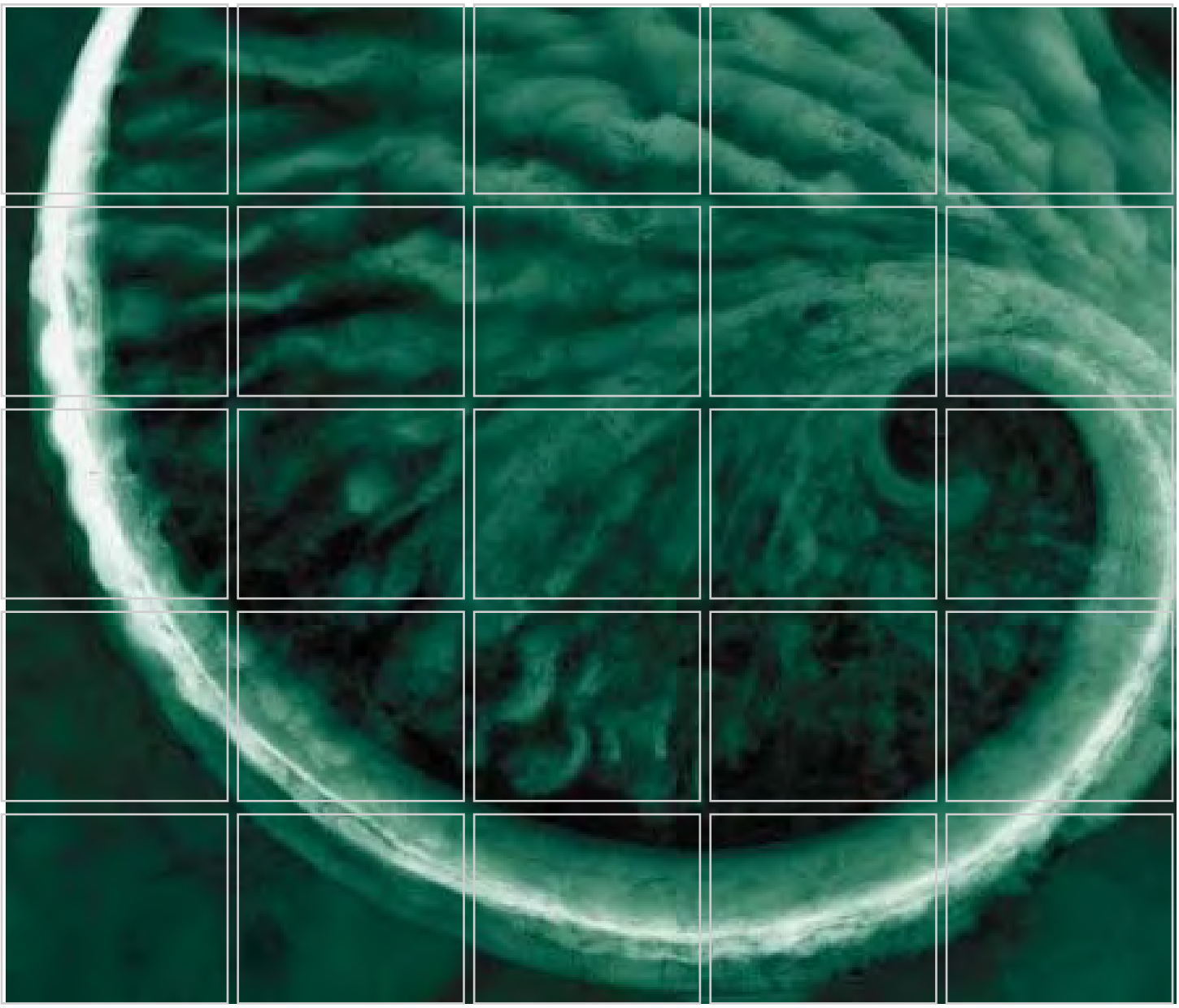

DRAFT - Data Gaps Assessment Work Plan

Arkema Inc. Facility
Portland, Oregon

March 2009

Prepared for:
Legacy Site Services LLC

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Legacy Site Services LLC

Draft - Data Gaps Assessment Work Plan

Arkema Inc. Facility
Portland, Oregon

March 2009

Project No. 93634.06

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LIST OF ACRONYMS

BES	Bureau of Environmental Services
bgs	Below Ground Surface
CDD	Chlorodibenzo-p-dioxins
CDF	Chlorodibenzo-p-furans
COI	Constituents of interest
DDT	Dichloro-diphenyl-trichloroethane
EPA	Environmental Protection Agency
ERM	ERM-West, Inc.
FS	Feasibility Study
gpm	gallons per minute
ID	Internal Diameter
ITRC	Interstate Technology and Regulatory Council
LSS	Legacy Site Services LLC
LWG	Lower Willamette Group
NTU	Nephelometric Turbidity Units
ODEQ	Oregon Department of Environmental Quality
PCP	Pentachlorophenol
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
R	Coefficient of Correlation
RP	Rhone-Poulenc
SCM	Source Control Measure
TEQ	Toxicity Equivalency Quotient
µg/L	Microgram per liter
USEPA	United States Environmental Protection Agency

1.0 INTRODUCTION

On behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc., ERM-West Inc. (ERM) has prepared this *Data Gaps Investigation Work Plan* (Work Plan) for the former Arkema Portland Plant (the Site) located at 6400 NW Front Avenue, Portland, Oregon (Figure 1-1). This work plan provides the rationale and proposed scope of work to fill identified data gaps in support of the upland feasibility study (FS) and groundwater source control measure (SCM) to be performed at the Site.

On 28 January 2009, and again on 24 February, representatives from LSS, Oregon Department of Environmental Quality (ODEQ), ERM, and Integral met to discuss and agree upon data gaps to be investigated at the Site as part of this investigation. This work plan has been prepared in accordance with the agreements reached in those meetings.

This work plan includes the following three scope of work elements:

- Collection of one round of groundwater samples from all site monitoring wells and analysis for a wide range of constituents of interest (COIs);
- Collection of soil samples from two areas of the site and analysis of the samples for dioxins/furans. The samples will be collected from 1) the vicinity of the historical chlorate cell room (now identified as the former maintenance shop) and, 2) the area of the former brine residue and asbestos ponds; and
- Performance of four aquifer hydraulic conductivity tests (i.e., pump tests): two in the shallow groundwater aquifer and two in the intermediate groundwater aquifer.

This work will be conducted in general accordance with the procedures described in *Elf Atochem Acid Plant Area Remedial Investigation and Feasibility Study Work Plan* (Exponent 1998) (RI/FS Work Plan).

The following subsections provide the objectives of this Work Plan and the data gaps investigation, a Site description and history, and the organization for the remainder of the work plan.

1.1 OBJECTIVES

The objectives of this Data Gaps Work Plan and the data gaps investigation are to:

- Provide an updated Conceptual Site Model (CSM) for dioxins/furans at the Site;
- Identify and fill data gaps sufficient to evaluate remedial technology alternatives in the uplands FS; and
- Collect data to support the design of the groundwater SCM.
- Provide additional information regarding the migration of contaminants from the upgradient Rhone-Poulenc facility (across NW Front Ave) onto the Site

1.2 SITE DESCRIPTION

The Site is located at 6400 N.W. Front Avenue in the Northwest Industrial Area of Portland, Oregon. The facility 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 Site is located on the southwest bank of the lower Willamette River between River Mile 6.9 and River Mile 7.6, immediately upstream of the Burlington Northern Santa Fe Railroad Bridge in the northwest industrial area of Portland, Oregon (Figure 1-1). The property is located adjacent to the Portland Harbor Superfund site.

The property lies within the Guild's Lake Industrial Sanctuary Plan (formerly the Northwest Portland Industrial Sanctuary). The Site is zoned and designated "IH" for heavy industrial use, which precludes it from non-industrial uses. The purpose of the Guild's Lake Industrial Sanctuary Plan is to maintain and protect this land as a dedicated area for heavy and general industrial uses. Therefore, while future use of the facility is unknown, it will likely be heavy industrial.

1.3 SITE HISTORY

Inorganic chemicals were manufactured at the Site from 1941 until 2001, when the facility was closed and chemical manufacturing was discontinued. For most of the Site's history, the chemical activities involved electrolytic decomposition of brine solutions to manufacture inorganic chemicals, including sodium chlorate, chlorine, sodium

hydroxide, hydrogen, and hydrochloric acid. Other chemical manufacturing processes during the Site's operational history included the production of dichloro diphenyl trichloroethane (DDT) from 1947 to 1954 and ammonium perchlorate from 1958 to 1962 (ERM 2005).

Decommissioning and removal of the manufacturing infrastructure were completed in early 2005. The only structure remaining is the office building at the Site entrance on Front Street and some concrete floor slabs left in place as environmental caps. Arkema maintains leases from the Oregon Department of State Lands for the docks in the Willamette River, but the docks are not currently in use. Current and historical upland contaminant sources are shown in Figure 1-2.

Arkema (formerly known as ATOFINA Chemicals, Inc., Elf Atochem North America, Inc., and the Pennwalt Corporation) has conducted investigations and performed a number of Interim Remedial Measures (also referred to as SCMs) in the upland portion of the Site since 1994. In 1995, Arkema (then known as Elf Atochem) submitted an intent to participate in the ODEQ Voluntary Cleanup Program, an agreement that was later signed with ODEQ in 1996. In 1998, Arkema signed a voluntary agreement with ODEQ to complete a remedial investigation and feasibility study (RI/FS) of the former DDT manufacturing area. The RI/FS was later expanded to include other areas and chemicals at the Site (e.g., hexavalent chromium and perchlorate). The *Upland Remedial Investigation Report Lots 3 & 4 and Tract A – Revision 1* (RI Report) was submitted to ODEQ in December 2005 (ERM 2005). For the RI, Arkema completed two phases of in-river investigations to assess the extent of chemicals from the former DDT manufacturing process in near shore Willamette River sediments and groundwater. In addition to the RI work, the Lower Willamette Group (LWG) has conducted a number of investigations that included sample stations adjacent to the Site as part of the Portland Harbor RI/FS. Brief descriptions of these investigations are provided in the draft EE/CA work plan (Section 3.1, Integral 2006a). In addition, following the submittal of the final RI Report, ODEQ and Environmental Protection Agency (EPA) issued the Portland Harbor Joint Source Control Strategy guidance document (ODEQ 2005).

Arkema and EPA entered into an Administrative Order on Consent on 27 June 2005 for the in water portion of the Site. The draft EE/CA work plan was submitted to EPA and stakeholders (the government team) on 26 September 2005, for review and comment. A revised work plan that incorporated responses to comments received from the government team was submitted to the government team on 14 July 2006 (Integral 2006a).

The revised work plan included screening results for sediments, river bank soils and groundwater, transition zone water, and surface water at the Site. In 2007, EPA prepared the *Arkema Early Action EE/CA Work Plan* (EPA 2007). An EE/CA work plan addendum was subsequently prepared by Integral and dated 22 July 2008 (Integral 2008b).

In May 2008, LSS submitted a focused feasibility study for a groundwater SCM at the Site (ERM 2008). On 23 February 2009, ODEQ approved the general approach for the groundwater SCM. This approach includes installation of a slurry groundwater barrier wall and a groundwater extraction and treatment system, with treated water discharge to the Willamette River.

Arkema and ODEQ entered into an Administrative Order on Consent on 31 October 2008 (Consent Order) for the upland portion of the Site. The upland Order requires submittal of various documents in support of upland source control (groundwater, storm water, and erodible soil) and the upland Feasibility Study. This Data Gaps Work Plan is one of the documents specified in the Consent Order.

1.4 REPORT ORGANIZATION

The remainder of this report is organized as follows:

- Section 2 provides an updated conceptual site model, focusing on dioxin and furans on site.
- Section 3 presents an analysis of data gaps to be investigated.
- Section 4 details the scope of activities to be performed as part of this investigation.
- Section 5 contains the schedule for activities proposed in this work plan.
- Section 6 lists the references cited in the work plan.

Appendix A provides standard operating procedures for the proposed aquifer pump test.

2.0 DIOXINS AND FURANS CONCEPTUAL SITE MODEL

The CSM for the Site has been presented in several previous documents, including the RI report (ERM 2005) and, most recently, the *Revised Draft Arkema Work Plan: Engineering Evaluation/Cost Analysis* (Integral 2006a). To date, the Site CSM has not included discussion of the presence of chlorodibenzo-p-dioxins (CDDs) and chlorodibenzo-p-furans (CDFs) (collectively referred to as dioxins/furans). This section presents the revised CSM for dioxins/furans at the Site.

2.1 BACKGROUND

When used in an environmental context, the term "dioxins" refers to CDDs and CDFs, of which there are 210 individual compounds, or congeners. Concentrations of dioxins are typically given as toxic equivalency quotients (TEQs), or equivalent amounts of 2,3,7,8-tetrachlorodibenzo-p-dioxin, the most toxic congener. Chromographic patterns associated with different congeners and their relative amounts, referred to as the "dioxin fingerprint," are also reflective of the sources of the dioxins.

The 75 individual CDDs and 135 CDFs form a set of CDD and CDF congeners. When CDDs and CDFs are subdivided by the degree of chlorination, the term homolog is used, e.g., the Tetrachlorodibenzo-p-dioxin homolog, in which there are 14 different CDD congeners each containing four chlorine atoms. CDDs and CDFs of a given homolog with different chlorine substitution positions are isomers. Individual CDDs and CDFs are referred to as congeners.

To evaluate dioxin/furan sources at the Site, in the immediate vicinity, and in the region, congener profiles were prepared from groundwater, soil, and sediment CDD and CDF analyses. Congener profiles present the fractional distribution of CDDs and CDFs contained in a sample (i.e., dioxin fingerprint). Congener profiles can be used to compare or distinguish differences in the types and amounts of congeners present and provide insights on formation of CDDs and CDFs from different sources. In the analysis of the CDDs and CDFs, congener profiles were prepared by summing the concentration of CDDs and CDFs in a sample and dividing the homologous groups by the total CDD/CDF concentration.

The histogram charts for solids (soil, river sediment, and catch basin sediment) and groundwater are shown on Figures 2-1 and 2-2, respectively. The pie charts for solids (soil, river sediment, and catch basin sediment) and groundwater are shown on Figure 2-3 and 2-4, respectively.

2.2 *CDD/CDF FORMATION AND SOURCES*

CDDs and CDFs are formed as a by-product or contaminant in manufacturing and combustion processes. Sources of CDDs/CDFs vary widely, but are typically a combination of chlorine, organics, and oxygen coupled with heat. The EPA has grouped the major sources of environmental releases of CDDs and CDFs into five broad categories (EPA 2006):

1) Combustion Sources: CDDs /CDFs are formed in most combustion systems, including waste incineration, burning of fuels such as coal and petroleum products, and uncontrolled combustion such as forest or building fires.

2) Metal Smelting, Refining, and Processing Sources: CDDs/CDFs can be formed during primary and secondary metals operations including sintering, steel production, and scrap metal recovery.

3) Chemical Manufacturing: CDDs/CDFs can be formed as by-products from the manufacture of chorine bleached wood pulp, chlorinated phenols, polychlorinated biphenyls, phenoxy herbicides, and chlorinated aliphatic compounds.

4) Biological and Photochemical Processes: Studies suggest that CDDs/CDFs can be formed under certain environmental conditions (e.g., composting) and from photolysis of highly chlorinated phenols.

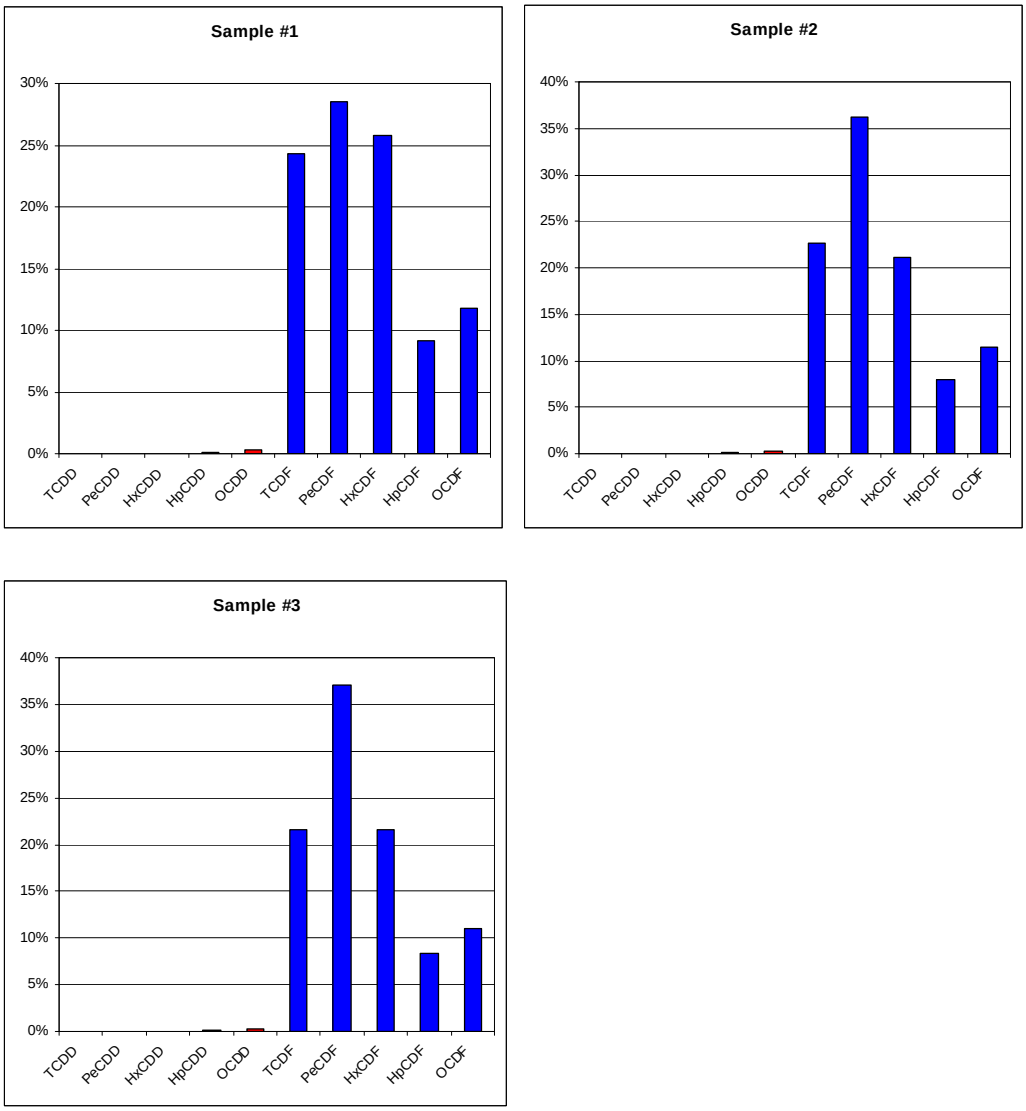
5) Reservoir Sources: Reservoirs are material or sources that contain previously formed CDDs/CDFs that have the potential for redistribution into the environment. Potential reservoir sources include soils sediments, biota, and water.

2.3 *CDDS/CDFS AND THE CHLOR-ALKALI PROCESS*

Rappe, et al (Rappe 1991) and EPA (EPA 2006) have reported that CDDs and CDFs are produced during chlorine production using the chlor-alkali process. Chlorine gas is produced by electrolysis of brine electrolytic cells. Until the late 1970s, the primary type of electrolytic process used in the chlor-alkali industry to produce chlorine consisted of the use of cells containing graphite electrodes (EPA 2006). Elevated concentrations of CDFs have been detected in the sludge formed on graphite electrodes. Although the origin of the CDFs in graphite electrode sludge is uncertain, chlorination of the cyclic aromatic hydrocarbons (such as dibenzofuran) present in the coal tar used as a binding agent in the graphite electrodes has been proposed as the primary source (Strandell 1994).

Both Rappe and EPA observed that, predominately, CDFs were produced in the process and that the concentrations of CDDs were below detection limits. Rappe has called this pattern the "chlor-alkali pattern." Various studies have observed this distribution of CDFs in sludge and soil at chlor-alkali plants (EPA 2006, Shields 2006). Examples of the chlor-alkali pattern, based on profiles presented in *An Inventory of Sources and Environmental Releases of Dioxin-Like Compounds in the United States for the Years 1987, 1995, and 2000* (EPA 2006), are provided in Figure 2-5 below.

Figure 2-5 *Examples of chlor-alkali CDF/CDD homolog patterns in three samples of graphite electrode sludge from chlorine production. Source:* **An Inventory of Sources and Environmental Releases of Dioxin-Like Compounds in the United States for the Years 1987, 1995, and 2000** *(EPA 2006)*



Based on the distinctions between CDD/CDF congener profiles observed in different sources, and the CDF-dominated congener profile observed by Rappe and others at chlor-alkali plants, comparison of congener profiles can be used to evaluate sources of groundwater, soil, and sediment CDD/CDF contamination at the Site.

2.4 *SOURCES OF CDDS/CDFS AT THE ARKEMA SITE*

Chlorine was manufactured in two areas of the facility: the old chlorine cell room (more recently used as a maintenance shop), and the new chlorine cell room (also referred to as "Diamond") (Figure 1-2). The old chlorine cell room used asbestos diaphragm chlorine cells with graphite anodes. As discussed in Section 2.3 above, chlorine production using graphite anodes is a potential source of predominately CDFs. Production in this area ceased in 1971.

Chlorine manufacturing was then moved to the new chlorine cell room. Graphite anodes were not employed in the new cell room; rather, titanium metal anodes were used. Sludge produced using titanium anodes are not expected to contain CDFs (EPA 2006). Waste asbestos from the new chlorine cell room was stored in the former asbestos pond located on Lot 2 of the Site (Figure 1-2).

2.5 *VICINITY SOURCES OF CDDS/CDFS*

The presence of CDDs/CDFs has been documented in "practically all media including air, soil, meat, milk, fish, vegetation, and human biological samples" (Travis 1991). The widespread occurrence of CDDs/CDFs is likely the result of "atmospheric dispersion and deposition of particles resulting from combustion processes, from forest fires to waste incineration to auto exhaust" (Shields 2006).

Table 1-1 provides a summary of known or suspected sources of CDDs/CDFs in the vicinity of the Site. This information has been obtained from the ODEQ Environmental Cleanup Site Information database. Many of the sites in Table 1-1 have undergone, or are currently undergoing, cleanup for CDD/CDF contamination. Possible transport pathways from these sites to surrounding sites include groundwater migration, air deposition, and surface run-off.

In addition to the vicinity sources identified in Table 1-1, other point and non-point sources of CDDs/ CDFs exist in the region, which fall within the five broad EPA categories identified above. These sources present a source of airborne CDDs/CDFs, and include coal fired utilities, metal smelting, incinerators, diesel trucks, land application of sewage sludge, burning treated wood, and trash burn barrels (EPA 2006).

2.6 *SOURCES OF DATA AT THE ARKEMA SITE*

Groundwater, soil, and sediment samples have been collected and analyzed for dioxins/furans during several rounds of sampling at the Site. The primary sources of dioxin/furan and other analytical data to prepare this revised CSM include:

- August 2006 groundwater sampling results from the Site;
- April 2007 groundwater sampling results from the Site;
- Storm water catch basin sampling results from the Site;
- Riverbank soil sampling from the Site;
- LWG river sediment sampling results; and
- Historical soil and groundwater sampling results from the former Rhone-Poulenc (RP) property (currently owned by Starlink Logistics, Inc.) and surrounding properties. Detailed references for RP data are provided in the last section of this report.

The analytical results from these sampling events, including CDD/CDF fingerprints, are presented on Figures 2-1 through 2-4.

2.7 *ANALYSIS OF CDD/CDF DISTRIBUTION*

The following sections present an analysis of the observed dioxin/furan fingerprint patterns for the various media for which data were obtained.

2.7.1 *Solids*

Solid samples include soil (shallow and deep), river sediment, and storm water catch basin sediment. The dioxin fingerprints for these media are shown on Figures 2-1 and 2-3. Figure 2-6 presents a "scatter diagram" of CDD and CDF detections in upland solid samples (soil and catch basin sediment) from the study area. Figure 2-7 presents a "scatter diagram" of CDD and CDF detections in river sediment samples from the study area.

Figure 2-6 Scatter diagram of CDD and CDF detections in upland solid samples (soil and catch basin sediment) from the study area (µg/kg)

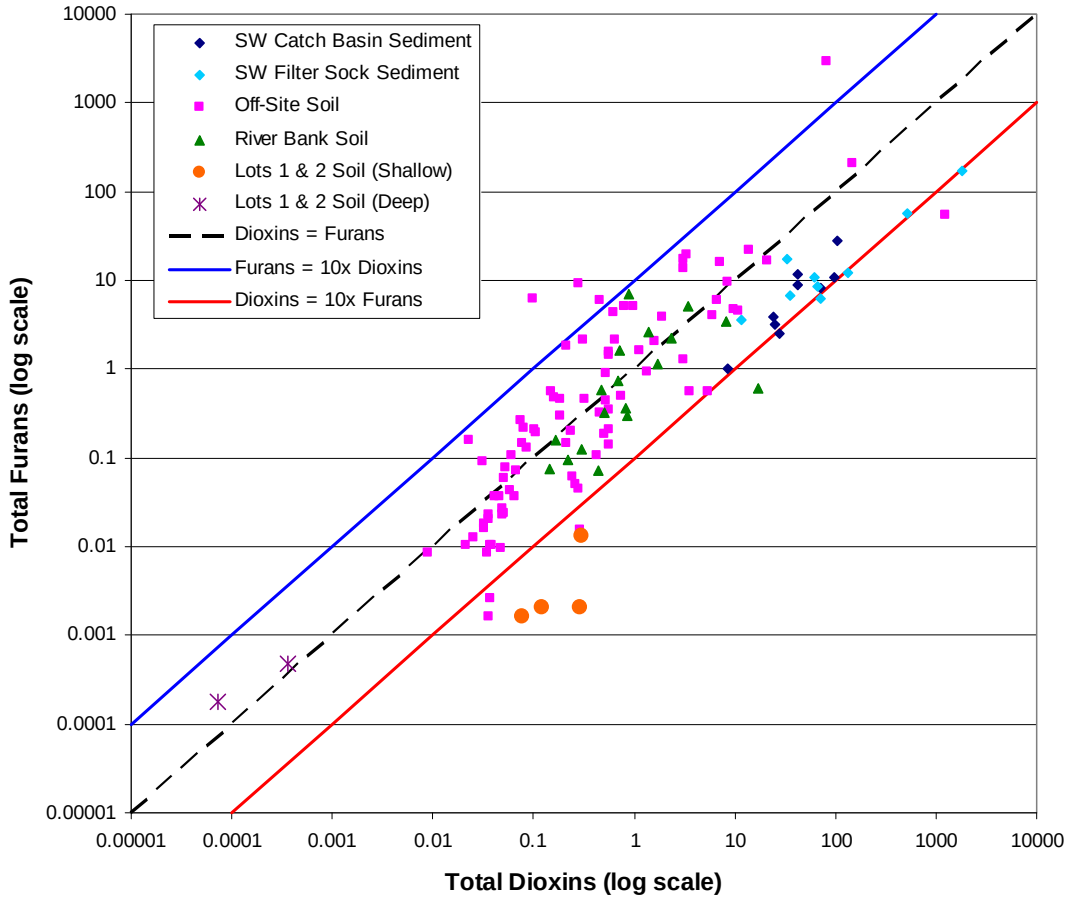
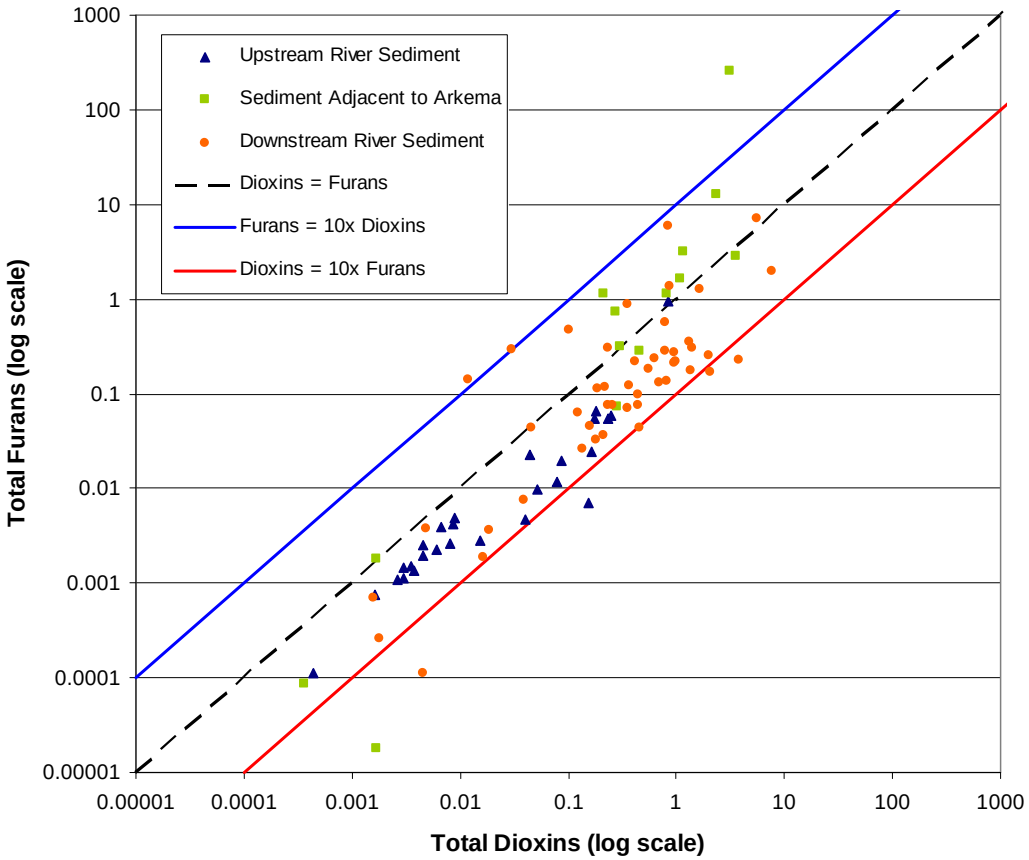


Figure 2-7 Scatter diagram of CDD and CDF detections in river sediment samples from the study area (µg/kg)



2.7.1.1 *Storm Water Catch Basin Samples*

Samples of storm water catch basin sediment (which include samples collected from the catch basins themselves and from filter socks placed above the catch basin) indicate a fairly uniform signature that is predominately composed of CDDs (average of 86 percent relative CDDs compared to total CDDs/CDFs). A typical fingerprint from the catch basin samples is shown on Figure 2-1 (Sample CB-001-05-FS). The high relative CDD content indicates the source of CDDs/CDFs in the catch basins is not likely associated with historical chlor-alkali operations at the Site. Figure 2-3 shows the close grouping with respect to percent composition of these samples – evidence of the consistent nature of these results. All of the catch basin sediment samples share remarkably similar dioxin fingerprints and concentrations. These fingerprints are similar to

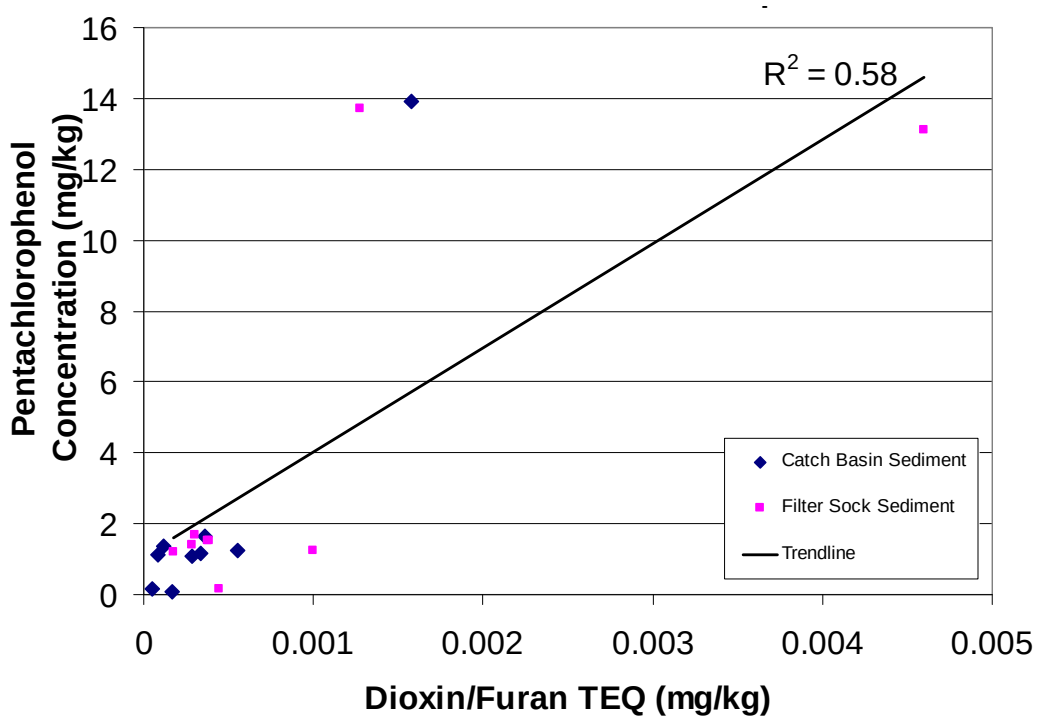
documented background dioxin fingerprints (Shields 2006, EPA 2006), providing evidence these detections are likely the result, at least in part, of ubiquitous atmospheric sources of CDDs/CDFs discussed above.

Sediment samples from the catch basins themselves are representative of material that could have been deposited years ago, up through the time of sampling. Since the filter socks were only recently placed (after site demolition), sediment samples from the filter socks are representative of material generated post-demolition. Figure 2-6 reveals that the samples with the highest CDD/CDF concentrations were collected from the filter socks, indicating that at least the majority of CDDs/CDFs were transported post-demolition. There is strong evidence that pentachlorophenol (PCP) from treated wood poles may be this post-demolition source, and is the major source of the CDD/CDF detections in the storm water catch basins and filter socks, especially the three samples with the highest detections.

PCP has historically been used for a variety of commercial applications, most commonly for wood treatment or use as a biocide. Utility poles, and other wood products, are still currently treated using PCP. CDDs and CDFs are common contaminants in PCP. During a walk of the Arkema property, it was observed that several cut power poles were located immediately adjacent to storm water catch basins that contained elevated CDD/CDF and PCP concentrations. It was noted that these power poles were removed immediately prior to the catch basin sampling, and thus CDDs/CDFs could have resulted from the cutting and removal of the power poles. Analytical results for samples from the power pole stumps confirmed the presence of elevated concentrations of CDDs and CDFs. The observed fingerprint was consistent with PCP.

Figure 2-8 presents a "scatter diagram" of the CDD/CDF TEQ and PCP concentrations in the Arkema storm water catch basins and filter socks. The diagram shows that the three samples with the highest CDD/CDF concentrations also possessed the three highest PCP concentrations. The coefficient of correlation (R) for the TEQ and PCP variables is 0.76 (coefficient of determination [R^2] is 0.58). This indicates good correlation between CDD/CDF concentrations and PCP concentrations (R = 1 indicates perfect correlation, R = 0 indicates no correlation), and offers evidence that the CDDs/CDFs detected in the catch basins is likely related to contaminated PCP from the nearby power poles. A comparison of PCP concentrations to the total Hx-CDF and Pe-CDF homologs, two homologs which have been associated with PCP contamination (Shields 2006), reveal an identical R value (0.76).

Figure 2-8 ***Scatter diagram of CDD/CDF TEQ and PCP concentrations in Arkema storm water catch basin sediment samples. R = 0.76***



While three of the sediment catch basin samples contained relatively high concentrations of CDFs, as well as CDDs, the total concentration of all CDFs was less than or on the same order of magnitude as soil samples from the upgradient RP site, and sediment samples from the vicinity of storm sewer Outfall 22B. The consistency in dioxin/furan fingerprint between all of the catch basin samples, regardless of magnitude of the concentrations detected, indicates that it is unlikely the elevated CDF detections in some of the catch basins are "masking" a chlor-alkali CDF signature. If chlor-alkali activities were responsible for the CDDs/CDFs detected in catch basin samples, a chlor-alkali signature would be evident in the samples with low concentration detections. This is not the case, and therefore other sources (e.g., treated wood poles or atmospheric sources) appear to be the more likely source of CDDs/CDFs in all of these catch basin samples.

2.7.1.2 *Soil*

Figures 2-1, 2-3, and 2-6 reveal that there is a diversity of relative CDD/CDF composition and fingerprints for soil results across the study

area (i.e., Arkema and upgradient sites). While soil samples from the former RP site display some localized patterns, the fingerprints from the RP site cover a spectrum of profiles. This is consistent with the variety of potential CDD/CDF sources which exist at the RP site and in the immediate vicinity, including herbicide production, lead smelting, and waste handling.

River bank soil samples from the Arkema site show similar variability with little consistency in dioxin fingerprints. While some samples show high relative concentrations of CDFs, only one river bank sample (out of 18 samples) indicated greater than 70 percent relative CDFs (compared to total CDD/CDF concentration). This appears to indicate that the source of CDDs/CDFs in the river bank soil is not predominately historical chlor-alkali operations.

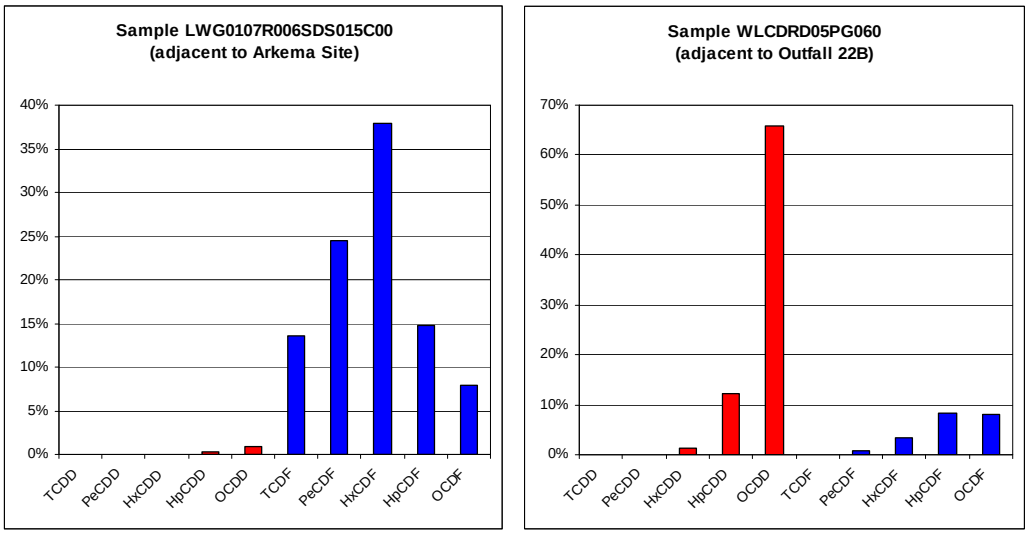
Soil samples that showed consistency were the shallow soil samples from Lots 1 and 2, which are clustered closely on Figure 2-6. These four samples, which were collected between 2- and 13-feet below ground surface (bgs) during Starlink Logistics, Inc.'s soil investigation of Lots 1 and 2, indicate relative CDD concentrations between ten and 100 times the respective CDF concentrations (96 to 99 percent CDDs). By comparison, the two deep soil samples from Lots 1 and 2 (86- to 93-feet bgs) indicated more evenly-distributed relative CDD and CDF concentrations. Although the number of samples in this data subset is small, these data indicate that the CDDs in these shallow soil samples are *not* attributable to historical chlor-alkali operations at the Site. The concentrations of CDDs detected in these samples are very low compared to other on- and off-site soil samples and may be attributable to dredge sediment historically placed on Lots 1 and 2.

2.7.1.3 *River Sediment*

Figure 2-7 provides relative CDD and CDF compositions for sediment samples from the Willamette River upstream, downstream (near the railroad bridge), and immediately adjacent to the Site. A few patterns are apparent from this figure. First, total CDD/CDF concentrations (but not TEQs) are generally higher immediately adjacent to the Site, although concentrations do span the entire spectrum for river sediments. This is driven primarily by the CDF concentrations in several samples in the vicinity of docks No. 1 and No. 2 (e.g., Sample LWG0107R006SDS015C00). Concentrations upstream of the Site are generally lower than adjacent and downstream samples.

Second, while upstream and downstream samples indicated CDD concentrations greater than the respective CDF concentrations (in-between the red and black bars on Figure 2-7), sediment samples from adjacent to the Site showed the opposite (in-between the blue and black bars on Figure 2-7). For example, the sediment sample collected from between docks No. 1 and No. 2 (LWG0107R006SDS015C00) contained 99 percent relative CDFs, whereas samples from the vicinity of Outfall 22B show a more CDD-dominated profile (see comparative fingerprints in Figure 2-9). This indicates a separate signature (and likely source) for the CDFs in these sediments samples. The high relative CDF concentrations in sample LWG0107R006SDS015C00 appear to suggest that the source of the CDDs/CDFs could be historical chlor-alkali operations at the Site.

Figure 2-9 Dioxin/furan fingerprints for sediment samples collected between No. 1 and No. 2 docks (left) and adjacent to Outfall 22B (right)



The dioxin fingerprints for the sediment samples collected downstream of the Arkema property, immediately adjacent to the railroad bridge and the RP storm water outfall 22B, are very similar in profile, relative percent CDD, and concentrations (see Figures 2-1, 2-3, and 2-7). This consistency appears to be indicative of a common source of the CDDs/CDFs in these samples. The location of the samples, and the associated consistent fingerprints which differ from those adjacent to the Arkema site, appear to indicate the nearby RP storm water outfall is the likely source of these CDDs/CDFs.

2.7.2 *Groundwater*

Detections of CDDs/CDFs in groundwater on the Site have been characterized by relatively low concentrations and predominately CDF compositions. Less than 30 percent of the wells sampled during the 2006 and 2007 monitoring events and analyzed for CDDs/CDFs indicated detectable levels of CDDs/CDFs (eight detections total). Six of the eight detections were 100 percent CDFs. Of the remaining two samples with CDD detections, the concentrations were very low ("J" or estimated values). Historical groundwater data (year 2000) from the properties immediately upgradient of the Site (e.g., Esco, Gould, and Metro) also reveal low concentration, all-CDF detections.

The CDD/CDF TEQs for the monitoring wells in the former Acid Plant area of the Site are higher than those observed on Lots 1 and 2, and in upgradient wells (Figure 2-4). Two possible explanations for CDF detections in the former Acid Plant area are: 1) CDFs are related to historical chlor-alkali operations at the Site, or 2) the elevated CDFs represent a "slug" of higher concentration groundwater moving from an upgradient source.

CDD/CDF impacts on Lots 1 and 2 appear to be minimal. Groundwater detections at the former RP site are relatively high and cover a spectrum of fingerprints (see Figure 2-2). Thus, it is possible that the CDDs/CDFs on Lots 1 and 2 result from an upgradient source (e.g., the former RP site).

3.0 IDENTIFICATION OF DATA GAPS

The following section present the rationale for identification of the data gaps addressed in this work plan.

3.1 DIOXINS/FURANS

As presented in the CSM for dioxins/furans in Section 2.0 above, sufficient data exists for groundwater, river bank soil, and sediment at the Site to allow risk assessment and evaluation of remedial alternatives in the upland FS. However, to date, upland soil samples have only been collected from Lots 1 and 2. As a result, several soil samples will be collected and analyzed for dioxins/furans as part of this data gap investigation.

Samples will be collected from two areas of the Site: the old chlorine cell room (Lot 4) and the former asbestos and brine residue ponds (Lot 2). As discussed in Section 2.4, chlorine was manufactured in the old chlorine cell room using diaphragm cells with graphite anodes. These graphite anodes are a possible source of predominately CDFs, and therefore several soil samples will be collected from this area.

The former asbestos pond received asbestos waste from the new chlorine cell room. While it is highly unlikely that the newer asbestos diaphragm chlorine cells that used titanium anodes would generate quantities of furans above industrial background levels (EPA 2006), soil samples will be collected from this area to confirm the absence of furans at concentrations indicative of a source area.

3.2 GROUNDWATER CHEMICAL DATA

The last complete round of groundwater sampling was performed at the Site in April 2007 (ERM 2007). Since that time, seven new monitoring wells have been installed that have not yet been sampled. In order to provide current groundwater data for the upland FS and the groundwater SCM, a complete round of groundwater samples will be collected and analyzed for a wide spectrum of COIs.

3.3 GROUNDWATER SOURCE CONTROL MEASURE

An important design component of the groundwater SCM is the groundwater extraction well design. Extraction wells must be properly designed and spaced to provide hydraulic capture. Hydraulic conductivities for both the shallow and intermediate groundwater aquifers (the two aquifers from which groundwater will be captured) are key parameters in the design of these extraction wells.

To date, hydraulic conductivity has been estimated based on several short pump tests performed at the Site. In order to provide a reliable estimate of hydraulic conductivity in both the shallow and intermediate groundwater aquifers, several long-term pump tests are required.

4.0 SCOPE OF WORK AND SAMPLING METHODOLOGY

4.1 GROUNDWATER MONITORING

One groundwater monitoring event will be conducted to support the design of the proposed groundwater SCM. A monitoring well location map is included in Figure 3-1. Groundwater sampling activities will be conducted in accordance with the Remedial Investigation/FS Work Plan.

Groundwater monitoring field work will include the collection of groundwater elevation data, general water quality data, and groundwater samples for laboratory analysis.

4.1.1 Groundwater Elevation Monitoring

Groundwater elevation data will be collected from monitoring wells to be sampled prior to sampling activities. The measurements will be recorded to the nearest 0.01 inch with an electronic water level indicator relative to a surveyed reference point. The water level indicator will be rinsed with isopropyl alcohol, followed by deionized water between each measurement.

4.1.2 Low Flow Groundwater Sample Collection Procedure

Groundwater samples will be collected using low flow sampling techniques from a total of 97 monitoring wells. One sample will be collected from each well, except for well MWA-75i. Samples will be collected from two depths in well MWA-75i, where a 15-foot screen interval was installed across two potential water-bearing zones. Monitoring well locations are shown on Figure 3-1. The proposed analytical schedule for each well is outlined in Table 3-1.

Groundwater samples will be collected using low-flow sampling techniques employing a submersible, air-actuated bladder pump. Low-flow purging and sampling methods will be used to obtain representative groundwater samples while minimizing the amount of purge water generated. Low-flow well purging procedures are as follows:

- New, disposable polyethylene (or equivalent) tubing will be attached to the outlet of the decontaminated pump prior to purging

each well. The pump will be slowly lowered into the well to minimize the mixing of casing water and the suspension of silt at the bottom of the well. The pump will be placed near the middle or slightly above the middle of the screened interval and as close as possible to the same depth used in past sampling events. The pumping rate will be adjusted to approximately 100 to 500 milliliters per minute, and as close to the same rate used during past sampling events based on field notes. The depth of the pump intake will be recorded in the field notes.

  - At well MWA-75i, the well will be purged and then sampled at two separate depths. The pump will first be set between 27 and 30 feet bgs. The pump will then be set between 34 to 40 feet bgs.

- Purge water temperature, pH, specific conductance, dissolved oxygen, redox potential, and turbidity will be monitored using an in-line flow cell. At a minimum, readings will be taken and recorded every three to five minutes.
- Purging will be suspended when the following parameters have stabilized for three successive readings or when at least one well casing volume has been purged:
  - Temperature: ± 1 degree Celsius;
  - pH: ± 0.1 units;
  - Specific conductance: ± 10 percent; and
  - Dissolved oxygen or turbidity: ± 10 percent.
- Purging will be continued with a goal of turbidity readings less than 10 nephelometric turbidity units (NTUs).
- After well-purging criteria are satisfied, the in-line flow cell will be disconnected and groundwater samples will be collected in the appropriate containers. Samples to be analyzed for dissolved phase constituents shown on Table 3-1 will be field filtered using a 0.45 micron filter.
- The pump will be removed from the well, disposable tubing will be discarded, and the pump will be decontaminated as described in Section 4.1.5.

When purging and sampling wells with relatively low-yield rates where continuous flow is not sustainable during well purging, the pump will be turned off and the well will be allowed to recover for a period not longer than 24 hours. After the water level in the well has recovered, the

required samples will be collected with the pump placed near the middle of the screened interval.

4.1.3 *Regenerative Cellulose Dialysis Membrane Sampling*

Several monitoring wells (MWA-15r and MWA-69) have historically elevated, but variable, concentrations of DDT. These samples are thought to be influenced by the inclusion of soil/sediment entrained in sample during collection. Previous efforts to investigate the interference of DDT absorbed to entrained soil have included decanting or filtering (0.45 micron) the samples. The results of these investigations have been inconclusive (ERM 2007).

Recent advancements in passive sampling technology include the development of regenerated-cellulose dialysis membrane (RCDM) samplers (Interstate Technology and Regulatory Council (ITRC) 2006). RCDM samplers are passive samplers consisting of a tube of high-grade regenerated-cellulose dialysis membrane filled with deionized water. The RCDM tube is held inside an outer protective layer of low density polyethylene (LDPE) mesh. The semi-permeable membrane allows diffusion of dissolved ionic species into the sampler.

The sampler is lowered into the well to the required sampling depth and secured. The sampler is left in place for approximately 2 weeks, and then retrieved. The sample bag is opened and the contents transferred into the appropriate laboratory container. The sample is then packaged and submitted for analysis as per the low flow sampling procedures (Section 4.1.2).

Currently, RCDM samplers are not commercially available, in part because they will tend to biodegrade over time. The proposed samplers will require custom construction for use at the Site following ITRC guidance on RCDM construction, modified for use in smaller (2-inch) diameter wells.

4.1.4 *Analytical Requirements*

Groundwater samples from monitoring wells will be selectively analyzed for one or more of the following:

- Volatile organic compounds by United States Environmental Protection Agency (USEPA) Method 8260B;

- Total Petroleum Hydrocarbons (Diesel range) by method NWTPH-Dx;
- Polycyclic Aromatic Hydrocarbons by USEPA Method 8270;
- Organochlorine pesticides by USEPA Method 8081A;
- Herbicides (silvex, 2,4-D) by USEPA 8151A;
- Dioxin and Furans by USEPA Method 8290;
- Chloride by USEPA Method 300.0;
- Perchlorate by USEPA Method 314.0;
- Hexavalent Chromium by USEPA Method 7195;
- Dissolved metals (arsenic, aluminum, cadmium, copper, lead, nickel, zinc, iron, and manganese) by USEPA Method 6010B; and
- Dissolved Methane by Method RSK 175.

The analytical requirements for individual monitoring wells are detailed in Table 3-1. These analyses are in accordance with the Quality Assurance Project Plan (QAPP) for the RI/FS Work Plan and addenda.

Based on the results of the April 2007 site-wide groundwater monitoring, the dissolved metals analytical schedule has been reduced in order to focus on areas that are potentially impacted by COIs, and provide information for the design of the proposed groundwater SCM. The proposed changes in analytical scope are as follows:

- Arsenic sampling to be focused on those areas that have historical arsenic concentrations greater than the Portland Harbor Joint Source Control Strategy screening level value of 50 micrograms per liter (µg/L), and have low or high pH.
- Removing total chromium from the list of dissolved metals analyses due to the low solubility and low toxicity of chromium and the historically low concentrations following implementation of the Hexavalent Chromium IRM. Hexavalent chromium will continue to be monitored.
- Manganese sampling to be focused on providing information for the planning and design of the aquifer pumping test and groundwater extraction and treatment system.

The samples collected for hexavalent chromium analysis will be delivered to Columbia Analytical Services in Kelso, Washington. All other samples

will be delivered either by hand or shipped to TestAmerica Laboratories in Beaverton, Oregon for analysis.

4.1.5 *Equipment Decontamination*

All non-disposable sampling equipment will be decontaminated prior to use and between sample locations. Sampling equipment will be scrubbed with an aqueous solution of laboratory-grade detergent (e.g., Alconox), followed by a rinse with tap water, followed by an iso-propyl alcohol rinse, followed by a rinse with deionized water. To avoid cross contamination between samples, the disposable bladder on the pump and the polyethylene tubing will be changed between each well.

4.1.6 *Investigation-Derived Waste Management*

Decontamination fluids and purge water will be contained in segregated 55-gallon drums. ERM will be responsible for collecting, sampling, characterizing, and labeling containers, as necessary. ERM will be responsible for coordinating disposal of investigation-derived wastes.

4.1.7 *Quality Assurance/Quality Control*

Field quality assurance/quality control (QA/QC) samples will be collected in accordance with the QAPP. Trip blanks will be included in each cooler that contains volatile organic compound samples. One field duplicate sample will be collected for every 20 samples with a minimum of one for each analyte. In order to verify efficacy of decontamination of equipment, one rinsate sample will be collected for every 20 samples with a minimum of one per sampling event. QA/QC samples will preferentially be collected at wells known to have significant concentrations of the selected analytes. A summary of all groundwater analyses, including the QA/QC samples, is provided in Table 3-2.

Field notes taken during sampling activities will be recorded in the field log book using indelible ink. Samples will be immediately labeled following collection, with the required data. Sample data will be entered into the Chain-of-Custody record to ensure proper tracking and control. Samples will be shipped or delivered to the laboratory in sealed containers and accompanied by the Chain-of-Custody record. QA/QC samples, including trip blanks, field duplicates, and rinsate samples will be collected, controlled, and shipped in the same manner as normal field samples.

4.2 *SOIL SAMPLING*

Soil samples will be collected from three locations (B-122 to B-124) near the historical chlorate cell room (now identified as the former maintenance shop) to assess for the presence of dioxins and furans. Dioxin and furan samples will also be collected from the former brine residue pond (B-125) and the former asbestos pond (B-126). Proposed soil sampling locations are shown on Figure 3-2.

4.2.1 *Utility Clearance*

Prior to drilling, the boring locations will be marked in the field for inspection and approval by a facility representative familiar with utilities at the Site. The boring locations will be cleared for underground utilities by facility personnel. In addition, the Oregon Utility Notification Center will be notified prior to any drilling activities. In the event that one of the planned locations interferes with subsurface utilities, the boring will be relocated as close to the original location as possible. Relocated drilling locations will be approved by ERM's project/site manager and an LSS representative.

Additionally, attempts will be made to hand-clear all selected drilling locations to a depth of 4 feet bgs.

4.2.2 *Soil Sampling Approach*

Soil samples will be collected from locations B-122, B-123, and B-124 using a hand auger (or equivalent) to 4 feet bgs and by direct-push drilling rig from 4 feet bgs to the top of the water table (approximately 10 feet bgs). One soil sample will be collected from each of B-125 and B-126 at approximately 10 feet bgs by direct-push drilling rig.

Soil samples will be collected in 2-foot intervals (i.e. 0 to 2 feet bgs, 2 to 4 feet bgs, etc.). Each interval will be composited by mixing in a stainless steel bowl and then transferred to laboratory-provided sample collection jars.

Composite samples collected from the 0 to 2-foot interval will be analyzed within standard turn-around-time. Deeper sample intervals will be held by the laboratory at 4 degrees Celsius. Samples from deeper sample intervals will be released for analysis if data indicates a need for further vertical delineation.

4.2.3 *Sample Identification*

Samples will be identified by the sample location (B-122 through B-126) and the sample depth interval. For instance, the soil sample collected from 4 to 6 feet bgs at location B-122 will be identified as B-122-4-6.

4.2.4 *Analytical Method*

All soil samples will be analyzed for dioxins and furans by USEPA Method 8290.

4.2.5 *Equipment Decontamination*

All reusable drilling and sampling equipment will be decontaminated prior to use and between borings or sample collection. Sample equipment may include the drill sample rod and shoe, hand auger, soil mixing bowl, and mixing trowel. Sampling equipment will be scrubbed with an aqueous solution of laboratory-grade detergent (e.g., Alconox), followed by a rinse with tap water, followed by a rinse with isopropyl alcohol, followed by a rinse with deionized water. All equipment will be positioned after the decontamination to preclude inadvertent contamination prior to reuse.

4.2.6 *Investigation-Derived Waste Management*

Decontamination fluids and soil cuttings will be contained in segregated 55-gallon drums. ERM will be responsible for collecting, sampling, characterizing, and labeling containers, as necessary. ERM will be responsible for coordinating disposal of investigation-derived wastes.

4.2.7 *Quality Assurance/Quality Control*

Field QA/QC samples will be collected in accordance with the QAPP, included in the Remedial Investigation/FS Work Plan, and will include the following samples:

- One field duplicate sample will be collected from a shallow soil sample within the study area. The field duplicate will be identified with the sample location name and depth followed by a "-D".
- One rinsate sample will be collected in order to verify efficacy of decontamination of equipment. The rinsate blank will be collected by collecting deionized water poured over the shoe of the sample collection rod and the hand auger collection bucket. Sample

identifiers for equipment rinsate blanks will be the same as the primary sample collected immediately prior to the rinsate blank, followed by an "R."

Field notes taken during sampling activities will be recorded in the field log book using indelible ink. Samples will be immediately labeled following collection, with the required data. Sample data will be entered into the Chain-of-Custody record to ensure proper tracking and control. Samples will be shipped or delivered to the laboratory in sealed containers and accompanied by the Chain-of-Custody record. QA/QC samples, including trip blanks, field duplicates, and rinsate samples will be collected, controlled, and shipped in the same manner as normal field samples.

4.3 AQUIFER TESTING PROGRAM

4.3.1 Objectives

Pumping tests will be performed on four new recovery wells installed near the proposed alignment of the barrier wall (Figure 4-1 and 4-2). These tests will be performed to obtain better estimates of the hydraulic properties of the Shallow and Intermediate Zones, and the radius of influence of pumping wells in this area. The drawdown data from the aquifer tests will also used to re-calibrate the groundwater flow model developed for the Groundwater SCM Focused Feasibility Study (ERM 2008).

4.3.2 Background

Currently, limited pumping test data are available from the Arkema facility to support the design of the barrier wall system. Short-term (4-hour), constant-rate pumping tests of three wells screened in the Shallow Zone were performed in April 2006. Two of the wells tested, PT-1 and PT-2, are located near the former Chlorate Cell Room and the third well, PT-3, is located downgradient of the former Chlorate Cell Room near the Willamette River (Figure 4-3). Only one of the wells tested, PT-2, had a significant yield (27.6 gallons per minute [gpm]) during testing. The other two wells had yields of less than 1.0 gpm and irregular drawdown responses indicating possible damage to the well borings during drilling. A more detailed discussion of the pumping tests performed on these three wells is provided in *Arkema Active Pilot Test Workplan, Appendix B, Hydraulic Testing Summary* (GeoSyntec 2006).

The following sections describe components of the aquifer testing program.

4.3.3 *Observation and Recovery Well Design and Installation*

4.3.3.1 *Observation Well Design and Installation*

Four shallow zone (i.e., approximately 30 feet bgs) and four intermediate zone (i.e., approximately 50 feet bgs) observation wells will be used during aquifer testing to monitor the effects of pumping in the shallow and intermediate aquifers. A pair of observation wells will serve to monitor the effects of pumping in each aquifer, at each recovery well location. The observation wells will be spaced approximately 15 feet and 50 feet from each recovery well (see Figures 4-1 and 4-2 for recovery well locations). Existing monitoring wells MWA-2, MWA-8i, MWA-41, and MWA-60 will be assessed (location and screened interval) for feasibility of use as observation wells.

The observation wells will be constructed such that the screen intervals are approximately the same as the screened interval of the recovery wells (see Section 4.3.3.2 for recovery well design). The observation wells will be installed using sonic drilling techniques, and continuous soil cores will be collected and described geologically by ERM personnel.

Representative soil samples will be collected from screen zone intervals from two shallow observation wells and two intermediate observation wells. Soil samples will be collected, described, and submitted to a geotechnical laboratory for grain size (sieve) analysis. The results of the sieve analyses will be used to properly size the recovery well filter packs and well screen slot size, in order to optimize the operational efficiency of each recovery well.

Construction specifications for the observation wells were based on previous boring logs and existing monitoring wells in the proposed installation areas, therefore, the following construction information is assumed. Modifications will be made based on actual observations and data. Observation wells will be constructed using 2-inch diameter, Schedule 40 PVC, flush-jointed well screen and riser pipe. The well screens will have 0.010-inch slots and have a sand pack consisting of No. 2/12 Morie sand (or equivalent) installed to a minimum height of 2 feet above the top of the well screen. Upon completion of the placement of the sand pack, bentonite chips will be installed to approximately 2 feet bgs. Observation wells will be completed with lockable well caps and flush-

mounted steel traffic-rated well boxes concreted to depth of approximately 2 feet bgs.

4.3.3.2 *Recovery Well Installation and Design*

Two shallow and two intermediate zone recovery wells will be installed for aquifer testing to determine hydraulic properties of the aquifers for the design of the barrier wall. A pair of recovery wells (one shallow and one intermediate) will be installed at the north and south ends of the proposed barrier wall alignment, as presented on Figures 4-1 and 4-2. The recovery well locations were selected such that:

- The recovery wells can be used as part of the proposed groundwater extraction system; and
- Impacted groundwater removed during the pump tests can be managed efficiently and cost effectively.

The screen intervals for the recovery wells were identified based on previous borings and monitoring wells completed in the vicinity of the north and south barrier wall end points. The actual screen intervals will be based on lithologic observations during well installation. The recovery well screen intervals are presented in Table 4-1.

The recovery wells will be installed using hollow stem auger drilling techniques. Sonic drilling techniques will not be used so as to not damage the aquifer during well installation. For the shallow zone recovery well installations, a borehole will be advanced to the top of the shallow-intermediate silt horizon using 6-1/4-inch internal diameter (ID) augers. Split spoon soil samples will be collected every five feet to a depth of 25 feet bgs and continuously thereafter, until the silt horizon is identified. All soil samples will be described geologically by ERM personnel.

For the intermediate zone recovery well installations, a borehole will be advanced to the top of the underlying shallow-intermediate silt horizon using 12-1/4-inch ID augers. Split spoon soil samples will be collected every five feet to a depth of 25 feet bgs and continuously thereafter, until the silt horizon is identified. Once the silt horizon is identified, a permanent conductor casing will be installed within the augers in the borehole and will be backfilled with cement grout. After the grout has cured, a borehole will be advanced through the conductor casing to the top of the deep zone (approximately 50 ft bgs) using 8-1/4-inch ID augers. Split spoon sampling will resume at a frequency of every five feet below the shallow-intermediate silt.

Recovery wells will be constructed using 4-inch diameter, stainless steel well screens (length as indicated above) and stainless steel casings. Recovery well sand pack and screen slot size will be determined based on the results of the sieve analyses completed by the geotechnical laboratory during the installation of the observation wells. Upon completion of the placement of the sand pack, bentonite chips will be installed to approximately 2 feet bgs. Recovery wells will be completed with lockable well caps and flush-mounted steel traffic-rated well boxes concreted to depth of approximately 2 feet bgs.

4.3.3.3 *Monitoring and Recovery Well Development*

The objectives of the observation and recovery well development will be to remove fines (silts and fine sands) from the filter pack and the natural formation in the vicinity of the well screen. Removal of the aforementioned materials will result in maximizing the well efficiency, porosity, permeability, and the hydraulic communication between the well and the adjacent formation. Proper well development increases both the reliability of data from aquifer tests and the operating efficiency of the well.

Following completion, the monitoring well and recovery well installations each will be developed by purging via a submersible pump and surge-block methods (Driscoll 1986). Each recovery well will be developed for a maximum duration of approximately 10 hours, or until sand-free/silt free water is obtained (i.e., less then 50 NTUs). Each observation well will be developed for a maximum of 4 hours or until sand free/silt free water is obtained (i.e., less than 50 NTUs).

Water generated during well development activities will be managed in accordance with the steps outlined in Section 4.3.5.10.

4.3.4 *Recovery Well Stepped-Discharge Testing*

Following well development, stepped-discharge tests will be performed on each of the four newly installed recovery wells to determine a sustainable discharge rate for the constant rate pumping test. Ground water will be pumped with a 3-inch submersible pump which is temporarily installed in the well. A total of three successive higher rate pumping steps will be conducted at flow rates to be determined (i.e., 5, 10 and 15 gpm). Each step rate will be maintained until drawdown appears

to stabilize and/or a maximum duration of four (4) hours per pumping rate (i.e., no longer than 12 hours per recovery well). Detailed procedures and guidelines for conducting the stepped-discharge tests are presented in Appendix A.

Step test data will be used to determine, specific capacities and specific drawdowns for each step rate and will be utilized in selecting the most appropriate pumping rate for the 24-hour constant rate aquifer test.

4.3.5 Groundwater Elevation Monitoring

4.3.5.1 Objectives

The objectives of the constant rate pumping tests will be to estimate the hydraulic properties of the shallow and intermediate zones and the radius of influence of pumping wells in this area for the design the barrier wall system. It has been assumed that each pump testing at each recovery well will be conducted independently. Detailed procedures and guidelines for conducting the constant rate discharge tests are presented in Appendix A.

4.3.5.2 Background Ground Water Level Monitoring

In order to facilitate the analysis of background water level fluctuations, hourly background water level data will be obtained from an on-site monitoring well (to be determined) that is located outside the expected area of influence of the tests. Hourly background water level data will be collected a minimum of 24 hours before the pumping tests begin, during the 24-hour test, and for a minimum of 24 hours after pumping is stopped. The water level data will be obtained using remote data loggers equipped with a pressure-sensitive transducer (one background well).

4.3.5.3 Synoptic Water Level Measurements

Static water level measurements prior to pumping tests will be collected from all on-site monitoring and observation wells. The depth-to-water in each well will be measured from the previously surveyed permanent elevation marks at the top of each inner well casing, and the measurements will be recorded in a field notebook. Water level measurements will be taken to the nearest 0.01 foot and double-checked to ensure that the readings are accurate.

The depth-to-water level measurements will be used to calculate ground water elevations in the shallow and intermediate zones, and to construct ground water contour maps.

4.3.5.4 *Weather Data*

Prior to initiating the pumping tests, barometric pressure will be monitored and recorded. The barometric monitoring will continue throughout the tests and for 24 hours following completion of the tests. The barometric pressure transducer (i.e., BaroTroll) will be placed in one well (to be determined) during the pumping tests.

4.3.5.5 *Equipment*

In order to perform the pumping tests of the four recovery wells, a 3-inch diameter submersible pump will be temporarily installed in the wells by a drilling subcontractor. The submersible pump will be suspended in the well and will be equipped with check valves, a pressure gauge, an instantaneous and totalizing flow meter, y-fitting and valve after flow meter to connect an inline flow through cell for measurement of field parameters and a gate valve for discharge rate control. The groundwater discharge will be directed to the on-site holding tanks and additional storage as described in Section 4.3.5.10

4.3.5.6 *Pumping Test Period*

A constant-discharge pumping test will be performed at each of the newly installed recovery wells. The duration of each pumping test will be 24 hours, and the discharge rate of the pump will be held at a constant rate as determined by the step test at each well. During the first hour of the pumping test, the discharge rate in each pumping well will be monitored and recorded from the instantaneous and totalizing flow meter as frequently as practical. At a minimum, the discharge rate will be checked four times after the first hour, throughout the pumping test period.

4.3.5.7 *Groundwater Sample Collection*

Groundwater samples will be collected from each of the four recovery wells during pump testing. Groundwater samples will be collected at the startup, during the mid-point, and at the completion of the constant rate pumping tests and will be analyzed for VOCs, pesticides, dissolved metals, perchlorate, and chloride using the methods described in Section

4.1 of this Work Plan. Samples will be delivered to Test America Inc., of Portland, Oregon and will be analyzed at a standard turnaround time.

4.3.5.8 Drawdown Measurements

During the pumping tests, water level measurements will be collected from the pumping well and the two new observation wells associated with each of the recovery wells using pressure transducer/data logging systems. Vented pressure transducer cables will be used, which will compensate for any changes in barometric pressure that might affect the water level measurements.

At the start of pumping, water level measurements for the aforementioned observation points and pumping well will be collected. The data loggers will be programmed to record logarithmically for 30 minutes followed by linear measurements every 5-10 minutes for the remainder of the tests.

As previously described, hourly water level data will be collected from a background monitoring well during the background monitoring period, the 24-hour pump test and the recovery period.

4.3.5.9 Recovery Measurements

At the 24 hour point of the pumping test, the pump in the recovery well will be shut off and the recovery water level data will be collected for approximately 24 hours. The recovery water level data will be collected in each of the observation wells associated with the recovery well that was pumped using data loggers equipped with pressure-sensitive transducers.

At the end of pumping, water level measurements for the aforementioned observation points and for the pumping well will be collected. The data loggers will continue to collect measurements every 5-10 minutes until the 24-hour recovery period is complete.

As previously described, hourly water level data will be collected from the background monitoring period, the 24-hour pump test and the recovery period.

4.3.5.10 Pump Test Water Conveyance and Disposal

Development and pump test water will be discharged to the Publicly Owned Treatment Works sewer network with permission from the City of Portland – Bureau of Environmental Services (BES). ERM will coordinate

with the City of Portland and will complete permitting requirements and the BES Batch Discharge Authorization Application prior to discharge of any development or pumping test water generated at the Site (see Appendix B).

Water generated during the well development and testing will be conveyed to the existing on-site tank for temporary storage and additional tank storage (i.e., 20,000 gallon steel tank) as necessary, through the existing on-site piping network. Prior to well development and testing activities, the on-site piping conveyance network will be checked by ERM personnel, and damaged or aged sections will be replaced as necessary.

Water collected in the tanks after well development and testing activities will be batch sampled for the presence of VOCs, pesticides, metals, perchlorate, and chloride. Batch samples will be submitted to Test America, Inc. of Portland, Oregon on an expedited 24-hour turnaround time. The analytical results from each batch test will be used to determine if concentrations meet the applicable discharge values. If the values exceed the approved discharge criteria, the accumulated water will need to be treated prior to discharge. As such, accumulated development and pump test water will be pumped through liquid phase granular activated carbon to remove the dissolved organic contamination ensuring that discharge limitations are achieved. Therefore, mobilization of the granular activated carbon treatment vessel prior to receipt of the analytical results of the first batch test will be necessary in order to meet the project schedule.

If discharge to the Publicly Owned Treatment Works is approved, water will be directed to a pre-designated sanitary sewer manhole. Water discharged to the sanitary sewer will not exceed the discharge rate limit established in the permit.

4.3.6 Calculation of Aquifer Parameters

4.3.6.1 Analytical Methods

The water level data from the constant-discharge and recovery tests will be analyzed to obtain estimates of the hydraulic conductivity and storage coefficient of the shallow and intermediate zones. The water level data will be analyzed using drawdown and recovery models that are appropriate for both the type of tests that are performed and the groundwater flow conditions at the Site. The flow test data will analyzed

with AQTESOLVE for Windows™, a software package for estimated aquifer properties from slug and pumping tests (HydroSOLVE, 2003).

The effective radius of influence of the pumping wells will also be estimated from the measured drawdown in the observation wells by projecting a linear regression of the maximum drawdown versus the log of the radial distance between the observation wells and the pumping well to zero drawdown according to the method described by Dawson and Istok (1991).

5.0 PROJECT SCHEDULE

The project is expected to start upon approval of this work plan. The following preliminary schedule is anticipated:

- Fieldwork completion: July 2009;
- Draft Report: January 2010; and
- Review Meeting: upon ODEQ review.

This schedule may be adjusted as needed.

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Figures

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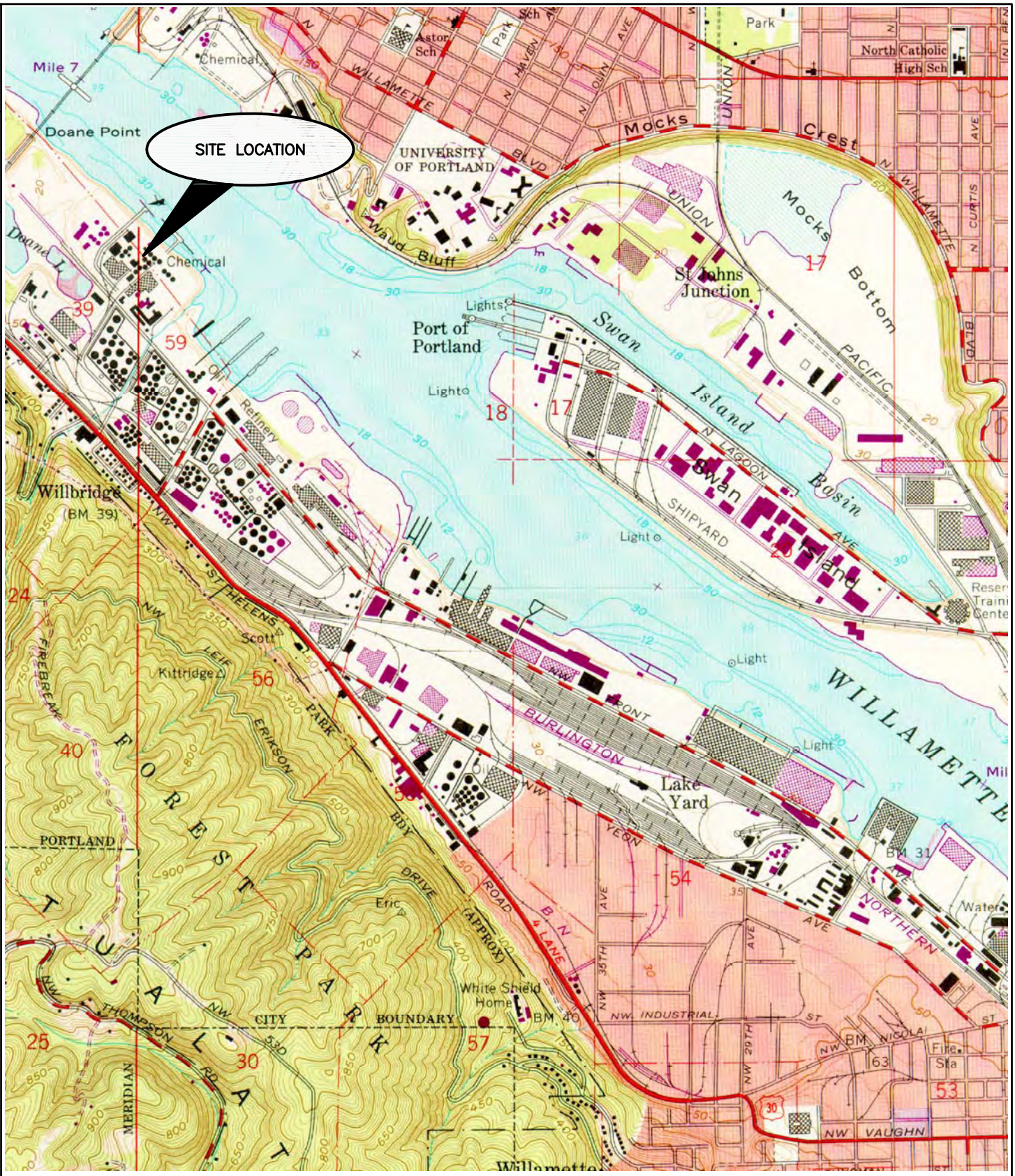

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1 1/2 0 1 MILE

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1 .5 0 1 KILOMETER

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References:
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Dated: 1961; Photorevised 1970 and 1977

Figure 1-1
Site Location Map
Arkema Inc.
Portland, Oregon

ERM 03/09

Project No. 0093634.06
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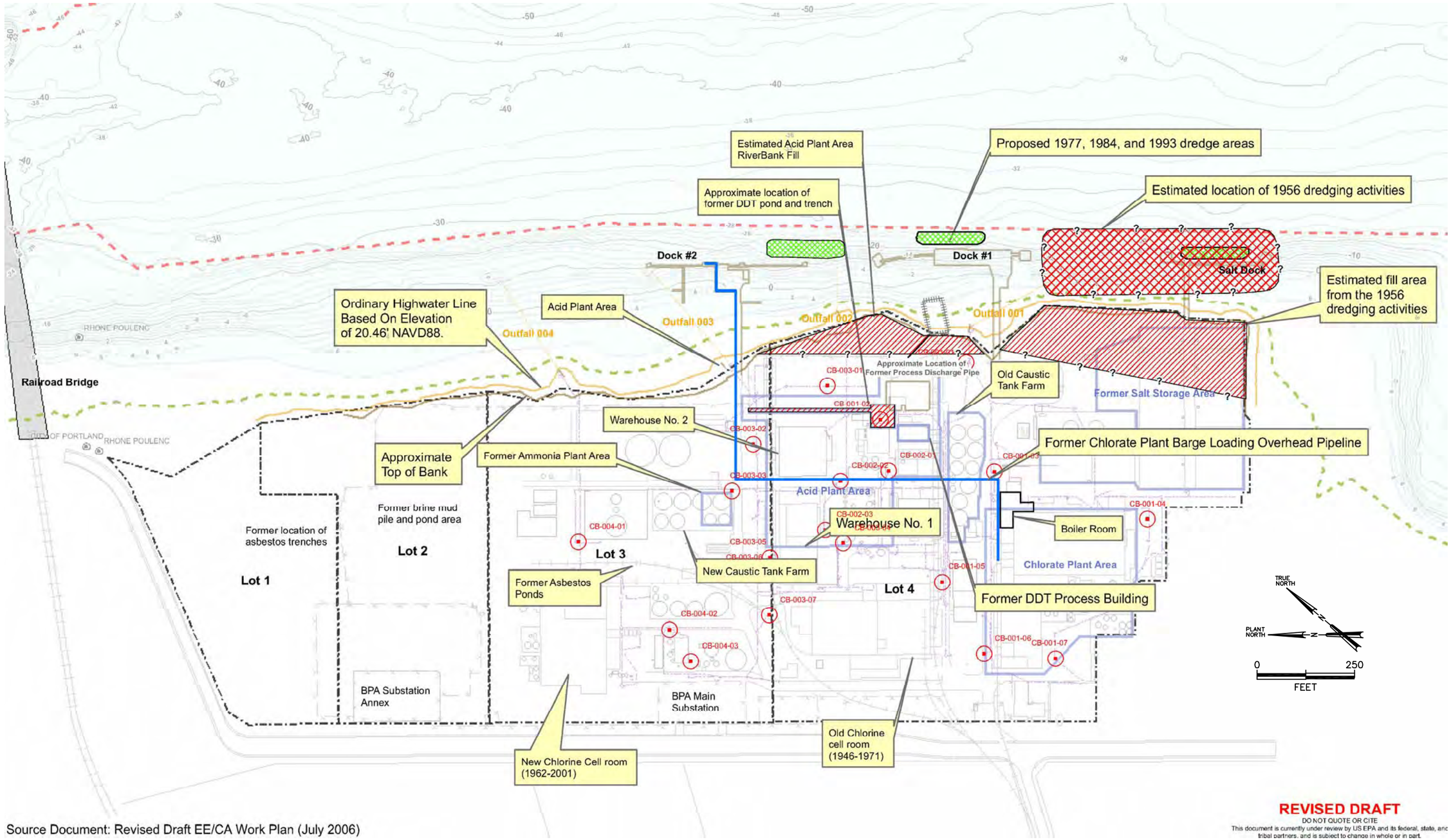


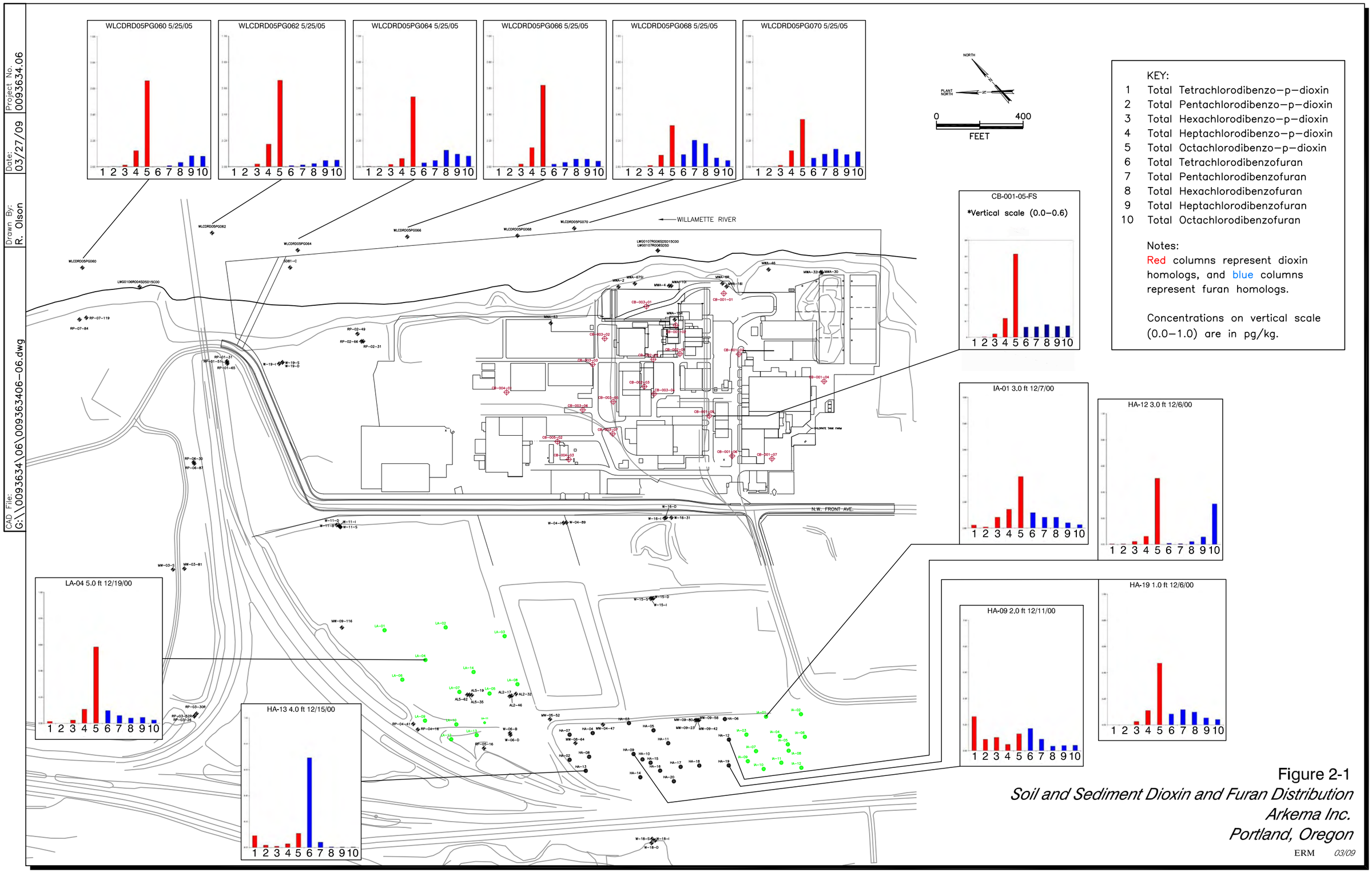
Source Document: Revised Draft EE/CA Work Plan (July 2006)

REVISED DRAFT
DO NOT QUOTE OR CITE
This document is currently under review by US EPA and its federal, state, and tribal partners, and is subject to change in whole or in part.

NOTE
Most buildings and structures noted on this diagram have been demolished and/or removed.

- Ordinary High Water
- Top of Bank
- E-Sewer-L
- Storm Drain
- 12ft_Contour
- Navigation Channel
- Bridges
- Property Lines
- Outfalls
- Catch Basins
- Overhead Pipeline
- Estimated Fill Area
- Proposed 1977, 1984, and 1993 dredge areas
- Estimated Dredged Area

Figure 1-2
Current and Historic Upland Contaminant Sources
Arkema Inc.
Portland, Oregon
ERM 03/09



KEY:

1 Total Tetrachlorodibenzo–p–dioxin
2 Total Pentachlorodibenzo–p–dioxin
3 Total Hexachlorodibenzo–p–dioxin
4 Total Heptachlorodibenzo–p–dioxin
5 Total Octachlorodibenzo–p–dioxin
6 Total Tetrachlorodibenzofuran
7 Total Pentachlorodibenzofuran
8 Total Hexachlorodibenzofuran
9 Total Heptachlorodibenzofuran
10 Total Octachlorodibenzofuran

Notes:
Red columns represent dioxin homologs, and blue columns represent furan homologs.

Concentrations on vertical scale (0.0–1.0) are in pg/kg.

Figure 2-1
Soil and Sediment Dioxin and Furan Distribution
Arkema Inc.
Portland, Oregon

ERM 03/09

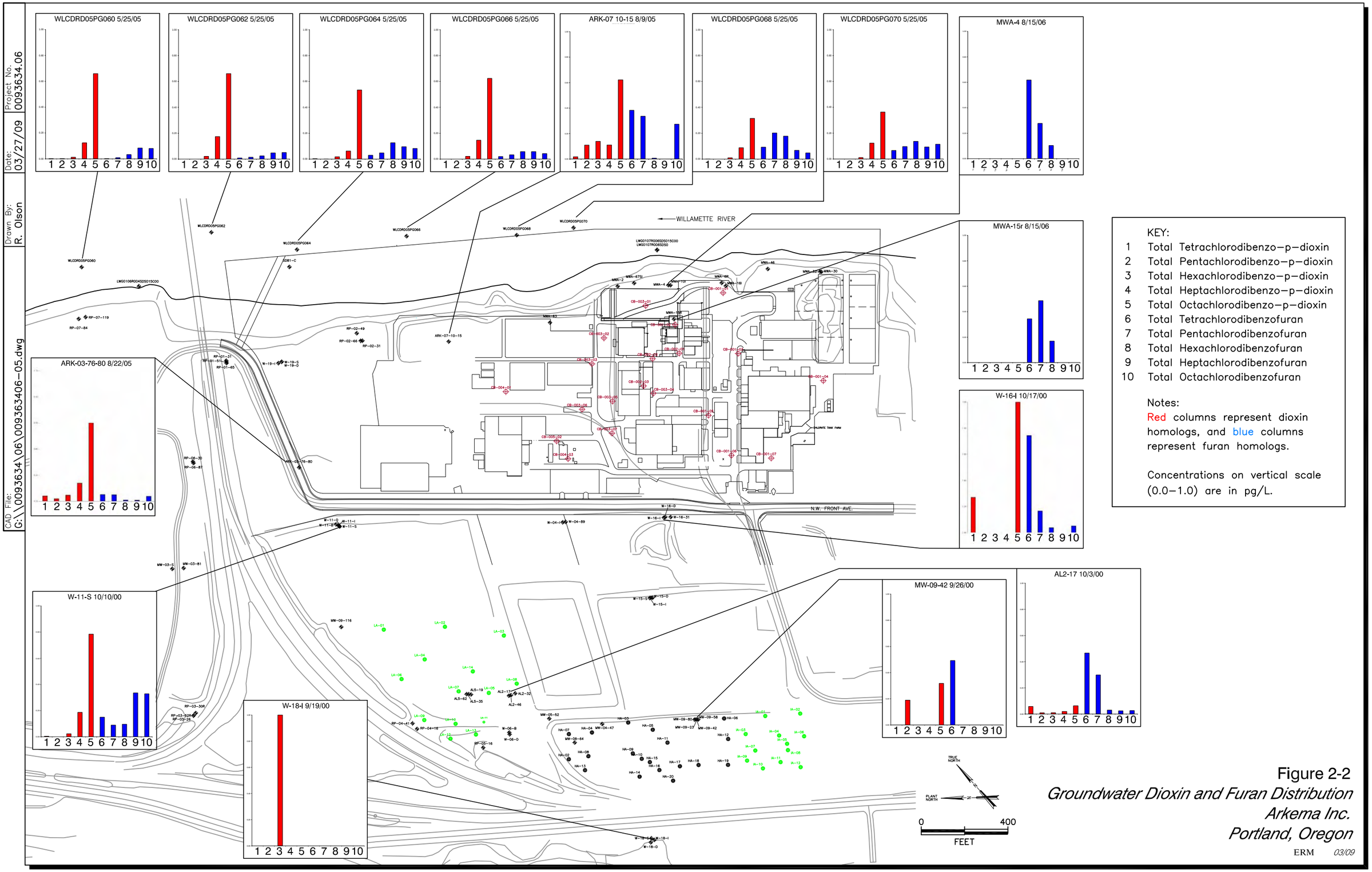
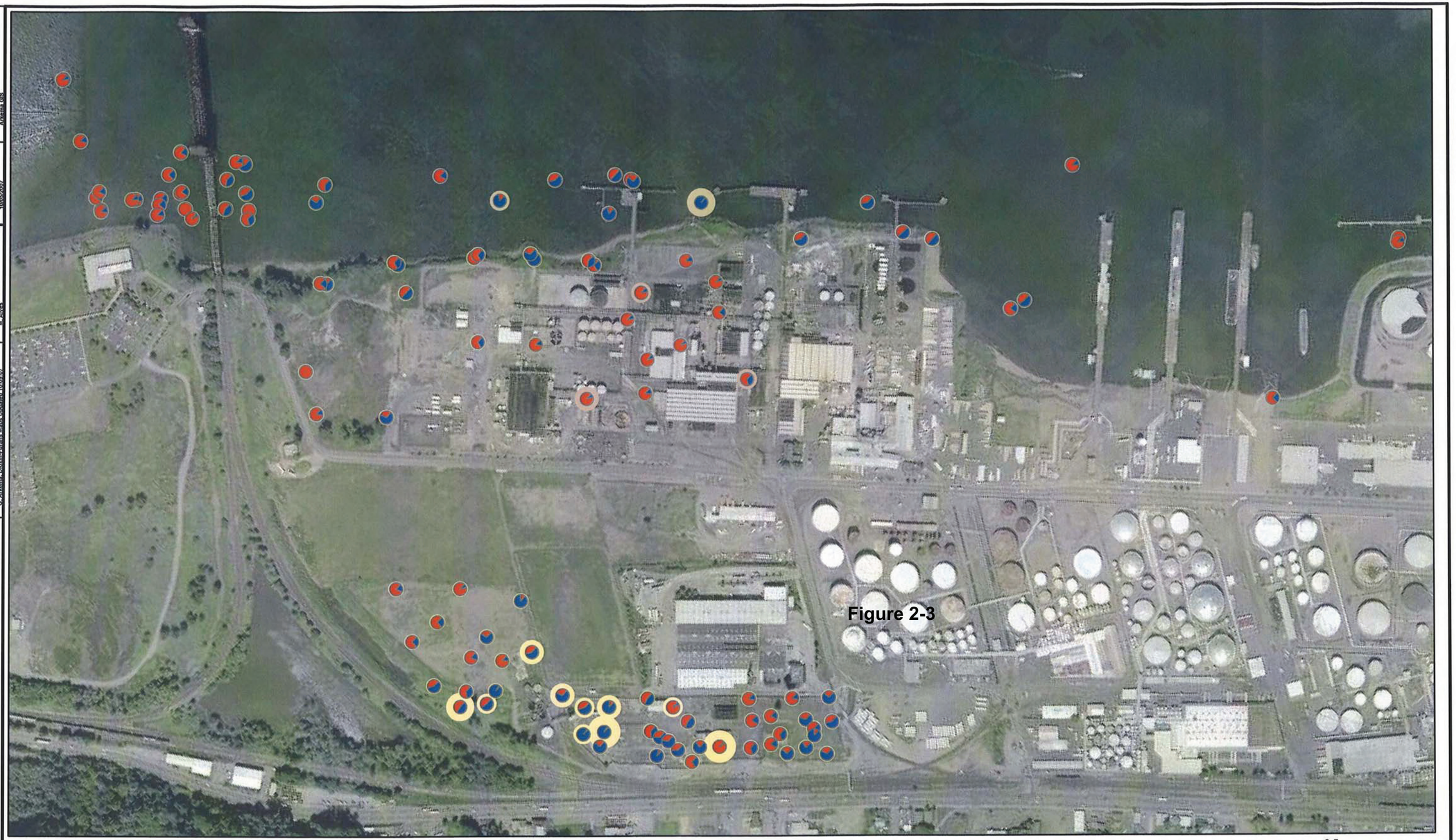


Figure 2-2
Groundwater Dioxin and Furan Distribution
Arkema Inc.
Portland, Oregon



Project Number
Arkema GIS

Date
10/05/2007

Drawn By:
M. Alves

GIS File
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Figure 2-3

Figure 2-3

Soil/River Sediment/Catch Basin Sediment
Dioxin-Furan Data
Arkema
Portland, OR

ERM 10/07

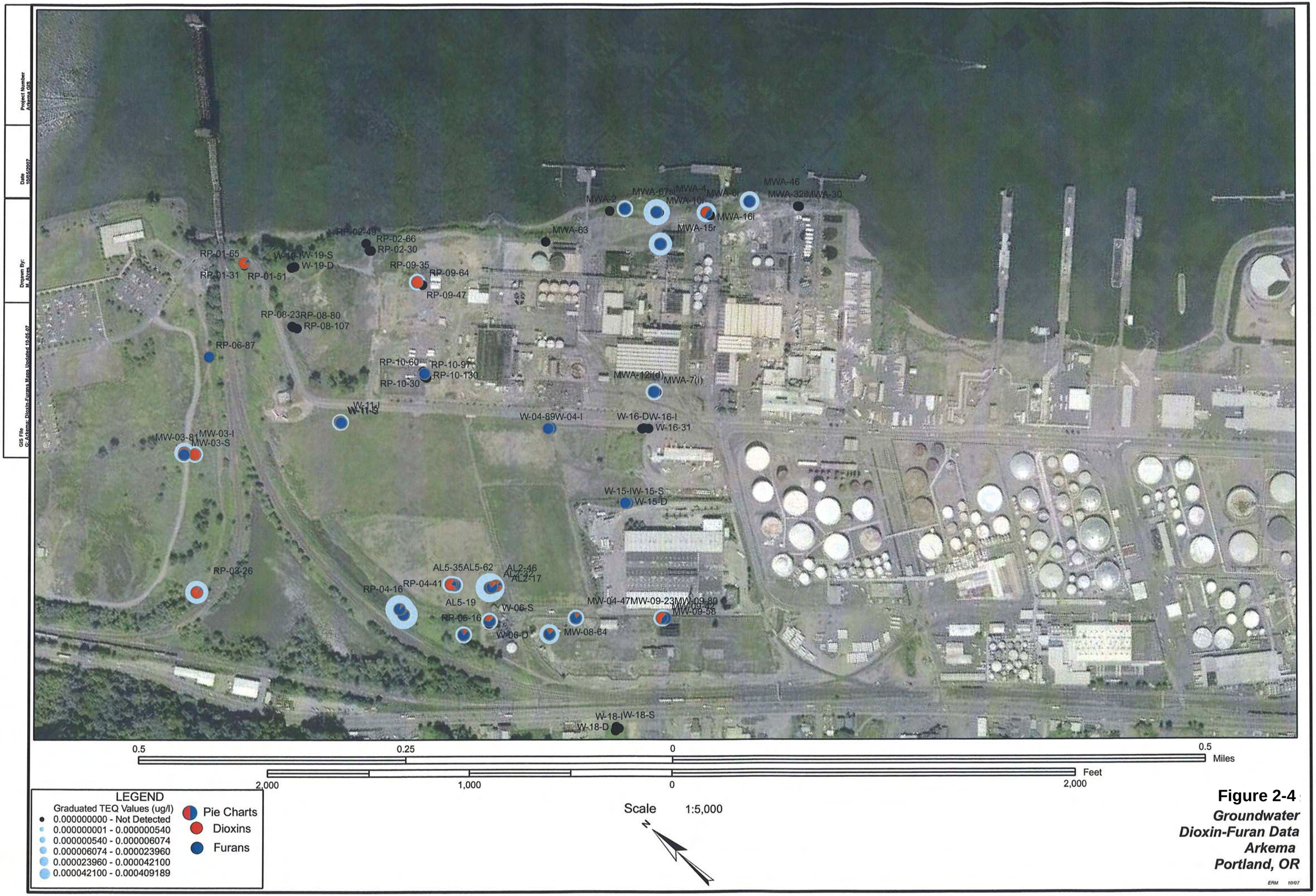

Figure 2-4

Groundwater Dioxin-Furan Data Arkema Portland, OR

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Date: 03/13/09
Drawn By: J.E./C.T.
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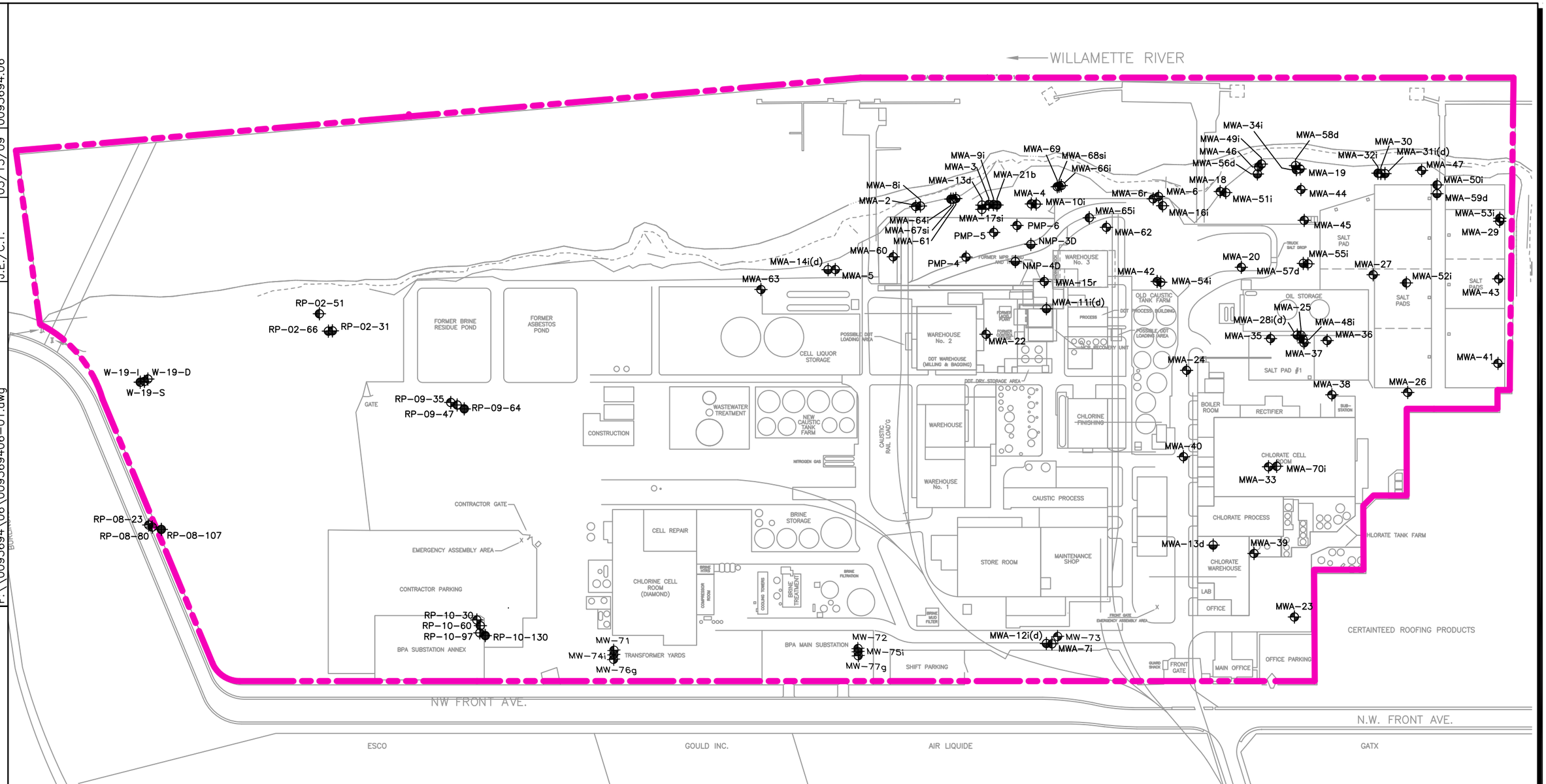


LEGEND

- Monitoring Well, Shallow Zone
- Monitoring Well, Shallow–Intermediate Zone
- Monitoring Well, Intermediate Zone
- Monitoring Well, Deep Zone
- Monitoring Well, Gravel Zone
- Monitoring Well, Basalt

NOTE
Most buildings and structures noted on this diagram have been demolished and/or removed.

TRUE NORTH
PLANT NORTH
0 200
FEET

Figure 3-1
Monitoring Well Locations
Arkema Inc.
Portland, Oregon

ERM 03/09

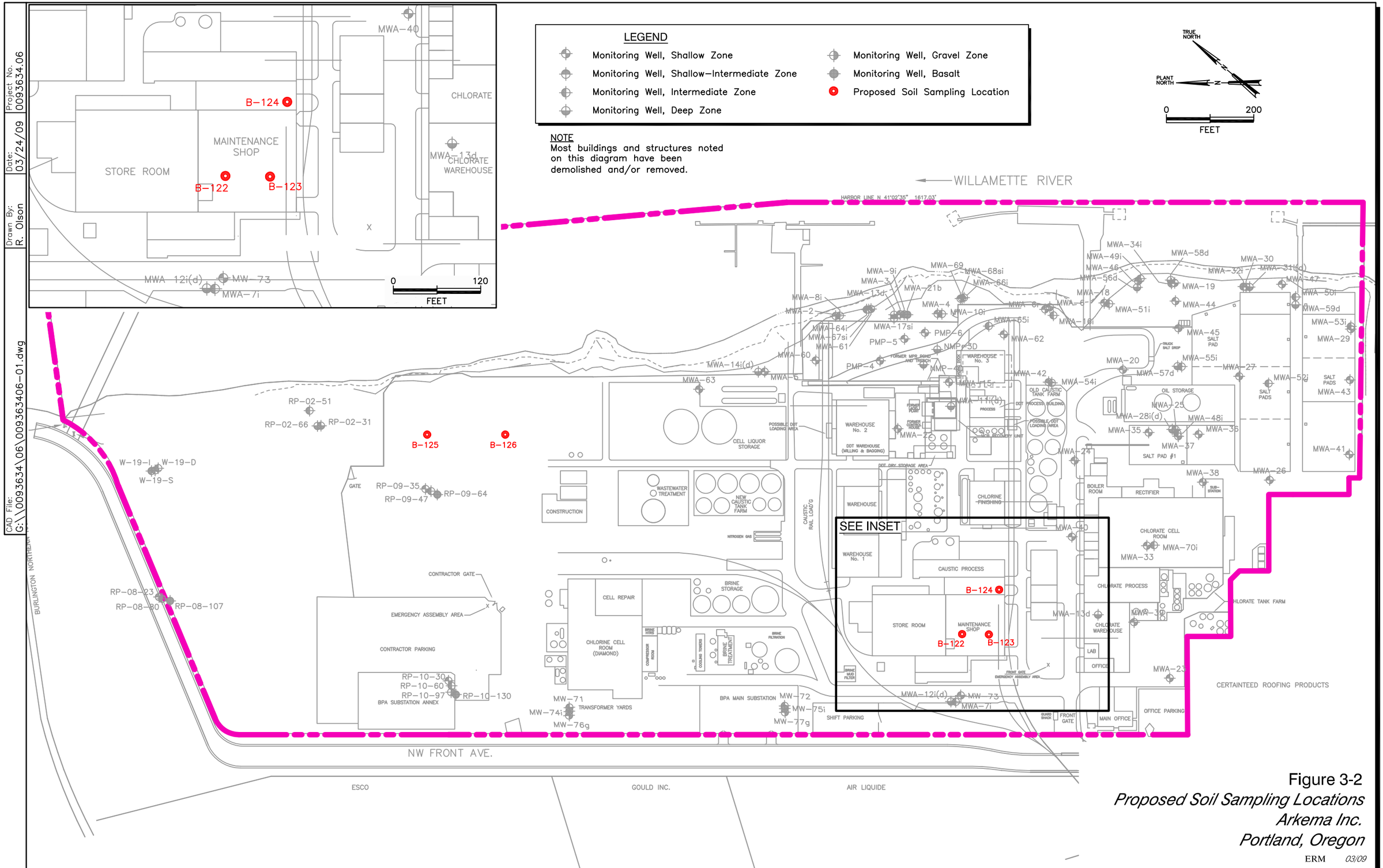


Figure 3-2
Proposed Soil Sampling Locations
Arkema Inc.
Portland, Oregon

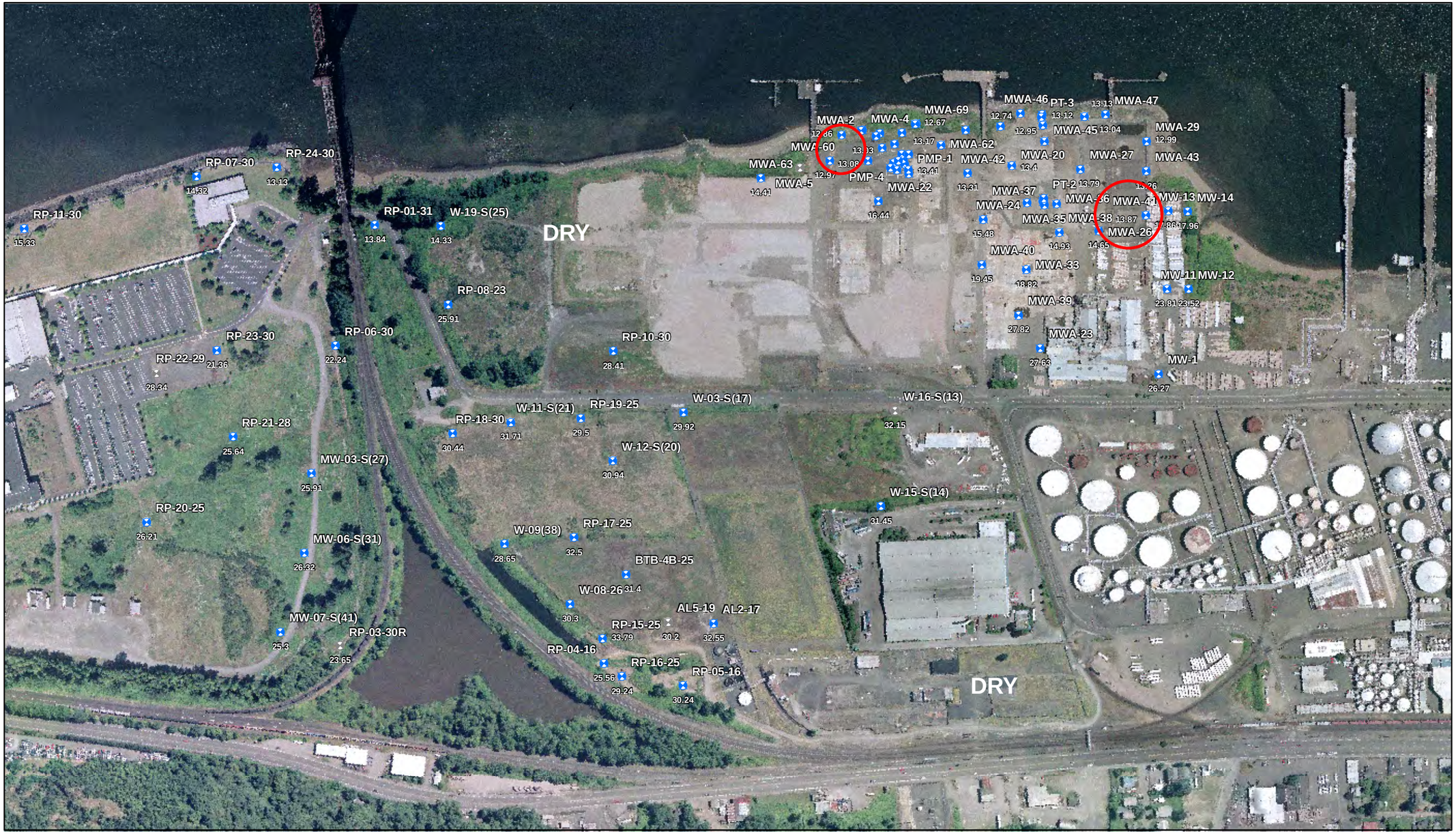
ERM 03/09

Project No. 0057055

Date: 10/03/07

Drawn By: T. Cota

GIS File:



Aerial Photography - July, 2005

LEGEND

Shallow Zone Monitoring Well

Monitoring Well Not Used for Contouring

True North

Plant North

0 400 800

Feet

General Area of Proposed Pumping and Observation Wells

Figure 4-1

Location of Shallow Zone Pumping Wells

March 2009

Arkema, Inc.

Portland, Oregon

ERM 03/09

Project No. 0057055

Date: 10/03/07

Drawn By: T. Cota

GIS File:

Aerial Photography - July, 2005

LEGEND

Intermediate Zone Monitoring Well

Monitoring Well Not Used for Contouring

True North

Plant North

0 400 800

Feet

General Area of Proposed Pumping and Observation Wells

Figure 4-2

Location of Intermediate Zone Pumping Wells

March 2009

Arkema, Inc.

Portland, Oregon

ERM 03/09

Project No. 0093634.06
Date: 03/24/09
Drawn By: R. Olson
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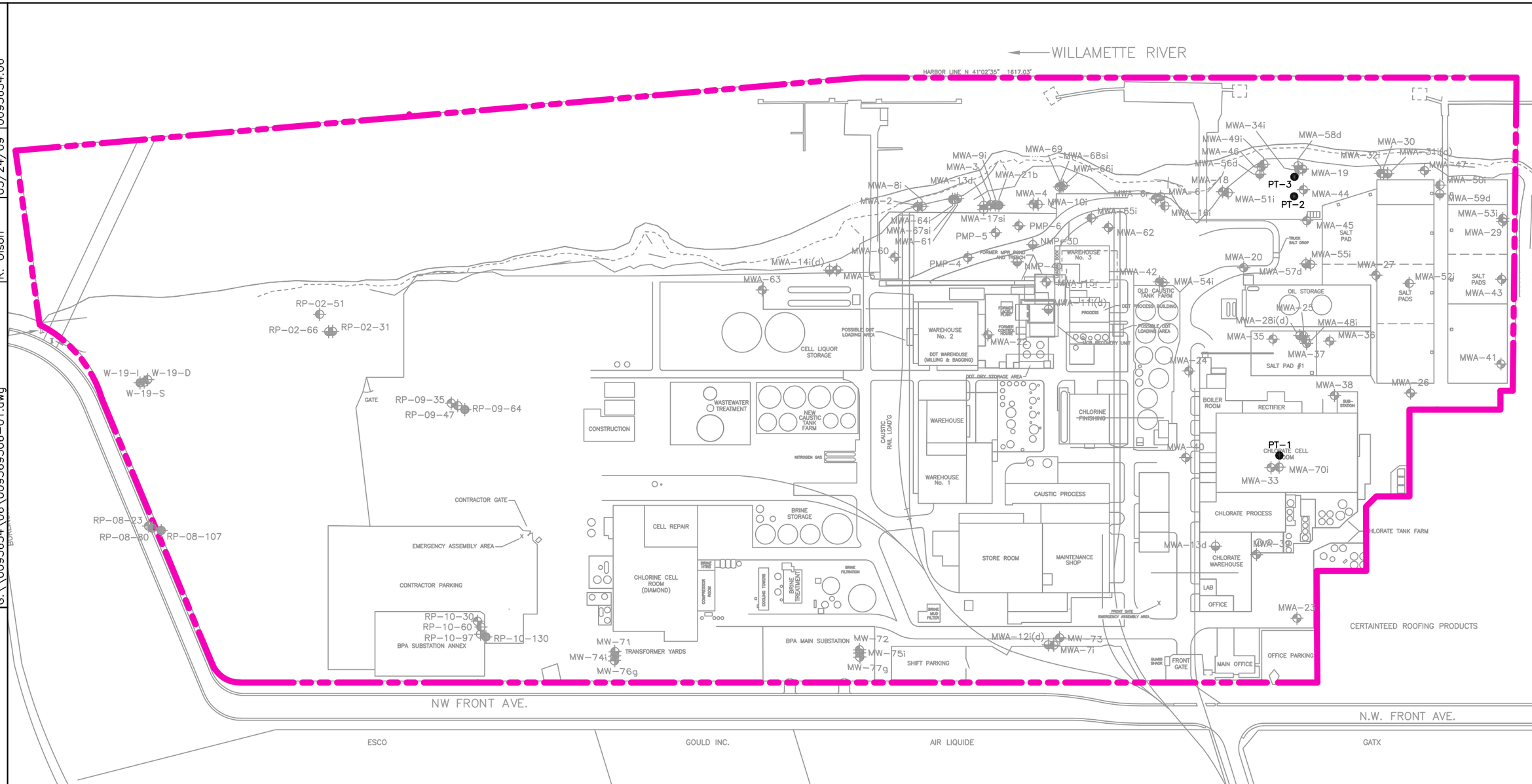

LEGEND

- Monitoring Well, Shallow Zone
- Monitoring Well, Shallow–Intermediate Zone
- Monitoring Well, Intermediate Zone
- Monitoring Well, Deep Zone
- Monitoring Well, Gravel Zone
- Monitoring Well, Basalt
- Pumping Well

NOTE
Most buildings and structures noted on this diagram have been demolished and/or removed.

TRUE NORTH
PLANT NORTH
0 200
FEET

Figure 4-3
Existing Pumping Well Locations
Arkema Inc.
Portland, Oregon

ERM 03/09

Tables

ODEQ ID	Site	Address	Activities	Data Source	Products	Precursors/Products used on site	Additional COCs/Indicator Compounds
183	Wacker Siltronic Corp.	7200 NW Front Ave	Former Oil-gas manufacturer (NW Natural), on site disposal of coal-tar (30,000 cyds). Subsequent releases of solvents (TCE) by current occupant (microchip wafer manufacturer).	ECSI	LPG	TCE, PAHs, Vinyl Chloride, BTEX, phenols	Coal-Tar. PAHs, TCE, VC, BTEX, phenols and metals detected in subsurface soils and groundwater
49	Gould Inc./NL Industries	5909 NW 61st Ave	Secondary lead smelter, lead-acid battery recycling, lead oxide production. Battery acid drained to Doan Lake. Smelter wastes and battery casings used as fill.	ECSI, EPA Website	Lead, lead oxide	Plastic battery casings, battery acid	pH, As, Cd, Cr, Zn
395	Schnitzer Investment - Doane Lake	6529 NW Front Ave	Acetylene manufacturer, on-site disposal of calcium hydroxide, releases of oil, acetone and MEK. Subsurface soils have detections of PCB1254, PCE, TCA, and 1,2-DCA. Dioxin contamination in subsurface soils, part of Rhone-Poulenc cleanup.	ECSI	Acetylene, calcium hydroxide	Acetone, MEK, heavy oils	Lead, arsenic, PCBs, pH, tetrachloroethane, PCE, 1,1-DCA
155	Rhone-Poulenc	6200 NW St Helens Rd, Portland, OR	Insecticide and herbicide manufacturer	ECSI, Consent Order, SOW and RI	Bromoxnil Octanoate, 2,4-D (2-(2,4-dichlorophenoxy)acetic acid), MCPA (2-(4-chloro-2-methyl-phenoxy)acetic acid), 2,4,5-TP (Silvex), 2,4-DB (butyl 2-(2,4-dichlorophenoxy)acetate), 2-(2,4-dichlorophenoxy)propanoic acid, DDT, Aldrin, Endrin, Heptachlor, Malathion, Arsenic based herbicides	2,4,6-Trichlorophenol, 2-Chlorophenol, Pentachlorophenol, Phenol, 1,4-Dichlorobenzene, benzene, chlorobenzene, TCE, diesel	Pb, Hg, Vn, 1,2,4-Trimethylbenzene, TCE, Vinyl Chloride, 2-Methylnaphthalene, Benzo(a)pyrene, Chrysene, Naphthalene, dioxins
74	McCormick and Baxter	6900 N Edgewater St	Wood Treatment Facility, directly across river from Arkema site. Undergoing remedial action (almost complete). Sheet-pile / slurry wall installed to contain upland plume, sediment cap. Known source of dioxins to sediment.	ECSI, RI/FS	Treated Wood Products	Creosote, pentachlorophenol, diesel, heavy oils, arsenic, chromium, copper, zinc.	Dioxins, metals, PAHs,
117	GenStar Roofing Products/Certainteed Roofing	6350 NW Front Ave	Asphalt roofing manufacturer. Historic releases of fuel oil and gasoline to soil and groundwater. NFA issued for site.	ECSI	Asphalt roof tiles	Fuel oil, asphalt	Gasoline, benzene
1549	Kinder Morgan Willbridge Terminal	5924 NW Front Avenue	Bulk Fuel Terminal. Petroleum releases to soil, groundwater, surface water. DDT and chlorinated solvents detected in soil and groundwater	ECSI	Petroleum products (gasoline, diesel, fuel oil, heavy oils)	Fuel oils, oil sludge	DDT, chlorinated solvents, VOCs, lead

Notes
ECSI = Oregon DEQ Environmental Cleanup Site Information database
RI/FS = Remedial Investigation / Feasibility Study
SOW = Scope of Work

Well ID	Screened Interval ft-bgs	VOCs USEPA 8260B	TPH- Diesel Range TPH-Dx	PAHs USEPA 8270	Organo-chlorine Pesticides USEPA 8081A	Dissolved[3] Organo-chlorine Pesticides USEPA 8081A	Silvex / 2,4-D USEPA 8151A	Dioxin-Furans USEPA 8290	Chloride USEPA 300.0	Perchlorate USEPA 314.0	Metals										Dissolved Methane RSK 175
											Hexavalent Chromium USEPA 7195	Dissolved Arsenic USEPA 6010B	Dissolved Aluminum USEPA 6010B	Dissolved Cadmium USEPA 6010B	Dissolved Copper USEPA 6010B	Dissolved Lead USEPA 6010B	Dissolved Nickel USEPA 6010B	Dissolved Zinc USEPA 6010B	Dissolved Iron USEPA 6010B	Dissolved Manganese USEPA 6010B	
Volume (L)		0.04	1	1	1		1	2	0.25	0.25	0.25	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.04
Containers		3	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
NMP-3D	25.0-30.0	X			X				X										X		X
NMP-4D	25.0-30.0	X			X				X										X		X
MWA-2	21.5-31.5	X			X				X	X									X	X	X
MWA-3	20.7-30.7	X			X				X	X									X		X
MWA-4	19.5-29.5	X			X				X	X	X										
MWA-5	36-38	X			X				X	X											
MWA-6r	30.5-33.5	X			X				X	X	X								X		X
MWA-7	28.2-33.2	X			X			X	X	X									X		X
MWA-8i	42-47	X			X				X	X		X								X	
MWA-9i	40.5-45	X			X				X	X											
MWA-10i	40.2-45.2	X			X				X	X	X	X									
MWA-11i	46.2-50.8	X			X				X	X	X	X									
MWA-12i	42-51.75	X			X			X	X	X		X									
MWA-13d	51-53	X			X				X										X		X
MWA-14i	44-49	X			X				X	X		X									
MWA-15r	22.5-32.5	X			X	X			X		X	X							X		X
MWA16i	39.2-44.2	X			X				X	X	X										
MWA-17si	33.5-35	X			X				X	X									X		X
MWA-18	19.2-29.2	X			X				X	X	X										
MWA-19	19.2-29.2	X			X				X	X	X										
MWA-20	24.7-34.7	X			X				X	X	X	X									
MWA-21b	61-68.2	X			X				X										X		X
MWA-22	24.7-34.7	X			X				X		X	X									
MWA-23	15.2-25.2								X		X	X							X		X
MWA-24	24-34	X							X	X	X	X									
MWA-25	23.7-33.7								X	X	X	X							X		X
MWA-26	21.2-31.2								X	X	X									X	
MWA-27	24-34								X	X	X								X		X
MWA-28i(d)	53.9-58.9								X	X	X	X									
MWA-29	24.9-34.9				X				X	X	X										
MWA-30	19.1-29.1	X			X				X	X	X	X							X	X	X
MWA-31i(d)	54.8-59.8	X			X				X	X	X								X		
MWA-32i	37-42	X			X				X	X	X	X							X		
MWA-33	20-30				X				X	X	X	X							X		
MWA-34i	32-37	X			X				X	X	X	X							X		
MWA-35	23-33								X	X	X	X							X		
MWA-36	23-33								X	X	X	X							X		
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MWA-38	22-32								X	X	X	X							X		
MWA-39	15.05-24.3								X	X	X								X		
MWA-40	20.25-29.5								X	X	X	X							X		
MWA-41	25.05-34.3								X	X	X								X	X	
MWA-42	21.55-30.8	X			X				X	X	X	X							X		
MWA-43	25.05-34.3								X	X	X								X	X	
MWA-44	25.05-34.3	X			X				X	X	X	X							X	X	
MWA-45	24.55-33.8	X			X				X	X	X	X							X		
MWA-46	19.75-29	X			X				X	X	X								X		
MWA-47	25.05-34.3	X			X				X	X	X								X		
MWA-48i	42.05-46.5								X	X	X	X							X	X	
MWA-49i	38.85-43.3	X			X				X	X	X	X							X		
MWA-50i	40.85-45.3	X			X				X	X	X								X		
MWA-51i	37.35-41.8	X			X				X	X	X	X							X		
MWA-52i	38.15-42.6								X	X	X								X	X	
MWA-53i	39.25-43.7								X	X	X								X		
MWA-54i	35.95-40.4	X			X				X	X	X								X		
MWA-55i	38.55-43	X			X				X	X	X	X							X		
MWA-56d	55.5-60.25	X			X				X	X	X								X		
MWA-57d	54.7-59.45	X			X				X	X	X								X		
MWA-58d	55.2-59.95	X			X				X	X	X								X		

Well ID	Screened Interval ft-bgs	VOCs USEPA 8260B	TPH- Diesel Range TPH-Dx	PAHs USEPA 8270	Organo-chlorine Pesticides USEPA 8081A	Dissolved[3] Organo-chlorine Pesticides USEPA 8081A	Silvex / 2,4-D USEPA 8151A	Dioxin-Furans USEPA 8290	Chloride USEPA 300.0	Perchlorate USEPA 314.0	Metals										Dissolved Methane RSK 175
											Hexavalent Chromium USEPA 7195	Dissolved Arsenic USEPA 6010B	Dissolved Aluminum USEPA 6010B	Dissolved Cadmium USEPA 6010B	Dissolved Copper USEPA 6010B	Dissolved Lead USEPA 6010B	Dissolved Nickel USEPA 6010B	Dissolved Zinc USEPA 6010B	Dissolved Iron USEPA 6010B	Dissolved Manganese USEPA 6010B	
MWA-59d	54.7-59.45	X			X				X	X	X								X		
MWA-60	27-36.8	X			X				X	X									X	X	
MWA-61	22.3-32.1	X			X				X	X									X		
MWA-62	20.5-30.3	X			X				X	X	X	X							X		
MWA-63	19.8-29.6	X			X				X	X		X	X	X	X	X	X	X	X	X	
MWA-64i	42-46.5	X			X				X	X		X							X		
MWA-65i	42-46.5	X			X				X		X								X		
MWA-66i	37.6-42.4	X			X				X	X	X								X		
MWA-67si	36.3-37.8	X			X				X	X		X							X	X	
MWA-68si	32.3-33.8	X			X				X	X	X	X							X		
MWA-69	19.5-29.3	X			X	X			X	X		X							X		
MWA-70i	42.5-32.7								X	X	X								X		
MWA-71	12.5-22.5	X	X	X	X		X	X	X			X									
MWA-72	12.0-22.0	X	X	X	X		X	X	X			X									
MWA-73	11.0-21.0	X	X	X	X		X	X	X			X									
MWA-74i	38.0-43.0	X	X	X	X		X	X	X			X									
MWA-75i[(1)]	25.0-40.0	X	X	X	X		X	X	X			X									
MWA-75i[(2)]	25.0-40.0	X	X	X	X		X	X	X			X									
MWA-76g	89.0-94.0	X	X	X	X		X	X	X			X									
MWA-77g	86.0-91.0	X	X	X	X		X	X	X			X									
PMP-4	21.6-31	X			X				X										X		
PMP-5	22.2-31.6	X			X				X										X		
PMP-6	25.9-34.9	X			X				X										X		
RP-02-31	25-30	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	
RP-02-51	43-48	X	X	X	X		X	X	X			X	X	X	X	X	X	X	X	X	
RP-02-66	60-65	X	X	X	X		X	X	X			X	X	X	X	X	X	X	X	X	
RP-08-23	13-22.5	X	X	X	X		X	X	X			X									
RP-08-80	73-79.5	X	X	X	X		X	X	X			X									
RP-08-107	102-107	X	X	X	X		X	X	X			X									
RP-09-35	24.5-35	X	X	X	X		X	X	X	X		X									
RP-09-47	42-46.5	X	X	X	X		X	X	X			X									
RP-09-64	59-64	X	X	X	X		X	X	X			X									
RP-10-30	20-29.5	X	X	X	X		X	X	X			X									
RP-10-60	55-59.5	X	X	X	X		X	X	X			X									
RP-10-97	92-97	X	X	X	X		X	X	X			X									
RP-10-130	125-130	X	X	X	X		X	X	X			X									
W-19-S	20-25	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	
W-19-I	44-49	X	X	X	X		X	X	X			X	X	X	X	X	X	X	X	X	
W-19-D	63-68	X	X	X	X		X	X	X			X	X	X	X	X	X	X	X	X	
	Totals	79	24	24	80	2	24	26	98	66	52	58	7	7	7	7	7	7	63	18	14

ft-bgs = Feet below ground surface
VOC = Volatile organic compound
TPH = Total Petroleum Hydrocarbons
PAH = Polycyclic Aromatic Hydrocaorbons
1 = Collect sample from middle of 27- to 30-foot range, within upper water-bearing zone
2 = Collect sample from middle of 34- to 40-foot range, within lower water-bearing zone
3 = Collected using regenerated cellulose dialysis membrane (0.0018 micron) diffusion samples

Table 3-2

Groundwater Quality Assurance/Quality Control Samples
Data Gaps Work Plan
March 2009

Parameters	Method	Standard Samples	Trip Blank[a]	Duplicate[b]	Rinsate[c]	Total
Volatile Organic Compounds	USEPA 8260B	79	7	4	4	94
TPH Diesel Range	NWTPH-Dx	24	-	1	1	26
PAHs	USEPA 8270	24	-	1	1	26
Organochlorine Pesticides	USEPA 8081A	82	-	4	4	90
Silvex / 2,4-D	USEPA 8151A	24	-	1	1	26
Dioxin-Furans	USEPA 8290	26	-	1	1	28
Chloride	USEPA 300.0	98	-	5	5	108
Perchlorate	USEPA 314.0	66	-	4	4	74
Hexavalent Chromium	USEPA 7195	52	-	3	3	58
Dissolved Arsenic	USEPA 6010B	58	-	5	5	68
Dissolved Aluminum	USEPA 6010B	7	-	1	1	9
Dissolved Cadmium	USEPA 6010B	7	-	1	1	9
Dissolved Copper	USEPA 6010B	7	-	1	1	9
Dissolved Lead	USEPA 6010B	7	-	1	1	9
Dissolved Nickel	USEPA 6010B	7	-	1	1	9
Dissolved Zinc	USEPA 6010B	7	-	1	1	9
Dissolved Iron	USEPA 6010B	63	-	4	4	71
Dissolved Manganese	USEPA 6010B	18	-	4	4	26
Dissolved Methane	RSK 175	14	-	1	1	16

a = To be included in each cooler containing volatile organic compound samples.
b = To be collected at the frequency of 1 per 20 standard samples with a minimum of 1 per sampling event.
c = To be collected at the frequency of 1 per 20 standard samples with a minimum of 1 per sampling event, and a minimum of one per each plant area in which the analyte is collected.
USEPA = United States Environmental Protection Agency

Table 4-1
Recovery Well Screen Intervals
Data Gaps Work Plan
March 2009

Location Along Proposed Barrier Wall	Aquifer Zone	Nearby Well	Approximate Screen Zone Setting (feet bgs)	Screen Length (feet)
North	Shallow	MWA-60	22 to 37	15
	Intermediate	None	37 to 47	10
South	Shallow	MWA-41	18 to 33	15
	Intermediate	MWA-41	39 to 54	15

Appendix A
Standard Operating Procedures: Stepped-Discharge and Constant Rate Discharge Testing

APPENDIX A - STANDARD OPERATING PROCEDURES: STEPPED-DISCHARGE AND CONSTANT RATE DISCHARGE TESTING

DEFINITIONS

Aquifer Testing - Refers to flow testing methods used to estimate the hydraulic properties of confined or unconfined aquifers. Slug tests, and specific capacity, stepped-discharge and constant-discharge pumping tests are commonly used testing methods.

Stepped-Discharge Pumping Tests - Used to estimate well performance, determine a sustainable optimum pumping rate for the well, and estimate aquifer properties. The test is conducted by pumping the well at several successively higher rates and measuring the corresponding water level drawdown.

The Constant-Discharge Pumping Test - Involves discharging water at a constant rate from a well by pumping and monitoring the corresponding water level drawdown. The recovery of water levels in the well may also be monitored after pumping is terminated (recovery test). Water level monitoring during a pumping and recovery test commonly includes the pumping well and one or more nearby observation wells. In certain instances, observation wells are not available and water level monitoring is limited to only the pumping well.

Cone of Depression - A depression in the groundwater table or potentiometric surface that has the shape of an inverted cone around a well from which water is being withdrawn.

Confined or Artesian Aquifer - An aquifer that is overlain and underlain by confining layers of lower hydraulic conductivity and, at a given point, the total head of the aquifer is higher than the base of the upper confining layer.

Drawdown - The difference between the height of the static water level and that of the water level in a well during pumping or water withdrawal. Or, in a confined aquifer, the reduction of the pressure head as a result of the withdrawal of free water.

Discharge (Q) - Volume of water removed per unit of time (l^3/t).

Electronic Water Level Indicator - A water level measuring device that uses a light, or sounds a buzzer, to show that the end of the tape has entered the water. The water in the well completes an electric circuit that turns on the light or sounds a buzzer. The tape is graduated to show the depth.

Flow Regulator - Flow regulators (flow controllers) are used to control the discharge rate (in volume/time) of water from the well while pumping. The discharge from the mechanical pump is normally set at a constant rate.

Hydraulic Conductivity (k) - A quantitative measure of the ability of a porous material to transmit a fluid. Also defined as the volume of water that will flow through a unit cross-sectional area of porous material per unit time under a unit hydraulic gradient (l/t). Hydraulic conductivity is dependent upon properties of the material and fluid.

Measuring Point - A fixed and clearly identified point of reference from which water levels in a monitoring well may be measured. It is generally established on the upper rim of the outer protective well casing and has a surveyed location and elevation.

Mechanical Pump - An electric-powered water pump used to withdraw water from the well during a pumping test.

Observation Well - A non-pumping well used to observe the groundwater levels during a pumping test.

Potentiometric Surface - The surface defined by water levels from multiple tightly cased wells that penetrate an aquifer or hydrogeologic unit. Also, a map of the hydraulic head of an aquifer.

Pressure Transducer and Data Logger - An electronic sensor that can accurately measure hydrostatic pressure. By relating hydrostatic pressure to depth below the water level, the water level can be electronically measured as the transducer is held in the water. Periodic water level measurements can be stored by the data logger for later recall and data evaluation.

Recovery - The time rate of return to the static water level during a slug test or after cessation of a pumping test. This is related to the aquifer's response to the change in water level during the flow test. After the water level has been raised or lowered by raising or lowering the slugging rod, or after the pump is turned off during a pumping test, the water will return to static conditions (static water level).

Saturated Thickness (b) - For unconfined aquifers, the interval between the water table and base of the unconfined water bearing unit. For confined aquifers, the interval between the base of the upper confining unit and the top of the lower confining unit.

Specific Capacity (C) - Discharge per unit of drawdown in a pumping well (Q/s).

Specific Yield (Sy) - The ratio of the volume of water that saturated soil or rock will yield under the influence of gravity, per unit volume of the saturated soil or rock. Specific yield is dimensionless.

Storage Coefficient or Storativity (S) - The volume of water that an aquifer releases from, or takes into storage per unit area of aquifer, per unit change in head. Storage coefficient is dimensionless.

Transmissivity (T) - A quantitative measure of the ability of an aquifer to transmit water. It is the product of the hydraulic conductivity and saturated thickness ($k \bullet b$) (l^2/t).

Unconfined Aquifer - An aquifer in which the water table forms the upper boundary.

Water Level - The position of the air-water interface in a well. The water level is usually measured as the depth to the water from a measuring point (such as the top of the outer protective well casing) by the use of a weighted measuring tape or electronic water level indicator. Changes in the water level over time may also be monitored by a pressure transducer installed at a known depth within the water column inside the well. The water level is called the static water level when it is not influenced by well drilling activities, aquifer testing, well development, or groundwater sampling.

Water Table - The saturated zone surface at which the pore water pressure is equal to atmospheric pressure. The water table is the potentiometric surface for an unconfined aquifer.

Wellhead Flow Meter - A meter installed in the water discharge line near the well head to measure the discharge (in volume/time) of water by the mechanical pump and controlled by the flow regulator.

FIELD METHODS

This section describes the field procedures, data collection methods, and documentation requirements for aquifer testing.

Stepped-Discharge and Constant-Discharge Testing

The pumping tests covered in this section include stepped-discharge and constant-discharge pumping tests. A stepped-discharge test is conducted for the pumping well and is recommended prior to initiation of any constant-discharge pumping test. The data provided by the stepped-discharge test is used to evaluate well performance and determine the optimum discharge rate for the subsequent constant-discharge test.

The stepped-discharge test entails conducting three or more steps of increased discharge while monitoring water level drawdown. This effectively produces successive stepped drawdown curves. Flow testing may potentially be discontinued at a well after the stepped-discharge pumping test if: 1) only a single well pumping test is planned; and 2) the stepped-discharge test provides all the necessary data of a single well pumping test.

The constant-discharge test involves the pumping of water from a well at a constant rate and monitoring the water level drawdown in response to the pumping. Water level recovery may also be monitored after the pumping is discontinued.

Water level monitoring may be limited to the pumping well (single well pumping test) or include one or more nearby observation wells (multiple well pumping test). The single well pumping test utilizes a single well (the pumped well) and a mechanical pump to remove water at a constant rate from the water bearing unit. The same well is used to measure water level drawdown and recovery in the formation. The multiple well test utilizes one or more observation wells at selected distances and locations relative to the pumping well. Water levels are monitored in the pumping and observation wells throughout the duration of the test.

The remaining discussion provides the general guidelines and procedures for stepped-discharge tests, and single and multiple well constant-discharge tests. These represent minimum requirements as site- and project-specific information and criteria must be incorporated in planning and conducting pumping tests.

The procedures below describe the use of pressure transducers/data loggers to monitor water levels during the pumping tests.

Stepped-Discharge Tests

Stepped-discharge testing should be conducted before other pumping tests. All newly installed wells should be developed before conducting stepped-discharge tests.

- Inspect the equipment to be used to ensure that it is in good working order. Equipment used for the stepped-discharge testing will vary widely based upon site-specific conditions. The project work plans will outline the type of equipment to be used.
- Measuring and test equipment (M&TE) used for field activities will be calibrated by the equipment manufacturer or an approved calibration laboratory using appropriate standards. Certificates of calibration for M&TE will be obtained from the M&TE supplier and kept in the project files. No M&TE will be utilized without verification of calibration certification.
- Decontaminate all downhole equipment.
- Visually inspect and access the well.
- Obtain a depth to water level measurement and sound the bottom of the well with the electronic water level indicator. Compare the measured total depth to the bottom of the well to the well construction diagram to determine if sediment is in the bottom of the well.
- Install the mechanical pump in the well using the manufacturer's instructions. The position of the pump intake inside the well should be based upon well construction and site specific factors stipulated in the project work plans. The criteria for placement of the pump in the well should also be contained on the project work plans. Note the height of the water column from the static water level to the pump intake. Record all information on the appropriate form as specified by the project work plans. During testing, the drawdown should not be so great as to cause the pump to cavitate.
- Connect the pressure transducer to the data logger. Lower the pressure transducer inside the pumping well to a depth below the bottom of the anticipated drawdown. The transducer should be installed at a level that: 1) eliminates effects from the pump intake; 2) is below the anticipated water level during maximum drawdown; and 3) does not exceed the maximum transducer head limitation. In addition, the transducer must be secured inside the pumping well in such a manner that the transducer will not be affected by turbulence from the pump. Record the depth of the transducer.
- Turn on the pressure transducer/data logger, set the recording frequency for pre-test monitoring to that specified by the project work plans. (Data loggers should be placed in a secure location to prevent tampering.)

- Physically measure the water level with the electronic water level indicator and record along with the time. Commence pre-test monitoring with the pressure transducer/data logger. The total length of time over which the pre-test measurements are made will be provided in the project work plans. Generally water levels are recorded for a period before the stepped-discharge test that is at least twice as long as the time expected for the stepped-discharge test and the recovery period. Record the information, including times of measurements, on the appropriate form as specified by the project work plans.
- Once the pre-test monitoring period is ended, re-measure the water level using the electronic water level indicator and record along with the time.
- Change the recording frequency on the data logger to the appropriate frequency of stepped-discharge data entry as required by the project work plans. Begin recording water level measurements with pressure transducer/data logger as required by the project work plans for the initial pumping phase of the stepped-discharge test. Start the mechanical pump and adjust the valve or flow regulator to maintain the constant rate of discharge specified by the project-specific work plan. This rate will be the first step in the stepped-discharge test. Record the time of the start of the stepped-discharge test as specified in the project work plans.
- Continue to monitor water level decline during the first step with the pressure transducer/data logger, taking periodic water level measurements with the electronic water level indicator. Data logger and electronic water level indicator readings should be conducted in accordance with the schedule outlined in the project work plans. As the first step continues, review the water level data and, if necessary, adjust the recording frequency of the data logger. Observe and record the wellhead flow meter readings as required by the project work plans.
- Continue pumping and recording water levels and flow meter readings in the first step as long as required by the project work plans.
- Once the first step is ended, measure the water level with the electronic water level indicatory and record depth and time. Adjust the data logger as necessary (based upon review of data from the first step) or specified in the project work plans for commencement of the second step of the test.
- Without turning the mechanical pump off, initiate the second step of the test by changing the pumping rate with the valve or flow regulator to the rate specified by the project work plans.
- Monitor the water levels and flow meter readings continue pumping and recording water levels and flow meter readings in the first step as long as required by the project work plan. Once the first step is ended, measure the water level with the electronic water level indicatory and record depth and time.

Adjust the data logger as necessary (based upon review of data from the first step) or specified in the project work plans for commencement of the second step of the test.

- Repeat the cycles of changing pumping rate and recording depth of water as often as is required (for each step of the stepped-discharge test) by the project work plan.
- Once the last step is completed, re-set the data logger for the recovery period measurement duration and frequency as specified in the project work plans. Obtain a water level measurement with the electronic water level indicatory and record the measurement and time. Shut down the mechanical pump. Record the time (to the nearest 10 sec) that the pump was shut down on the appropriate form.
- Continue to measure and record the water level recovery with the pressure transducer/data logger as long as is required by the project work plans or until the water level has recovered to within 90 percent of the level expected from the pretest trends. Also, continue to take physical water level measurements periodically during recovery. Once the recovery period is ended, take a physical water level measurement at the end of the test. Record the measurement and time on the appropriate form.
- The data should be reviewed in the field to help ensure the validity of the test. The field data review may also be used to determine the discharge rate to be used during the subsequent single or multiple well pumping test. Complete all documentation on the appropriate form as outlined in the project work plans.
- Once the stepped-discharge test is satisfactorily completed for the well, the equipment may be left in the well for subsequent single or multiple well pump testing. If the subsequent testing will not be conducted then the downhole equipment may be removed and the wellhead secured.

Single and Multiple Well Constant-Discharge Tests

The procedures in this section are written for a multiple well constant-discharge test; however, these procedures are directly applicable to a single well constant-discharge test. The only difference is that testing and measuring equipment are installed only in the pumping well, and water level measurements are only collected from this well.

- Inspect the equipment to be used to ensure that it is in good working order. Equipment used for the pump testing will vary widely based upon site-specific

conditions. The project work plans will outline the type of equipment to be used.

- M&TE used for field activities will be calibrated by the equipment manufacturer or an approved calibration laboratory using appropriate standards. Certificates of calibration for M&TE will be obtained from the M&TE supplier and kept in the project files. No M&TE will be utilized without verification of calibration certification.
- Decontaminate all downhole equipment. Equipment maintained inside the pumping well from the stepped-discharge test and to be used directly for the subsequent pumping test does not need to be re-decontaminated.
- Visually inspect and access the wells to be used during the pumping test.
- Obtain a depth to water level measurement and sound the bottom of each well to be used with the electronic water level indicator. Compare the measured total depths to the bottom of the wells to their respective construction diagrams to determine if sediment is in the bottom of the wells.
- If necessary, install the mechanical pump in the well using the manufacturer's instructions. The position of the pump intake inside the well should be based upon well construction and site specific factors stipulated in the project work plans. The criteria for placement of the pump in the well should also be contained on the project work plans. Note the height of the water column from the static water level to the pump intake. Record all information on the appropriate form as specified by the project work plans. During testing, the drawdown should not be so great as to cause the pump to cavitate.
- If a multiple well test is being conducted, connect the pressure transducers to their respective data loggers. Install the transducers inside the observation wells at this time. The transducers should be installed at a position inside each well that is below the anticipated water level during maximum drawdown, and does not exceed the maximum head limitation. Set up another pressure transducer in an outlying well (outside of the suspected influence of the pumping well) to record station barometric effects. Connect the pressure transducer to the data logger. Lower the pressure transducer inside the pumping well to a depth below the bottom of the anticipated drawdown. The transducer should be installed at a level that: 1) eliminates effects from the pump intake; 2) is below the anticipated water level during maximum drawdown; and 3) does not exceed the maximum transducer head limitation. In addition, the transducer must be secured inside the pumping well in such a manner that the transducer will not be affected by turbulence from the pump. Record the depth of the transducer.

- If any transducer cables are run across traffic areas, they must be appropriately protected. Data loggers should also be placed in a secure location to prevent tampering.
- Turn on the pressure transducers/data loggers, set the recording frequencies for pre-test monitoring to that specified by the project work plans. It is also important before initiating pre-test monitoring for the pumping test to ensure that water levels from any previous stepped-discharge testing have completely recovered.
- Physically measure the water levels in the pumping and observation wells with the electric tape and record along with the time. Separate data sheets should be used for each well.
- Commence pre-test monitoring with the pressure transducers/data loggers. The total length of time over which the pre-test measurements are made will be provided in the project work plans. Generally water levels are recorded for a period before the pumping test that is at least as long as the time expected for the pumping and recovery period. Record the information, including times of measurements, on the appropriate form as specified by the project work plans.
- Once the pre-test monitoring period is ended, re-measure the water levels in the wells using the electronic water level indicator and record along with time.
- Change the recording frequencies in the data loggers for the pumping test as required by the project work plans. Just before starting the pump, begin recording the pressure transducer measurements.
- Start the mechanical pump and adjust the valve or flow regulator to maintain a constant rate of discharge as determined from the stepped-discharge test and/or specified by the project work plans. Record pump start time on the appropriate form.
- Continue to monitor water levels during pumping with the pressure transducers/data loggers, taking periodic water level measurements in each of the wells with the electronic water level indicator. Data logger and electronic water level indicator readings should be conducted in accordance with the schedule outlined in the project work plans. However, the water level data should be evaluated during the test and, if necessary, the recording frequencies of the data loggers adjusted.
- Observe and record the wellhead flow meter readings as required by the project work plans.
- The project hydrogeologist or designee will determine the time that the mechanical pump should be shut down as specified in the project work plans

and/or based on review of field generated drawdown versus time plots from the pumping and observation wells.

- Once the pumping phase is completed, re-set the data loggers for the recovery period recording duration and frequencies as specified in the project work plans. Obtain a water level measurement in each of the wells with the electronic water level indicator and record the measurements and times. Shut down the mechanical pump. Record the time (to the nearest 10 sec) that the pump was shut down on the appropriate form.
- Continue to record the water level recovery in the wells with the pressure transducers/data loggers as long as is required by the project work plans or until the water levels have recovered to within 90 percent of the level expected from the pretest trends. Also, continue to take physical water level measurements periodically during recovery. Once the recovery period is ended, take a physical water level measurement in each well at the end of the test. Enter the measurements and times on the appropriate form.
- The project work plans may require additional depth to water measurements to be physically taken following complete well recovery in order to monitor post test trends in water level. The project work plans will specify the frequency of measurements, and the length of time that the measurements must be taken.
- The data should be reviewed in the field to help ensure the validity of the test. Complete all documentation on the appropriate form as outlined in the project work plans.
- Once the pump test is satisfactorily completed for the wells, the downhole equipment may be removed and the wellheads secured.

FIELD DOCUMENTATION

At minimum, flow testing information will be documented on a Flow Test Field Data form and in the field logbook. Both documents will be completed in the field at the time of flow testing. All entries will be legible and recorded in indelible black ink.

Changes or corrections on any project documentation will be made by lining through the erroneous entry and dating and initialing (by the person performing the correction) the correction. The original entry, although erroneous, must remain legible. The new information will be written above the crossed-out entry. Corrections must be written clearly and legibly with indelible ink.

Flow Test Field Data

The following items will be recorded on the Flow Test Field Data form:

- Project Name
- Project Location
- Project Number (OHM)
- Date
- Observers
- Pumping Well
- Observation Well
- Type of Test
- Measuring Point
- Measuring Point Elevation
- Radial Distance to Pumping Well
- Static Water Level
- Discharge Rate
- Water Level Measurement Method
- Discharge Measurement Method
- Start Time of Test
- End Time of Test
- Duration of Test
- Elapsed Time Since Pumping Started
- Elapsed Time Since Pumping Stopped
- Depth to the Water Level
- Drawdown or Recovery of the Water Level
- Comments.

Field Logbook

A permanently bound field logbook with consecutively pre-numbered pages will be assigned to this project. All entries will be recorded in indelible black ink. Corrections will be made by lining through erroneous data with a single line,

dating, and initialing the correction. At the end of each workday, the logbook pages will be signed by the responsible sampler and any unused portions of logbook pages will be crossed out, signed, and dated.

If it is necessary to transfer the logbook to another person, the person relinquishing the logbook will sign and date the last page used, and the person receiving the logbook will sign and date the next page to be used.

At minimum, the logbook will contain the following information:

- Project name and location;
- Date and time;
- Personnel in attendance;
- General weather information;
- Work performed;
- Field observations;
- Flow testing performed, including well tested, type of test performed, start time of test, end time of test, test duration;
- Instruments used during flow testing and instrument checks, including problems, and calibration records;
- Descriptions of deviations from Flow Testing Procedures;
- Problems encountered and corrective action taken;
- QC activities;
- Verbal or written instructions; and
- Any other events that could affect the flow tests.

Appendix B
BES Batch Discharge
Authorization Application

ENVIRONMENTAL SERVICES
CITY OF PORTLAND

BATCH DISCHARGE AUTHORIZATION APPLICATION

Batch Discharge Number:

_____ -- _____
(For City use only)

Date of Request: _____

Requested by:

Contact Name: _____

Company Name: _____

Company Address: _____

City: _____ State: _____ Zip: _____

Telephone: _____ Cellular: _____

Facsimile: _____ Pager: _____

Email Address: _____

Waste Generator:

Facility Name: _____

Facility Address: _____

City: _____ State: _____ Zip: _____

Facility Contact: _____ Telephone: _____

Description of Discharge (attach analytical data report if applicable): _____

_____

Proposed Date(s) of Discharge: _____

Discharge Volume: _____ gallons Requested Rate of Discharge: _____ gallons per minute

Building Permit/City Project Number: _____

City of Portland Project Manager (if applicable): _____

Proposed point of disposal (attach diagram): _____

_____

_____ _____
Signature Date

June 8, 2009

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 ODEQ/USEPA Comments on Pump Test Work Plan
ECSI No. 398

Dear Matt,

This document provides responses to comments received from the Oregon Department of Environmental Quality (DEQ) and United States Environmental Protection Agency (USEPA) on 12 May 2009 related to the March 2009 *Draft Data Gaps Assessment Work Plan, Arkema Inc. Facility Portland, Oregon* (Work Plan). The Work Plan was prepared by Environmental Resources Management (ERM) on behalf of Legacy Site Services, LLC (LSS), agent for Arkema, Inc. Each of the DEQ/USEPA comments is provided below in italic font, followed by LSS's response. LSS does not intend to submit a revised Work Plan, but rather provides these responses to comments as an addendum to the Work Plan.

General Comments

1. *Section 4.3.1 – Objectives. Based on discussions with the Arkema team during the DEQ review of the groundwater focused feasibility study, the objective of the groundwater extraction system is to hydraulically contain groundwater flow in the fractured basalt in addition to the alluvial aquifer. The ability for the groundwater extraction system completed in the shallow and intermediate alluvial zones to contain groundwater flow in the basalt was predicted by the groundwater transport model. Additionally, DEQ understands that basalt groundwater captured by the modeled groundwater extraction system is significant enough to limit the cost effectiveness of a fully enclosed barrier wall.*

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The proposed pump test program will not provide any data on the proposed extraction system's ability to hydraulically contain groundwater flow in the fractured basalt. The pump test needs to be augmented to provide data necessary to conduct this evaluation.

The objective of the groundwater source control measure (GW SCM) is to hydraulically contain the flow of contaminants from the uplands to the Willamette River. As presented in the *Upland Remedial Investigation Report Lots 3 & 4 and Tract A – Revision 1* (RI Report) (ERM 2005) and subsequent documents, the chemicals of concern (COCs) are primarily associated with the Shallow and Intermediate Zones. Impacts to the low permeability Deep Zone are limited to the upper portions of the aquifer on Lots 3 and 4. No impacts to the fractured Basalt Zone have been observed on Lots 3 and 4.

The barrier wall and groundwater extraction system are intended to maintain hydraulic control specifically of the Shallow and Intermediate zones. The lowered hydraulic head required in these zones is predicted to cause a portion of the groundwater in the Deep Zone and the underlying Fractured Basalt Zone to be captured by the extraction system in the long term. However, this is not the primary purpose of the groundwater extraction system, but is rather an ancillary effect.

The barrier wall will be installed to the top of the fractured basalt. Groundwater flow through the Basalt Zone will not be affected by the alignment (fully enclosed or riverbank) of the barrier wall. A fully enclosed barrier wall will have the greatest potential effect on limiting groundwater inflows in the Shallow, Intermediate, and to a lesser extent, the Deep Zone – not the Basalt Zone.

Groundwater data collected from the Basalt Zone during the proposed aquifer testing program will not provide useful data for the estimation of Shallow and Intermediate Zone hydrogeologic properties. Monitoring of groundwater flow in the Basalt Zone will require installation of monitoring and pumping wells screened in basalt zone. Based on previous experience at the Site, there is risk of creating routes of contaminant migration by installing wells in the Acid Plant area, particularly for wells installed in the basalt zone.

In summary, LSS reiterates that the basalt zone has not been impacted, therefore the objectives of the pump test (and groundwater recovery system) are to maintain hydraulic control specifically of the Shallow and Intermediate zones. In addition, the risks of installing additional Basalt Zone monitoring wells outweigh the benefit of obtaining additional extraneous data that will not be used in the current testing program.

2. *Related to Comment 1: The plan only proposes observation wells at vertical intervals equivalent or similar to the screened intervals of the extraction wells. This will provide information on horizontal or lateral extent of capture but doesn't provide good data on vertical capture/containment.*

   As stated in the response to DEQ Comment 1, the objective of the proposed aquifer testing is to characterize the Shallow and Intermediate Zones for the purposes of sizing and designing the groundwater extraction system.

   However, in order to monitor the effects of pumping within the Shallow and Intermediate Zones upon the Deep Zone, and to assess the degree of hydraulic connectivity between the various water-bearing zones, water levels within existing Deep Zone wells in the area of pumping will be monitored during the pump tests.

3. *Locations of the recovery and observation wells need to be specified and located on a site figure. Ideally, the observation wells should be oriented to help define the extraction wells' radius of influence along the outer boundary of the containment area.*

   Comment noted. Individual recovery and observation well locations are presented in the attached Figures A-1 and A-2.

4. *Section 4.3.3.1 – Monitoring well installation. Section 4.3.3.2 states that the recovery wells will be installed by telescoping through the silt layer but no such stipulation is given for the intermediate zone observation monitoring wells. The specifics of the design and installation of intermediate zone observation wells need to be provided.*

   Comment noted. Intermediate Zone recovery and observation wells, located in the Acid Plant Area (northern area) will be drilled using conductor casing installed in the Shallow-Intermediate silt.

5. *Sections 4.3.3.1 and 4.3.3.2 - Monitoring and Recovery Well Design and Installation. Products proposed for use for well seals (e.g., bentonites and grout) need to be specified and compatible with the high total dissolved solids and chloride present in site groundwater.*

   Section 4.3.3.1 specifies bentonite chips as a seal material for monitoring well. Section 4.3.3.2 specifies bentonite chips as a seal material for recovery wells. These well seal materials are in compliance with OAR 690-200 *Well Construction Standards* and OAR-690-240 *Construction, Maintenance, Alteration, Conversion, and Abandonment of Monitoring Wells, Geotechnical Holes and Other Holes in Oregon*. Bentonite chips have successfully been used at the site for construction of well seals. Bentonite has been determined to be chemically compatible with total dissolved solids (TDS) and

chloride present in groundwater at the site (*Draft Groundwater Source Control Focused Feasibility Study*, ERM 2008).

6. *Section 4.3.3.3- Monitoring and Recovery Well Development. This section needs to note that well development will not commence until at least 24 hours after well completion*

   Comment noted. Wells will be developed in accordance with OAR 690-240-0485. Well development will not commence until 24 hours after well completion if grout is used, or 12 hours after completion if dry bentonite is used.

7. *Section 4.3.3.3- Extraction wells and monitoring wells need to be allowed to fully recover between the well development/step test and the step test/constant rate test. The plan needs to state the recovery criteria (e.g., percent recovery or time frame).*

   Comment noted. A minimum of 24 hours recovery time will be required between well development and sampling or aquifer testing, as per OAR 690-240-485. After the step test, wells will be allowed to recover to 95% recovery, or for a maximum of 24 hours, prior to performance of the constant rate test.

8. *Section 4.3.4 - Step test data should also be used to calculate well efficiency.*

   Comment noted.

9. *Section 4.3.5.2 – Background Ground Water Level Monitoring – The distance the chosen well is setback from the river should be roughly equivalent to that of the extraction and recovery wells*

   Comment noted. The background groundwater level monitoring wells are specified in the attached Table A-1 and presented in the attached Figures A-1, and A-2.

10. *Section 4.3.5.2 – The background water level measurements should be collected for at least three days prior to the pump test rather than 24 hours specified in the plan.*

    Comment noted. Background water levels will be measured in the observation and background monitoring wells 3 days prior to the step-rate test.

11. *Section 4.3.5.7 - Groundwater Sample Collection. Groundwater monitoring conducted during the pump test program needs to be expanded to include total metals analysis. Data quality objectives (e.g., detection limits) should be consistent with screening criteria identified in the DEQ/EPA Joint Source Control Strategy.*

Batch samples of stored pumping test discharge water will be collected at the completion of all the tests. These samples will be analyzed for yet-to-be-determined parameters in the City of Portland BES Discharge Permit.

The purpose of collecting groundwater samples directly from recovery wells during the pump test is to characterize the potential influent, in support of the groundwater treatment system design. The analytical results from these samples will not be used for source control screening purposes, and therefore the Joint Source Control Strategy is not applicable.

The specific analyses were selected based upon information required for the design of the treatment system. The potential fluctuation in dissolved metals concentrations is a key design parameter for the metals co-precipitation and clarifier components. A combination of total metals concentrations, in addition to the dissolved metals concentrations, is not required for the design of the groundwater treatment system.

12. *Section 4.3.5.8 – At the end of the constant rate pump test, DEQ requests Arkema to collect water level measurements from additional wells in the vicinity of the recovery well to enable a more detailed description of the final capture zone.*

    At the end of the constant rate pump test, water level measurements will be collected from additional monitoring wells located within 200 feet of the recovery well, to the extent present. These wells are listed in the attached Table A-1. Water levels from these wells will be collected prior to the start, during, and at the end of the constant rate pumping test.

13. *Section 4.3.6.1 – DEQ requests Arkema to collect water level measurements from additional on-site wells such as MWA-63 and MWA-5 to improve the extrapolation of an effective radius of influence.*

    Water levels will be collected from additional wells, as noted in the response to DEQ Comment 12.

14. *Section 4.3.6 – Analysis of the pumping test needs to be more robust than just estimating aquifer parameters and the effective radius of influence. The results of the pumping test need to be evaluated in accordance with EPA's January 2008 "A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems" to determine the effective capture zone of the extraction wells.*

The objective of the Work Plan is to provide more accurate estimates of Shallow and Intermediate Zone aquifer parameters. These parameter estimates will be used to update (i.e. re-calibrate) the existing groundwater model. The groundwater extraction system design (specifically barrier wall location, recovery well layout and the subsequent development of Target Capture Zones) will be based on these updated modeling results. The assessment of actual capture zones against target capture zones will be conducted as part of the performance monitoring program of the SCM.

U.S. EPA Comments

General Comments:

1. *Comment 1 – The Standard Operating Procedure (SOP) and related Section 4.3 discussing the Aquifer Testing Program (Program) should be more detailed and descriptive to provide clear step-by-step procedures to be followed by field staff implementing the Program. The SOP and Section 4.3 should be worded to be specific to the wells to be tested at the Arkema site. Information is missing that will be needed by field staff using the Data Gaps Assessment Work Plan (Work Plan) to execute the Program. For example, the depth that the conductor casing will be installed into the silt unit needs to be specified and the proposed well construction details need to be provided. Section 4.3 of the Work Plan should provide a comprehensive summary of the major requirements presented in the SOP to allow stakeholders and field staff to understand the overall Program and requirements of the SOP.*

   DEQ has discussed this comment with EPA. DEQ is okay with the SOP and believes that the plan, as outlined in the body of the report, needs to provide additional detail on the elements of the plan that are specific to the subject pump test (e.g., well construction details, well locations and completion depths and observation well program details). EPA did not object to DEQ's position.

   See responses to DEQ comments 3, 9, 10, and 12.

   LSS notes that a field reference document will be prepared for use by field staff implementing the aquifer testing program. This field briefing document will contain detailed items including a Health and Safety Plan, specific equipment operation instructions, nearby boring logs, previously established field sampling procedures, and field data collection forms.

   In reference to the comment on conductor casing, because the depth of the shallow-intermediate silt varies across the site, it is impossible to specify conductor casing depth. Instead, ERM field geologists will be utilized who are experienced with the lithology at the site and in identifying the shallow-intermediate silt.

2. *Comment 2 – The discussion on well installation specifically for the aquifer test program do not reference State of Oregon well construction regulations. These regulations should be referenced as necessary to confirm that all well construction materials and methods meet these regulations.*

   Comment noted. Well construction installation will be in accordance with OAR 690-200 *Well Construction Standards* and OAR-690-240 *Construction, Maintenance, Alteration, Conversion, and Abandonment of Monitoring Wells, Geotechnical Holes and Other Holes in Oregon*.

Specific Comments:

1. *Comment 1 – Page 27, Section 4.3.1 and Figures 4-1 and 4-2 – The text should state that aquifer tests will be performed on two wells to be installed in the Shallow Zone and two wells to be installed in the Intermediate Zone. The location of the proposed recovery wells should be shown directly on the figures, rather than showing the General Area for these wells.*

   See response to DEQ Comment 3.

2. *Comment 2 - Page 28, Section 4.3.3.1, Paragraph 1 – The location of the eight proposed observation wells should be identified on the figures. The evaluation criteria used to determine whether the four existing wells (MWA-2, MWA-8i, MWA-41, and MWA-60) can be used as observation wells should be included in the text. It is also assumed that the four existing wells will be used in addition to the eight proposed observation wells. The text should be revised to specifically state that the existing wells may serve as observation wells in addition to the eight proposed observation wells.*

   LSS proposes to monitor two observation wells per pumping well in conjunction with existing, nearby monitoring wells. A total of eight observation wells will be monitored during the aquifer testing program. In order to minimize the number of new wells required, LSS proposes to utilize existing monitoring wells as observation wells where feasible. The assessment criteria to determine the feasibility of using existing monitoring wells in the aquifer pump testing program includes:

   - Proximity to the proposed recovery well location;
   - Known well construction details;
   - Appropriate screen elevations relative to recovery wells; and
   - Hydraulic connection to the aquifer.

   The existing monitoring wells will be used as follows:

- MWA-2 and MWA-60 will be used for the two observation wells for the testing of the Shallow Zone Recovery well located in the northern area;
- MWA-8i will be used for one of the observation wells for testing of the Intermediate Zone Recovery Well located in the northern area; and
- MWA-41 will be used as one of the observation wells for testing of the Shallow Zone Recovery Well located in the southern area.

The location of individual recovery wells, new observation wells, and existing monitoring wells that will be used as observation wells are provided in the attached Figures A-1 and A-2. The observation wells that will be monitored during each individual pumping test are specified in the attached Table A-1.

3. *Comment 3 - Page 28, Section 4.3.3.1, Paragraph 2, Line 2 – Add text that elaborates on the word "same" (e.g., same elevation).*

   Comment noted. Observation wells will be installed at equivalent elevations as the recovery well.

4. *Comment 4 - Page 28, Section 4.3.3.1, Paragraph 3 – The filter pack and screen for the recovery wells should not be designed based on samples collected at the observation well boreholes. The design should be based on samples collected from the recovery well boreholes or a pilot hole drilled in advance at the location of each recovery well.*

   DEQ expects that ERM, will at a minimum, field confirm that the aquifer material in the target screen zone of the extraction well is consistent with the aquifer material sampled from the observation wells for grain-size analysis. DEQ's position is to make EPA's comment a recommendation and to defer to ERM. EPA does not object to this.

   The aquifer material in the target screen zone will be sampled during installation of the recovery well. As per the procedures defined in the RI Work Plan (Exponent, 1998), the soil samples will be described by field staff using the Unified Soil Classification System (USCS). These samples will be qualitatively compared to the samples collected from the observation wells to confirm the consistency of aquifer materials.

5. *Comment 5 – Page 28, Section 4.3.3.1, Paragraph 4, Line 10 – The bentonite chips that are in the vadose zone should be hydrated with potable water in two foot lifts following Oregon well construction standards.*

Comment noted.

6. *Comment 6 – Page 29, Section 4.3.3.2, Paragraph 2, Lines 3 and 4 – The rationale and criteria used to determine the well screen intervals should be listed in the text.*

   The recovery wells will be installed with the goals of:

   - Full penetration of the target aquifer;
   - Installation of adequate well seal across potential confining layers; and
   - Preventing cross contamination of aquifers.

   Based on these criteria, anticipated construction depths were obtained from boring logs of nearby monitoring wells and presented in Table 4-1 of the Work Plan.

7. *Comment 7 – Page 29, Section 4.3.3.2, Paragraphs 3 and 4 – The rationale for using 6-1/4 inch ID augers for the shallow recovery wells and 8-1/4 inch ID augers to finish the intermediate recovery wells should be provided.*

   Comment noted. All recovery wells will be installed using minimum 8-1/4 inch ID augers.

8. *Comment 8 - Page 29, Section 4.3.3.2, Paragraph 4 – The depth that the conductor casing will be installed into the silt unit should be identified. Also, the nominal diameter of the casing should be noted.*

   See response to EPA General Comment 1. The silt unit is approximately 1 foot thick in the Acid Plant Area. Conductor casing will be installed at a target depth of approximately 0.5-feet into the shallow-intermediate silt. As the depth of the shallow-intermediate silt varies across the site, it is impossible to specify a depth of conductor casing. Instead, ERM field geologists will be utilized who are experienced with the lithology at the site and in identifying the shallow-intermediate silt. Actual depth of penetration will be based on conditions encountered in the field.

   The conductor casing will be 12-1/4 inch inner diameter (ID) augers. These sized augers create a borehole approximately 18 inches in diameter. OAR 690-210 and OAR 690-240 specify that the ID should be used when determining appropriate auger size for the installation of wells.

9. *Comment 9 – Page 30, Section 4.3.3.3, Paragraph 2 – Flow rate and drawdown should be measured at regular intervals throughout the development process of the recovery wells. The measurements should be used to chart specific capacity versus time, which will provide a measure of the development process and give an initial indication of pumping flow rates to be used for the step-drawdown aquifer tests.*

   DEQ's position is to make EPA's comment a recommendation and to defer to ERM. EPA does not object to this.

   Flow rate and drawdown will be measured during the pumping phase of the development process. Field observations, including pH, temperature, conductivity, and turbidity will be used to monitor the development process.

10. *Comment 10- Page 31, Section 4.3.5.2 – Continuous background water level measurements should be collected at each observation well and each recovery well for a period of at least seven days.*

    EPA does not object to DEQ's position identified in DEQ Comment # 10.

    Comment noted. Background water levels will be monitored as per response to DEQ comment 10.

11. *Comment 11 – Page 32, Section 4.3.5.4 – Barometric pressure and precipitation data should be recorded to coincide with water level measurements made during the background water level monitoring period and during the aquifer performance tests.*

    Barometric pressure and precipitation data will be recorded during the background monitoring, pumping, and recovery periods of each pump test.

12. *Comment 12 – Page 32, Section 4.3.5.5, Line 7 – A gate valve is better suited for starting and stopping flow; another valve type (e.g., a ball valve) is better suited for controlling the flow rate.*

    Comment noted. A ball valve will be used for flow rate control.

13. *Comment 13 – Page 34, Section 4.3.6.1, Line 2 – Transmissivity will be estimated from the aquifer testing data prior to estimating hydraulic conductivity. Text identifying this typical sequence should be added to the work plan.*

    Accepted methods of pump test data analysis typically provide an estimate of transmissivity, which is then divided by the saturated aquifer thickness to obtain a

value of hydraulic conductivity. Transmissivity will be reported as part of the calculation of hydraulic conductivity.

14. *Comment 14 – Section 4.3.3, 4.3.5.8, and 4.3.6.1 – In addition to the proposed observation wells, other existing wells within the anticipated capture zone extent should be used to monitor water levels during the aquifer tests. The water levels measured in all observation wells should be used to verify the capture zone extent developed during each test.*

    See response to DEQ Comment 12.

15. *Comment 15 – Page A-5, Bullet 6 - The position of the pump intake inside the well should be stipulated in the work plan.*

    The intake of the pump will be placed as close to the bottom of the well screen as possible, while maintaining adequate flow around the pump motor body for cooling. Based on the dimensions of the proposed pump, the intake will be placed approximately 3 feet from the bottom of the well.

16. *Comment 16 – Page A-5, Last Bullet and Page A-6 Bullet 2– A section is needed that is dedicated to discussing a prescriptive background water level monitoring period rather than a brief mention to pre-test monitoring in these two bullets.*

    Background water level monitoring will be conducted as per response to DEQ Comment 10.

17. *Comment 17 – Page A-6, Bullet 6 – The criterion (or criteria) that will be used to switch from Step 1 to Step 2 should be specified.*

    Each step of the step drawdown test will be run until stabilization of water level is achieved, to a maximum of 4 hours. The switch between steps will be made once the drawdown has stabilized (i.e. less than 0.1 foot of drawdown over 1 hour), or at 4 hours after start, whichever is sooner.

18. *Comment 18 – Page A-7, Bullets 1 and 2 – The criterion (or criteria) that will be used to switch from one step to the next and to terminate the Step Test should be specified*

    See response to EPA Comment 17.

19. *Comment 19 – Page A-7, The last bullet of the Step Test should allow for data review and selecting the rate to be used for the long term test with approval of the rate from ODEQ.*

    DEQ will not require review and approval of the pump rate for the long term test

LSS notes that approval of the selected constant flow rate is not required by DEQ. The design flow rate for the constant rate test is 50 gallons per minute (gpm). The actual flow rate selected will be based on the results of the step drawdown test, and determined by a hydrogeologist during the recovery period of the step drawdown test.

20. *Comment 20 – Page A-9, Bullets 4 and 5 – The pre-test monitoring that is identified here should be defined more explicitly to distinguish it from the pre-test monitoring identified in the Step Test procedures.*

    The constant rate test will commence as soon as practical after the completion of the step drawdown test recovery (minimum 24 hours). The constant rate pre-test monitoring will consist of measurements taken between the end of the step drawdown recovery and the start of the constant rate test. Background monitoring will continue throughout this period and the duration of both tests.

21. *Comment 21 – Page A-9, Bullet 6 – The recommend time period (e.g., approximately 5-20 seconds) between water level recording and pump starting should be specified rather than using the qualitative phrase "Just before starting the pump…"*

    A recommended time period of 30 seconds is specified.

<u>City of Portland Comments</u>

The work plan includes long-term aquifer pumping tests on four new groundwater recovery wells to be installed near the alignment of the proposed barrier wall. The plan states water generated from the development and testing of these new recovery wells will be discharged to the City's Publicly Owned Treatment Works (POTW). Arkema must obtain a BES Batch Discharge Permit before this water may be discharged to the City's POTW (Portland City Code 17.34.070). The work plan does not provide adequate information regarding groundwater contaminants that may be captured by the pump tests, therefore, the proposed analytical testing for the batch discharges is unsupported (i.e., volatile organic compounds, pesticides, metals, perchlorate, and chloride). The City recommends that Arkema provide the City with the following information to support the proposed testing and to facilitate processing of the batch permit application:

- *Table(s) showing all analytes detected in site groundwater and maximum concentrations measured.*
- *Table with the estimated volume of water from each long-term pumping test.*

The City will consider the additional information submitted by Arkema or their representative before determining the analyses required on the proposed batch discharges. Additional information regarding the City's batch discharge permit can be obtained by

contacting Brett Hulstrom with the BES Industrial Source Control Program at (503) 823-7807.

A table of the most recent analytical results from monitoring wells located near the proposed recovery well locations will be provided to the City of Portland as part of the BES Batch Discharge Permit Application. Anticipated volumes of discharge water will also be provided in the application.

Sincerely,

FOR

Todd Slater
Legacy Site Services LLC

Attachments

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

Project No.	Date:	Drawn By:	GIS File:
0057055	06/02/09	T. Cota	

Aerial Photography - July, 2005

LEGEND

- Shallow Zone Pumping Well
- Shallow Zone Observation Well
- Intermediate Zone Observation Well
- Deep Zone Observation Well
- Shallow Zone Background Well

True North

Plant North

0 150 300

Feet

Figure A-1

Proposed Shallow Zone Pumping and Observation Wells
Arkema, Inc.
Portland, Oregon

ERM 06/09

Project No.	Date:	Drawn By:	GIS File:
0057055	06/02/09	T. Cota	

Aerial Photography - July, 2005

LEGEND

- Intermediate Zone Pumping Well
- Intermediate Zone Observation Well
- Shallow Zone Observation Well
- Deep Zone Observation Well
- Intermediate Zone Background Well

True North

Plant North

0 150 300

Feet

Figure A-2

Proposed Intermediate Zone Pumping and Observation Wells
Arkema, Inc.
Portland, Oregon

ERM 06/09

Tables

Table A-1

Aquifer Pump Test Observation Wells
Arkema Inc. Facility
Portland, Oregon

Recovery Well[1]		Observation Well[1]		Background Well[1]		Additional Observation Well[2]	
Well ID	**Aquifer Zone**	**Well ID**	**Aquifer Zone**	**Well ID**	**Aquifer Zone**	**Well ID**	**Aquifer Zone**
RW-1	Shallow	MWA-2	Shallow	MWA-6	Shallow	MWA-3	Shallow
		MWA-60	Shallow			MWA-5	Shallow
						MWA-8i	Intermediate
						MWA-9i	Intermediate
						MWA-13d	Deep
						MWA-14i(d)	Deep
						MWA-17si	Shallow
						MWA-61	Shallow
						MWA-64i	Intermediate
						MWA-67si	Shallow
						PMP-4	Shallow
						PMP-5	Shallow
RW-2i	Intermediate	MWA-8i	Intermediate	MWA-16i	Intermediate	MWA-3	Shallow
		MWA-78i[3]	Intermediate			MWA-5	Shallow
						MWA-61	Shallow
						MWA-64i	Intermediate
						MWA-67si	Shallow
						MWA-8i	Intermediate
						MWA-9i	Intermediate
						MWA-13d	Deep
						MWA-14i(d)	Deep
						MWA-17si	Shallow
						PMP-4	Shallow
						PMP-5	Shallow
RW-3	Shallow	MWA-41	Shallow	MWA-42	Shallow	MWA-26	Shallow
		MWA-79[3]	Shallow			MWA-52i	Intermediate
						MWA-43	Shallow
RW-4i	Intermediate	MWA-80i[3]	Intermediate	MWA-54i	Intermediate	MWA-26	Shallow
		MWA-81i[3]	Intermediate			MWA-52i	Intermediate
						MWA-43	Shallow

Notes:
1 - Water levels will be monitored throughout pump test using pressure transducers
2 - Water levels will be measured at least three times during pump test using an electronic water elvel indicator
3 - New observation well