability barrier. As such, contours will not be directly perpendicular to the barrier wall. Additionally, as seen in the particle tracking result, flow paths between the extraction wells and barrier will be complex, and in some case parallel to the barrier

wall before entering a recover well. These complex flow paths may not be apparent at a 1-foot contour spacing.

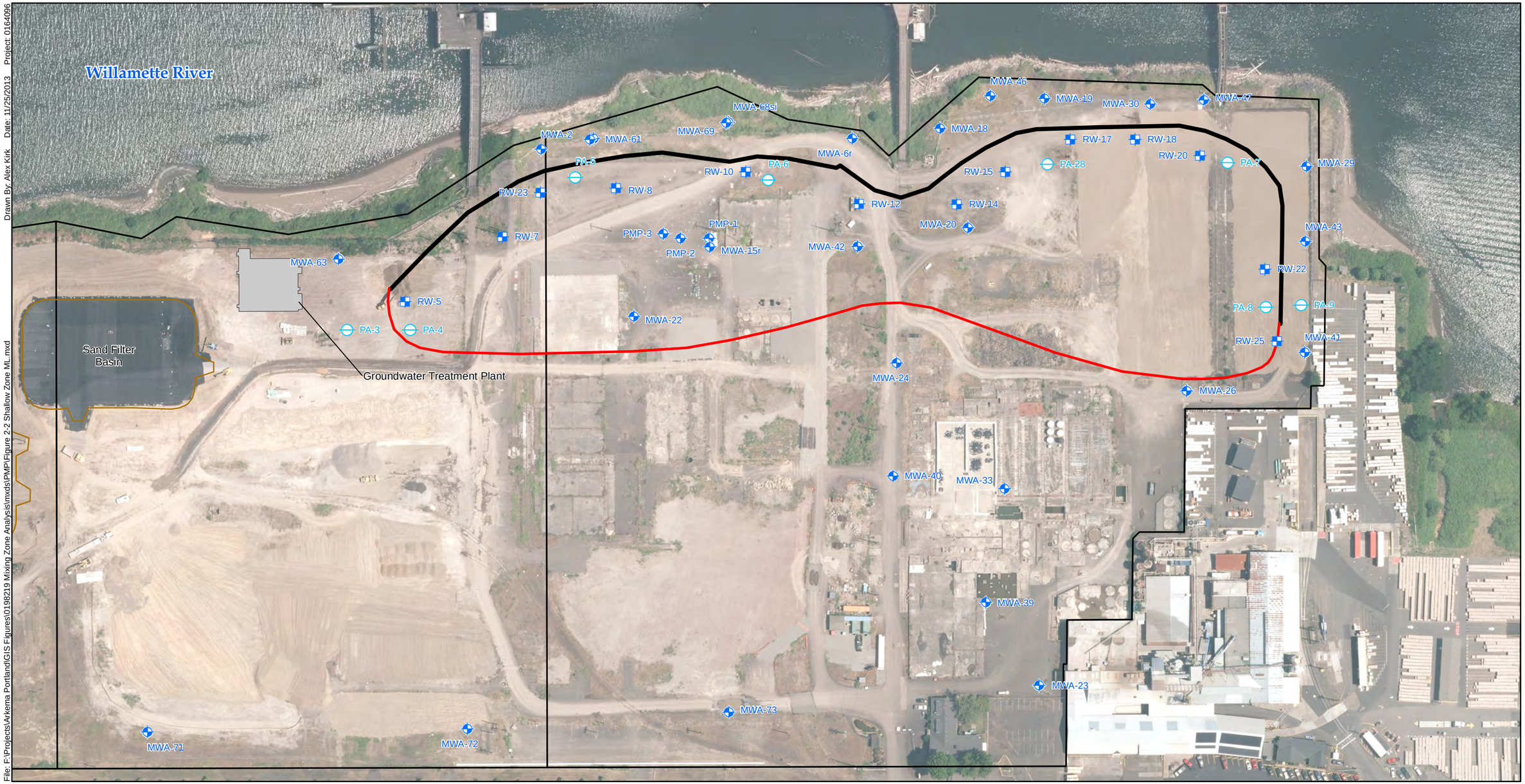
Sincerely,

FOR

Todd Slater
Legacy Site Services LLC

cc: Sean Sheldrake, EPA
Tom Gainer, DEQ
Henning Larsen, DEQ
Karen Traeger, LSS
Steve Parkinson, Groff Murphy
Erik Ipsen, ERM
Larry Patterson
David Livermore, Integral

Figures



File: F:\Projects\Arkema Portland\GIS Figures\0198219 Mixing Zone Analysis\mxds\PMP\Figure 2-2 Shallow Zone ML.mxd

Drawn By: Alex Kirk Date: 11/25/2013 Project: 0164096

Legend

- Shallow Zone Piezometer
- Shallow Zone Recovery Well
- Shallow Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- Barrier Wall Alignment
- Target Capture Zone
- Parcel and Property Boundaries

0 75 150 300 Feet

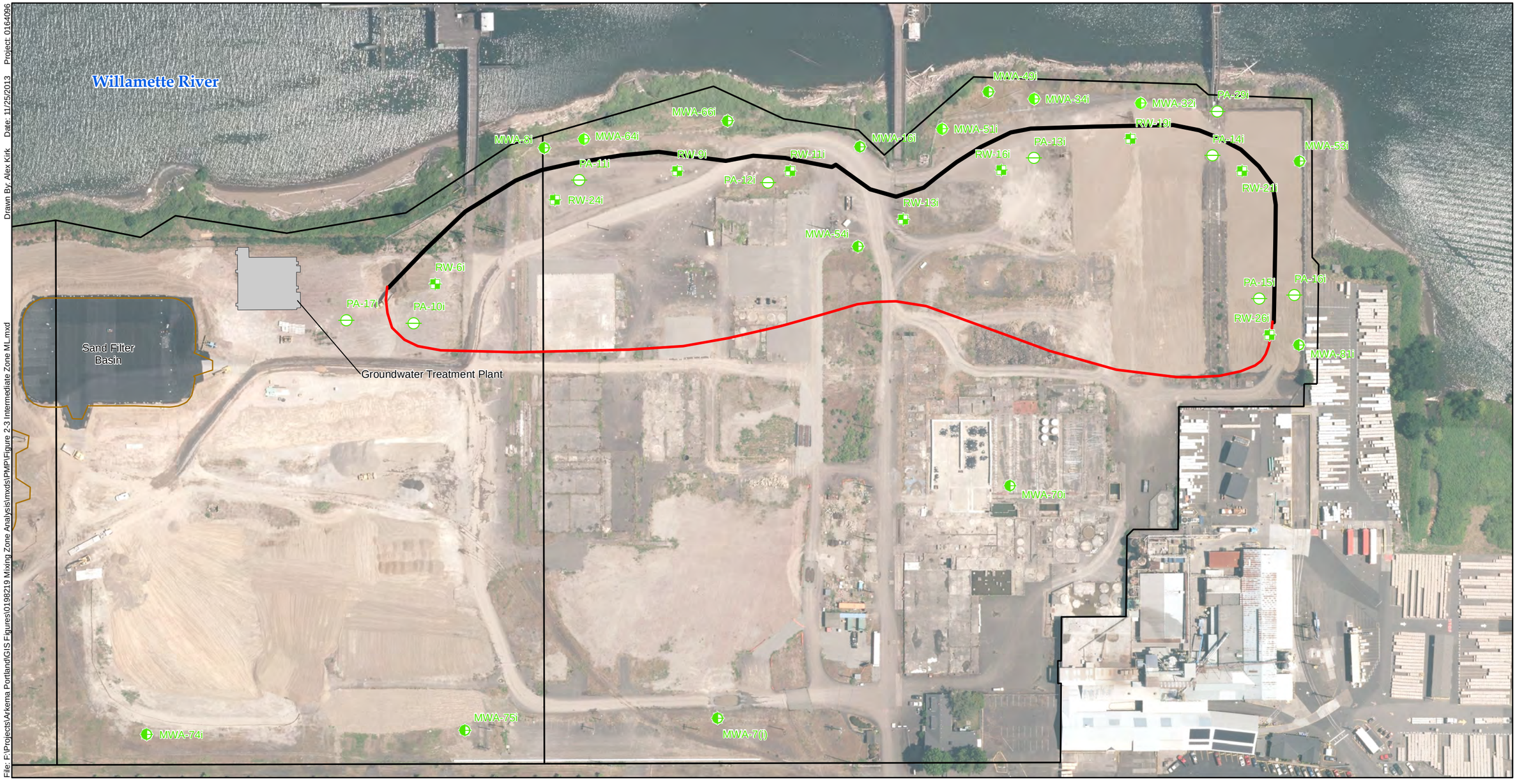
1 inch : 150 feet

Aerial Photo: City of Portland, July 8, 2012

Figure 2-2

Shallow Zone Water Level Monitoring Locations
Performance Monitoring Plan
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
1001 SW 5th St, Suite 1010
Portland, Oregon 97204
ERM.



File: F:\Projects\Arkema Portland\GIS Figures\0198219 Mixing Zone Analysis\mxds\PMP\Figure 2-3 Intermediate Zone ML.mxd

Drawn By: Alex Kirk Date: 11/25/2013 Project: 0164096

Legend

- Intermediate Zone Piezometer
- Intermediate Zone Extraction Well
- Intermediate Zone Monitoring Well
- Barrier Wall Alignment
- Target Capture Zone
- Parcel and Property Boundaries

0 75 150 300 Feet

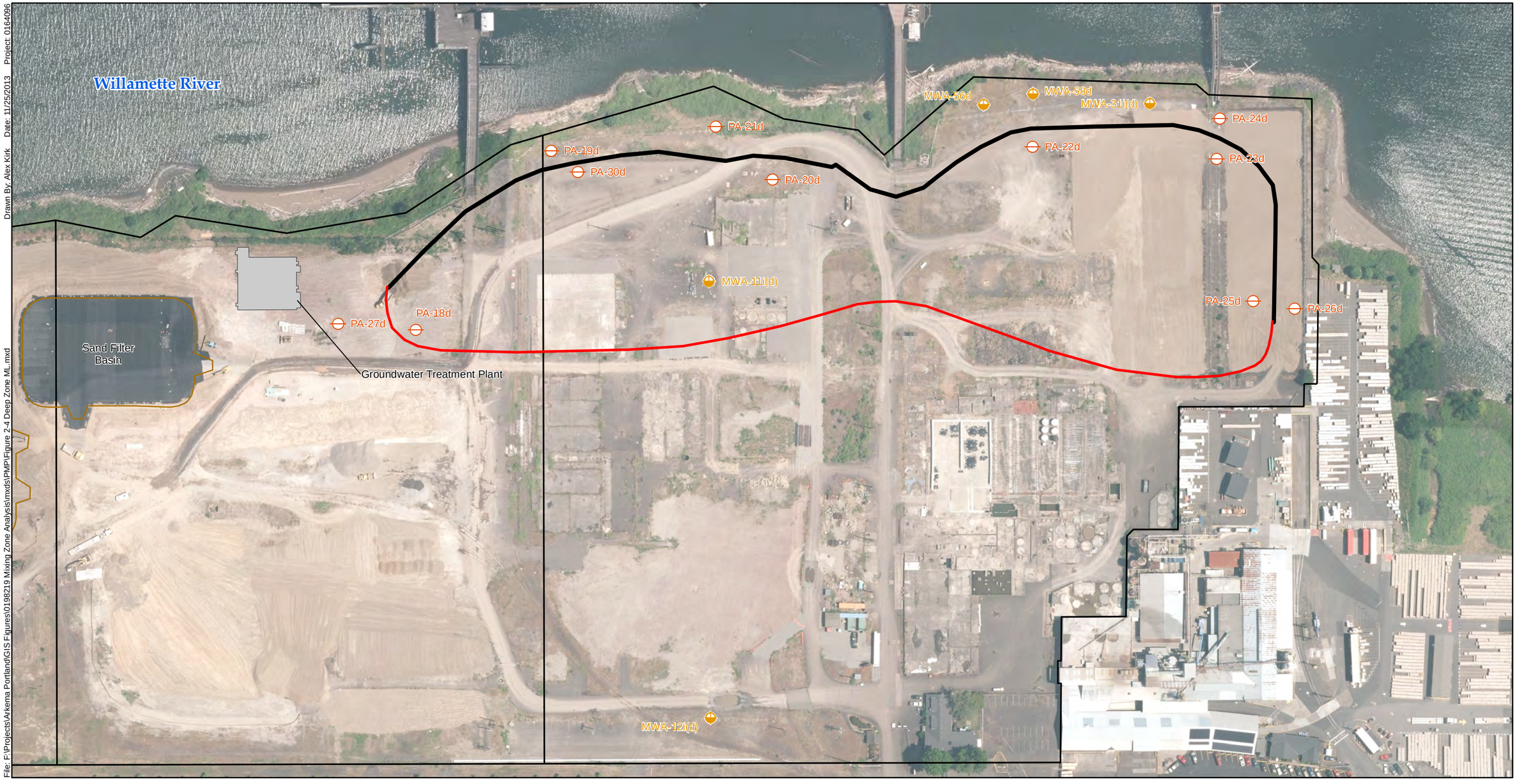
1 inch : 150 feet

Aerial Photo: City of Portland, July 8, 2012

Figure 2-3

Intermediate Zone Water Level Monitoring Locations
Performance Monitoring Plan
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
1001 SW 5th St, Suite 1010
Portland, Oregon 97204
ERM.



File: F:\Projects\Arkema Portland\GIS Figures\0198219 Mixing Zone Analysis\mxds\PMP\Figure 2-4 Deep Zone ML.mxd
Drawn By: Alex Kirk Date: 11/25/2013 Project: 0164096

Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Barrier Wall Alignment
- Target Capture Zone
- Parcel and Property Boundaries

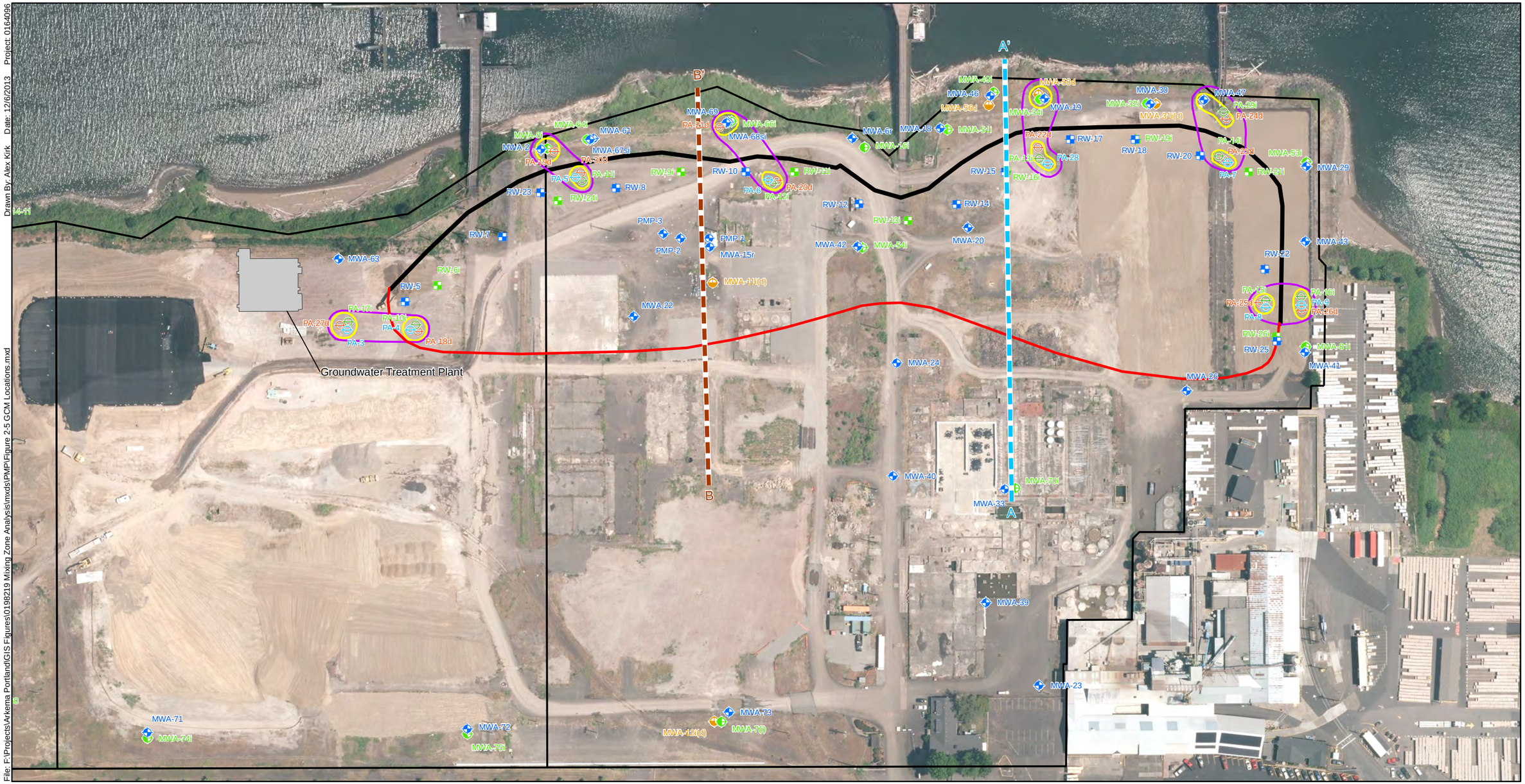
0 75 150 300 Feet

1 inch : 150 feet

Aerial Photo: City of Portland, July 8, 2012

Figure 2-4
Deep Zone Water Level Monitoring Locations
Performance Monitoring Plan
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
1001 SW 5th St, Suite 1010
Portland, Oregon 97204
ERM.



Legend

- Shallow Zone Recovery Well
- Intermediate Zone Recovery Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Shallow Monitoring Well
- Shallow-Intermediate Monitoring Well
- Intermediate Monitoring Well
- Existing Deep Zone Monitoring Well
- Barrier Wall Alignment
- Target Capture Zone
- Gradient Control Cluster
- Vertical Flow Cluster

0 75 150 300 Feet

1 inch : 150 feet

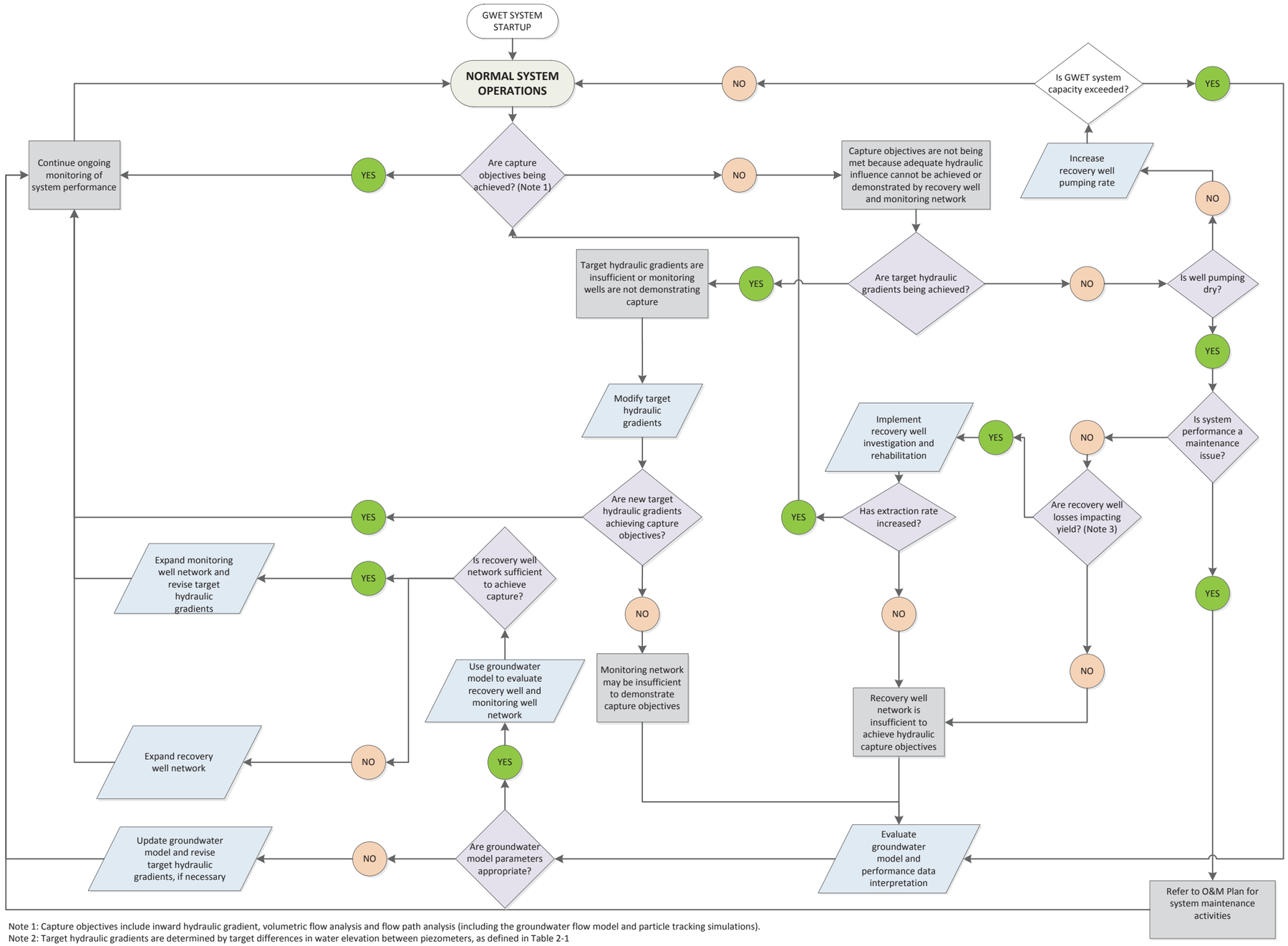
Aerial Photo: City of Portland, July 8, 2012

Figure 2-5

Gradient Control Monitoring Locations
Performance Monitoring Plan
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
1001 SW 5th St, Suite 1010
Portland, Oregon 97204
ERM.

File: F:\Projects\Arkema Portland\GIS Figures\0198219 Mixing Zone Analysis\mxds\PMP\Figure 2-5 GCM Locations.mxd
Drawn By: Alex Kirk Date: 12/6/2013 Project: 0164096



Note 1: Capture objectives include inward hydraulic gradient, volumetric flow analysis and flow path analysis (including the groundwater flow model and particle tracking simulations).
Note 2: Target hydraulic gradients are determined by target differences in water elevation between piezometers, as defined in Table 2-1
Note 3: Insufficient well yield factors can include inadequate well development, bio-fouling, well construction

Environmental Resources Management
1001 SW 5th St, Suite 1010
Portland, Oregon 97204

Figure 4-1
Adaptive Management Flow Process
Performance Monitoring Plan
Arkema Inc.
Portland, Oregon

Tables

Table 2-1
Well Construction and Monitoring Summary
Performance Monitoring Plan
Groundwater Source Control Measure
Arkema Inc. Facility
Portland, Oregon

Monitoring Point	Status	Northing	Easting	Aquifer Classification	Depth Drilled	Measuring Point Elevation	Ground Surface Elevation	Measuring Point Stickup	Well Depth	Screened Interval								Sandpack Interval					Performance Monitoring		Gradient Control						
										Screen Length	Screen Material	Screen Slot Size	Sump Length	Depth Below Surface		Elevation		Depth Below Surface		Elevation		Sandpack Thickness	Capture Zone Monitoring Point	Real-time Monitoring	Gradient Calculation Point	Comparison Point	Model Predicted Head Difference	Distance Between Observation Wells	Model Predicted Target Gradient	Selected Target Gradient	Target Head Difference
														Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top										
					(ft)	(ft)	(ft)	(ft)	(ft)	(ft)		(in)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)					(ft)	(ft)	(ft)	(ft)	(ft)
MWA-2	Active	702507.29	7627621.41	Shallow	32.3	36.20	36.52	-0.32	35.17	10.0	304 S.S.	0.010	0.5	31.5	21.5	5.0	15.0	32.3	18.5	4.2	18.0	13.8	Y	Y	Y	PA-5	-0.84	68.3	-0.012	-0.012	-0.84
MWA-6r	Active	702150.87	7627942.75	Shallow	34.0	36.46	36.75	-0.29	33.21	5.0	304 S.S.	0.010	0.3	33.2	28.2	3.6	8.6	33.5	25.5	3.3	11.3	8.0	Y	N	N						
MWA-7(i)	Active	701726.90	7627124.30	Intermediate	33.0	36.24	36.15	0.09	33.39	2.5	304 S.S.	0.010	0.3	33.0	30.5	3.2	5.7	33.3	28.0	2.9	8.2	5.3	N	N	N						
MWA-8i	Active	702500.54	7627628.33	Intermediate	47.3	36.25	36.53	-0.28	49.60	5.0	304 S.S	0.010	0.3	47.0	42.0	-10.5	-5.5	47.3	39.8	-10.8	-3.3	7.5	Y	Y	Y	PA-11i	-1.12	73.4	-0.015	-0.015	-1.12
MWA-	Active	702172.18	7627634.01	Deep	51.0	36.49	36.62	-0.13	51.00	4.5	304 S.S	0.010	0.3	50.8	46.2	-14.2	-9.6	51.0	44.0	-14.4	-7.4	7.0	Y	N	N						
MWA-	Active	701735.80	7627117.50	Deep	52.0	35.86	36.15	-0.30	51.76	10.0	304 S.S	0.010	0.3	51.8	42.0	-15.6	-5.9	52.0	40.0	-15.9	-3.9	12.0	Y	N	N						
MWA-15r	Active	702211.10	7627673.20	Shallow	32.5	36.06	36.39	-0.34	29.21	10.0	304 S.S.	0.10	0.1	32.5	22.5	3.9	13.9	32.5	22.5	3.9	13.9	10.0	N	N	N						
MWA-16i	Active	702127.25	7627944.39	Intermediate	45.3	36.58	36.99	-0.41	44.09	5.0	304 S.S	0.010	0.3	44.2	39.2	-7.2	-2.2	45.3	37.2	-8.3	-0.2	8.1	Y	N	N						
MWA-18	Active	702056.87	7628041.35	Shallow	29.5	39.43	36.44	2.99	32.49	10.0	304 S.S.	0.010	0.3	29.2	19.2	7.2	17.2	29.5	17.0	6.9	19.4	12.5	N	N	N						
MWA-19	Active	701963.23	7628180.37	Shallow	35.5	38.26	38.65	-0.39	29.11	10.0	304 S.S.	0.010	0.3	29.2	19.2	9.5	19.5	30.5	17.0	8.2	21.7	13.5	Y	Y	Y	PA-28	-0.74	101.6	-0.007	-0.007	-0.74
MWA-20	Active	701925.54	7627952.11	Shallow	35.5	40.95	38.46	2.49	37.49	10.0	304 S.S.	0.010	0.3	34.7	24.7	3.8	13.8	35.5	22.5	3.0	16.0	13.0	Y	N	N						
MWA-22	Active	702232.00	7627516.00	Shallow	36.0	36.59	36.91	-0.31	34.69	10.0	304 S.S.	0.010	0.3	34.7	24.7	2.2	12.2	36.0	23.0	0.9	13.9	13.0	Y	N	N						
MWA-23	Active	701387.76	7627481.85	Shallow	26.0	36.81	37.10	-0.30	25.12	10.0	304 S.S.	0.010	0.3	25.2	15.2	11.9	21.9	26.0	13.5	11.1	23.6	12.5	N	N	N						
MWA-24	Active	701875.73	7627721.74	Shallow	36.0	37.58	37.94	-0.36	33.48	10.0	304 S.S.	0.010	0.3	34.0	24.0	3.9	13.9	36.0	22.0	1.9	15.9	14.0	Y	N	N						
MWA-29	Active	701587.00	7628359.88	Shallow	35.2	37.23	37.51	-0.28	33.70h	10.0	304 S.S.	0.010	0.3	34.9	24.9	2.6	12.6	35.2	22.9	2.3	14.6	12.3	Y	N	N						
MWA-30	Active	701832.68	7628278.84	Shallow	30.0	38.34	38.75	-0.41	29.25	10.0	304 S.S.	0.010	0.3	29.1	19.1	9.7	19.7	29.4	17.4	9.4	21.4	12.0	N	N	N						
MWA-31i(d)	Active	701826.17	7628283.95	Deep	60.0	38.36	38.74	-0.38	59.80	5.0	304 S.S	0.010	0.2	59.8	54.8	-21.1	-16.1	60.0	54.0	-21.3	-15.3	6.0	N	N	N						
MWA-32i	Active	701837.47	7628275.46	Intermediate	44.0	38.70	38.92	-0.22	41.98	5.0	304 S.S	0.010	0.2	42.0	37.0	-3.1	1.9	42.0	35.0	-3.1	3.9	7.0	N	N	N						
MWA-33	Active	701623.46	7627679.75	Shallow	30.0	37.26	37.75	-0.49	29.71	10.0	Sch 40 PVC	0.010	0.2	30.0	20.0	7.7	17.7	30.0	19.0	7.7	18.7	11.0	Y	N	N						
MWA-34i	Active	701968.03	7628174.50	Intermediate	38.0	38.02	38.40	-0.38	36.82	5.0	304 S.S	0.010	0.2	37.0	32.0	1.4	6.4	37.5	31.5	0.9	6.9	6.0	Y	Y	Y	PA-13i	-1.61	91.4	-0.018	-0.018	-1.61
MWA-39	Active	701532.86	7627527.05	Shallow	26.5	37.06	37.23	-0.17	25.00	9.25	Sch 40 PVC	0.010	0.7	24.3	15.1	12.9	22.2	26.0	13.0	11.2	24.2	13.0	N	N	N						
MWA-40	Active	701767.86	7627584.45	Shallow	31.0	36.96	37.18	-0.21	30.20	9.25	Sch 40 PVC	0.010	0.7	29.5	20.3	7.7	16.9	29.5	18.0	7.7	19.2	11.5	N	N	N						
MWA-41	Active	701404.34	7628138.42	Shallow	35.0	37.77	38.01	-0.24	35.00	9.25	Sch 40 PVC	0.010	0.7	34.3	25.1	3.7	13.0	35.0	23.0	3.0	15.0	12.0	Y	N	N						
MWA-42	Active	702036.96	7627820.55	Shallow	33.5	37.24	37.62	-0.38	31.50	9.25	Sch 40 PVC	0.010	0.7	30.8	21.6	6.8	16.1	31.8	19.1	5.8	18.5	12.7	Y	N	N						
MWA-43	Active	701513.44	7628269.72	Shallow	35.0	37.22	37.46	-0.24	35.00	9.25	Sch 40 PVC	0.010	0.7	34.3	25.1	3.2	12.4	35.0	23.0	2.5	14.5	12.0	Y	N	N						
MWA-46	Active	702029.70	7628129.61	Shallow	30.5	36.67	36.68	-0.01	29.70	9.25	Sch 40 PVC	0.010	0.7	29.0	19.8	7.7	16.9	28.5	17.3	8.2	19.4	11.2	N	N	N						
MWA-47	Active	701773.75	7628336.57	Shallow	35.0	39.02	39.40	-0.38	35.00	9.25	Sch 40 PVC	0.010	0.7	34.3	25.1	5.1	14.4	35.0	23.0	4.4	16.4	12.0	Y	Y	Y	PA-07	1.58	103.7	0.015	-0.005	-0.52
MWA-49i	Active	702029.26	7628137.40	Intermediate	44.0	36.68	36.84	-0.16	44.00	4.45	Sch 40 PVC	0.010	0.7	43.3	38.9	-6.5	-2.0	43.0	36.6	-6.2	0.2	6.4	N	N	N						
MWA-51i	Active	702046.99	7628047.09	Intermediate	44.0	36.33	36.59	-0.26	42.50	4.45	Sch 40 PVC	0.010	0.7	41.8	37.4	-5.2	-0.8	42.5	35.2	-5.9	1.4	7.3	N	N	N						
MWA-53i	Active	701590.84	7628364.82	Intermediate	44.5	37.27	37.52	-0.25	44.40	4.45	Sch 40 PVC	0.010	0.7	43.7	39.3	-6.2	-1.7	43.5	36.3	-6.0	1.2	7.2	Y	N	N						
MWA-54i	Active	702030.36	7627823.95	Intermediate	41.5	37.31	37.72	-0.41	41.10	4.45	Sch 40 PVC	0.010	0.7	40.4	36.0	-2.7	1.8	41.1	35.3	-3.4	2.4	5.8	Y	N	N						
MWA-56d	Active	702022.47	7628117.01	Deep	61.0	36.68	36.82	-0.14	60.80	4.75	Sch 40 PVC	0.010	0.55	60.3	55.5	-23.4	-18.7	61.0	53.0	-24.2	-16.2	8.0	N	N	N						
MWA-58d	Active	701974.54	7628179.53	Deep	63.0	37.97	38.36	-0.39	60.50	4.75	Sch 40 PVC	0.010	0.55	60.0	55.2	-21.6	-16.8	61.5	52.8	-23.1	-14.4	8.7	Y	Y	Y	PA-22d	-1.14	90.3	-0.013	-0.013	-1.14
MWA-61	Active	702455.71	7627686.02	Shallow	33.5	36.21	36.15	0.06	32.50	10.0	Sch 40 PVC	0.010	0.0	32.1	22.3	4.1	13.9	32.5	21.0	3.7	15.2	11.5	N	N	N						
MWA-63	Active	702637.66	7627291.45	Shallow	30.5	36.29	36.38	-0.09	30.00	10.0	Sch 40 PVC	0.010	0.4	29.6	19.8	6.8	16.6	30.5	17.0	5.9	19.4	13.5	Y	N	N						
MWA-64i	Active	702462.46	7627678.56	Intermediate	49.0	35.84	36.17	-0.33	47.00	4.5	Sch 40 PVC	0.010	0.5	46.5	42.0	-10.3	-5.8	49.0	40.0	-12.8	-3.8	9.0	N	N	N						
MWA-66i	Active	702309.97	7627843.28	Intermediate	49.0	33.35	33.79	-0.44	42.50	4.5	Sch 40 PVC	0.010	0.1	42.4	37.6	-8.6	-3.8	43.5	35.8	-9.7	-2.0	7.7	Y	Y	Y	PA-12i	-0.86	114.1	-0.008	-0.008	-0.86
MWA-67si	Active	702458.92	7627681.48	Shallow	38.0	36.34	36.14	0.20	38.00	1.5	Sch 40 PVC	0.010	0.2	37.8	36.3	-1.7	-0.2	38.0	36.0	-1.9	0.1	2.0	N	N	N						
MWA-68si	Active	702312.58	7627839.61	Shallow	34.0	33.50	33.99	-0.49	34.00	1.5	Sch 40 PVC	0.010	0.2	33.8	32.3	0.2	1.7	34.0	32.0	0.0	2.0	2.0	N	N	N						
MWA-69	Active	702314.52	7627836.40	Shallow	30.0	33.73	34.08	-0.35	29.50	10.0	Sch 40 PVC	0.010	0.2	29.3	19.5	4.8	14.6	30.0	18.0	4.1	16.1	12.0	Y	Y	Y	PA-6	-1.05	109.1	-0.010	-0.010	-1.05
MWA-70i	Active	701611.69	7627691.20	Intermediate	46.5	37.62	37.84	-0.23	43.00	9.8	Sch 40 PVC	0.010	0.5	32.7	42.5	5.1	-4.7	32.5	43.0	5.3	-5.2	-10.5	N	N	N						
MWA-71	Active	702394.12	7626543.33	Shallow	23.0	34.82	35.23	-0.41	22.18	10.0	304 S.S	0.010	0.3	22.5	12.5	12.7	22.7	23.0	10.0	12.2	25.2	13.0	N	N	N						
MWA-72	Active	702019.73	7626864.10	Shallow	23.0	34.16	34.57	-0.41	22.34	10.0	304 S.S	0.010	0.3	22.0	12.0	12.6	22.6	23.0	10.0	11.6	24.6	13.0	N	N	N						
MWA-73	Active	701727.58	7627143.03	Shallow	22.0	36.01	36.37	-0.36	20.15	10.0	304 S.S	0.010	0.3	21.0	11.0	15.4	25.4	21.0	9.0	15.4	27.4	12.0	N	N	N						
MWA-74i	Active	702388.62	7626536.38	Intermediate	44.0	34.72	34.98	-0.26	72.78	5.0	304 S.S	0.010	0.3	43.0	38.0	-8.0	-3.0	43.0	35.5	-8.0	-0.5	7.5	N	N	N						
MWA-75i	Active	702014.68	7626858.37	Intermediate	48.0	34.09	34.43	-0.34	39.88	15.0	304 S.S	0.010	0.3	40.0	25.0	-5.6	9.4	41.0	23.5	-6.6	10.9	17.5	N	N	N						
MWA-76g	Active	702010.18	7626853.34	Gravel	94.0	34.96	35.23	-0.26	94.12	5.0	304 S.S	0.010	0.3	94.0	89.0	-58.8	-53.8	94.0	87.5	-58.8	-52.3	6.5	N	N	N						
MWA-77g	Active	702382.88	7626528.75	Gravel	91.0	34.03	34.40	-0.37	90.20	5.0	304 S.S	0.010	0.3	90.5	85.5	-56.1	-51.1	91.0	83.5	-56.6	-49.1	7.5	N	N	N						
MWA-81i	Active	701408.82	7628145.87	Intermediate	48.0	37.50	37.96	-0.46	44.00	5.0	Sch 40 PVC	0.010	0.3	44.0	39.0	-6.0	-1.0	45.0	37.5	-7.0	0.5	7.5	Y	N	N						
NMP-1D	Active	702247.30	7627690.20	Shallow	36.0	35.82	36.18	-0.36	34.14	4.5	Sch 40 PVC	0.010	0.5	34.0	29.5	2.2	6.7	35.0	27.8	1.2	8.4	7.2	N	N	N						
NMP-1S	Active	702255.40	7627696.30	Shallow	30.5	35.90	36.11	-0.21	29.49	9.5	Sch 40 PVC	0.010	0.2	29.5	20.0	6.6	16.1	30.0	18.0	6.1	18.1	12.0	N	N	N						
NMP-2D	Active	702263.50	7627701.90	Shallow	37.0	35.56	35.97	-0.41	36.59	4.5	Sch 40 PVC	0.010	0.5	36.5	32.0	-0.5	4.0	37.0	30.0	-1.0	6.0	7.0	N	N	N						
NMP-2S	Active	702271.20	7627707.60	Shallow	30.5	35.75	35.88	-0.14	29.57	9.5	Sch 40 PVC	0.010	0.2	29.5	20.0	6.4	15.9	30.0	18.0	5.9	17.9	12.0	N	N	N						
NMP-3S	Active	702287.50	7627718.30	Shallow	30.5	35.68	36.02	-0.33	29.37	9.5	Sch 40 PVC	0.010	0.2	29.5	20.0	6.5	16.0	30.0	18.0	6.0	18.0	12.0	N	N	N						
NMP-4D	Active	702281.80	7627666.30	Shallow	36.0	35.63	35.91	-0.27	35.23	4.5	Sch 40 PVC	0.010	0.5	35.0	30.5	0.9	5.4	36.0	28.0	-0.1	7.9	8.0	N	N	N						
NMP-4S	Active	702290.70	7627672.40	Shallow	30.5	35.67	35.89	-0.22	29.48	9.5	Sch 40 PVC	0.010	0.2	29.5	20.0	6.4	15.9	30.0	18.0	5.9	17.9	12.0	N	N	N						
NMP-5D	Active	702273.20	7627684.40	Shallow	35.5	35.38	35.84	-0.47	33.54	4.5	Sch 40 PVC	0.010	0.5	33.5	29.0	2.3	6.8	34.5	27.0	1.3	8.8	7.5	N	N	N						
NMP-5S	Active	702281.50	7627689.70	Shallow	30.5	35.57	35.55	0.02	29.72	9.5	Sch 40 PVC	0.010	0.2	29.5	20.0	6.1	15.6	30.0	18.0	5.6	17.6	12.0	N	N	N						
NMP-6D	Active	702259.90	7627730.00	Shallow	36.0	36.08	36.27	-0.19	33.81	4.5	Sch 40 PVC	0.010	0.5	33.5	29.0	2.8	7.3	35.0	27.0	1.3	9.3	8.0	N	N	N						
NMP-6S	Active	702251.90	7627724.50	Shallow	30.5	35.94	36.23	-0.29	29.41	9.5	Sch 40 PVC	0.010	0.2	29.5	20.0	6.7	16.2	30.0	18.0	6.2	18.2	12.0	N	N	N						
PA-03	Proposed	7627216.44	702557.55	Shallow	29.2	37.10	37.72	-0.62	28.90	5.0	Sch 40 PVC	0.010	0.3	29.2	24.2	8.5	13.5	29.2	22.2	8.5	15.5	7.0	Y	Y	Y	PA-4	-1.57	97.2	-0.016	-0.016	-1.57
PA-04	Proposed	7627278.72	702482.87	Shallow	33.2	36.67	37.22	-0.55	32.97	5.0	Sch 40 PVC	0.010	0.3	33.2	28.2	4.0	9.0	33.2	26.2	4.0	11.0	7.0	Y	Y	Y	PA-3	--				
PA-05	Proposed	7627622.28	702439.04	Shallow	37.9	37.22	37.89	-0.67	37.52	5.0	Sch 40 PVC	0.010	0.3	37.9	32.9	0.0	5.0	37.9	30.9	0.0	7.0	7.0	Y	Y	Y	MWA-2	--				
PA-06	Proposed	7627810.48	702208.51	Shallow	38.6	38.03	38.56	-0.53	38.33	5.0	Sch 40 PVC	0.010	0.3	38.6	33.6	0.0	5.0	38.6	31.6	0.0	7.0	7.0	Y	Y	Y	MWA-69	--				
PA-07	Proposed	7628285.98	701683.25	Shallow	34.9	39.30	39.90	-0.60	34.60	5.0	Sch 40 PVC	0.010	0.3	34.9	29.9	5.0	10.0	34.9	27.9	5.0	12.0	7.0	Y	Y	Y	MWA-47	--				
PA-08	Proposed	7628152.67	701494.83	Shallow	36.9	40.47	40.86	-0.39	36.77	5.0	Sch 40 PVC	0.010	0.3	36.9	31.9	4.0	9.0	36.9	29.9	4.0	11.0	7.0	Y	Y	Y	PA-09	--				
PA-09	Proposed	7628190.77	701455.26	Shallow	36.7	40.24	40.73	-0.49	36.54	5.0	Sch 40 PVC	0.010	0.3	36.7	31.7	4.0	9.0	36.7	29.7	4.0	11.0	7.0	Y	Y	Y	PA-08	0.03	54.9	0.000	-0.005	-0.27
PA-10i	Proposed	7627290.20	702481.40	Intermediate	43.2	36.67	37.22	-0.55	42.97	5.0	Sch 40 PVC	0.010	0.3	43.2	38.2	-6.0	-1.0	43.2	36.2	-6.0	1.0	7.0	Y	Y	Y	PA-17i	--				

Table 2-1
Well Construction and Monitoring Summary
Performance Monitoring Plan
Groundwater Source Control Measure
Arkema Inc. Facility
Portland, Oregon

Monitoring Point	Status	Northing	Easting	Aquifer Classification	Depth Drilled	Measuring Point Elevation	Ground Surface Elevation	Measuring Point Stickup	Well Depth	Screened Interval								Sandpack Interval					Performance Monitoring		Gradient Control						
										Screen Length	Screen Material	Screen Slot Size	Sump Length	Depth Below Surface		Elevation		Depth Below Surface		Elevation		Sandpack Thickness	Capture Zone Monitoring Point	Real-time Monitoring	Gradient Calculation Point	Comparison Point	Model Predicted Head Difference	Distance Between Observation Wells	Model Predicted Target Gradient	Selected Target Gradient	Target Head Difference
														Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top										
					(ft)	(ft)	(ft)	(ft)	(ft)	(ft)		(in)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)					(ft)	(ft)	(ft)	(ft)	(ft)
PA-11i	Proposed	7627625.25	702427.17	Intermediate	48.0	37.63	38.01	-0.38	47.93	5.0	Sch 40 PVC	0.010	0.3	48.0	43.0	-10.0	-5.0	48.0	41.0	-10.0	-3.0	7.0	Y	Y	Y	MWA-8i	--				
PA-12i	Proposed	7627810.14	702200.79	Intermediate	45.6	38.03	38.56	-0.53	45.33	5.0	Sch 40 PVC	0.010	0.3	45.6	40.6	-7.0	-2.0	45.6	38.6	-7.0	0.0	7.0	Y	Y	Y	MWA-66i	--				
PA-13i	Proposed	7628104.19	701909.50	Intermediate	47.1	38.48	39.08	-0.60	46.78	5.0	Sch 40 PVC	0.010	0.3	47.1	42.1	-8.0	-3.0	47.1	40.1	-8.0	-1.0	7.0	Y	Y	Y	MWA-34i	--				
PA-14i	Proposed	7628284.93	701700.25	Intermediate	47.9	39.30	39.93	-0.63	47.60	5.0	Sch 40 PVC	0.010	0.3	47.9	42.9	-8.0	-3.0	47.9	40.9	-8.0	-1.0	7.0	Y	Y	Y	PA-29i	--				
PA-15i	Proposed	7628161.26	701501.92	Intermediate	49.9	40.62	40.93	-0.31	49.92	5.0	Sch 40 PVC	0.010	0.3	49.9	44.9	-9.0	-4.0	49.9	42.9	-9.0	-2.0	7.0	Y	Y	Y	PA-16i	--				
PA-16i	Proposed	7628200.47	701463.79	Intermediate	50.1	40.30	41.06	-0.76	49.60	5.0	Sch 40 PVC	0.010	0.3	50.1	45.1	-9.0	-4.0	50.1	43.1	-9.0	-2.0	7.0	Y	Y	Y	PA-15i	-0.10	54.7	-0.002	-0.005	-0.27
PA-17i	Proposed	7627227.23	702563.89	Intermediate	43.8	37.22	37.81	-0.59	43.52	5.0	Sch 40 PVC	0.010	0.3	43.8	38.8	-6.0	-1.0	43.8	36.8	-6.0	1.0	7.0	Y	Y	Y	PA-10i	-0.96	103.8	-0.009	-0.009	-0.96
PA-18d	Proposed	7627285.10	702471.91	Deep	50.2	36.55	37.18	-0.63	49.85	5.0	Sch 40 PVC	0.010	0.3	50.2	45.2	-13.0	-8.0	50.2	43.2	-13.0	-6.0	7.0	Y	Y	Y	PA-27d	--				
PA-19d	Proposed	7627631.96	702489.77	Deep	51.2	36.65	37.18	-0.53	50.95	5.0	Sch 40 PVC	0.010	0.3	51.2	46.2	-14.0	-9.0	51.2	44.2	-14.0	-7.0	7.0	Y	Y	Y	PA-30d	-0.40	52.9	-0.007	-0.007	-0.40
PA-20d	Proposed	7627817.79	702198.24	Deep	63.6	37.91	38.62	-0.71	63.21	5.0	Sch 40 PVC	0.010	0.3	63.6	58.6	-25.0	-20.0	63.6	56.6	-25.0	-18.0	7.0	Y	Y	Y	PA-21d	--				
PA-21d	Proposed	7627824.81	702318.79	Deep	60.2	34.36	35.22	-0.86	59.66	5.0	Sch 40 PVC	0.010	0.3	60.2	55.2	-25.0	-20.0	60.2	53.2	-25.0	-18.0	7.0	Y	Y	Y	PA-20d	-0.16	120.8	-0.001	-0.005	-0.60
PA-22d	Proposed	7628115.97	701922.28	Deep	64.4	38.75	39.36	-0.61	64.05	5.0	Sch 40 PVC	0.010	0.3	64.4	59.4	-25.0	-20.0	64.4	57.4	-25.0	-18.0	7.0	Y	Y	Y	MWA-58d	--				
PA-23d	Proposed	7628285.33	701692.13	Deep	82.9	39.31	39.90	-0.59	82.61	5.0	Sch 40 PVC	0.010	0.3	82.9	77.9	-43.0	-38.0	82.9	75.9	-43.0	-36.0	7.0	Y	Y	Y	PA-24d	-1.47	62.3	-0.024	-0.024	-1.47
PA-24d	Proposed	7628335.03	701727.31	Deep	82.6	39.06	39.55	-0.49	82.36	5.0	Sch 40 PVC	0.010	0.3	82.6	77.6	-43.0	-38.0	82.6	75.6	-43.0	-36.0	7.0	Y	Y	Y	PA-23d	--				
PA-25d	Proposed	7628152.49	701506.80	Deep	81.9	40.44	40.86	-0.42	81.74	5.0	Sch 40 PVC	0.010	0.3	81.9	76.9	-41.0	-36.0	81.9	74.9	-41.0	-34.0	7.0	Y	Y	Y	PA-26d	--				
PA-26d	Proposed	7628185.21	701450.16	Deep	81.8	40.33	40.82	-0.49	81.63	5.0	Sch 40 PVC	0.010	0.3	81.8	76.8	-41.0	-36.0	81.8	74.8	-41.0	-34.0	7.0	Y	Y	Y	PA-25d	-0.73	65.4	-0.011	-0.011	-0.73
PA-27d	Proposed	7627214.29	702570.40	Deep	49.6	37.10	37.56	-0.46	49.40	5.0	Sch 40 PVC	0.010	0.3	49.6	44.6	-12.0	-7.0	49.6	42.6	-12.0	-5.0	7.0	Y	Y	Y	PA-18d	-0.45	121.3	-0.004	-0.005	-0.61
PA-28	Proposed	7628105.84	701894.74	Shallow	34.2	38.58	39.22	-0.64	33.88	5.0	Sch 40 PVC	0.010	0.3	34.2	29.2	5.0	10.0	34.2	27.2	5.0	12.0	7.0	Y	Y	Y	MWA-19	--				
PA-29i	Proposed	7628341.94	701738.56	Intermediate	48.6	39.18	39.59	-0.41	48.48	5.0	Sch 40 PVC	0.010	0.3	48.6	43.6	-9.0	-4.0	48.6	41.6	-9.0	-2.0	7.0	Y	Y	Y	PA-14i	1.73	68.7	0.025	-0.005	-0.34
PA-30d	Proposed	7627633.26	702436.89	Deep	52.1	37.34	38.06	-0.72	51.64	5.0	Sch 40 PVC	0.010	0.3	52.1	47.1	-14.0	-9.0	52.1	45.1	-14.0	-7.0	7.0	Y	Y	Y	PA-19d	--				
PMP-1	Active	702220.30	7627682.50	Shallow	35.0	36.36	36.35	0.02	34.02	10.0	304 S.S	0.010	0.0	34.0	24.0	2.3	12.3	35.0	22.5	1.3	13.8	12.5	N	N	N						
PMP-2	Active	702254.40	7627654.50	Shallow	35.0	36.36	36.32	0.05	33.85	10.0	304 S.S	0.010	0.0	33.8	23.8	2.5	12.5	35.0	21.0	1.3	15.3	14.0	N	N	N						
PMP-3	Active	702279.20	7627643.20	Shallow	35.0	36.17	36.14	0.03	35.03	10.0	304 S.S	0.010	0.0	35.0	25.0	1.1	11.1	35.0	22.8	1.1	13.3	12.2	N	N	N						
RW-05	Proposed	7627307.13	702516.89	Shallow	30.7	34.80	37.70	-2.90	28.10	10.0	304 S.S	0.010	0.3	30.7	20.7	7.0	17.0	29.5	17.5	7.0	19.0	12.0	Y	Y	N						
RW-06i	Proposed	7627358.43	702494.65	Intermediate	42.8	34.98	37.78	-2.80	40.28	5.0	304 S.S	0.010	0.3	42.8	37.8	-5.0	0.0	41.5	33.0	-5.0	3.5	8.5	Y	Y	N						
RW-07	Proposed	7627480.16	702466.26	Shallow	36.9	33.98	36.91	-2.93	34.28	10.0	304 S.S	0.010	0.3	36.9	26.9	0.0	10.0	36.5	24.0	0.0	12.5	12.5	Y	Y	N						
RW-08	Proposed	7627650.10	702380.41	Shallow	37.1	34.21	37.08	-2.87	34.51	10.0	304 S.S	0.010	0.3	37.1	27.1	0.0	10.0	39.0	26.4	0.0	12.6	12.6	Y	Y	N						
RW-09i	Proposed	7627733.53	702319.88	Intermediate	44.6	33.73	36.62	-2.89	42.03	5.0	304 S.S	0.010	0.3	44.6	39.6	-8.0	-3.0	44.1	37.0	-8.0	-0.9	7.1	Y	Y	N						
RW-10	Proposed	7627796.06	702242.19	Shallow	37.2	34.33	37.17	-2.84	34.63	10.0	304 S.S	0.010	0.3	37.2	27.2	0.0	10.0	37.0	24.2	0.0	12.8	12.8	Y	Y	N						
RW-11i	Proposed	7627840.09	702183.18	Intermediate	45.7	34.77	37.67	-2.90	43.07	5.0	304 S.S	0.010	0.3	45.7	40.7	-8.0	-3.0	45.5	38.1	-8.0	-0.6	7.4	Y	Y	N						
RW-12	Proposed	7627871.99	702077.07	Shallow	34.4	35.58	38.43	-2.85	31.88	10.0	304 S.S	0.010	0.3	34.4	24.4	4.0	14.0	31.0	18.0	4.0	17.0	13.0	Y	Y	N						
RW-13i	Proposed	7627901.05	702003.55	Intermediate	43.9	36.09	38.88	-2.79	41.39	5.0	304 S.S	0.010	0.3	43.9	38.9	-5.0	0.0	42.0	33.5	-5.0	3.5	8.5	Y	Y	N						
RW-14	Proposed	7627968.41	701962.17	Shallow	33.9	36.08	38.87	-2.79	31.38	10.0	304 S.S	0.010	0.3	33.9	23.9	5.0	15.0	32.5	20.0	5.0	17.5	12.5	Y	Y	N						
RW-15	Proposed	7628048.90	701930.66	Shallow	33.7	35.81	38.70	-2.89	31.11	10.0	304 S.S	0.010	0.3	33.7	23.7	5.0	15.0	38.0	25.0	5.0	18.0	13.0	Y	Y	N						
RW-16i	Proposed	7628054.92	701936.85	Intermediate	44.7	35.77	38.66	-2.89	42.07	5.0	304 S.S	0.010	0.3	44.7	39.7	-6.0	-1.0	49.0	36.0	-6.0	7.0	13.0	Y	Y	N						
RW-17	Proposed	7628150.24	701884.88	Shallow	34.5	36.55	39.50	-2.95	31.85	10.0	304 S.S	0.010	0.3	34.5	24.5	5.0	15.0	34.0	21.0	5.0	18.0	13.0	Y	Y	N						
RW-18	Proposed	7628203.98	701810.54	Shallow	34.4	36.51	39.42	-2.91	31.81	10.0	304 S.S	0.010	0.3	34.4	24.4	5.0	15.0	42.0	29.5	5.0	17.5	12.5	Y	Y	N						
RW-19i	Proposed	7628213.30	701818.09	Intermediate	47.5	36.56	39.46	-2.90	44.86	5.0	304 S.S	0.010	0.3	47.5	42.5	-8.0	-3.0	50.0	42.7	-8.0	-0.7	7.3	Y	Y	N						
RW-20	Proposed	7628266.91	701723.11	Shallow	34.0	37.07	39.99	-2.92	31.37	10.0	304 S.S	0.010	0.3	34.0	24.0	6.0	16.0	35.5	23.0	6.0	18.5	12.5	Y	Y	N						
RW-21i	Proposed	7628292.81	701650.87	Intermediate	48.4	37.38	40.42	-3.04	45.68	5.0	304 S.S	0.010	0.3	48.4	43.4	-8.0	-3.0	53.0	36.1	-8.0	8.9	16.9	Y	Y	N						
RW-22	Proposed	7628197.13	701534.02	Shallow	33.9	38.02	40.90	-2.88	31.32	10.0	304 S.S	0.010	0.3	33.9	23.9	7.0	17.0	33.0	20.0	7.0	20.0	13.0	Y	Y	N						
RW-23	Proposed	7627551.09	702466.07	Shallow	36.8	33.63	36.75	-3.12	33.93	10.0	304 S.S	0.010	0.3	36.8	26.8	0.0	10.0	37.2	24.5	0.0		12.7	Y	Y	N						
RW-24i	Proposed	7627566.33	702443.43	Intermediate	43.8	34.03	36.79	-2.76	41.33	5.0	304 S.S	0.010	0.3	43.8	38.8	-7.0	-2.0	45.0	37.5	-7.0	0.5	7.5	Y	Y	N						
RW-25	Proposed	7628122.95	701474.02	Shallow	38.0	38.06	40.96	-2.90	35.36	10.0	304 S.S	0.010	0.3	38.0	28.0	3.0	13.0	38.5	25.0	3.0	16.5	13.5	Y	Y	N						
RW-26i	Proposed	7628130.55	701480.56	Intermediate	48.0	38.10	40.95	-2.85	45.40	5.0	304 S.S	0.010	0.3	48.0	43.0	-7.0	-2.0	47.0	40.0	-7.0	0.0	7.0	Y	Y	N						

Notes:
Y = Yes
N = No
NA = Not applicable

Table 2-2
Vertical Head Difference Monitoring Locations
Performance Monitoring Plan
Groundwater Source Control Measure
Arkema Inc. Facility
Portland, Oregon

Aquifer Designation			Vertical Flow Calculation	
Shallow	**Intermediate**	**Deep**	**Shallow/Intermediate**	**Intermediate/Deep**
PA-3	PA-17i	PA-27d	X	X
PA-4	PA-10i	PA-18d	X	X
PA-5	PA-11i	PA-30d	X	X
MWA-2	MWA-8i	PA-19d	X	X
MWA-69	MWA-66i	PA-21d	X	X
PA-6	PA-12i	PA-20d	X	X
MWA-19	MWA-34i	MWA-58d	X	X
PA-28	PA-13i	PA-22d	X	X
PA-7	PA-14i	PA-23d	X	X
MWA-47	PA-29i	PA-24d	X	X
PA-8	PA-15i	PA-25d	X	X
PA-9	PA-16i	PA-26d	X	X

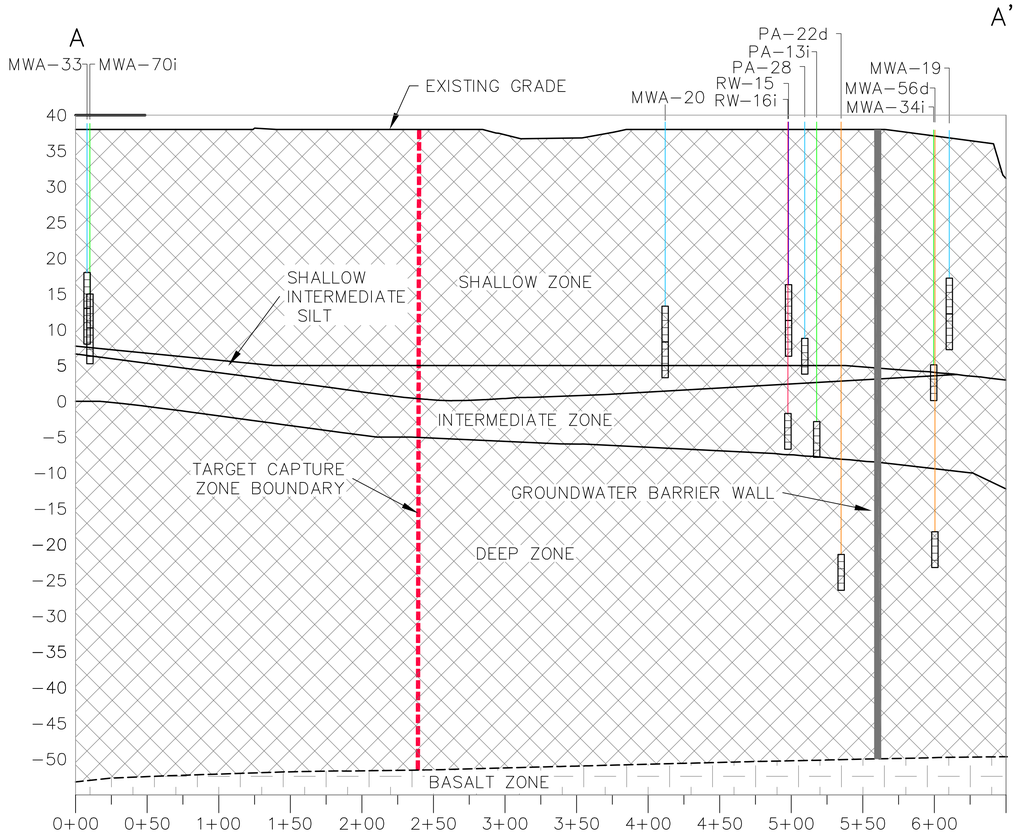
FINAL

Table 2-3
Data Collection Objectives
Performance Monitoring Plan
Groundwater Source Control Measure
Arkema Inc. Facility
Portland, Oregon

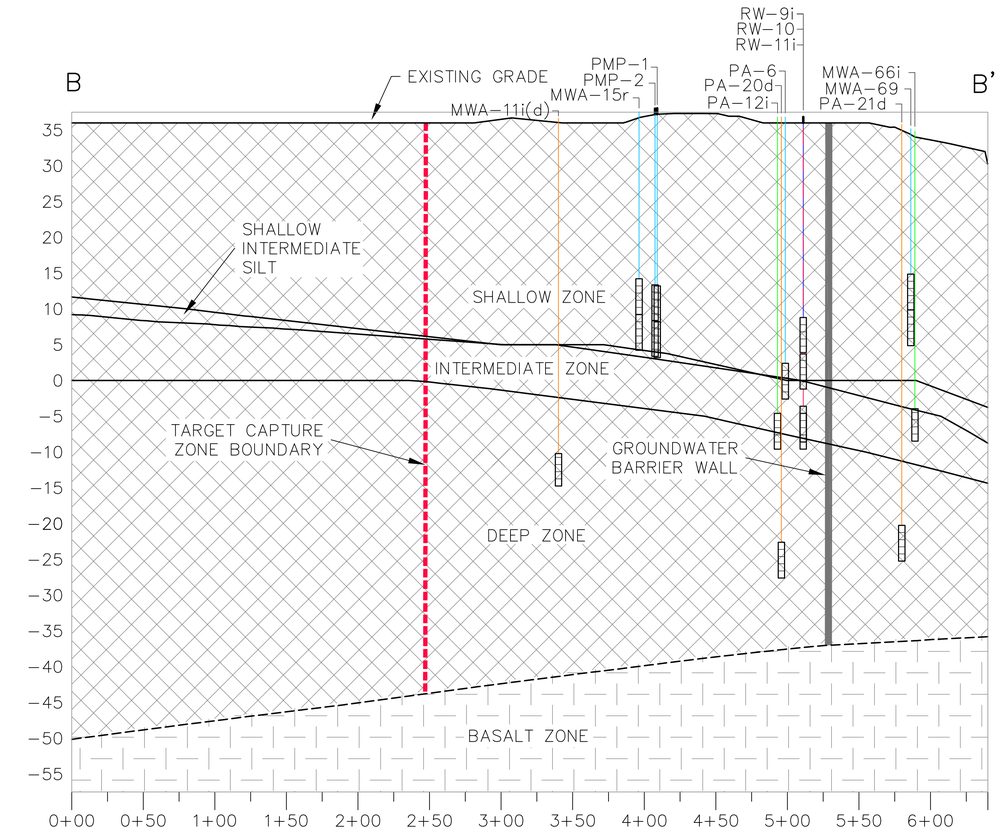
Parameter	Minmium Measurement Frequency	Reporting Frequency
Monitoring Well Hydrograph	15-Minutes	Monthly
Precipitation	Daily	Monthly
Potentiometric Surface*	Monthly	Monthly
System Flow Rate	15-Minutes	Monthly

Notes:
* Potentiometric maps generated from a combination of electronic and monthly manual water level measurements

Attachment



CROSS-SECTION A-A'



CROSS-SECTION B-B'

10
0
0
50
SCALE (IN FEET)

10
0
0
50
SCALE (IN FEET)

LEGEND

- EXISTING GRADE
- EXISTING GROUNDWATER ELEVATION
- TOP OF BASALT (BEDROCK)
- SHALLOW PA WELL
- INTERMEDIATE PA WELL
- DEEP PA WELL
- SHALLOW RW WELL
- INTERMEDIATE RW WELL
- SCREENED INTERVAL
- SUBSURFACE MATERAIL
- BASALT

REV.	DATE	DESCRIPTION	BY	CHK

DRAWN BY RMK | CADD Review FGB | CHECKED BY JD-POR

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SEAL

GROUNDWATER SOURCE CONTROL MEASURE
GWET SYSTEM
ARKEMA, INC.
PORTLAND, OREGON

CROSS-SECTIONS A-A' AND B-B'

SCALE	PROJECT NUMBER	SHEET	REV.
AS NOTED	0198219	2	
DATE 11/27/2013			

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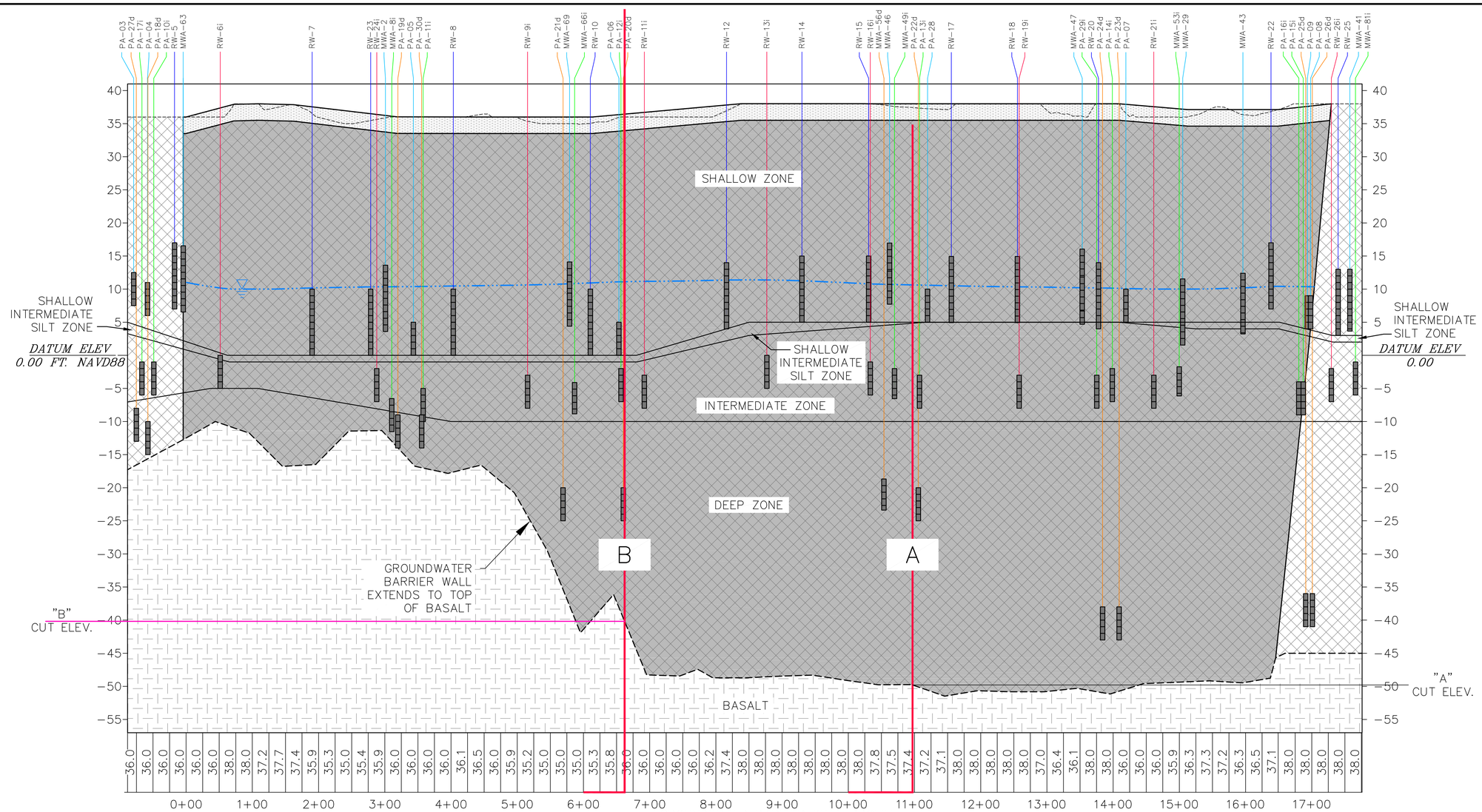
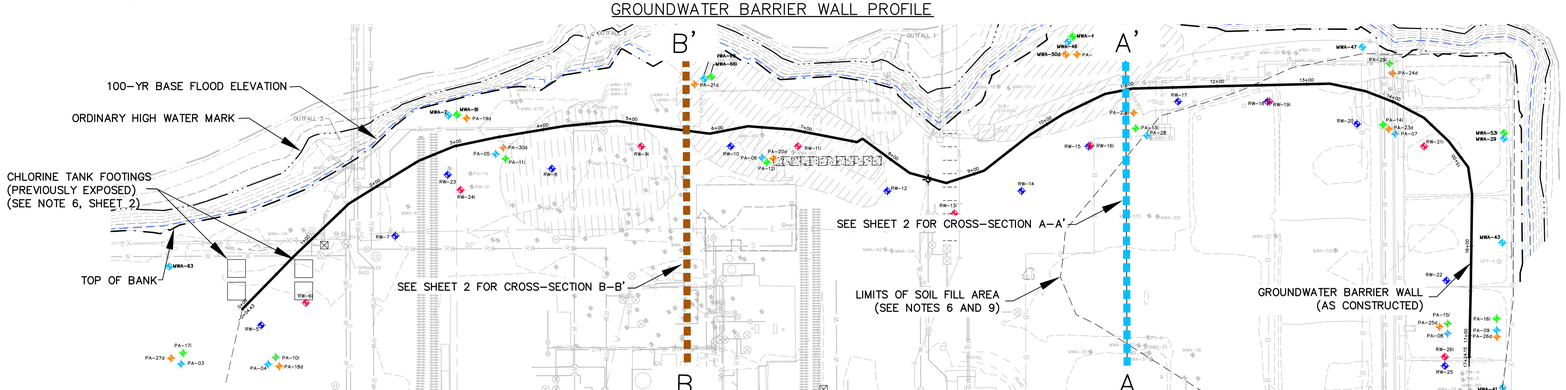


GROUNDWATER BARRIER WALL PROFILE

LEGEND

- EXISTING GRADE
- PROPOSED FINAL GRADE (APPROXIMATE)
- EXISTING GROUNDWATER ELEVATION
- TOP OF BASALT (BEDROCK)
- SHALLOW PA WELL
- INTERMEDIATE PA WELL
- DEEP PA WELL
- SHALLOW RW WELL
- INTERMEDIATE RW WELL
- SCREENED INTERVAL
- BARRIER WALL CAP (2.5' THICK TYP.)
- GROUNDWATER BARRIER WALL
- SUBSURFACE MATERAIL

0 80 SCALE (IN FEET)



GROUNDWATER BARRIER WALL PLAN

0 80 180 SCALE (IN FEET)

ISSUED FOR AGENCY APPROVAL

REV.	DATE	DESCRIPTION	BY	CHK
1	2/5/13	ADDRESS AGENCY COMMENTS	RK	BR

DRAWN BY RMK | CADD Review FGB | CHECKED BY SL-ANN

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Environmental Resources Management, Inc.

REGISTERED PROFESSIONAL ENGINEER 78496PE OREGON DECEMBER 31, 2014 BRENDAN ANDREW ROBINSON 2012-7-13

EXP. 12/31/2014 P.E.

GROUNDWATER SOURCE CONTROL MEASURE PERFORMANCE MONITORING SYSTEM

ARKEMA INC.
PORTLAND, OREGON

HYDRAULIC GRADIENT CONTROL POINT CROSS SECTION

SCALE	PROJECT NUMBER	SHEET	REV.
AS NOTED	0180382	1	1
DATE 07/20/2010			

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17 March 2014

Mr. Matt McClincy
Oregon Department of Environmental Quality
Northwest Region
2020 Southwest 4th Avenue, Suite 400
Portland, Oregon 97201-4987

Subject: Former Arkema Portland Plant
Responses to DEQ Review Comments
Arkema Portland Performance Monitoring Plan
ECSI No. 398

Dear Matt:

This document provides responses to the comments received from the Oregon Department of Environmental Quality (ODEQ) on 14 February2014 related to the *Final Performance Monitoring Plan* (PMP) – *Groundwater Source Control Measure - Arkema Inc.* (Arkema) *Portland Plant* and supporting documents. The PMP was prepared by ERM-West, Inc. (ERM), on behalf of Legacy Site Services, LLC (LSS), agent for Arkema, to memorialize monitoring requirements for the implementation of a groundwater source control measure (GW SCM) at the Arkema facility in Portland, Oregon (the "site"). LSS understands that the comment set received from the ODEQ incorporates comments received from United States Environmental Protection Agency (EPA) and the Five Tribes. Each of the ODEQ comments is provided below in italic font, followed by the LSS response.

LSS does not intend to submit a revised PMP, but will incorporate these responses and associated attachment as an addendum to the PMP.

General Comments

1. *Response accepted.*

2. *In the response, Legacy Site Services (LSS) states that "A net groundwater flux into the target capture zone (i.e., groundwater extraction rate greater than total recharge rate) will*

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

be indicative of successful containment." This is necessary, but in itself not a definitive indicator of successful containment. Localized flow through the barrier may occur under conditions where the overall extraction rate is greater than the total recharge rate through the surface area of the target capture zone. This might occur for instance if one or more wells is drawing water from outside the target capture zone, while simultaneously localized leakage through the barrier is causing the achieved capture zones of individual wells to be less than the expected capture area. It's also not clear from this statement as to how the recharge rate would be determined in practice and no reference was identified in the original document that outlined the methodology for estimation of recharge. DEQ requests that the PMP be modified to state that this criterion will not be used as an indicator of the success of hydraulic containment if the primary criteria of inward flow at all points has not also been demonstrated.

Inward gradients across the groundwater barrier wall (GWBW) and target capture zone boundary, and upward vertical gradients, will be considered the primary indicator of successful containment. The comparison of modeled groundwater flux in each hydrogeologic layer to observed extraction rates will be used as a secondary line of evidence to provide further verification of hydraulic containment. If the potentiometric surface maps and vertical gradients indicate the hydraulic capture is not being achieved, LSS will use the adaptive management approach summarized in Figure 4-1 of the PMP to determine the appropriate response action (e.g., target gradient set point adjustment).

The text of the PMP will be revised to read "The potentiometric contour maps, as well as the updated groundwater model in conjunction with particle tracking, will be used to evaluate flow paths and estimate overall groundwater flux through the individual hydrogeologic layers."

3. *Potentiometric maps based on monthly averages do not provide sufficient temporal resolution to demonstrate hydraulic containment is consistently achieved, and the unfiltered monitoring well hydrographs have to be interpreted to demonstrating effective containment. Therefore, additional data and comparisons, beyond those identified in Table 2-3 will need to be presented in monthly reports. DEQ requests that hydrographs of all electronically monitored wells based on filtered data using the Serfes method be presented in the monthly reports.*

   The hydrographs of wells located behind the wall should be superimposed on hydrographs of their corresponding comparison point to evaluate the direction and strength of gradients.

   Furthermore, interpretation of the well hydrographs and a more robust evaluation of containment will require relatively accurate and precise measurements of river stage. If a

stilling well has not been installed to collect river stage measurements off the Arkema site, LSS will need to construct one and include it in the performance monitoring program.

LSS intends to install a surveyed river stage control point with a transducer for real-time data collection on Dock Two (adjacent to existing river stage staff).

In addition to data comparisons already referenced, the monthly reports will present hydrographs, based on Serfes method filtered data, of gradient cluster wells superimposed on hydrographs of their corresponding comparison point and river stage data. A revised Table 2-3 reflecting the additional monitoring data to be collected, is included as Attachment 1.

4. *Response accepted.*

Specific Comments

1. *Response accepted.*

2. *Response accepted.*

3. *Response accepted.*

4. *Response accepted.*

5. *Response accepted.*

6. *The LSS' response to this comment is not accepted. To clarify, the proposed PMP addendum should clearly show that the third paragraph in Section 2.2.2 has been revised to not imply that only 6 control point clusters are the only line of evidence being used to confirm sufficient inward gradients across the Groundwater Barrier Wall (GWBW) are being achieved. LSS' response introduces additional lines of evidence that are not explicitly stated in the August 2013 PMP (e.g. calculations of estimated flow rates/and groundwater flux through the system). The rationale of these concepts needs to be explained in more depth, but more importantly they do not address Specific Comment 6. To clarify, a sufficient response from LSS would be to state that the specific paragraph in the document will be revised to include the use of potentiometric surface maps developed from all wells monitored along the GWBW between the control points, and that groundwater gradient maps will be generated for each hydrostratigraphic layer.*

   Finally, the last paragraph in LSS' response describes an "original intent" which implies there is some new intent that is yet to be described. If so, LSS should provide details on what revisions to gradient control and the use of flow rate/groundwater flux through the

individual hydrostratigraphic layers as a line of evidence. These concepts were not explained, or provided in the August 2013 PMP reviewed.

The third paragraph in Section 2.2.2 of the August 2013 PMP is revised as follows:

"The hydraulic gradient across the GWBW will be continuously monitored in six areas (i.e., control point "clusters") along the GWBW alignment, as shown on Figure 2-5. The measured gradients will used as the primary logic control for operation of the recovery wells (i.e. pump speed). Pump speeds for individual recovery wells will be adjusted in order to maintain a pre-determined target inward hydraulic gradient across the GWBW for each well pair. The methods used to develop the pre-determined target gradient for each well pair is discussed below."

The calculation of estimated flow rates and groundwater fluxes are required elements identified in Step 4 of *EPA guidance document A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems* (EPA 2008). The concepts of groundwater flux and flows rates is also inherent in the underlying rationale used in the development of three-dimensional groundwater models.

To clarify, there was no new intent implied in the 10 December 2013 response; LSS is in agreement with ODEQ regarding the comment "For this, all monitoring wells along the GWBW, between the control points, and completed in each stratigraphic layer should be evaluated with potentiometric surface maps developed from manual or temporary transducer monitoring data to verify capture."

7. *DEQ recognizes LSS response that the groundwater model will be used as a secondary line of evidence, but this organized hierarchical order of evidence is not explicitly stated in Section 2.2.2, or even presented in the August 2013 PMP. This concept of first order and second order lines of evidence is good in concept, but needs elaboration and should be clearly presented in the proposed PMP addendum.*

   In addition, the response does not acknowledge and comment on calibration expectations. It is unclear whether LSS accepts DEQ's criteria for using the model to evaluate containment. Please clarify.

LSS has agreed to use the groundwater model "as a secondary line of evidence" in accordance with the expectations of ODEQ presented in the 10 December 2013 comments on the PMP. Per the direction from ODEQ and the response to General Comment #2, the primary assessment of capture will be through evaluation of gradient

conditions, plotted spatially for each hydrostratigraphic layer, based on the water level data collected manually and electronically via water level transmitters.

LSS has recently completed an aquifer testing program of the constructed recovery wells. At the time of this response, the data is currently being analyzed and used to re-calibrate the groundwater model in accordance with the ODEQ-approved *Recovery Well Pump Test Work Plan* and addenda. Recalibration is performed by using the groundwater model to replicate the individual observed pump test results (i.e., a transient simulation). The results of the recalibration will be presented to ODEQ for verification that the model is sufficient as a line of evidence for evaluation of hydraulic containment.

In accordance with the adaptive management plan summarized in Figure 4-1 of the Performance Monitoring Plan, future updates, including additional transient recalibrations of the groundwater model, may be performed as the available groundwater level data set increases and is incorporated into the conceptual hydrogeologic site model.

8. *Response accepted.*

9. *The LSS response is not accepted. LSS indicates the use of the 3-day moving average is more limited than DEQ's understanding. DEQ requests that the Serfes method be used to filter data from all electronic monitoring points in order to evaluate containment.*

All data from electronic monitoring locations that will be used in the evaluation of containment will be filtered using the Serfes method.

10. *See Specific Comment #9.*

11. *See General Comment #3.*

12. *Response accepted.*

13. *Response accepted.*

14. *Response accepted.*

15. *Response accepted.*

16. *Response accepted.*

17. *Response accepted.*

18. *LSS identifies the 25-foot model resolution and a 1-foot contour interval as limitations in the interpretation of simulated water level contours. DEQ requests that LSS consider using a finer model grid and smaller groundwater contour intervals throughout the model, or at least specifically within the area of the barrier to provide a more representative depiction of the potentiometric surface.*

LSS considers the groundwater model to be of sufficient resolution to assess flow paths and be used as a means of verification of hydraulic containment. If the evaluation of performance monitoring data indicates the model resolution is insufficient for its intended purpose, refinement of model grid size and groundwater contour intervals will be considered.

Sincerely,

FOR

Todd Slater
Legacy Site Services LLC

cc: Sean Sheldrake, EPA
Tom Gainer, DEQ
Henning Larsen, DEQ
Karen Traeger, LSS
Steve Parkinson, Joyce Ziker Parkinson
Erik Ipsen, ERM
David Livermore, Integral

Attachment 1

FINAL

Table 2-3
Data Collection Objectives
Performance Monitoring Plan
Groundwater Source Control Measure
Arkema Inc. Facility
Portland, Oregon

Parameter	Minimium Measurement Frequency	Reporting Frequency
Monitoring Well Hydrograph[1]	15-Minutes	Monthly
River Stage Height[2]	15-Minutes	Monthly
Precipitation	Daily	Monthly
Potentiometric Surface[3]	Monthly	Monthly
System Flow Rate	15-Minutes	Monthly

Notes:
[1] = Hydrographs will consist of data sets corrected using the Serfes method.
[2] = River stage height collected from a transducer installed on Dock 2.
[3] = Potentiometric maps generated from a combination of electronic and monthly manual water level measurements