Expanded RTC Data Gaps Investigation Work Plan

Former Arkema Manufacturing Site

Agreed Order No. DE 5668

Facility/Site ID No. 1220

Cleanup Site ID No. 3405

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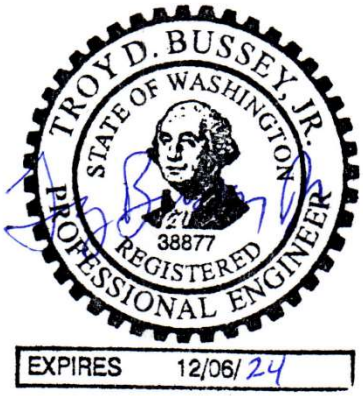
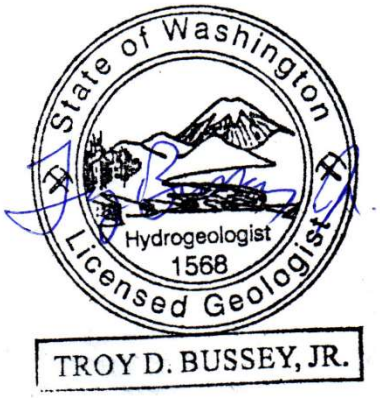
Professional Certification

This document (excluding the appendices) was prepared under my direction. The information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I hereby certify that I was in responsible charge of the work performed for this document (excluding the appendices).





June 28, 2023

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List of Acronyms

Acronym	Explanation
ARI	Analytical Resources, Inc.
BAZ	Biologically Active Zone
bgs	Below Ground Surface
Brooks	Brooks Applied Labs
Caustic	Sodium Hydroxide
CB/NT	Commencement Bay/Nearshore Tide Flats
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CPOC	Conditional Point of Compliance
CSM	Conceptual Site Model
DOF	Dalton, Olmsted, & Fuglevand, Inc.
Ecology	Washington State Department of Ecology
Eh	Activity of Electrons
EM	Electromagnetic Induction
FS	Feasibility Study
GPS	Global Positioning System
GW	Groundwater
HASP	Health and Safety Plan
HPT	Hydraulic Profiling Tool
MTCA	Model Toxics Control Act
MW	Monitoring Well
NAVD88	North American Vertical Datum of 1988
NSDS	Nylon-Screen Diffusion Sampler
PDI	Pre-Design Investigation
Penite	Sodium Arsenite
pH	Activity of Hydrogen Ions
PIONEER	PIONEER Technologies Corporation
POC	Point of Compliance
Port	Port of Tacoma
PPS	Pushpoint Sampler

Acronym	Explanation
P&T	Pump & Treat
PW	Pore Water
QAPP	Quality Assurance Project Plan
QC	Quality Control
RI	Remedial Investigation
RL	Remediation Level
RTC	Response to Comments
SAP	Sampling and Analysis Plan
Site	Former Arkema Manufacturing Site
SL	Screening Level
SOP	Standard Operating Procedure
SPW	Sheet Pile Wall
SW	Surface Water
TCLP	Toxicity Characteristic Leaching Procedure
USEPA	United States Environmental Protection Agency
USG	United States Gypsum
VI	Vapor Intrusion
VOC	Volatile Organic Compound
WAC	Washington Administrative Code
Work Plan	Expanded RTC Data Gaps Investigation Work Plan
XRF	X-ray Fluorescence

SECTION 1: INTRODUCTION

1.1 Purpose

The purpose of this Response to Comments (RTC) Data Gaps Investigation Work Plan (Work Plan) for the Former Arkema Manufacturing Site (Site) is to present the plans for implementing investigation activities that will provide data and information to:

1. Address data gaps identified in response to Washington State Department of Ecology's (Ecology's) August 25, 2021 comments (Ecology 2021b) on the April 2021 Feasibility Study (FS) Report (PIONEER Technologies Corporation [PIONEER] 2021); and
2. Support the design of a barrier wall around the arsenic groundwater (GW) plume core.

1.2 Site Location and Boundary

The relevant Arkema properties are an approximately 45-acre portion of a 64.8-acre parcel (tax parcel number 0321351053) located at 2901 Taylor Way and a 3.2-acre parcel (tax parcel number 0321362056) located at 2920 Taylor Way in Tacoma, Washington.[1] The combined Arkema property boundary is shown on Figure A.

The Site boundary is the same as the Arkema property boundary with the following exceptions (see Figure A):

- Cleanup actions for the North Boundary Area are being conducted as part of Agreed Order No. DE 3405 for the United States Gypsum (USG) Taylor Way Plant Site (Ecology 2021a; PIONEER 2023a).
- A triangular-shaped portion of the Intermediate Aquifer on the adjacent Arkema Mound site is part of the Site boundary (Dalton, Olmsted, & Fuglevand, Inc. [DOF] 2013).

For the purposes of this Work Plan, key areas/features within the Site boundary include the former Central Manufacturing Area, former Penite Pits #1 and #2, the former Penite Manufacturing Building, the former Caustic Manufacturing Area, the former Taylor Lake area surface impoundments, the main arsenic plume, and the sheet pile wall (SPW; see Figure A).

Consistent with Port of Tacoma (Port) practices, all references to direction (i.e., north, south, east, and west) in this document are in relation to "site north," which is parallel to the Hylebos Waterway shoreline (see Figure A). "Site north" is approximately 45 degrees west (counterclockwise) from true north. Both "site north" and true north are shown on the figures for this document.

1.3 Work Plan Organization

The remainder of this Work Plan is organized as follows:

- Section 2: Summary of Background Information

[1] The Port purchased these properties from Arkema in May 2007. The Wypenn property is located at 2920 Taylor Way.

- Section 3: Sampling and Analysis Plan
- Section 4: Quality Assurance Project Plan
- Section 5: Implementation
- Section 6: References

SECTION 2: SUMMARY OF BACKGROUND INFORMATION

A summary of the Site background information most pertinent to this Work Plan is presented in this section. Arsenic is the primary concern at the Site, and the primary pathway of concern is the potential for GW transport of arsenic to cause unacceptable exposures in Hylebos Waterway surface water (SW) and sediment. All RTC data gaps and proposed investigation activities are associated with potential migration of arsenic from the main arsenic plume to the Hylebos Waterway. As a result, the contents in Section 2 and the rest of the Work Plan are focused on the potential for GW transport of arsenic in the main arsenic plume to cause unacceptable exposures in Hylebos Waterway SW and sediment. For a more comprehensive presentation of Site background information, refer to the Remedial Investigation (RI) Report (DOF 2013), FS Data Gap Investigation Report (PIONEER 2019), and the FS Report (PIONEER 2021).

2.1 Hydrogeology

The relevant hydrostratigraphic units at the Site, from shallowest to deepest, correspond to a specific lithologic unit and include the following:

- **Upper Aquifer**: The Upper Aquifer is the saturated portion of the fill unit. The thickness of the Upper Aquifer is approximately ten to 15 feet. Upper Aquifer GW is typically encountered at depths of less than six feet below ground surface (bgs) in most portions of the Site, and is encountered at depths less than two feet bgs within portions of the main arsenic plume.
- **First Aquitard**: The First Aquitard is the upper silt unit. The thickness of the First Aquitard is approximately five to ten feet. Thin and/or leaky portions of the First Aquitard have been identified in portions of the Site (see Figure B).
- **Intermediate Aquifer**: The Intermediate Aquifer is the intermediate sand unit. The thickness of the Intermediate Aquifer is approximately ten to 20 feet.
- **Second Aquitard**: The Second Aquitard is the lower silt unit. The thickness of the Second Aquitard is approximately five to 15 feet.
- **Deep Aquifer**: The Deep Aquifer is the lower sand unit. The thickness of the Deep Aquifer appears to be at least 20 feet thick.

In general, for the main arsenic plume, GW in all three aquifers flows east towards the Hylebos Waterway. There may also be localized GW flow in the Upper Aquifer and Intermediate Aquifer towards the north or south near the SPW. The Intermediate Aquifer and the Deep Aquifer are tidally influenced and can experience flow reversals. Tidal fluctuations and mixing occur seaward of the SPW in the Upper Aquifer, but are less noticeable in the Upper Aquifer landward of the SPW.

The primary hydrostratigraphic units of interest for this Work Plan are the Upper Aquifer, First Aquitard, and Intermediate Aquifer because the majority of the arsenic mass is located in these three units.

2.2 Overview of Operational History

The Site was used as a chemical manufacturing facility from 1927 to 1997 and the majority of the manufacturing operations were performed in the former Central Manufacturing Area (see Figure A). The products that were manufactured in that area included chlorine, sodium hydroxide (caustic), sodium chlorate, hydrochloric acid, and sodium arsenite (Penite). Penite, which is the product most relevant to this Work Plan, was manufactured between circa 1944 and the early 1970s. The remaining chlorine-based manufacturing facility operations ceased in 1997, at which time the manufacturing facilities were dismantled and removed from the Site. The Port removed all remaining aboveground structures in 2008. The Site is covered with vegetation, crushed rock, and some former building/tank foundations. The planned future land use for the Site is Port Maritime Industrial, consistent with the Port's Land Use Plan (Port 2014) and local zoning.

2.3 Overview of Regulatory Context

This Model Toxics Control Act (MTCA) Site is currently being addressed pursuant to Agreed Order No. DE 5668 between the Port and Ecology, which became effective on July 25, 2011. The MTCA RI Report was approved in 2013 (DOF 2013; Ecology 2013), and the Site is currently in the MTCA FS phase. One or more MTCA interim actions (e.g., barrier wall around the arsenic plume core) may be completed under the agreed order before the FS Report is finalized. Many important remedial actions were previously completed as discussed in Section 2.6 pursuant to a 1987 Clean Water Act Consent Decree between Arkema and Ecology. The Site is also part of the larger Commencement Bay/Nearshore Tide Flats (CB/NT) Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) site, and Site remedial actions were completed under CERCLA (e.g., sediment dredging, shoreline caps). The Site is one of many source areas included within Operable Unit OU 05 of the CB/NT site. Ecology is the lead agency for OU 05 source control actions, with United States Environmental Protection Agency (USEPA) coordination and oversight.

2.4 Definition of Arsenic Plume Terms

To facilitate clear communication about arsenic in GW at the Site, the following terms are used for the purposes of this Work Plan:

- Main arsenic plume: The main arsenic plume is conceptually defined as the plan-view area encompassed by the 2017 Upper Aquifer dissolved arsenic isoconcentration contour of 500 micrograms per liter (ug/L), areas downgradient of this contour, and associated areas with activity of hydrogen ions (pH) levels exceeding nine (see Figure A). The main arsenic plume includes GW within this plan-view area in the Upper, Intermediate, and Deep Aquifers.
- Source Area: The source area for the main arsenic plume is generally defined as the area encompassed by the known and potential Penite manufacturing features shown on Figure A.
- Plume core: The plume core is loosely defined as the areas where historical and/or 2017 arsenic concentrations in monitoring wells (MWs) exceeded 50,000 ug/L.
- GW: GW is defined in Washington Administrative Code (WAC) 173-340-200 as “water in a saturated zone or stratum beneath the surface of land or below a surface water.”

- Pore water (PW): PW is defined as the subset of GW that is located within the 0 - 10 centimeter biologically active zone (BAZ) used for the CB/NT site (DOF 2011).
- SW: SW is defined in WAC 173-340-200 as "lakes, rivers, ponds, streams, inland waters, salt waters, and all other surface waters and water courses within the state of Washington or under the jurisdiction of the state of Washington."

2.5 Summary of the Main Arsenic Plume CSM

A summary of the current conceptual site model (CSM) for the main arsenic plume is presented in this section. The CSM includes conceptual site fate and transport elements and a conceptual site exposure model. A more detailed version of the CSM is presented in the FS Data Gap Investigation Report (PIONEER 2019). The CSM will be updated as new information is obtained.

Key conceptual fate and transport elements are:

- Former Penite Pits #1 and #2 are known primary sources and sludge-like material remains in former Penite Pit #2.
- The former Penite Manufacturing Building is a suspected third primary source based on the nature of historical Penite manufacturing operations, evaluation results presented in the FS Data Gap Investigation Report, and GW modeling results.[2]
- Transport of arsenic in GW from the source area towards the Hylebos Waterway is currently conceptualized as three separate plume lobes emanating from each of the three primary sources that have combined to form a single large arsenic plume. GW in the Upper and Intermediate Aquifers near former Penite Pit #1 generally flows due east towards the SPW, while GW near former Penite Pit #2 has a slight southeastern flow direction and GW near the former Penite Manufacturing Building has a slight northeastern flow direction. The central plume lobe emanating from former Penite Pit #1 is currently less prominent than the northern and southern lobes because of the success of completed remediation actions within and downgradient of former Penite Pit #1.
- Completed remedial actions (i.e., soil excavations and operation of the arsenic pump-and-treat [P&T] system) have removed arsenic mass from the main arsenic plume.
- The majority of arsenic within the main arsenic plume resides within the upper portion of First Aquitard soil.
- The majority of arsenic within the main arsenic plume is either precipitated or co-precipitated with highly stable minerals or co-precipitated with metal oxides.
- Elevated pH levels within the northern and southern portions of the main arsenic plume limit opportunities for sorption and cause reducing conditions (e.g., activity of electrons [Eh] less than 0 volts) that further hamper sorption and limit co-precipitation with metal oxides in these areas.
- Thin/leaky First Aquitard locations upgradient of 124+00-2 on the landward side of the SPW are preferential pathways that likely contribute to elevated dissolved arsenic concentrations at 124+00-2 and two PW nylon-screen diffusion sampler (NSDS) locations downgradient of 124+00-2.

[2] When used in this Work Plan, the term former Penite Manufacturing Building refers to the former building itself and the three adjacent former tanks located immediately southeast of the former building.

- The main arsenic plume is stable or declining due to completed remedial actions and ongoing natural attenuation processes.
- The existing SPW, intertidal shoreline cap, and subtidal shoreline cap help attenuate arsenic concentrations in GW prior to discharge to SW.
- Highly favorable geochemical conditions for arsenic attenuation are present near the shoreline due to mixing of marine SW with GW.
- The mixing of SW within GW in the transition zone along the Site shoreline causes hydraulic tidal dispersion, which limits the amount of fresh GW discharged to SW.

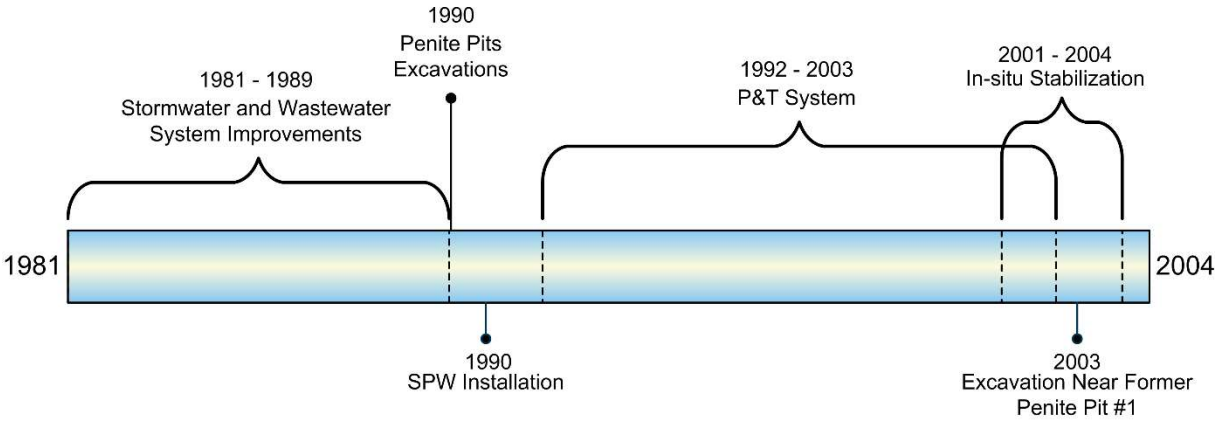
The key exposure pathways for the purposes of this Work Plan are those related to potential SW and sediment exposures:

- Absorption by marine aquatic organisms
- Bioaccumulation by marine aquatic organisms
- Incidental ingestion and dermal contact with SW and sediment by recreators/fishers
- Consumption of marine aquatic organisms by recreators/fishers

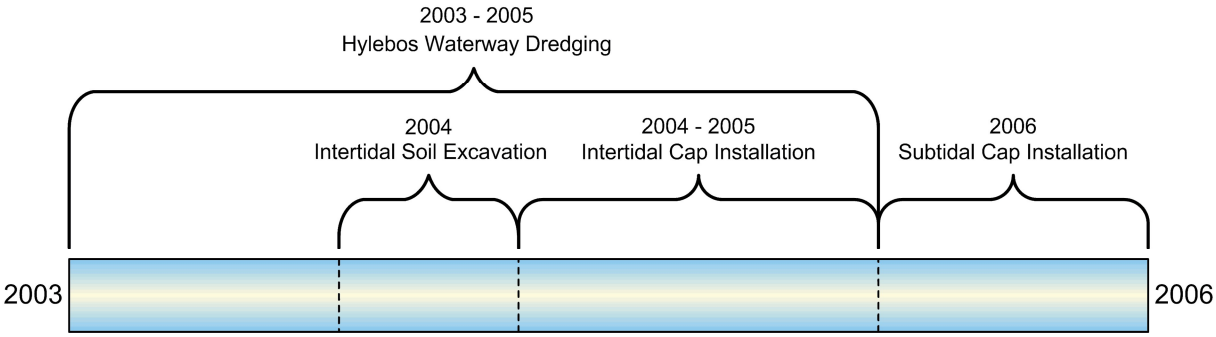
2.6 Overview of Completed Remedial Actions

A substantial number of cleanup activities have been completed for the Site pursuant to the Clean Water Act, CERCLA, and MTCA. Approximately $16 million dollars have been spent through February 2021 to investigate and evaluate the Site, and approximately $66 million dollars have been spent through February 2021 to cleanup the Site (Groff Murphy Trachtenberg & Everard, PLLC 2006; DOF 2011; PIONEER 2016; 2021 personal correspondence with DOF and the Port). Completed remedial actions include improving historical stormwater and wastewater systems, removing soil and sediment, installing soil and sediment caps, installing a SPW, installing and operating a P&T system for the main arsenic plume, conducting in-situ stabilization for the main arsenic plume, remediating volatile organic compound (VOC) source areas, and completing remediation for miscellaneous other releases.

A timeline of the most important completed remedial actions within the plume core of the main arsenic plume are presented in the following graphic.



A timeline of the most important completed remedial actions along the shoreline and within the Hylebos Waterway (on the seaward side of the main arsenic plume) are presented in the following graphic.



2.7 Summary of Current GW Conditions for the Main Arsenic Plume

The current GW conditions for the main arsenic plume and GW transport elements from the CSM that are most salient for this Work Plan were identified (see following bullets) and were summarized on Figure B.

- The 5,000 ug/L and 50,000 ug/L dissolved arsenic isoconcentration contours, which highlight the areas with the highest remaining concentrations at the Site (e.g., current plume core).
- Upper Aquifer Angled Shoreline MW and Intermediate Aquifer pushpoint sampler (PPS) locations with a current dissolved arsenic concentration exceeding the MTCA screening level (SL) for protection of aquatic organisms (36 ug/L). Upper Aquifer Angled Shoreline MWs and Intermediate Aquifer PPSs are one of several potential points of compliance (POC) options for the main arsenic plume. The MTCA SL for protection of aquatic organisms (36 ug/L) is a potential GW remediation level (RL).
- Upper Aquifer and Intermediate Aquifer PW NSDS locations with a current dissolved arsenic concentration exceeding the MTCA SL for protection of aquatic organisms (36 ug/L). PW NSDSs are one of several potential POC options for the main arsenic plume.
- Locations of known and potential Penite manufacturing features, which include known primary sources (i.e., former Penite Pits #1 and #2) and a suspected primary source (i.e., former Penite Manufacturing Building).
- Locations where the First Aquitard is thin or leaky. These locations could provide a preferential pathway for arsenic migration from the Upper Aquifer to the Intermediate Aquifer. In particular, the two thin/leaky First Aquitard locations immediately upgradient of 124+00-2 on the landward side of the SPW likely contribute to elevated dissolved arsenic concentrations at 124+00-2 and two PW NSDSs downgradient of 124+00-2.
- Locations where pH currently exceed or equal 10. These locations have notably high pH levels that will likely limit opportunities for arsenic sorption and cause reducing conditions that further hamper arsenic sorption and limit co-precipitation of arsenic with metal oxides for an extended time frame.
- Locations where active arsenic remediation components have already been completed and remain intact (i.e., soil and sediment removals, soil and sediment caps, SPW).

In addition, the key locations seaward of the SPW that have particularly elevated dissolved arsenic GW and PW concentrations seaward of the SPW are (see Figure B):

- The 2017 and 2018 concentrations in 124+00-2 (on the order of 50,000 ug/L) were one to four orders of magnitude higher than concentrations in the other Intermediate Aquifer vertical shoreline MWs and the Upper Aquifer vertical shoreline MWs.[3]
- One Upper Aquifer Angled Shoreline MW (125+50-0) and three Intermediate Aquifer PPS locations (120+75-ST1, 123+25-ST1, and 128+50-ST1) exceeded 36 ug/L in 2017 or 2018.[4]
- One Upper Aquifer PW NSDS location (125+50-0-DS) and two Intermediate Aquifer PW NSDS locations (123+25-ST1-DS and 125+00-ST1-DS) exceeded 36 ug/L in 2017 or 2018.[5]
- One PW NSDS location exceeded 360 ug/L in 2017 or 2018 (550 ug/L in 123+25-ST1-DS).

2.8 GW POC Options

Several GW POC options are potentially applicable to this Site based on MTCA regulations for the protection of potential SW receptors. The standard GW POC, which is defined in WAC 173-340-720(8)(b) as all GW across a site, is potentially applicable to all sites. However, this standard POC is typically not appropriate for complex sites like this Site because it is not practicable to achieve GW cleanup levels throughout the site within a reasonable restoration time frame. In addition, the standard GW POC is unnecessarily conservative for protection of marine SW and sediment receptors because the standard POC assumes that (1) marine aquatic organisms live in upland fresh GW, and (2) recreators/fishers consume marine aquatic organisms obtained from upland fresh GW. As a result, MTCA regulations allow two general types of GW conditional POCs (CPOCs) that could be applied to a complex shoreline site such as this Site. Per WAC 173-340-720(8)(c), the first general CPOC option is "as close as practicable to the source of hazardous substances" but not exceeding the property boundary. Since this Site abuts SW, a second general CPOC option per WAC 173-340-720(8)(d)(i) if certain criteria are met is “within the surface water as close as technically possible to the point or points where ground water flows into the surface water.” As a result, the standard GW POC and the four following CPOC locations in the Upper and Intermediate Aquifers (see Figure C) were evaluated as potential POCs in the April 2021 FS Report:

1. Upper Aquifer and Intermediate Aquifer vertical shoreline MWs
2. Upper Aquifer Angled Shoreline MWs (located approximately two feet landward of the SW interface) and Intermediate Aquifer PPS locations (which have a pump intake approximately one foot landward of the SW interface)
3. Upper Aquifer and Intermediate Aquifer PW NSDSs conservatively located at the bottom of the BAZ (a depth of approximately 10 centimeters)
4. SW samples collected as close as technically possible to where GW flows into SW

[3] The dissolved arsenic concentrations in the 124+00-2 samples collected during 2017 and 2018 were 39,000 ug/L and 76,000 ug/L, respectively.

[4] Dissolved arsenic concentrations in 125+50-0, 120+75-ST1, 123+25-ST1, and 128+50-ST1 ranged from 75 ug/L to 110 ug/L, 48 ug/L to 280 ug/L, 160 ug/L to 190 ug/L, and 3.1 ug/L to 70 ug/L, respectively.

[5] Dissolved arsenic concentrations in 125+50-0-DS and 125+00-ST1-DS ranged from 39 ug/L to 44 ug/L and 6.4 ug/L to 44 ug/L, respectively. 123+25-ST1-DS was only sampled in 2018 (with a dissolved arsenic concentration of 550 ug/L).

2.9 Activity Since April 2021 FS Report Submittal

Ecology provided comments for the April 2021 FS Report on August 25, 2021 (Ecology 2021b). In general, key Ecology concerns regarded (1) some context presented in the report, (2) some FS evaluations, and (3) additional data needed to support some FS evaluations and/or selection of a recommended cleanup action alternative. Specific data gaps identified or implied in Ecology's comments were related to arsenic soil concentrations in the plume core, arsenic soil concentrations in the "wedge" (i.e., seaward of the SPW), the source(s) of elevated arsenic GW concentrations, and arsenic SW concentrations. The Port, Ecology, and PIONEER met to discuss Ecology's August 25, 2021 comments and the associated data gaps on September 14, 2021. A "streamlined" RTC Data Gaps Investigation Work Plan and an accompanying RTC table were submitted to Ecology on June 8, 2022 to address Ecology's concerns and facilitate the collection of data necessary to revise the FS Report and support the selection of a recommended cleanup action alternative (PIONEER 2022a, 2022b).[6] Ecology issued comments on the "streamlined" RTC Data Gaps Investigation Work Plan on July 15, 2022 (Ecology 2022). Ecology (Andy Smith) and PIONEER (Troy Bussey) discussed Ecology's July 15, 2022 comments during a July 29, 2022 video call. At the end of the July 29, 2022 call, Ecology verbally agreed that there were no concerns about the proposed investigation activities and that no revisions were needed for the investigation design in the "streamlined" work plan beyond providing more Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) details within the work plan itself (rather than referencing previously approved Site work plans). As a result, this "expanded" Work Plan has been prepared per Ecology's request.[7]

As part of the response to Ecology's August 25, 2021 FS Report comments, the Port, Ecology, and PIONEER also met on October 13, 2021 to discuss potential MTCA interim action options. Specifically, the Port proposed to conduct MTCA interim actions to construct (1) a barrier wall around the arsenic plume core (i.e., remedial component APR-5A in the April 2021 FS Report), and (2) a surface cap/cover in the approximately 24-acre portion of the Site where active remediation components are not being contemplated. Ecology verbally agreed in concept with these conceptual interim actions. The Port is moving forward to prepare a design for the barrier wall. DOF completed a Barrier Wall Basis of Design Report in March 2023. Three key outcomes from that report were (1) the barrier wall alignment was slightly expanded to minimize the potential for encountering subsurface obstacles (e.g., building foundations), (2) vibratory beam installation is the recommended installation method for the barrier wall, and (3) pre-design investigation (PDI) activities were identified to support the barrier wall design. The Barrier Wall PDI Work Plan in Appendix A presents the details for these barrier wall PDI activities.

[6] The RTC table submitted to Ecology on June 8, 2022 just responded to Ecology's general FS Report comments (PIONEER 2022b). An RTC table that responded to all of Ecology's FS Report comments was submitted to Ecology on July 14, 2022 (PIONEER 2022c).

[7] A RTC table that responds to Ecology's July 15, 2022 comments on the June 8, 2022 "streamlined" work plan accompanied this "expanded" Work Plan (PIONEER 2023b).

SECTION 3: SAMPLING AND ANALYSIS PLAN

The purpose of this SAP is to present the methodology for collecting and analyzing samples pursuant to this Work Plan in accordance with WAC 173-340-820 and applicable components of Ecology guidance (Ecology 1995). Typical background contents of a stand-alone SAP are not repeated if included elsewhere in this Work Plan.

3.1 Investigation Design for the Barrier Wall PDI

The investigation design for the Barrier Wall PDI is presented in the Barrier Wall PDI Work Plan (see Appendix A). In summary, the Barrier Wall PDI activities include:

- Locating, identifying, and documenting utilities and other potential subsurface obstructions via surface geophysics and shallow trenching along the barrier wall alignment.
- Collecting one composite soil sample during shallow trenching along the barrier wall alignment, and analyzing that sample for total metals and toxicity characteristic leaching procedure (TCLP) metals to evaluate on-site reuse and off-site disposal options for soil excavated from the trench.
- Advancing 15 soil borings along the barrier wall alignment and collecting geotechnical data (e.g., standard penetration tests, gradation analyses, Atterberg Limits, triaxial tests, consolidation tests).
- Evaluating different slurry mix design options.
- Completing compatibility testing for one or more slurry mix design options.

3.2 Investigation Design for the RTC Data Gaps Investigation

3.2.1 Context for Investigation Design

RTC data gap investigation tasks were identified to (1) address Ecology's August 25, 2021 comments on the April 2021 FS Report, and (2) evaluate the six existing hypotheses for the cause(s) of elevated dissolved arsenic concentrations at 124+00-2 (a key Intermediate Aquifer MW seaward of the existing SPW) and downgradient PW. The dissolved arsenic concentrations at 124+00-2 (on the order of 50,000 ug/L) and downgradient PW (e.g., 550 ug/L at 123+25-ST1-DS) are the largest concern for potential future Site impacts to Hylebos Waterway SW and sediment. Determining the cause(s) of elevated dissolved arsenic concentrations at 124+00-2 and downgradient PW is critical for developing and selecting a successful and cost-effective remedy. The six existing hypotheses for the cause(s) of elevated dissolved arsenic concentrations at 124+00-2 and downgradient PW are:

1. Remaining soil source landward of the SPW (i.e., former Penite Pits, former Penite Manufacturing Building);
2. Potential preferential pathways (e.g., thin/leaky First Aquitard locations, historical stream channels, historical sewer lines, historical pilings) funnel high arsenic concentrations from the source area towards 124+00-2 on the landward side of the SPW;
3. Geochemical conditions (e.g., Eh, pH) are limiting adsorption and co-precipitation with metal oxides near 124+00-2;

4. Preferential leakage through the SPW near 124+00-2;
5. Preferential leakage under the SPW near 124+00-2 (associated with historical stream channels); and
6. Remaining soil source seaward of the SPW (in the wedge) near 124+00-2.

3.2.2 Tasks and Proposed Locations

A total of 12 RTC data gap tasks were identified to (1) address Ecology's August 25, 2021 comments on the April 2021 FS Report, and (2) evaluate the six existing hypotheses for the cause(s) of elevated dissolved arsenic concentrations at 124+00-2 and downgradient PW. The investigation design for these 12 RTC data gap tasks is presented in Table 1. The investigation design (Table 1) includes for each task: the objective(s), the number of locations, the location IDs, the corresponding figure that shows the proposed locations, key task-specific details, field analyses, and lab analyses, as well as the corresponding RTC number (see PIONEER 2022c) and corresponding 124+00-2 hypothesis number (see Section 3.2.1). As described in the investigation design (Table 1), the 12 tasks and the associated proposed locations are:

- Task 1A: Geophysical survey (see proposed survey area in Figure 1).
- Task 1B: Hydraulic profiling tool (HPT) borings (see four proposed locations in Figure 1).
- Task 2A: Plume core borings (see 25 proposed locations in Figure 2A).
- Task 2B: Plume core Upper Aquifer GW samples (see one proposed location in Figure 2B).
- Task 2C: Plume core Intermediate Aquifer GW samples (see eight proposed locations in Figure 2C).
- Task 2D: Sequential extraction and PW samples from plume core borings (see five proposed locations in Figure 2D).
- Task 3: Tidal fluctuation study (see four proposed locations in Figure 3).
- Task 4A: Wedge borings (see three proposed locations in Figure 4).
- Task 4B: Wedge Intermediate Aquifer GW samples (see five proposed locations in Figure 4).
- Task 4C: Sequential extraction and PW samples from wedge boring (see one proposed location in Figure 4).
- Task 5: SW and Intermediate Aquifer PW and PPS samples (see 18 proposed locations in Figure 5).
- Task 6: Additional plume core borings (proposed locations for Task 6 to be determined in the future, if necessary, based on the results from previous tasks [e.g., Task 2A] and the determination of an arsenic soil RL).

In addition to these 12 tasks, field x-ray fluorescence (XRF) and laboratory data will be opportunistically collected from the 15 Barrier Wall PDI borings (to the extent practicable) to support Tasks 2A and 6. There will be depth intervals in these Barrier Wall PDI borings where XRF data cannot be collected (e.g., within the excavated trench along the barrier wall alignment, where Shelby Tube samples are collected).

3.2.3 Key Investigation Design Concepts

Key overarching concepts for the investigation design include:

- Tasks 2A through 2D are all interrelated and will be completed concurrently. The Task 2B MW, the Task 2C MWs, and the Task 2D sequential extraction and PW samples will be collected from a subset of Task 2A borings. In other words, some Task 2A borings will be used to complete related work for Task 2B, Task 2C, and/or Task 2D. For example, Task 2B MW (i.e., 6E30-1) will be installed in Task 2A Boring PTC-309.
- Tasks 4A through 4C are all interrelated and will be completed concurrently. The Task 4B grab GW samples at PTC-401 and PTC-403 will be collected from Task 4A Borings PTC-401 and PTC-403. Likewise, the Task 4C sequential extraction and PW samples at PTC-402 will be collected from Task 4A Boring PTC-402.
- The tasks are intended to be implemented in sequential numeric order (e.g., Tasks 1A-1B will be completed before Tasks 2A-2D) so that results from a given task can inform and refine the investigation activity for the subsequent task. For instance, some sampling locations may be adjusted based on results from previously completed tasks.
- Field and lab analyses are focused on the essential data necessary to (1) address Ecology's August 25, 2021 comments on the April 2021 FS Report, and (2) evaluate the six existing hypotheses for the cause(s) of elevated dissolved arsenic concentrations at 124+00-2 and downgradient PW.
- The field investigation procedures for completing all tasks are presented in the next section. In addition, key task-specific details (e.g., expectations on sample depths, sample intervals, type and number of analyses) are presented in Table 1. If there is an inadvertent discrepancy between the investigation design in Table 1 and any SAP/QAPP procedures presented in subsequent sections, then the investigation design in Table 1 will be followed.

3.3 Field Investigation Procedures

The key sampling and analysis details for the 12 RTC data gap tasks are presented in Table 1. With a few minor exceptions, the additional field and lab investigation procedures necessary to implement these 12 tasks are standard Site procedures that were included in the SAP and QAPP portions of the Ecology-approved FS Data Gap Investigation Work Plan (PIONEER 2017).

3.3.1 Geophysical Survey (Task 1A)

HydroGeophysics will conduct an electromagnetic induction (EM) survey in the area shown in Figure 1 to provide information about the topography of the surface of First Aquitard surface, where the First Aquitard is thinner or absent, and any remaining subsurface utilities/infrastructure features that could serve as a potential preferential pathway. The EM method is being used because it can map changes in soil conductivity (due to changes in lithology, soil moisture, or other conductivity changes caused by physical property contrasts), detect metallic objects (both ferrous and non-ferrous), and facilitate rapid data acquisition across the survey area. A GEM2 multi-frequency instrument or equivalent will collect electromagnetic data (e.g., conductivity and in-phase measurements) along parallel survey lines approximately five feet apart. The sample rate will be at least five measurements per second. The EM survey depth will be approximately 20 to 30 feet bgs, depending on soil conditions. The electromagnetic data will be acquired in conjunction with a survey grade global positioning system (GPS) in order to provide real-time GPS location control to within 1.5 feet.

If further investigation of locations where the First Aquitard is thin or absent is deemed necessary by PIONEER and the Port, HydroGeophysics will conduct an electrical resistivity survey in a portion of the area shown in Figure 1 immediately following the EM survey. The electrical resistivity method would provide high-resolution details about the topography and thickness of the First Aquitard in two-dimensional cross-sections. A Supersting™ R8 multichannel electrical resistivity system or equivalent would collect electrical resistivity data along up to nine survey lines containing 24-inch-long steel rod electrodes (typically installed 12-18 inches into the ground using a small sledgehammer). A dipole-dipole electrode configuration would be used due to its increased resolution and reduced interference potential to metallic infrastructure. The survey lines would be approximately 50 feet apart, although they would need to be adjusted to avoid metal MW casings and other metallic subsurface infrastructure that could cause interference in the electrical resistivity measurements. The maximum electrical resistivity survey depth would be approximately 40 to 50 feet bgs, with emphasis on characterizing the much shallower First Aquitard across the desired portion of the study area. A handheld Garmin GPS would be used to layout and record the location of all electrodes, and obtain surface topography information.

3.3.2 HPT Borings (Task 1B)

A Cascade driller licensed in Washington State per Chapter 173-162 WAC will advance direct-push HPT borings at the four approximate locations shown on Figure 1A, Cascade will operate the associated HPT equipment and software in accordance with their standard operating procedures (SOPs), and Cascade will prepare HPT logs for each boring. The HPT system consists of several key components. Clean water is injected at a constant flow rate from an aboveground reservoir through the direct-push rods and out into the surrounding soil via an injection port on the side of the HPT probe. Simultaneously, sensors in the HPT probe continuously record the electrical conductivity, the injected water flow rate, the back pressure required by the pump to maintain that flow rate, and the current depth of the HPT probe. These measurements are collected by the onboard software and an estimated hydraulic conductivity value is calculated (based on the recorded pressure changes). The continuous electrical conductivity, flow rate, and pressure measurements and the estimated hydraulic conductivity values are then plotted versus depth in a vertical HPT boring log. An HPT boring log provides high-resolution vertical characterization for the relative permeability of unconsolidated materials to better understanding what subsurface zones are exhibiting higher or lower relative permeability at a given location.[8] Once all applicable samples have been collected from a given soil boring, the Cascade driller will decommission the soil boring in accordance with Chapter 173-160 WAC.

[8] The estimated hydraulic conductivities generated by HPT are relative, with a typical accuracy of one to two orders of magnitude. As a result, the HPT estimated values should not be used in place of traditional hydraulic conductivity values if more certainty is required.

3.3.3 Soil Boring Related Tasks (Tasks 2A-2D, 4A-4C, and 6 and Data from Barrier Wall PDI Borings)

3.3.3.1 Drilling and Soil Sampling (Tasks 2A, 4A, and 6 and Data from Barrier Wall PDI Borings)

Drilling and soil sampling will occur at the 25 Task 2A soil borings, three Task 4A soil borings, and to-be-determined Task 6 borings (see approximate locations for Task 2A and Task 4A borings in Figures 2A and 4, respectively). In addition, drilling and sampling will occur at the 15 Barrier Wall PDI Borings as described in Appendix A. See Table 1 for task-specific details regarding the target drilling depths, sample intervals, and other soil sampling-related details at each boring location. Drilling and soil sampling activities will be conducted in accordance with the applicable procedures in DOF SOP-125 (see Appendix B).[9] A driller licensed in Washington State per Chapter 173-162 WAC will complete all drilling activities. Although not mentioned in DOF SOP-125, water should be decanted from a given soil sample to the extent practicable, and particles larger than approximately ¼-inch should be removed from the containerized sample.

3.3.3.2 XRF Field Screening (Tasks 2A, 4A, and 6 and Data from Barrier Wall PDI Borings)

PIONEER will conduct high-resolution vertical characterization of arsenic in soil with a field XRF at all Task 2A, Task 4A, and Task 6 borings (i.e., at least one XRF analysis for every 2.5 feet of soil depth). PIONEER will also conduct high-resolution vertical characterization of arsenic in soil with a field XRF at all Barrier Wall PDI borings to the extent practicable. The PIONEER procedures for field XRF sample preparation and analysis are presented in Appendix C.

3.3.3.3 Grab GW Samples from Temporary MWs (Tasks 2C and 4B)

Grab GW samples will be collected from temporary MWs installed in four Task 2A borings (i.e., PTC-315, PTC-319, PTC-320, and PTC-322) per Task 2C and two Task 4A borings (i.e., PTC-401 and PTC-403) per Task 4B. The temporary MWs will be installed and developed using the procedures for permanent MWs in Section 3.3.5.1 and 3.3.5.2 to the extent practicable. All temporary MWs will be screened in the Intermediate Aquifer, and may be constructed using pre-packed screens. GW samples will be collected from the temporary MWs using the procedures for permanent MWs in Section 3.3.5.4 to the extent practicable. Final values for field water quality parameters (i.e., pH, conductivity, temperature, dissolved oxygen, oxidation reduction potential, and turbidity) will be recorded, even if purging stability cannot be achieved. GW samples for dissolved arsenic analysis will be field filtered with an in-line 0.45-micron filter. Temporary MWs will be decommissioned in accordance with Chapter 173-160 WAC immediately following GW sampling.

[9] The procedures in DOF SOP-125 to "test headspace for VOCs" and "sheen testing" are not applicable for the work conducted under this Work Plan.

3.3.3.4 Soil Sequential Extraction and PW Sampling from Borings (Tasks 2D and 4C)

Soil samples from the top foot of the First Aquitard will be collected in five Task 2A borings (i.e., PTC-308, PTC-310, PTC-315, PTC-316, and PTC-321 as shown on Figure 2D) and one Task 4A boring (i.e., PTC-402 as shown on Figures 2D and 4) for sequential extraction and follow-on analyses. In addition, one soil sample from a worst-case Intermediate Aquifer sample interval in PTC-402 (based on field XRF results and professional judgment) will be collected for sequential extraction and follow-on analyses. The soil samples for sequential extraction will be field preserved to minimize oxidation of metals in the soil samples consistent with the concepts in *Mineral Preservation of Solid Samples Collected from Anoxic Subsurface Environments* (USEPA 2006). The field procedures for anoxic preservation of these soil samples will include the following steps: (1) capping both ends of the soil sample interval, (2) placing the sample interval in a Mylar bag (e.g., Mitsubishi Chemical), (3) adding oxygen absorbing packets to the Mylar bag, (4) purging the Mylar bag with nitrogen, helium, or argon gas, (5) manually expressing as much gas as possible from the Mylar bag, (6) sealing the Mylar bag with a portable heat sealer, (7) placing the sealed Mylar bag in a re-sealable plastic bag, (8) manually expressing as much air as possible from the plastic bag, and (9) storing the sample in a cooler with dry ice.

PW samples from the top foot of the First Aquitard will be collected in five Task 2A borings (i.e., PTC-308, PTC-310, PTC-315, PTC-316, and PTC-321 as shown on Figure 2D) and one Task 4A boring (i.e., PTC-402 as shown on Figures 2D and 4) for dissolved arsenic analysis. Collocated borings will be necessary to obtain sufficient PW volume at each location. It is envisioned that all necessary soil samples from the top foot of the First Aquitard (i.e., samples for field XRF arsenic analysis and laboratory arsenic, pH, TCLP arsenic, and sequential extraction analyses) will be collected from the original boring, and that one or two additional collocated borings will be necessary to collect the PW sample.[10] The procedure to collect a PW sample from the First Aquitard will be the same procedure that DOF previously used to successfully collect PW samples from the First Aquitard at this Site (DOF 2008). Specifically, PW will be extracted from First Aquitard soil by centrifugation. Soil samples will be centrifuged in a 2000 x g (g-force) centrifuge at approximately 4 degrees Celsius for one hour or until sufficient volume of water is generated to perform the dissolved arsenic analysis. PW will be carefully decanted or aspirated to minimize turbulence and aeration. The PW samples for dissolved arsenic analysis will be field filtered with an in-line 0.45-micron filter. If it is not practicable to field filter the PW samples, then the field team will request the laboratory to filter the sample with a 0.45-micron filter in an expedited fashion.

3.3.4 GPS Coordinates for All New Borings

PIONEER will collect the coordinates for all new borings (i.e., borings advanced per Tasks 1B, 2A, 4A, and 6 as well as the Barrier Wall PDI borings) with a Trimble GeoXH or similar GPS unit. The GPS accuracy will be within +/- one meter.

[10] If two collocated borings are not sufficient to collect enough PW volume from the top foot of the First Aquitard at a given location, PW samples will be collected from the top few feet of the First Aquitard in order to obtain enough PW volume.

3.3.5 Permanent MW Related Tasks (Tasks 2B, 2C, and 4B)

3.3.5.1 MW Installation (Tasks 2B and 2C)

Five new permanent MWs will be installed:

- Upper Aquifer MW 6E30-1 will be installed pursuant to Task 2B (in the Task 2A boring PTC-309) at the approximate location shown in Figure 2B.
- Intermediate Aquifer MWs 6E30-2, 5E31-2, 6D32-2, and 6D33-2 will be installed pursuant to Task 2C (in the Task 2A boring PTC-310, PTC-316, PTC-323, and PTC-324, respectively) at the approximate locations shown in Figure 2C.

These MWs will be installed in accordance with the DOF SOP-100 (see Appendix B). Two-inch diameter MWs will be installed, and MW screens will not cross multiple lithologic units (e.g., portions of the MW screen for an Intermediate Aquifer MW will not be within the First Aquitard or Second Aquitard). It is expected that (1) MW screen lengths will be 10 feet or 5 feet, (2) 10-slot MW screens will be used, and (3) sand filter packs will be used (not pre-packed screens) for permanent MWs.

3.3.5.2 MW Development (Tasks 2B and 2C)

The five new permanent MWs (i.e., 6E30-1, 6E30-2, 5E31-2, 6D32-2, and 6D33-2) will be developed in accordance with the DOF SOP-105 (see Appendix B).

3.3.5.3 MW Surveying (Tasks 2B, 2C, and 3)

A licensed surveyor will determine the vertical and horizontal location of the MW reference point (notch or mark, or north side of the top of casing if no notch or mark) for the five new permanent MWs (i.e., 6E30-1, 6E30-2, 5E31-2, 6D32-2, and 6D33-2) as well as 124+00-2 and 125+50-2 (to support Task 3). The vertical elevation will be surveyed to an accuracy of 0.01-foot with the North American Vertical Datum of 1988 (NAVD88). Vertical elevations in Mean Lower Low Water will also be provided to the nearest 0.01-foot. The horizontal accuracy will be approximately one foot.

3.3.5.4 GW Sampling from Permanent MWs (Tasks 2B, 2C, and 4B)

After the five new permanent MWs are installed and developed, water level measurements will be obtained and GW samples will be collected from the five new permanent MWs (i.e., 6E30-1, 6E30-2, 5E31-2, 6D32-2, and 6D33-2) per Tasks 2B and 2C and three existing MWs (i.e., 122+60-2, 124+00-2, and 125+50-2) per Task 4B. It is envisioned that two separate events will be conducted to obtain water levels and collect GW samples from permanent MWs: one Task 2B/2C event (i.e., 6E30-1, 6E30-2, 5E31-2, 6D32-2, and 6D33-2) and a subsequent Task 4B event (i.e., 122+60-2, 124+00-2, and 125+50-2).

Water level measurements will be obtained in accordance with the applicable procedures in DOF SOP-110 (see Appendix B).[11] In addition, measurements will begin near the end of a falling or rising tide so

[11] The procedures in DOF SOP-110 to measure light non-aqueous phase liquid levels/thicknesses and dense non-aqueous phase liquid levels/thicknesses are not applicable for the work conducted under this Work Plan.

that as much as the slack tidal period as possible can be incorporated into the measurement period. MWs closest to the shoreline will be measured first, followed by MWs located further landward.

GW samples will be collected via the low-flow GW sampling procedures in accordance with DOF SOP-115 (see Appendix B). In addition, MWs landward of the SPW (i.e., 6E30-1, 6E30-2, 5E31-2, 6D32-2, and 6D33-2) will be sampled within three hours of low tide. MWs seaward of the SPW (i.e., 122+60-2, 124+00-2, and 125+50-2) will be sampled within one hour of low tide. The sampling pump intake will be placed near the center of screened interval, or the center of the saturated portion of the screened interval. Final values for field water quality parameters (i.e., pH, conductivity, temperature, dissolved oxygen, oxidation reduction potential, and turbidity) will be recorded, even if purging stability cannot be achieved. GW samples for dissolved arsenic analysis will be field filtered with an in-line 0.45-micron filter.

3.3.6 Tidal Fluctuation Study (Task 3)

Tidal fluctuations will be measured and recorded at two MW pairs that straddle the SPW to estimate the hydraulic conductivity through the SPW at 124+00-2 and 125+50-2: (1) the 124+00-2 and 6D32-2 pair, and (2) the 125+50-2 and 6D33-2 pair (see Figure 3). The estimated SPW hydraulic conductivities at these two locations will be compared with SPW hydraulic conductivities previously estimated at other locations along the SPW (Appendix J in PIONEER 2019) in order to evaluate the preferential leakage through the SPW hypothesis. Even though a new barrier wall should address any preferential SPW leakage, this task is important in order to determine the primary cause(s) for 124+00-2 and evaluate the anticipated effectiveness of various cleanup action alternatives. A vented pressure transducer (which accounts for atmospheric pressure effects) and data logger capable of measuring and recording water levels, pressure, conductivity, and temperature (e.g., In-Situ's vented AquaTroll 200) will be placed approximately one foot above the MW bottom in each of the four MWs. The depth to water in each MW from the MW measuring point will be determined with an electronic water level indicator (to the nearest 0.01 feet) after the pressure transducer is placed and once the data logger is ready to start recording (so that water column measurements can be converted to elevations). Measurements will be obtained for at least 72 hours (and no longer than 120 hours), with a frequency of one measurement per minute, ideally during a period that includes average to large tide changes and little to no precipitation forecasted. SW level, barometric pressure, and water temperature data to support the study will be obtained as necessary from National Oceanic and Atmospheric Administration Station ID 9446484 (https://tidesandcurrents.noaa.gov/stationhome.html?id=9446484) in the Sitcum Waterway for the same period when the study is conducted. Precipitation data will be obtained from a nearby weather station if necessary.

3.3.7 NSDS and PPS Sampling (Task 5)

3.3.7.1 Intermediate Aquifer PW Sampling with NSDSs

Intermediate Aquifer PW samples will be collected at six shoreline stations (i.e., 120+75-ST1-DS, 122+60-ST1-DS, 123+25-ST1-DS, 124+00-ST1-DS, 125+00-ST1-DS, 128+50-ST1-DS) using NSDSs (see Figure 5). NSDS sampling will be conducted using the following established Site procedures that were utilized for the 2017 and 2018 NSDS samples (PIONEER 2017, 2019).[12] Each NSDS, which consists of (1) a clean polyethylene sample jar with a threaded rim, (2) deoxygenated, deionized water, (3) a 22-micron nylon screen mesh, and (4) a threaded jar ring, will be prepared prior to deployment. The deionized water will be deoxygenated with nitrogen, argon, or helium gas. Following deoxygenation, the nylon screen mesh will be placed over the mouth of the jar and secured in place by the jar ring. Multiple NSDSs may be necessary at each sample station and depth to provide the required volume of water for field water quality measurements and laboratory analyses. Divers will install two sets of NSDSs at each sample station: one set of NSDSs with the NSDS mouths at approximately 10 centimeters landward of the SW interface and one set of NSDSs with the NSDS mouths at approximately 3 centimeters landward of the SW interface. The mesh mouths of all NSDSs will be facing landward. All NSDSs will be installed by carefully digging a small trench at the target location with a non-metal hand trowel or equivalent in order to minimize disturbed sediment, and placing the NSDSs in the small trench. The NSDSs will be covered with native sediment and marked with flags or equivalent to assist in retrieval of NSDSs. The NSDSs will be allowed to equilibrate for a minimum of two weeks prior to retrieval by divers. Following retrieval, water samples will be collected from the NSDSs using either (1) a disposable syringe and hypodermic needle, or (2) a peristaltic pump equipped with a 0.45-micron filter. Field water quality parameters (i.e., pH, conductivity, temperature, dissolved oxygen, oxidation reduction potential, and turbidity) will be measured and recorded for each set of NSDSs at a given sample station. The samples for dissolved arsenic analysis will be field filtered with an in-line 0.45-micron filter. If it is not practicable to field filter the samples, then the field team will request the laboratory to filter the sample with a 0.45-micron filter in an expedited fashion.

3.3.7.2 SW Sampling with NSDSs

SW samples will be collected at six shoreline stations (i.e., 120+75-SW, 122+60-SW, 123+25-SW, 124+00-SW, 125+00-SW, 128+50-SW) using NSDSs (see Figure 5). NSDSs for SW sampling will be prepared prior to deployment in the same manner described above for PW NSDSs. Divers will install two sets of NSDSs at each sample station: one set of NSDSs with the NSDS mouths facing landward and one set of NSDSs with the NSDS mouths facing seaward. Divers will install the NSDSs by securing the necessary number of NSDSs in a plastic-coated, wire mesh mussel cage to the mudline. NSDSs will be secured to the mussel cage with heavy duty mesh bags and plastic cable ties or equivalent. The mussel cage will be secured to the shoreline with a screw anchor or equivalent, and the mussel cage will be marked with flags or

[12] These Site procedures were based on procedures in USGS 2002, USGS 2005, Peijnenburg et al 2013, and GSI 2016.

equivalent to assist in retrieval of NSDSs. The equilibrium time and sample collection procedures will be the same as described above for PW NSDSs.

3.3.7.3 Intermediate Aquifer GW Sampling with PPSs

Intermediate Aquifer GW samples will be collected at six shoreline stations (i.e., 120+75-ST1, 122+60-ST1, 123+25-ST1, 124+00-ST1, 125+00-ST1, 128+50-ST1) using PPSs (see Figure 5). PPS sampling will be conducted using the following established Site procedures that were utilized for the 2008, 2012, 2017, and 2018 PPS samples (DOF 2012, 2013; PIONEER 2017, 2019). PPS samples will be collected on a falling tide near low tide. Each PPS will consist of a ½-inch diameter stainless steel probe with a retractable stainless steel screened tip, capable of penetrating 9-12 inches into the sediment/subtidal cap and shielded by a 24-inch diameter pan with a 3-inch lip to impede SW short-circuiting. The probe will be connected to ¼-inch diameter polyethylene tubing and a peristaltic pump positioned on the shoreline. A diver will install each PPS such that the bottom of the PPS is inserted approximately 9-12 inches deep into the shoreline, and then retract the probe to expose the screen. GW will be purged at a low flowrate (ideally less than 50 milliliters per minute and no more than 500 milliliters per minute) until three times the tubing volume has been purged. Field water quality parameters (i.e., pH, conductivity, temperature, dissolved oxygen, oxidation reduction potential, and turbidity) will be measured and recorded for each PPS sample. The samples for dissolved arsenic analysis will be field filtered with an in-line 0.45-micron filter.

3.3.8 Equipment Decontamination

Equipment decontamination procedures will be conducted in accordance with DOF SOP-120 (see Appendix B).

3.3.9 Field Recordkeeping

The following field recordkeeping forms in Appendix B will be used to document fieldwork activities:

- Soil Sampling/Well Field Log (in DOF SOP-100 and DOF SOP-125)
- MW Development (in DOF SOP-105)
- Water Level Record (in DOF SOP-110)
- MW Sampling Field Sheet (in DOF SOP-115)

In addition, electronic records (e.g., GPS coordinates, XRF analyses), waterproof notepads, and daily field report forms will be used to supplement the aforementioned forms as necessary.

3.4 Laboratory Analyses and Sample Containers

Soil, GW, PW, and SW samples will be collected pursuant to this Work Plan. The laboratory analyses that are required for each RTC Data Gaps Investigation task are presented in Table 1. Almost all of the laboratory analyses for Barrier Wall PDI activities are geotechnical analyses (see Appendix A). The only chemical analyses for the Barrier Wall PDI are total metals and TCLP metals analyses for one composite soil sample to evaluate on-site reuse and off-site disposal options for soil excavated from the

investigation trench. The analytical methods, sample container expectations, preservation requirements, and holding times for all chemical analyses are presented in Table 2.

3.5 Sample Labeling and Shipment

3.5.1 Sample Labeling

Sample labels will clearly indicate the Site location, sample number identification, date, time, sampler's initials, parameters to be analyzed, and added preservative (if any). Each sample will be individually labeled. Each sample number identification will be unique and will adhere to the PIONEER sample number schema included in Appendix D.

3.5.2 Chain-of-Custody Documentation

Chain-of-custody procedures will be followed to maintain and document sample possession. A sample is considered under a person's custody if it is in that person's physical possession, within visual sight of that person after taking physical possession, secured by that person so that the sample cannot be tampered with, or secured by that person in an area that is restricted to unauthorized personnel.

The originator (the sampler) will complete requested information on the custody record, including signature and date. Original signed custody records listing the samples in the cooler will accompany sample shipments.[13] The originator of the custody record will retain a copy of the custody record.

3.5.3 Sample Shipment

Sample packaging and shipping procedures are based on USEPA specifications and United States Department of Transportation regulations as specified in 49 Code of Federal Regulations (CFR) 173.6 and 49 CFR 173.24. Soil and water samples will be packed in coolers with bubble wrap, bags, and ice in a manner to achieve preservation requirements while also preventing breakage of sample containers and leakage of melting ice. If shipping is required, samples will be shipped as environmental samples and not hazardous material. Samples will be hand delivered or shipped express delivery to the laboratories. Custody seals will be used when samples are shipped via courier service or commercial carriers. The chain of custody record will accompany each shipment. The method of shipment, courier name(s), and other pertinent information will be entered in the chain of custody record.

3.6 Investigation-Derived Waste

For RTC Data Gap Investigation activities, the following types of investigation-derived waste will be generated during sampling activities and will be handled as follows:

- Cuttings from soil borings will be placed in sealed and labeled drums or bins, and temporarily stored in a secure area of the Site.
- Development water, purge water, and decontamination water will be placed in sealed and labeled drums or totes, and temporarily stored in a secure area of the Site.

[13] More than one custody form may be needed per cooler to list all the samples contained in the cooler.

- Personal protective equipment (e.g., nitrile gloves) and other disposable sampling equipment will be disposed of as solid waste in the standard municipal solid waste stream.

All containerized investigation-derived waste will be characterized and then removed by a licensed waste transporter for off-Site treatment and/or disposal at a facility permitted to accept the waste within 90 days of the completion of fieldwork.

See Sections 3.1.2.1 and 3.2.1.4 in Appendix A for handling of soil generated during Barrier Wall PDI activities.

SECTION 4: QUALITY ASSURANCE PROJECT PLAN

The purpose of this QAPP is to summarize the methodology for ensuring usable sampling and analysis data of acceptable quality are generated. This QAPP was prepared in general accordance with WAC 173-340-820 and Ecology guidance (Ecology 2016).

Typical contents of a stand-alone QAPP are not repeated if included elsewhere in this Work Plan. For instance, requirements for laboratory analytical methods, sample containers, preservation, and holding times are already described in the SAP. Likewise, field procedures associated with quality assurance (e.g., equipment decontamination, field recordkeeping, sample identification schema, sample handling and shipment) are already described in the SAP.

4.1 Field Measurements and Calibration

Field measurements and notes (e.g., lithologic logging of soil borings, XRF field analyses, diver notes, NSDS and PPS installation notes, water quality measurements) are of vital importance to this Work Plan and will be documented (see Section 3.3.9). In addition, representative photographs will be taken as necessary to support documentation of the procedures used to collect field measurements. Calibration procedures for the XRF are presented in Appendix C. The water quality meter(s) will be calibrated daily (at the start of the day) using procedures in accordance with the manufacturer's recommendations. The calibration will be documented in the field notes.

4.2 Field Quality Control Samples

Field quality control (QC) samples will include field duplicates, matrix spike/matrix spike duplicates,[14] equipment rinsate blanks, and cooler temperature blanks. Field QC soil samples will only be analyzed for arsenic and pH, and field QC water samples will only be analyzed for dissolved arsenic. The frequency expectation for each type of field QC sample is listed below:

- Field duplicates: One sample per 20 samples per matrix
- Matrix spike/matrix spike duplicates: One sample per 20 samples per matrix
- Equipment rinsate blanks: One sample per 20 samples per matrix per equipment type
- Cooler temperature blanks: One per cooler of samples for chemical analyses

Field QC samples will be collected, handled, preserved, and documented in the same manner as primary samples. Field duplicates and the matrix spike/matrix spike duplicate will be collected at random locations selected by the field sampling team. Blind duplicates will not be collected; rather, the duplicate sample will be identified with the same Site ID as the primary sample (using the PIONEER sample schema in Appendix D). Equipment rinsate blanks will be collected by pouring deionized water on non-

[14] Matrix spikes and matrix spike duplicates are lab QC samples, but are also included with the field QC samples since the field sampling team is responsible for ensuring that appropriate sample volumes are collected for analysis of matrix spikes and matrix spike duplicates.

dedicated sampling equipment following its decontamination. Cooler temperature blanks will be prepared and provided by the laboratory.

4.3 Laboratory Quality Control Samples

The project laboratories will be responsible for conducting laboratory QC procedures and reporting laboratory QC results in accordance with the analytical methods and their SOPs. Laboratory QC samples provide important qualitative results used to evaluate the laboratory QC procedures. Laboratory QC samples for applicable analyses will include method blanks, laboratory control samples (also known as blank spikes), matrix spikes, and matrix spike duplicates once per batch of analyses. Expectations for laboratory control limits for laboratory control samples, matrix spikes, and matrix spike duplicates are presented in Table 3.

4.4 Laboratory Target Reporting Limits

Analytical methods and laboratories have been selected to achieve low target reporting limits in each medium. A comparison of target reporting limits with applicable criteria for the purposes of this Work Plan are presented in Table 4. All of the target reporting limits are less than the applicable criteria. Therefore, the target reporting limits are considered appropriate for the purposes of this investigation.

4.5 Data Quality Review and Validation

An evaluation of data quality will be performed for all field and lab data, with the exception of sequential extraction and associated follow-on analyses. Specifically, field records will be reviewed by DOF and/or PIONEER for completeness, accuracy, and legibility. The laboratories will review their results relative to method criteria and laboratory QC procedures as the data are generated. The laboratories will report their QC results and qualify data as necessary in a report suitable for a Level II data validation. An independent data quality validator will evaluate precision, accuracy, representativeness, comparability, completeness, and sensitivity by reviewing the following items relative to analytical method criteria, laboratory control limits, and national functional guidelines (USEPA 2016a, 2016b) as necessary:

- Comparison of actual analyses versus requested analyses
- Comparison of consistency between laboratory reports and associated electronic data deliverables
- Holding times
- Field QC sample frequency
- Field QC sample results
- Lab QC sample frequency
- Lab QC sample results
- Actual reporting limits

The data quality validator may reject data or add other qualifications in addition to the laboratory qualifications. The data quality review documentation will be included with the applicable laboratory reports for reporting purposes.

4.6 Corrective Action

The need for corrective action will be evaluated as appropriate for deviations from the SAP/QAPP and other potential data quality issues that arise in the field or the laboratory. Relatively minor field issues will be discussed, resolved, and documented by the On-Site Field Project Manager and/or the PIONEER Project Manager. Relatively minor laboratory issues will be discussed, resolved, and documented by the laboratory, the PIONEER Project Manager, and/or the independent data quality validator. Corrective action decisions will be situation-dependent. Potential corrective action decisions may include one or more of the following:

- Revising the sampling and analysis methodology
- Collecting a new sample
- Reanalyzing an existing sample
- Accepting the data with a recognized level of uncertainty
- Revising the investigation design

In the event of a significant data quality issue, the PIONEER Project Manager will call a meeting to discuss, resolve, and document the situation with the Port and Ecology.

SECTION 5: IMPLEMENTATION

5.1 Investigation Roles and Responsibilities

The project team for implementing this Work Plan includes representatives from Ecology, Port, DOF, PIONEER, HydroGeophysics, Cascade, Analytical Resources, Inc. (ARI), Brooks Applied Labs (Brooks), QA/QC Solutions, and various field contractors (e.g., licensed driller, divers). The specific roles and responsibilities that are anticipated for key personnel involved in this investigation project are summarized in Table 5.

5.2 Pre-Mobilization Tasks

Prior to the implementation of this Work Plan, several pre-mobilization contracting tasks will need to be completed. The Port will need to obtain additional funding authorization and revise its existing contract with DOF to implement this Work Plan. DOF will need to modify existing and/or develop new contract agreements with PIONEER and other contractors.

Prior to the implementation of this Work Plan, a number of important pre-mobilization coordination tasks will need to be completed. Key pre-mobilization coordination tasks for the DOF On-Site Field Project Manager (or delegate) to complete include:

- Coordinate with the PIONEER Project Manager about the objectives and sampling design for the investigation activities.
- Coordinate the anticipated field schedule with the Port and PIONEER.
- Coordinate the scope of work and field schedule with all on-site personnel.
- Coordinate with DOF, PIONEER, on-site contractors, and the Port regarding health and safety details specific to this project (e.g., field team organization and communication, potential hazards and associated controls, work zones, decontamination, personal protective equipment, air monitoring).
- Obtain necessary health and safety paperwork from team members (e.g., training records).
- Call the Washington Call Before You Dig phone number for all proposed drilling locations.
- If necessary, conduct a private utility locate for drilling locations.
- If necessary, core through asphalt/concrete to facilitate drilling activities.
- Ensure the licensed driller(s) submits the necessary notices of intent and associated fees to the Ecology Water Resources Program for proposed drilling locations.
- Coordinate with the project laboratories on key elements of the SAP/QAPP (e.g., sample preservation, analytical methods and analytes, field QC samples, target reporting
- limits).
- Obtain sample containers from the project laboratories.
- Obtain the necessary equipment and supplies (e.g., XRF, supplies for anoxic preservation of soil samples, centrifuge, water quality meter(s), 0.45-micron filters, NSDS and PPS supplies).
- Coordinate access with the Port.

5.3 Health and Safety

A copy of the current Site-specific Health and Safety Plan (HASP) for investigation activities is included in Appendix E. The original HASP with applicable signatures, certifications, et cetera will be kept at the Site during all investigation activities.

5.4 Reporting

Investigation activities and results associated with this Work Plan will be documented and submitted to Ecology. It is envisioned that one comprehensive report will be prepared to document all of the activities and results from the RTC Data Gaps Investigation work. That report could be a revised FS Report or an interim deliverable prior to revising the FS Report. The Barrier Wall PDI results will likely be reported in the context of a design document, and will therefore be documented separately from the RTC Data Gaps Investigation results.

5.5 Schedule

The schedule for implementing this Work Plan has not been determined yet, and will be influenced by Ecology's review of this Work Plan, Port contracting, the availability of contractors, and the duration of evaluation tasks and Work Plan refinements between RTC Data Gap Investigation tasks. As previously mentioned in this Work Plan, the RTC Data Gap Investigation tasks will be implemented sequentially so that results from a given task can inform and refine the investigation activity for the subsequent task (e.g., Tasks 2A through 2D will be completed after Tasks 1A and 1B are complete and before Task 3 is initiated). The schedule for the Barrier Wall PDI activities is not tied to the schedule for the RTC Data Gap Investigation tasks with one important exception – no Barrier Wall PDI activities will be conducted until after RTC Data Gaps Investigation Tasks 1A and 1B are completed. An implementation schedule for the first few RTC Data Gap Investigation tasks and the Barrier Wall PDI activities will be developed and submitted to Ecology before any investigation activities are conducted.

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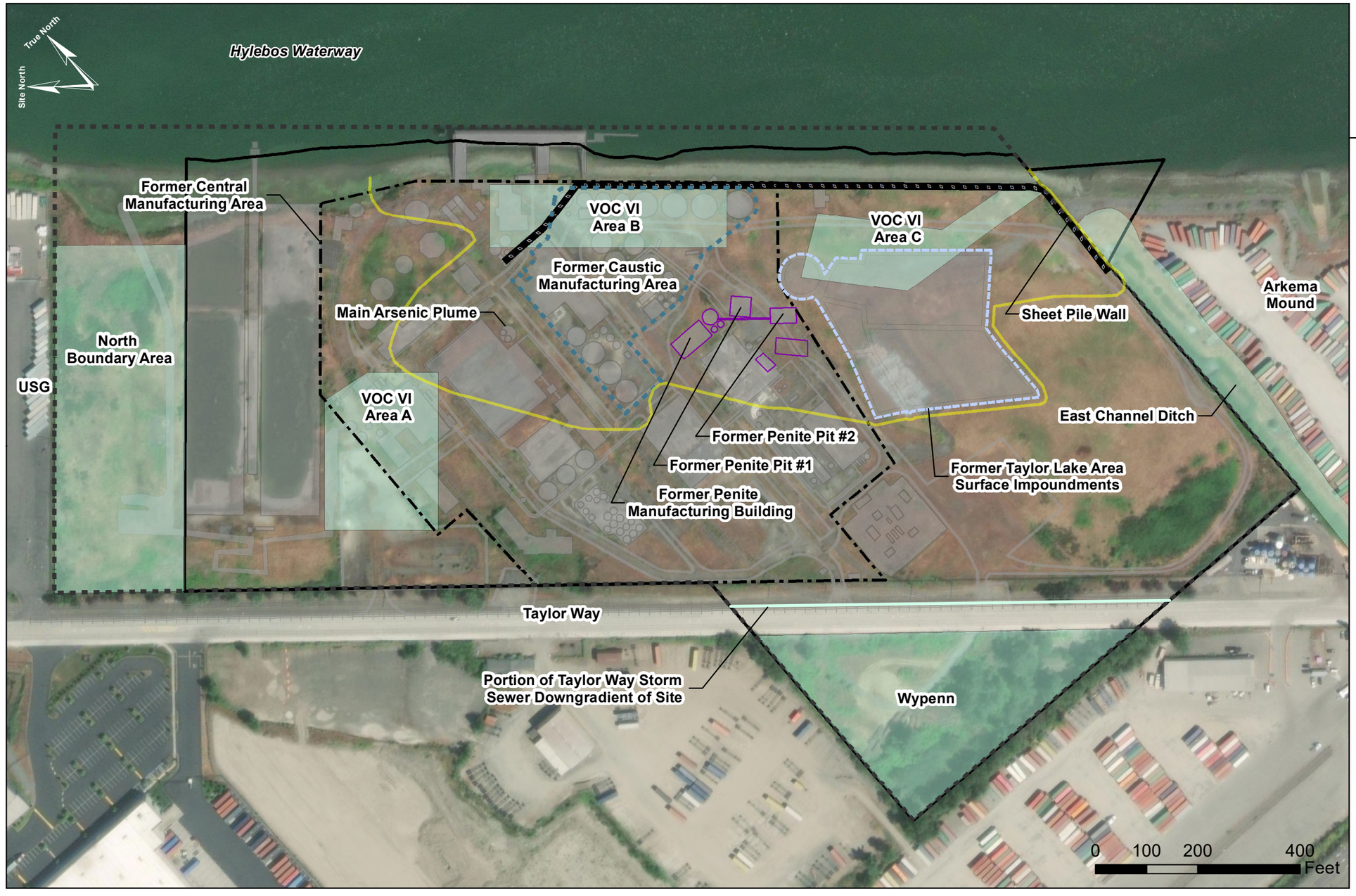
Figures



Legend

- Arkema Property Boundary
- Site Boundary
- Former Central Manufacturing Area
- Known and Potential Penite Manufacturing Features
- Former Caustic Manufacturing Area
- Former Taylor Lake Area Surface Impoundments
- Main Arsenic Plume
- Sheet Pile Wall
- Historical Infrastructure
- Other Areas

Notes:
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.

PIONEER TECHNOLOGIES CORPORATION

Key Site Areas and Other Areas
Expanded RTC Data Gaps Investigation Work Plan
Former Arkema Manufacturing Site

Figure A

Legend

Groundwater Sampling Location

- Vertical Monitoring Well
- Upper Aquifer Angled Shoreline Monitoring Well / Intermediate Aquifer PPS
- Upper / Intermediate Aquifer Pore Water NSDS

Updated 2017 Dissolved Arsenic Groundwater Isoconcentration Contours

- 5,000 ug/L
- 50,000 ug/L
- 500,000 ug/L

Key 2017/2018 Dissolved Arsenic Exceedances Near the Shoreline

- 36 - 360 ug/L
- 360 - 3,600 ug/L

Completed Remedial Actions

- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

Other Features

- Known and Potential Penite Manufacturing Features
- Thin or Leaky First Aquitard Location
- Area with pH ≥ 10[1]
- Historical Infrastructure
- Intermediate Aquifer Outcrop
- Site Boundary

Notes:
[1]Area with pH >= 10 for Intermediate Aquifer is based on First Aquitard and Intermediate Aquifer data.

0 50 100 200 300 Feet

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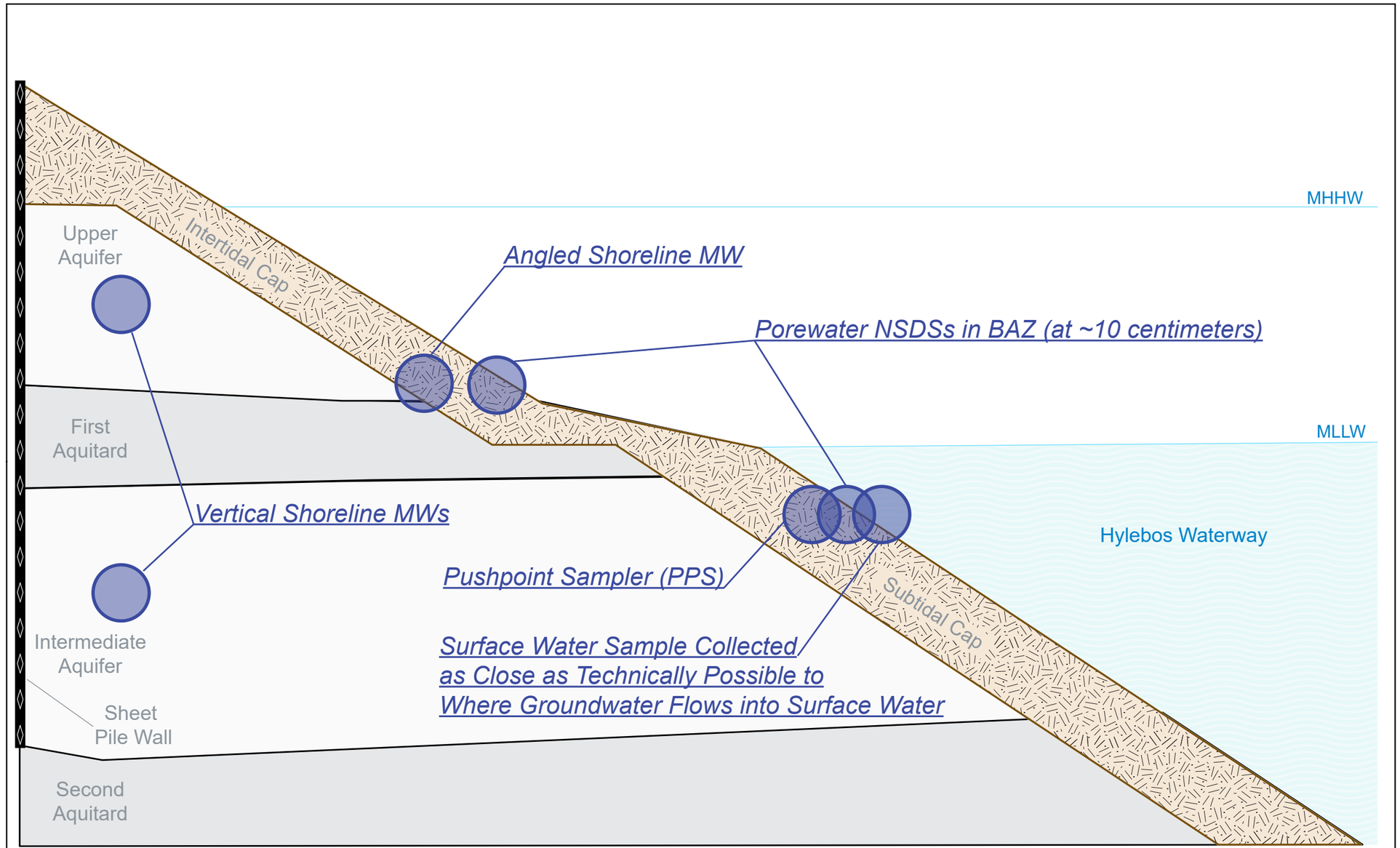
Summary of Current Conditions for the Main Arsenic Plume
Expanded RTC Data Gaps Investigation Work Plan
Former Arkema Manufacturing Site

Figure B



Legend

Potential Groundwater Conditional Point of Compliance Location

PIONEER TECHNOLOGIES CORPORATION

Potential Groundwater Conditional Point of Compliance Locations
Expanded RTC Data Gaps Investigation Work Plan
Former Arkema Manufacturing Site

Figure C

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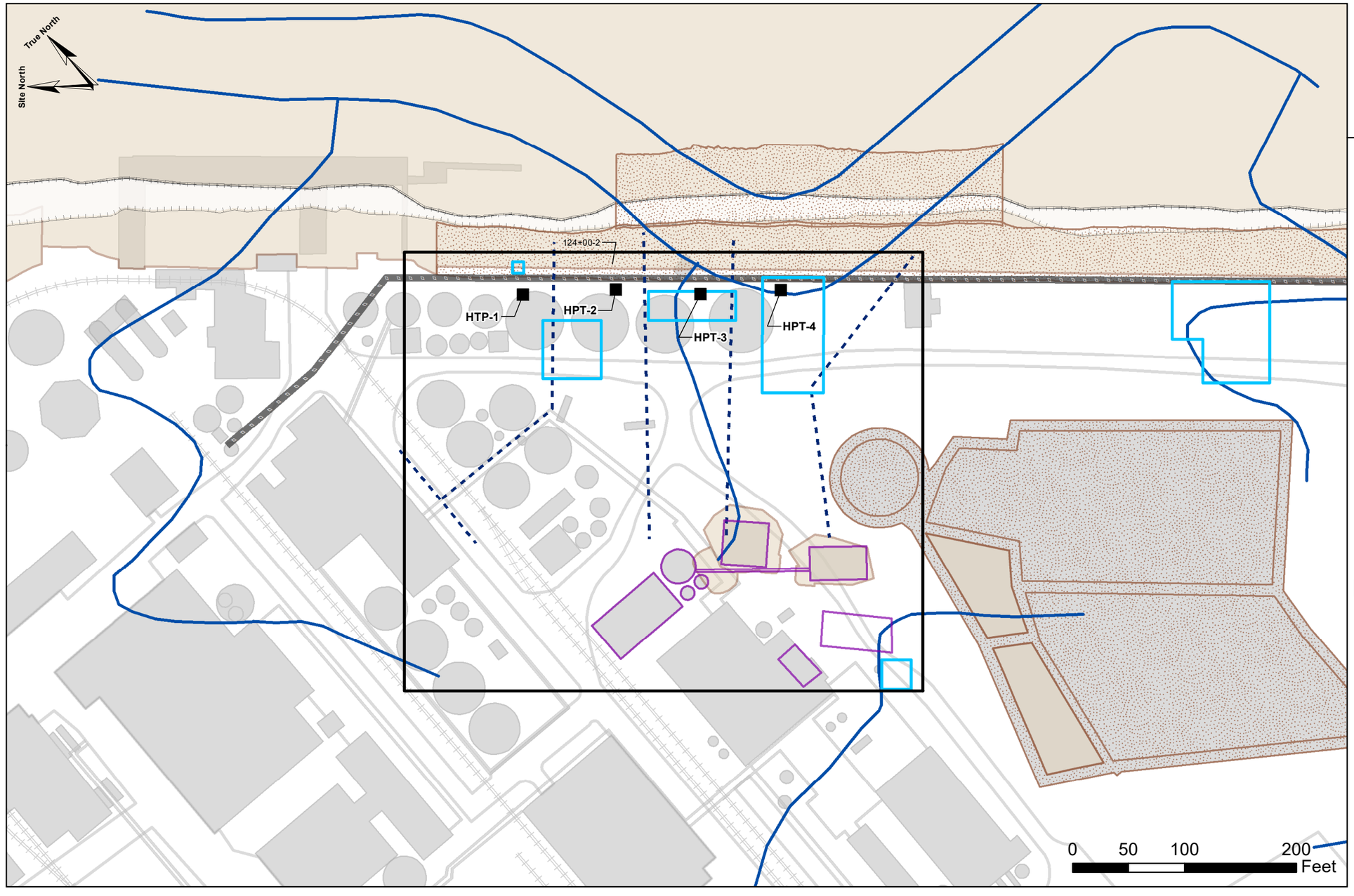


Legend

- Proposed Geophysical Survey Area
- Proposed HPT Borings

Potential Preferential Pathways
- Thin or Leaky First Aquitard Location
- Approximate Historical Stream Channels
- Approximate Historical Sewers

Completed Remedial Actions
- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

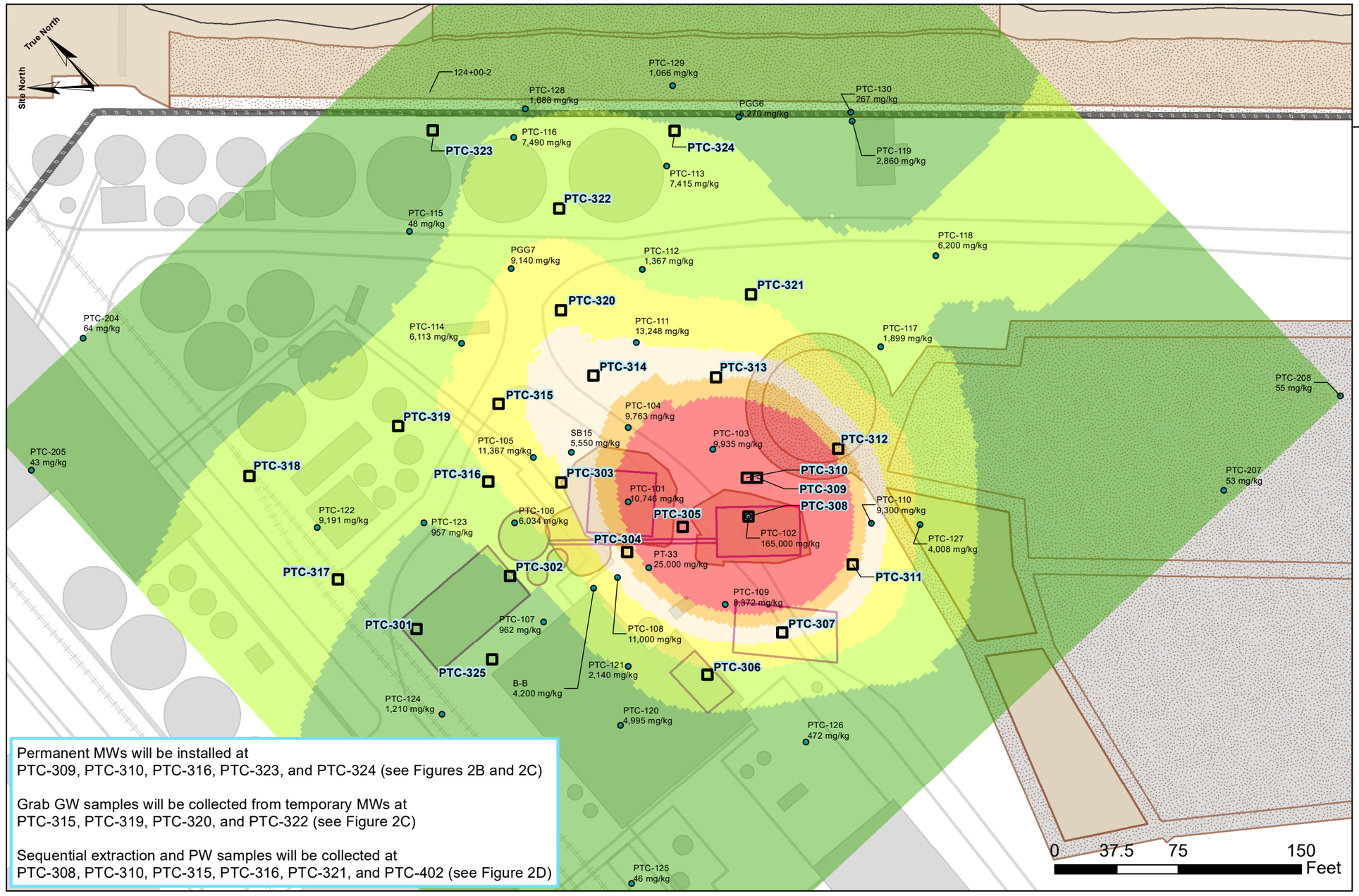
Other Features
- Known and Potential Penite Manufacturing Features
- Historical Infrastructure
- Intermediate Aquifer Outcrop
- RI/FS Site Boundary

Notes:
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.

PIONEER TECHNOLOGIES CORPORATION

Proposed Locations for Tasks 1A and 1B (Geophysical Survey and HPT Borings)
Expanded RTC Data Gaps Investigation Work Plan
Former Arkema Manufacturing Site

Figure 1



Permanent MWs will be installed at
PTC-309, PTC-310, PTC-316, PTC-323, and PTC-324 (see Figures 2B and 2C)

Grab GW samples will be collected from temporary MWs at
PTC-315, PTC-319, PTC-320, and PTC-322 (see Figure 2C)

Sequential extraction and PW samples will be collected at
PTC-308, PTC-310, PTC-315, PTC-316, PTC-321, and PTC-402 (see Figure 2D)

Legend

- Proposed Soil Boring

Empirical Bayesian Kriging of Maximum Arsenic Soil Concentrations in Upper Aquifer and Top Foot of First Aquitard

- Arsenic ≤ 4,000 mg/kg
- 4,000 mg/kg < Arsenic ≤ 6,000
- 6,000 mg/kg < Arsenic ≤ 8,000
- 8,000 mg/kg < Arsenic ≤ 10,000
- 10,000 mg/kg < Arsenic ≤ 12,000 mg/kg
- Arsenic > 12,000 mg/kg

Completed Remedial Actions

- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

Other Features

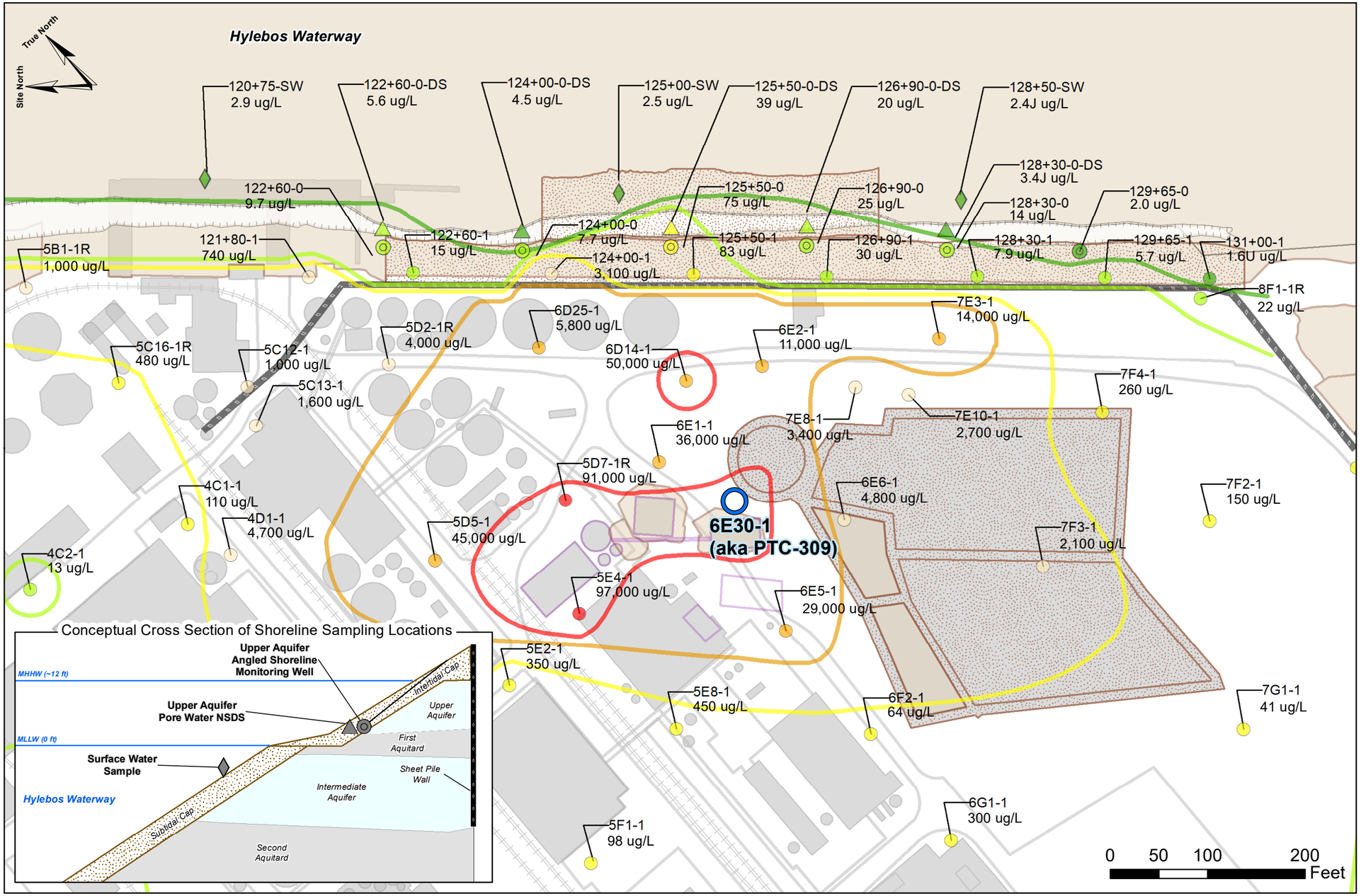
- Known and Potential Penite Manufacturing Features
- Historical Infrastructure
- RI/FS Site Boundary

Notes:
-The sample locations shown on this figure are the 2017 – 2018 soil borings (which included high resolution vertical characterization with XRF field screening) and the five 2001 – 2012 sampling locations with a maximum arsenic concentration greater than 4,000 mg/kg (i.e., B-B, PGG6, PGG7, PT-33, and SB15).
-The maximum concentrations of in place soil samples within the Upper Aquifer and top one foot of the First Aquitard (i.e., sample top is less than one foot beneath the Upper Aquifer/First Aquitard interface) are shown on this figure. Laboratory, field x-ray fluorescence, and sequential extraction results were included.
-A soil sample was not collected in the top foot of the First Aquitard at PTC-123, PTC-125, PTC-126, PTC-128, PTC-207, B-B, PT-33, and SB15.
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.

PIONEER TECHNOLOGIES CORPORATION

Proposed Locations for Task 2A (Plume Core Borings)
Expanded RTC Data Gaps Investigation Work Plan
Former Arkema Manufacturing Site

Figure 2A



Legend

Proposed Upper Aquifer

Sample Type
- Monitoring Well
- Upper Aquifer Angled Shoreline Monitoring Well
- Upper Aquifer Pore Water NSDS
- Surface Water Sample

2017 Upper Aquifer Dissolved Arsenic Concentrations
- Dissolved Arsenic ≤ 5 ug/L (or Not Detected)
- 5 ug/L < Dissolved Arsenic ≤ 36 ug/L
- 36 ug/L < Dissolved Arsenic ≤ 500 ug/L
- 500 ug/L < Dissolved Arsenic ≤ 5,000 ug/L
- 5,000 ug/L < Dissolved Arsenic ≤ 50,000 ug/L
- Dissolved Arsenic > 50,000 ug/L

2017 Upper Aquifer Dissolved Arsenic Groundwater Isoconcentration Contours[1]
- 5 ug/L
- 36 ug/L
- 500 ug/L
- 5,000 ug/L
- 50,000 ug/L

Completed Remedial Actions
- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

Other Features
- Known and Potential Penite Manufacturing Features
- Historical Infrastructure
- Intermediate Aquifer Outcrop
- RI/FS Site Boundary

Notes:
J: Estimated concentration
U: Constituent was not detected at the shown reporting limit
[1]The contours will most likely be revised in the future based on insights gained during ongoing calibration/verification of the groundwater models.
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-Some pore water and surface water samples were co-located. The symbols for these samples were adjusted slightly for visibility.
-Results are shown to two significant figures.
-Portions of some contour lines are inferred (e.g., near the Penite Pits).

PIONEER TECHNOLOGIES CORPORATION

Proposed Locations for Task 2B (Plume Core Upper Aquifer GW Samples)
Expanded RTC Data Gaps Investigation Work Plan
Former Arkema Manufacturing Site

Figure 2B

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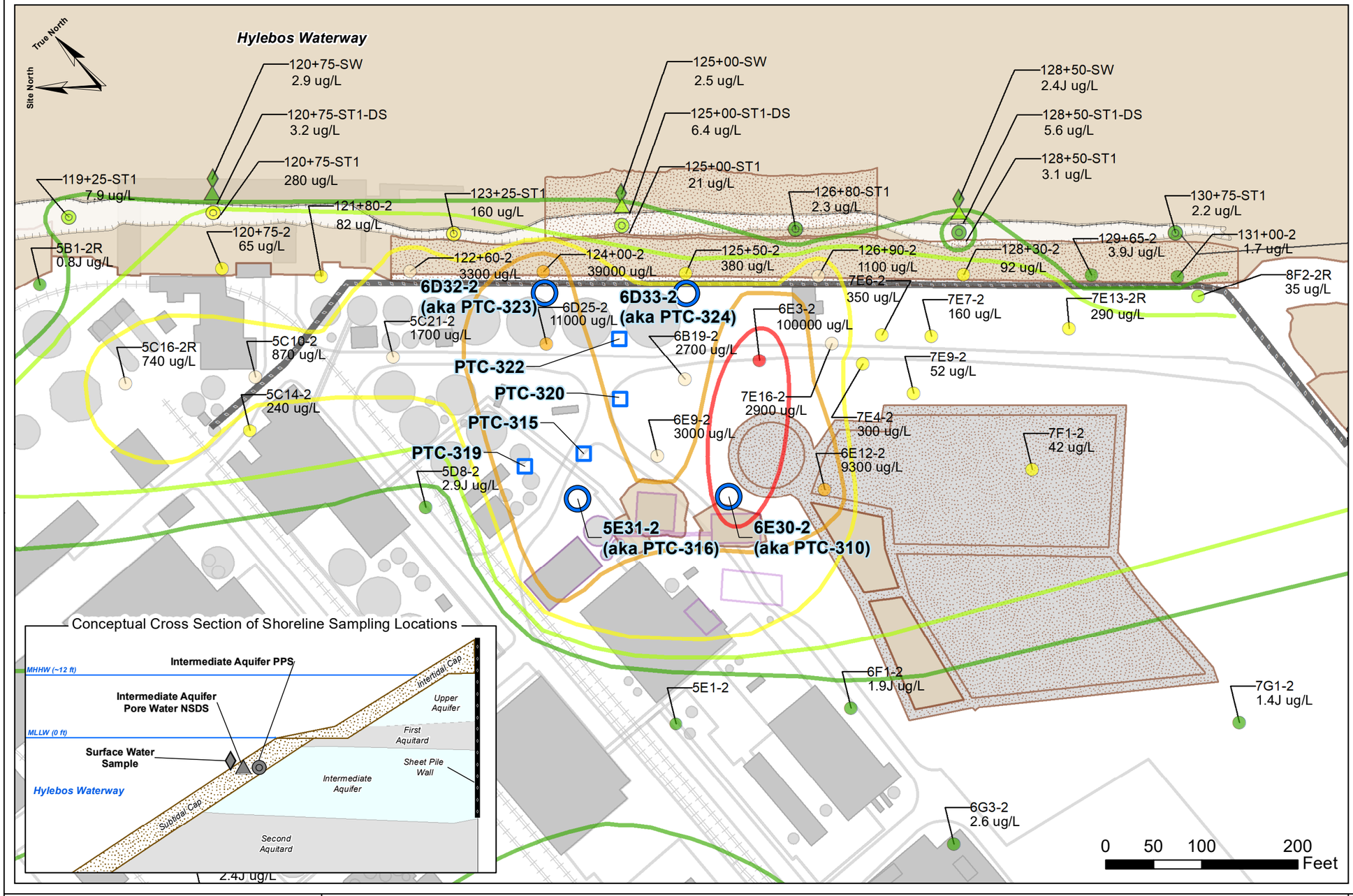

Legend

- Proposed Grab GW Sample
- Proposed Intermediate Aquifer

Sample Type

- Monitoring Well
- Intermediate Aquifer PPS
- Intermediate Aquifer Pore Water NSDS
- Surface Water Sample

2017 Intermediate Aquifer Dissolved Arsenic Concentrations

- Dissolved Arsenic ≤ 5 ug/L (or Not Detected)
- 5 ug/L < Dissolved Arsenic ≤ 36 ug/L
- 36 ug/L < Dissolved Arsenic ≤ 500 ug/L
- 500 ug/L < Dissolved Arsenic ≤ 5,000 ug/L
- 5,000 ug/L < Dissolved Arsenic ≤ 50,000 ug/L
- Dissolved Arsenic > 50,000 ug/L

2017 Intermediate Aquifer Dissolved Arsenic Groundwater Isoconcentration Contours[1]

- 5 ug/L
- 36 ug/L
- 500 ug/L
- 5,000 ug/L
- 50,000 ug/L

Completed Remedial Actions

- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

Other Features

- Known and Potential Penite Manufacturing Features
- Historical Infrastructure
- Intermediate Aquifer Outcrop
- RI/FS Site Boundary

Notes:
J: Estimated concentration
U: Constituent was not detected at the shown reporting limit
[1]The contours will most likely be revised in the future based on insights gained during ongoing calibration/verification of the groundwater models.
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-Some pore water and surface water samples were co-located. The symbols for these samples were adjusted slightly for visibility.
-Results are shown to two significant figures.
-Portions of some contour lines are inferred (e.g., near the Penite Pits).

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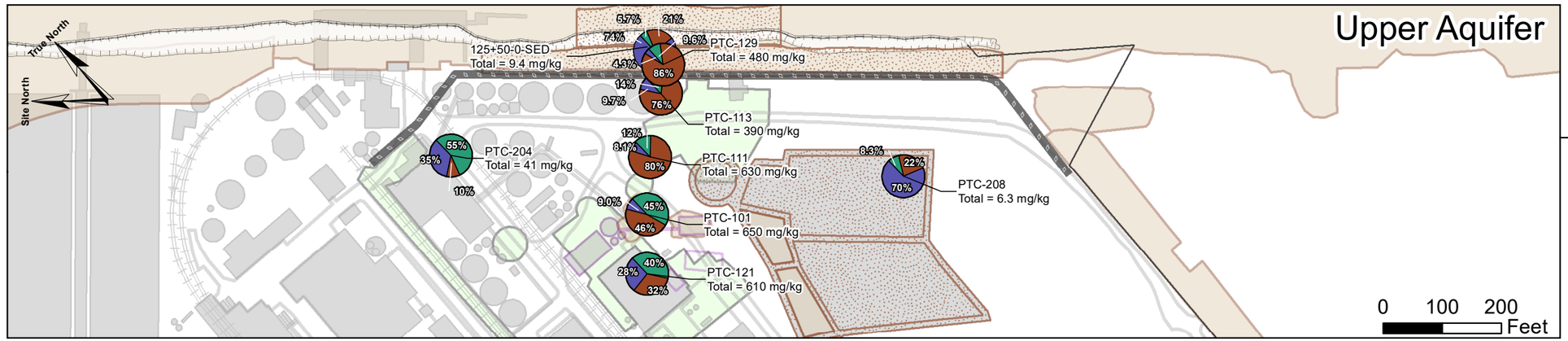
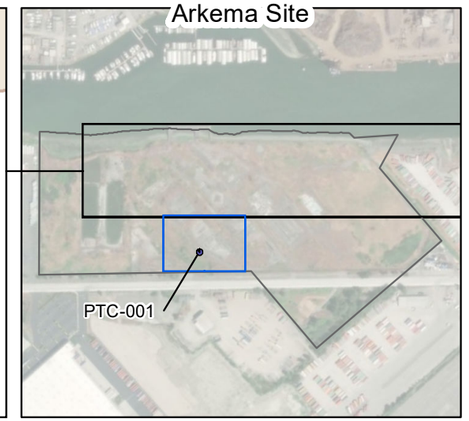
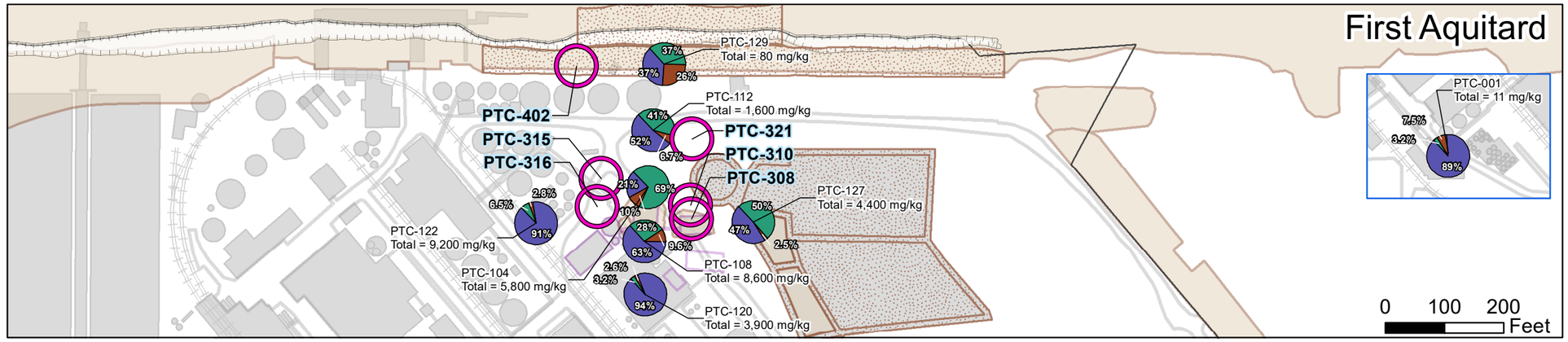
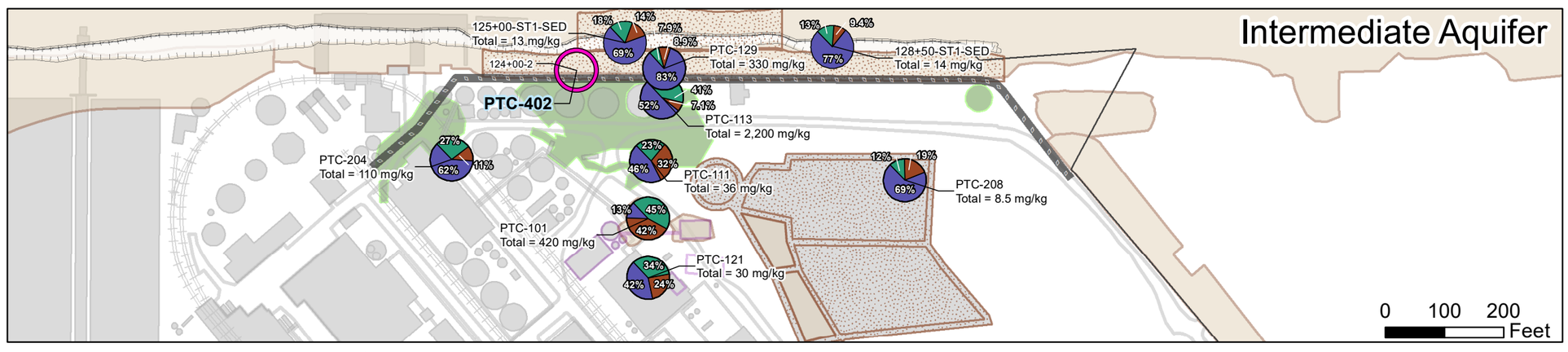
Proposed Locations for Task 2C (Plume Core Intermediate Aquifer GW Samples)
Expanded RTC Data Gaps Investigation Work Plan
Former Arkema Manufacturing Site

Figure 2C









Legend

- Proposed Sequential Extraction and PW Samples

Sequential Extraction Arsenic

- Arsenic Associated with Highly Stable Minerals
- Arsenic Co-precipitated with Metal Oxides
- Sorbed Arsenic

Completed Remedial Actions

- Soil / Sediment Removal
- Soil / Sediment Cap
- Arsenic In-Situ Stabilization Upper Aquifer Injection Areas
- Arsenic In-Situ Stabilization Intermediate Aquifer Injection Locations
- Sheet Pile Wall

Other Features

- Known and Potential Penite Manufacturing Features
- Historical Infrastructure
- Intermediate Aquifer Outcrop
- RI/FS Site Boundary

Notes:
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-Results are shown to two significant figures.
-Non-detect results were assumed to equal half the reporting limit.

PIONEER TECHNOLOGIES CORPORATION

Proposed Locations for Task 2D (Sequential Extraction and PW Samples)
Expanded RTC Data Gaps Investigation Work Plan
Former Arkema Manufacturing Site

Figure 2D

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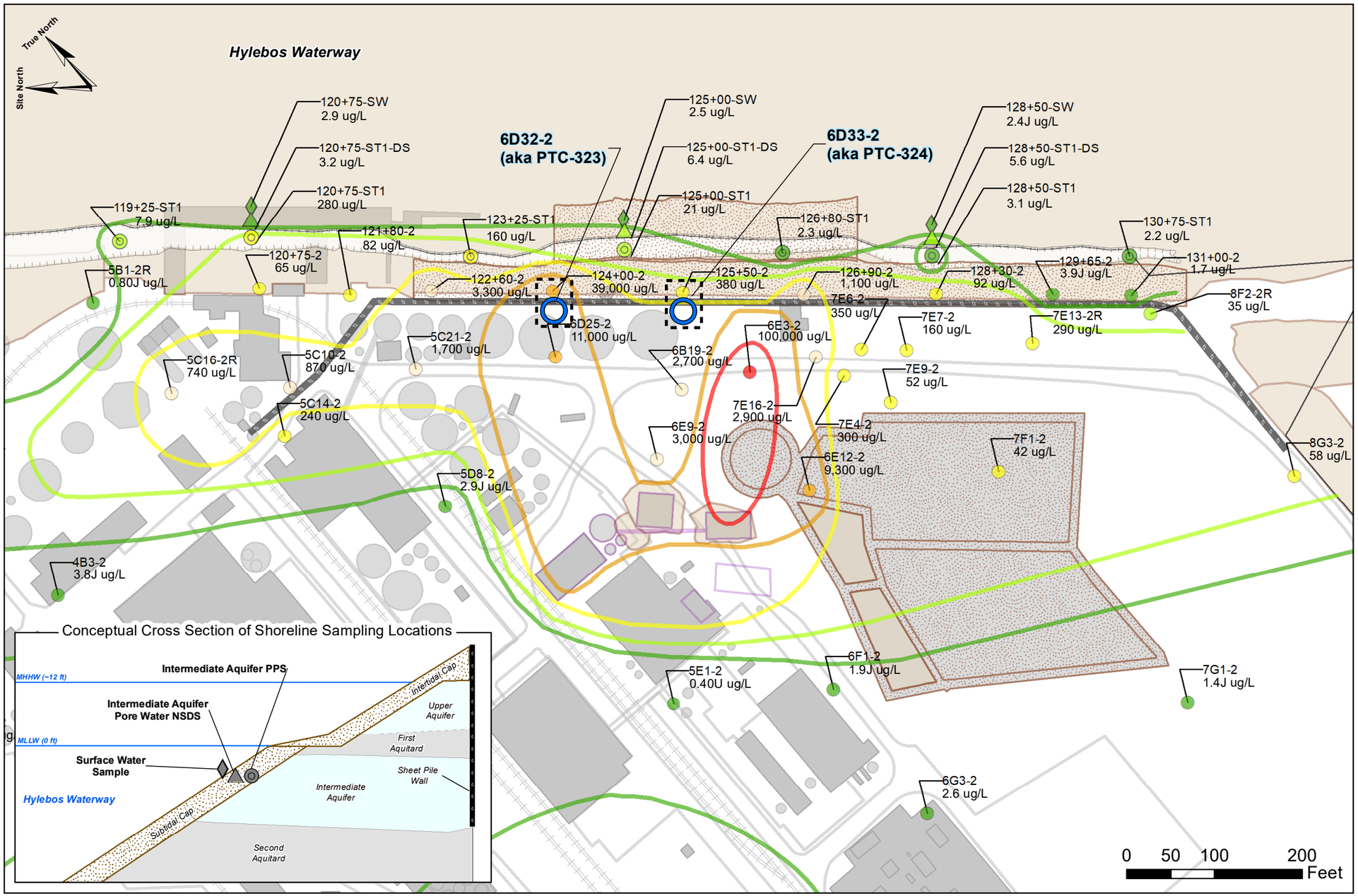

Legend

- Proposed Intermediate Aquifer MW
- Proposed Intermediate Aquifer MW Pairs for Tidal Fluctuation Study

Sample Type

- Monitoring Well
- Intermediate Aquifer PPS
- Intermediate Aquifer Pore Water NSDS
- Surface Water Sample

2017 Intermediate Aquifer Dissolved Arsenic Concentrations

- Dissolved Arsenic ≤ 5 ug/L (or Not Detected)
- 5 ug/L < Dissolved Arsenic ≤ 36 ug/L
- 36 ug/L < Dissolved Arsenic ≤ 500 ug/L
- 500 ug/L < Dissolved Arsenic ≤ 5,000 ug/L
- 5,000 ug/L < Dissolved Arsenic ≤ 50,000 ug/L
- Dissolved Arsenic > 50,000 ug/L

2017 Intermediate Aquifer Dissolved Arsenic Groundwater Isoconcentration Contours[1]

- 5 ug/L
- 36 ug/L
- 500 ug/L
- 5,000 ug/L
- 50,000 ug/L

Completed Remedial Actions

- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

Other Features

- Known and Potential Penite Manufacturing Features
- Historical Infrastructure
- Intermediate Aquifer Outcrop
- RI/FS Site Boundary

Notes:
J: Estimated concentration
U: Constituent was not detected at the shown reporting limit
[1]The contours will most likely be revised in the future based on insights gained during ongoing calibration/verification of the groundwater models.
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-Some pore water and surface water samples were co-located. The symbols for these samples were adjusted slightly for visibility.
-Results are shown to two significant figures.
-Portions of some contour lines are inferred (e.g., near the Penite Pits).

PIONEER TECHNOLOGIES CORPORATION

Proposed Locations for Task 3 (Tidal Fluctuation Study)
Expanded RTC Data Gaps Investigation Work Plan
Former Arkema Manufacturing Site

Figure 3

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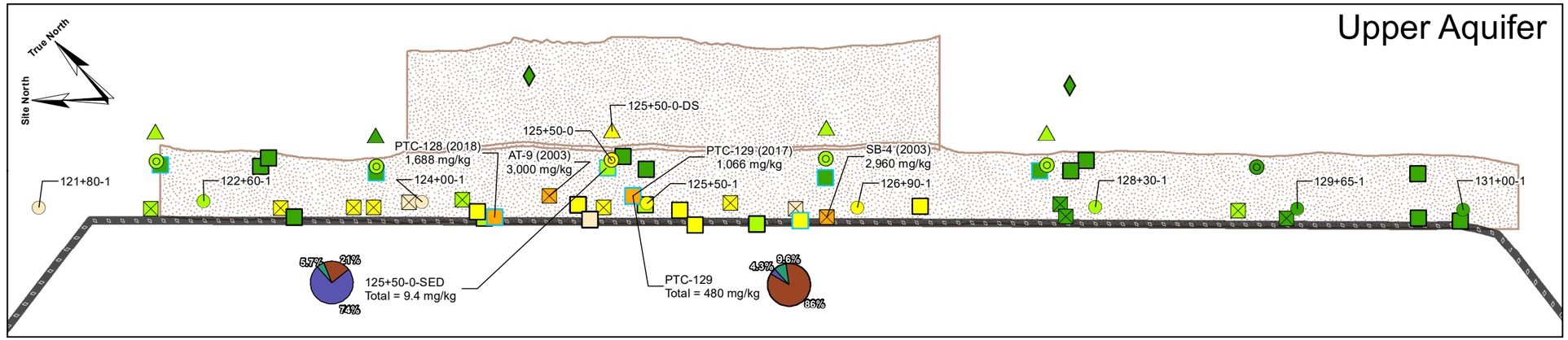

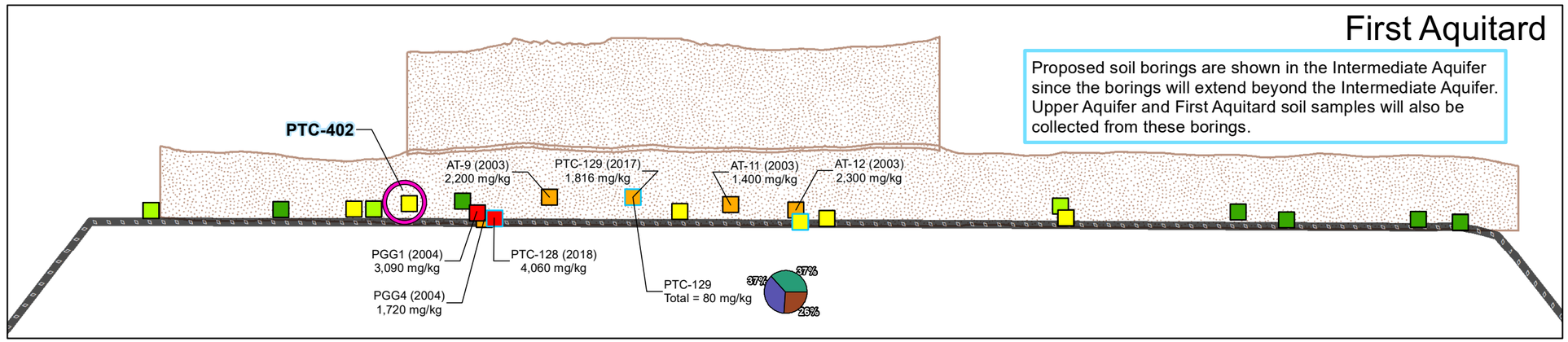

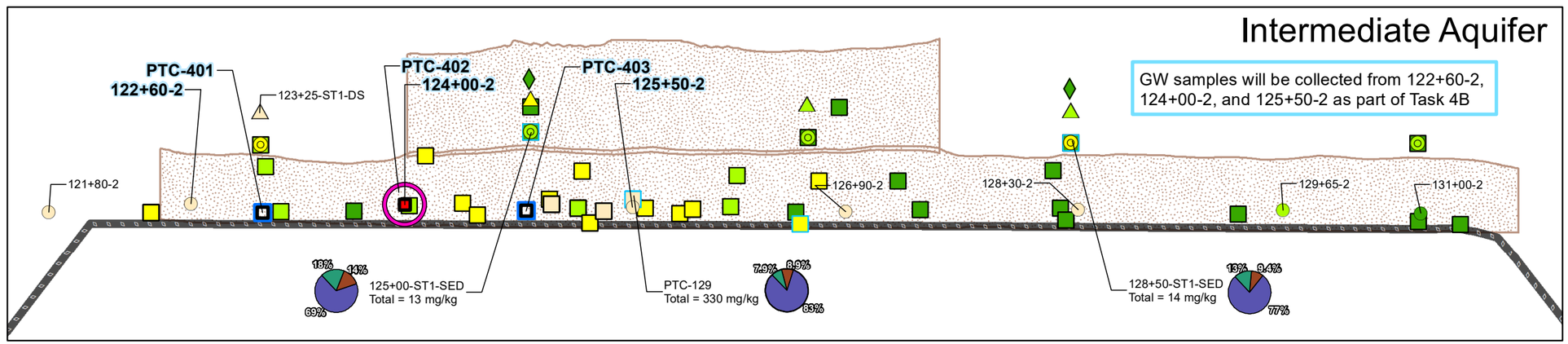

Legend

- Proposed Soil Boring
- Proposed Grab GW Sample
- Proposed Sequential Extraction and PW

Sample Type

- Soil Sample
  - Date Soil Sample was Collected
    - 2017 - 2018
    - Pre 2017
- Soil Sample No Longer In Place
- Monitoring Well
- Upper Aquifer Angled Shoreline Monitoring Well / Intermediate Aquifer PPS
- Upper / Intermediate Aquifer Pore Water NSDS
- Surface Water Sample

Arsenic Soil or Sediment Concentratoin

- Arsenic ≤ 30 mg/kg (or Not Detected)
- 30 < Arsenic ≤ 100 mg/kg
- 100 < Arsenic ≤ 300 mg/kg
- 300 < Arsenic ≤ 1,000 mg/kg
- 1,000 < Arsenic ≤ 3,000 mg/kg
- Arsenic > 3,000 mg/kg

2018 Dissolved Arsenic Concentrations

- Dissolved Arsenic ≤ 5 ug/L (or Not Detected)
- 5 ug/L < Dissolved Arsenic ≤ 36 ug/L
- 36 ug/L < Dissolved Arsenic ≤ 500 ug/L
- 500 ug/L < Dissolved Arsenic ≤ 5,000 ug/L
- 5,000 ug/L < Dissolved Arsenic ≤ 50,000 ug/L
- Dissolved Arsenic > 50,000 ug/L

Sequential Extraction Arsenic

- Arsenic Associated with Highly Stable Minerals
- Arsenic Co-precipitated with Metal Oxides
- Sorbed Arsenic

Other Features

- Sheet Pile Wall
- Soil / Sediment Cap

Notes:
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-The maximum concentration is shown if multiple sample intervals were collected from the same lithologic unit in a given boring.
-Both laboratory and field x-ray fluorescence sample results were included.
-Some pore water and surface water samples were co-located. The symbols for these samples were adjusted slightly for visibility.

0 25 50 100 150 Feet

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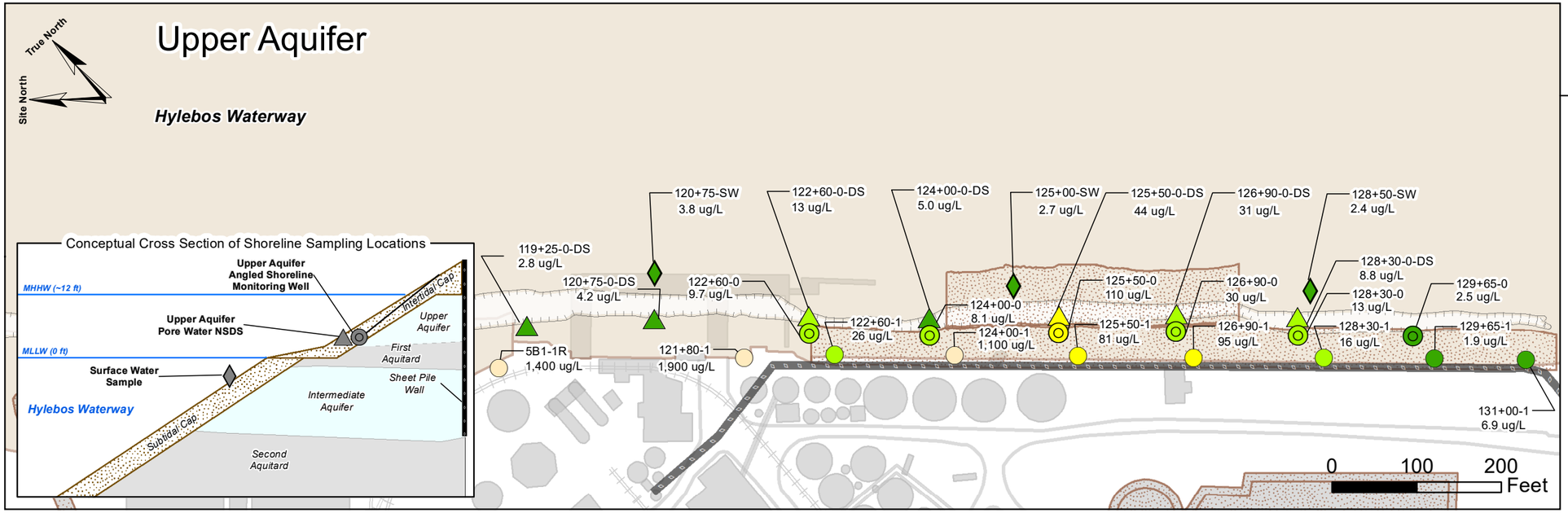
Proposed Locations for Tasks 4A - 4C (Wedge Samples)
Expanded RTC Data Gaps Investigation Work Plan
Former Arkema Manufacturing Site

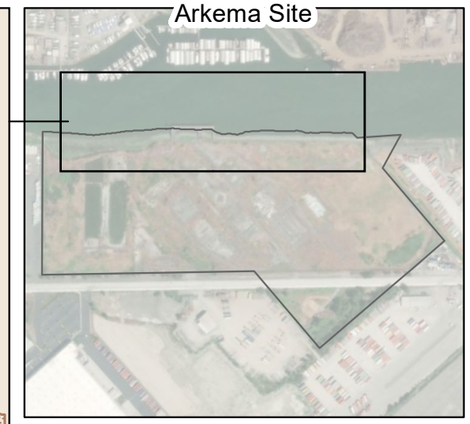
Figure 4

Document Path: G:\Projects\Arkema\Maps\Exp RTC Data Gaps Inv WP\Fig 4_Conc Locations for Task 4A-4C-Wedge.mxd; Author: VN; Date Saved: 3/31/2023

Upper Aquifer

Hylebos Waterway





Legend

- Proposed New SW Sample Location
- Proposed New Intermediate Aquifer PW NSDS Location
- Proposed New Intermediate Aquifer PPS Location

Sample Type

- Monitoring Well
- Upper Aquifer Angled Shoreline Monitoring Well / Intermediate Aquifer PPS
- Upper / Intermediate Aquifer Pore Water NSDS
- Surface Water Sample

2018 Upper Aquifer Dissolved Arsenic

- Dissolved Arsenic ≤ 5 ug/L (or Not Detected)
- 5 ug/L < Dissolved Arsenic ≤ 36 ug/L
- 36 ug/L < Dissolved Arsenic ≤ 500 ug/L
- 500 ug/L < Dissolved Arsenic ≤ 5,000 ug/L
- 5,000 ug/L < Dissolved Arsenic ≤ 50,000 ug/L
- Dissolved Arsenic > 50,000 ug/L

Completed Remedial Actions

- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

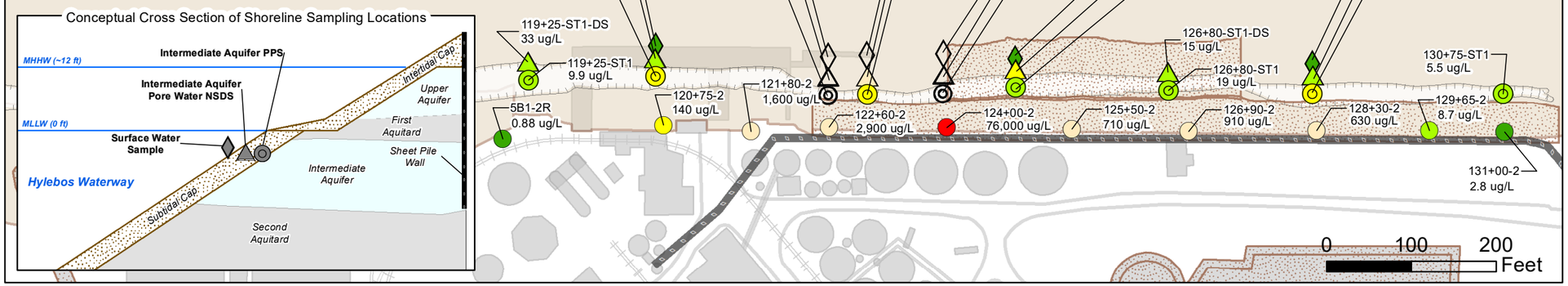
Other Features

- Historical Infrastructure
- Intermediate Aquifer Outcrop
- RI/FS Site Boundary

Intermediate Aquifer

Hylebos Waterway

Samples will be collected from existing and new locations with a light blue halo symbol.



Notes:
J: Estimated concentration
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-Some pore water and surface water samples were co-located. The symbols for these samples were adjusted slightly for visibility.
-Results are shown to two significant figures.

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Proposed Locations for Task 5 (SW and Intermediate Aquifer PW and PPS Samples)
Expanded RTC Data Gaps Investigation Work Plan
Former Arkema Manufacturing Site

Figure 5

Tables

Table 1: Investigation Design for the RTC Data Gaps

Task #	Task	RTC #	124+00-2 Hypothesis #	Objective(s)	# of Locations	Location IDs [1]	Figure #	Key Task-Specific Details	Field		# of Lab Analyses				
									XRF arsenic (soil) [2]	WQ parameters [3]	Arsenic (soil)	pH (soil)	TCLP arsenic (soil)	SEQ (soil) [4,5]	Dissolved arsenic (water) [5,6]
1A	Geophysical survey	12	2	Conduct an electromagnetic induction survey (and follow-up electrical resistivity survey if necessary) to assess the 1stA surface topography, locations where the 1stA is thin or absent, and potential preferential flow pathways in order to evaluate the hypothesis that a potential preferential pathway may be a primary cause of elevated dissolved arsenic concentrations at and downgradient of 124+00-2.	N/A	N/A	1	• See Section 3.3.1 text • No lab analyses							
1B	HPT borings	12	5	Advance HPT borings and obtain continuous soil hydraulic conductivity estimates near 124+00-2 to evaluate the preferential leakage under the SPW hypothesis.[7]	4	HPT-1 through HPT-4	3	• HPT boring depth = 50 ft or direct-push depth capability, whichever is shallower • No lab analyses							
Data from Barrier Wall PDI Borings		N/A	N/A	Opportunistically collect field XRF arsenic and laboratory data to the extent practicable in soil borings being advanced as part of the Barrier Wall PDI to support Task 2A and Task 6.	11	DOF-B1 through DOF-B9, DOF-B14, DOF-B15	Appendix A Figure 2	• XRF high-resolution vertical characterization of arsenic in each boring to depth of 5 ft into 1stA • Up to one worst-case soil sample may be collected in each boring and analyzed for arsenic and pH	X		11	11			
					4	DOF-B10 through DOF-B13		• XRF high-resolution vertical characterization of arsenic in each boring to bottom of boring • Up to three worst-case soil samples may be collected in each boring and analyzed for arsenic, pH, and TCLP arsenic	X		12	12	12		
2A	Plume core borings	6,12	1	Advance and sample soil borings within the arsenic plume core to (1) delineate known hot spots (e.g., locations where arsenic > 10,000 mg/kg) with more certainty, (2) evaluate unsampled potential sources (i.e., former Penite Manufacturing Building, two potential pits upgradient of former Penite Pits #1 and #2), (3) facilitate determination of a soil remediation level for a focused soil excavation remedial component in the source area, and/or (4) support remedial design and implementation of a future focused soil excavation in the source area.	25	PTC-301 through PTC-325	2A	• Boring depth = 5 ft into 1stA • XRF high-resolution vertical characterization of arsenic in each boring • One soil sample collected from worst-case UA depth in each boring and analyzed for arsenic and pH • One soil sample collected from top 1 ft of 1stA in each boring and analyzed for arsenic, pH, and TCLP arsenic • PTC-323 (which will become 6D32-2) and PTC-324 (which will become 6D33-2) will need to be installed at least ten ft landward of the proposed barrier wall alignment	X		50	50	25		
2B	Plume core Upper Aquifer GW samples	6,12	1	Install, develop, and sample a permanent UA MW (a likely future performance MW) to assess the impact of remaining soil source in former Penite Pit #2 on the UA dissolved arsenic GW concentration immediately downgradient of former Penite Pit #2.	1	6E30-1 (aka PTC-309)	2B	• MW screened in UA (screen length of 10 ft or 5 ft) • Field WQ parameters measured during low-flow purging • One GW sample collected from new MW and analyzed for dissolved arsenic only		X					1
2C	Plume core Intermediate Aquifer GW samples	6,12	1 - 4	Install, develop, and sample permanent IA MWs (likely future performance MWs) to (1) assess the impact of remaining soil source in former Penite Pit #2 on the IA dissolved arsenic GW concentration immediately downgradient of former Penite Pit #2, (2) assess the impact of a potential soil source at the former Penite Manufacturing Building on the IA dissolved arsenic GW concentration immediately downgradient of the former Penite Manufacturing Building, and (3) evaluate the potential preferential pathway, geochemical conditions, and preferential leakage through the SPW hypotheses. Collect grab GW samples from temporary MWs in a few key locations to (1) assess the impact of potential soil source at or near the former Penite Manufacturing Building and/or former Pit #1 on IA dissolved arsenic GW concentrations between these source areas and 124+00-2, (2) assess the impact of remaining soil source in former Penite Pit #2 on the IA dissolved arsenic GW concentration between this source area and 124+00-2 (via a preferential pathway), and (3) support the evaluation of the potential preferential pathway and geochemical conditions hypotheses.	8	Permanent MWs: 6E30-2 (aka PTC-310), 5E31-2 (aka PTC-316), 6D32-2 (aka PTC-323), 6D33-2 (aka PTC-324) Grab GW Samples from Temporary MWs: PTC-315, PTC-319, PTC-320, PTC-322	2C	• 6D32-2 and 6D33-2 will need to be installed at least ten ft landward of the proposed barrier wall alignment • Each boring extended to top of 2ndA • No XRF analyses needed after Task 2A completed • MWs screened in IA (screen length of 10 ft or 5 ft) • Field WQ parameters measured during low-flow purging • One GW sample collected from each new MW and analyzed for dissolved arsenic only		X					8
2D	Sequential extraction and PW samples from plume core borings	6,12	1,3	Collect 1stA SEQ and PW samples at a few key source area and plume core locations to (1) evaluate the amount of arsenic in 1stA soil that is available for desorption into GW, (2) support the evaluation of geochemical conditions hypothesis, and (3) evaluate the key GW model assumptions that are driving the predicted restoration time frames (i.e., 1stA isotherm values in neutral pH areas, 1stA PW concentrations).	5	PTC-308, PTC-310, PTC-315, PTC-316, and PTC-321 Note: PTC-402 is part of Task 4C and is shown on Figure 2D for reference purposes only.	2D	• One soil sample collected from top 1 ft of 1stA and analyzed for SEQ only • One PW sample collected from top 1 ft of 1stA and analyzed for dissolved arsenic only • It will not be practicable to obtain field WQ parameter measurements from PW samples						5	5
3	Tidal fluctuation study	12	4	Measure static water level changes due to tidal fluctuations in MW pairs that straddle the SPW to estimate the hydraulic conductivity through the SPW at 124+00-2 and 125+50-2.	4	Pair 1: 124+00-2 and 6D32-2 (aka PTC-323) Pair 2: 125+50-2 and 6D33-2 (aka PTC-324)	3	• See Section 3.3.6 text • No lab analyses							

Table 1: Investigation Design for the RTC Data Gaps

Task #	Task	RTC #	124+00-2 Hypothesis #	Objective(s)	# of Locations	Location IDs [1]	Figure #	Key Task-Specific Details	Field		# of Lab Analyses				
									XRF arsenic (soil) [2]	WQ parameters [3]	Arsenic (soil)	pH (soil)	TCLP arsenic (soil)	SEQ (soil) [4,5]	Dissolved arsenic (water) [5,6]
4A	Wedge borings	4,6	6	Advance and sample soil borings within the wedge at and near 124+00-2 to evaluate the hypothesis that soil source material in the wedge may be a primary cause of elevated dissolved arsenic concentrations at and downgradient of 124+00-2.	3	PTC-401 through PTC-403	4	• Boring depth = 5 ft into 2ndA • XRF high-resolution vertical characterization of arsenic in each boring • One soil sample collected from worst-case UA depth in each boring and analyzed for arsenic, pH, and TCLP arsenic • One soil sample collected from top 1 ft of 1stA in each boring and analyzed for arsenic, pH, and TCLP arsenic • One soil sample collected near bottom of 1stA in each boring and analyzed for arsenic and pH • Two soil samples collected from worst-case IA depths in each boring and analyzed for arsenic and pH • One soil sample collected from worst-case depth in top 5 ft of 2ndA in each boring and analyzed for arsenic and pH	X		18	18	6		
4B	Wedge Intermediate Aquifer GW samples	4,6	3,6	Collect GW samples from temporary MWs and existing MWs at and near 124+00-2 to (1) assess the impact of arsenic in wedge soil on dissolved arsenic GW concentrations, and (2) evaluate the geochemical conditions hypothesis.	5	Grab GW Samples from Temporary MWs: PTC-401, PTC-403 Existing MWs: 122+60-2, 124+00-2, 125+50-2	4	• Each temporary MW screened in IA (screen length of 10 ft or 5 ft) • Field WQ parameters measured during low-flow purging • One GW sample collected from each Task 4B MW and analyzed for dissolved arsenic only		X					5
4C	Sequential extraction and PW samples from wedge boring	4,6	3	Collect 1stA SEQ and PW samples at 124+00-2 to (1) evaluate the amount of arsenic in 1stA soil that is available for desorption into GW, (2) support the evaluation of geochemical conditions hypothesis, and (3) evaluate the key GW model assumptions that are driving the predicted restoration time frames (i.e., 1stA isotherm values in neutral pH areas, 1stA PW concentrations). Collect an IA SEQ sample at 124+00-2 to (1) evaluate the amount of arsenic in IA soil that is available for desorption into 124+00-2 GW, and (2) support the evaluation of geochemical conditions hypothesis.	1	PTC-402	4	• One soil sample collected from top 1 ft of 1stA and analyzed for SEQ only • One PW sample collected from top 1 ft of 1stA and analyzed for dissolved arsenic only • It will not be practicable to obtain field WQ parameter measurements from PW samples • One soil sample collected from worst-case IA depth and analyzed for SEQ only						2	1
5	SW and Intermediate Aquifer PW and PPS samples	5	N/A	Collect PW (with NSDS), SW (with NSDS), and GW samples (with PPS) from existing and new shoreline locations to (1) improve characterization of dissolved arsenic concentrations downgradient of 124+00-2 and near 123+25-ST1-DS, (2) evaluate the protectiveness of dissolved arsenic concentrations at actual exposure point locations, and (3) support the potential development of a 1-dimensional or 2-dimensional GW transport model between a vertical MW seaward of the SPW (e.g., 124+00-2) and SW.	18	PW: 120+75-ST1-DS, 122+60-ST1-DS, 123+25-ST1-DS, 124+00-ST1-DS, 125+00-ST1-DS, 128+50-ST1-DS SW: 120+75-SW, 122+60-SW, 123+25-SW, 124+00-SW, 125+00-SW, 128+50-SW PPS: 120+75-ST1, 122+60-ST1, 123+25-ST1, 124+00-ST1, 125+00-ST1, 128+50-ST1	5	• Two sets of NSDSs at each PW location (one NSDS set with mouths at ~ 10 cm and one NSDS set with mouths at ~ 3 cm) • Two sets of NSDSs at each SW location (one NSDS set facing landward and one NSDS set facing seaward) • Field WQ parameters measured at each set of SW NSDSs, each set of PW NSDSs, and each PPS location • One water sample collected from each set of SW NSDSs, each set of PW NSDSs, and each PPS location and analyzed for dissolved arsenic only		X					30
6	Additional plume core borings	6,12	1	Advance and sample additional soil borings within the source area as necessary to (1) delineate arsenic soil concentrations to a TBD soil remediation level, and (2) support remedial design and implementation of a focused soil excavation in the source area.	TBD	TBD	N/A	TBD							
								Total Anticipated Primary Lab Analyses			91	91	43	7	50

Notes:

1stA: First Aquitard; 2ndA: Second Aquitard; cm: centimeter; ft: feet; IA: Intermediate Aquifer; N/A: not applicable; NSDS: nylon screen diffusion sampler; PPS: pushpoint sampler; PW: pore water; SEQ: sequential extraction; SW: surface water; TBD: to be determined; TCLP: toxicity characteristic leaching procedure; UA: Upper Aquifer; WQ: water quality; XRF: x-ray fluorescence

[1] All drilling locations may be adjusted as necessary in the field based on access, underground utilities, proximity to barrier wall alignment, etc.

[2] For XRF high-resolution vertical characterization of arsenic in soil, at least one XRF analysis will be conducted for every 2.5 ft of soil depth. Unless otherwise specified (e.g., top 1 ft of 1stA), soil sample depth intervals for samples being selected for laboratory analysis will be biased towards worst-case arsenic impacts based on XRF results.

[3] The field water quality parameters for all water samples will include pH, conductivity, temperature, dissolved oxygen, oxidation reduction potential, and turbidity.

[4] SEQ will include anoxic soil sample preservation and follow-on analyses for arsenic, iron, aluminum, manganese, and silicon. In addition, each SEQ sample will be analyzed by Brooks for total arsenic.

[5] Brooks will perform all SEQ analyses and all dissolved arsenic analyses for all GW, PW, and SW locations seaward of the SPW. ARI will perform the rest of the analyses.

[6] All GW, PW, and SW samples for dissolved arsenic analyses will be field filtered with an in-line 0.45-micron filter. If it is not practicable to field filter some samples (e.g., First Aquitard PW samples, NSDSs), then the field team will request the laboratory to filter the sample with a 0.45-micron filter in an expedited fashion.

[7] Although the HPT results will not be able to directly determine if leakage under the SPW is a primary cause of elevated dissolved arsenic concentrations at 124+00-2 (especially since the bottom of the 124+00-2 MW screen is approximately 7 ft higher than the SPW bottom), the HPT results may providing supporting evidence for the preferential leakage under the SPW hypothesis and will be helpful for determining the design depth of the barrier wall (which may need to extend deeper into the 2ndA than the SPW did due to the sandy silt nature of the 2ndA).

Table 2: Analytical Methods, Sample Containers, Preservation, and Holding Times

Project	Media	Category	Analyte	Lab	Analytical Method	Sample Container Expectations	Preservation Requirements	Extraction Holding Time (days)	Analysis Holding Time (days)
RTC Data Gaps Investigation	Soil	Total Metals	Arsenic	ARI	USEPA SW846-3050B followed by USEPA SW846-6010D	One 8 oz. glass jar	Cool to ≤ 4°C +/- 2°C	N/A	180
		Conventionals	pH	ARI	USEPA SW846-9045	In same container as total metals analysis	Same as total arsenic analysis	N/A	7
		TCLP Metals	Arsenic	ARI	USEPA SW846-1311 followed by USEPA SW846-6010D	In same container as total metals analysis	Same as total arsenic analysis	N/A	180
		Sequential Extraction and Follow-on Analyses [1]	Arsenic	Brooks	Sequential Extraction [1] followed by USEPA SW846-6020 Mod (ICP-QQQ-MS)	Mylar bag collected with anoxic field procedures [2] and minimum sample volume of approximately 8 oz.	Anoxic preservation [2]	N/A	365
			Iron						
			Aluminum						
			Manganese						
			Silicon						
	GW, PW, SW	Dissolved Metals	Arsenic	Brooks [3]	USEPA 1638 Mod (ICP-QQQ-MS)	One 125 mL HDPE	Cool to ≤ 4°C +/- 2°C, HNO3 in lab to pH < 2 within 14 days of collection	N/A	180
			Arsenic	ARI [3]	USEPA SW846-6020A	One 500 mL HDPE	Pre-preserved with HNO3, cool to ≤ 4°C +/- 2°C	N/A	180
Barrier Wall PDI	Soil	Total Metals	Arsenic	ARI	USEPA SW846-3050B followed by USEPA SW846-6010D/7471B	One 8 oz. glass jar	Cool to ≤ 4°C +/- 2°C	N/A	180
			Barium						
			Cadmium						
			Chromium						
			Lead						
			Selenium						
			Silver						
			Mercury					N/A	28
		TCLP Metals	Arsenic	ARI	USEPA SW846-1311 followed by USEPA SW846-6010D/7470A	In same container as total metals analysis	Same as total metals analysis	N/A	180
			Barium						
			Cadmium						
			Chromium						
			Lead						
			Mercury						
			Selenium						
			Silver						

Notes:

°C: degrees Celsius; HDPE: high density polyethylene; HNO_3: nitric acid; ICP: inductively coupled plasma; MS: mass spectrometry; N/A: not applicable; oz: ounce; QQQ: triple quadrupole

[1] Sequential extraction will be in accordance with Brooks standard procedures using a modified version of the *Wenzel et al 2001* methodology. The five sequential extraction steps will be (1) NH4H2PO4, (2) NH2OH*HCl, (3) NH4+-oxalate, (4) HNO3/H2O2, and (5) HCl/HF/HNO_3. Each analyte in this category will be analyzed after each extraction step.

[2] See Section 3.3.3.4 for field procedures for anoxic preservation with these analyses that are sensitive to oxidation. Lab anoxic preservation procedures will include (1) storing samples at a minimum of -15 degrees Celsius, (2) deoxygenating deionized water being used with nitrogen, helium, or argon, and (3) processing of solids in an anaerobic glove box.

[3] Brooks will analyze all GW, PW, and SW samples seaward of the SPW (i.e., Task 4B/4C samples [PTC-401, PTC-402, PTC-403, 122+60-2, 124+00-2, 125+50-2] and Task 5 samples [all SW, PW, and PPS samples]). ARI will analyze GW and PW samples landward of the SPW (i.e., 6E30-1, Task 2C GW samples [6E30-2, 5E31-2, 6D32-2, 6D33-2, PTC-315, PTC-319, PTC-320, PTC-322] and Task 2D PW samples [PTC-308, PTC-310, PTC-315, PTC-316, PTC-321]).

Table 3: Laboratory Control Limits

Project	Media	Category	Analyte	Lab	Analytical Method	LCS	MS/MSD		Surrogates
						% Recovery	% Recovery	RPD %	% Recovery
RTC Data Gaps Investigation	Soil	Total Metals	Arsenic	ARI	USEPA SW846-3050B followed by USEPA SW846-6010D	80-120	75-125	20	N/A
		Conventionals	pH	ARI	USEPA SW846-9045	N/A	N/A	20	N/A
		TCLP Metals	Arsenic	ARI	USEPA SW846-1311 followed by USEPA SW846-6010D	80-120	75-125	20	N/A
		Sequential Extraction and Follow-on Analyses	Arsenic	Brooks	Sequential Extraction followed by USEPA SW846-6020 Mod (ICP-QQQ-MS)	N/A [(1)]	N/A [(1)]	N/A [(1)]	N/A
			Iron			N/A [(1)]	N/A [(1)]	N/A [(1)]	N/A
			Aluminum			N/A [(1)]	N/A [(1)]	N/A [(1)]	N/A
			Manganese			N/A [(1)]	N/A [(1)]	N/A [(1)]	N/A
			Silicon			N/A [(1)]	N/A [(1)]	N/A [(1)]	N/A
	GW, PW, SW	Dissolved Metals	Arsenic	Brooks	USEPA 1638 Mod (ICP-QQQ-MS)	75-125	70-130	20	N/A
				ARI	USEPA SW846-6020A	75-125	70-130	20	N/A
Barrier Wall PDI	Soil	Total Metals	Arsenic	ARI	USEPA SW846-3050B followed by USEPA SW846-6010D/7471B	80-120	75-125	20	N/A
			Barium			80-120	75-125	20	N/A
			Cadmium			80-120	75-125	20	N/A
			Chromium			80-120	75-125	20	N/A
			Lead			80-120	75-125	20	N/A
			Mercury			80-120	75-125	20	N/A
			Selenium			80-120	75-125	20	N/A
			Silver			80-120	75-125	20	N/A
		TCLP Metals	Arsenic	ARI	USEPA SW846-1311 followed by USEPA SW846-6010D/7470A	80-120	75-125	20	N/A
			Barium			80-120	75-125	20	N/A
			Cadmium			80-120	75-125	20	N/A
			Chromium			80-120	75-125	20	N/A
			Lead			80-120	75-125	20	N/A
			Mercury			80-120	75-125	20	N/A
			Selenium			80-120	75-125	20	N/A
			Silver			80-120	75-125	20	N/A

Notes:

ICP: inductively coupled plasma; LCS: laboratory control sample; MS: mass spectrometry; MS/MSD: matrix spike/matrix spike duplicate; N/A: not applicable; RPD: relative percent difference

[(1)] Typical laboratory control limits are not applicable due to the nature of sequential extraction. However, other QC measures (e.g., method duplicates, post spikes) are implemented as appropriate.

Table 4: Target Reporting Limits

Project	Media	Category	Analyte	Lab	Analytical Method	Target Reporting Limit [1]	Applicable Criterion [2]	Units
RTC Data Gaps Investigation	Soil	Total Metals	Arsenic	ARI	USEPA SW846-3050B followed by USEPA SW846-6010D	5.0	88	mg/kg
		Conventionals	pH	ARI	USEPA SW846-9045	0.01	N/A [3]	pH units
		TCLP Metals	Arsenic	ARI	USEPA SW846-1311 followed by USEPA SW846-6010D	0.25	5.0	mg/L
		Sequential Extraction and Follow-on Analyses	Arsenic	Brooks	Sequential Extraction followed by USEPA SW846-6020 Mod (ICP-QQQ-MS)	TBD [4]	N/A [3]	mg/kg
			Iron					
			Aluminum					
			Manganese					
			Silicon					
	GW, PW, SW	Dissolved Metals	Arsenic	Brooks	USEPA 1638 Mod (ICP-QQQ-MS)	2.0	8.0	ug/L
				ARI	USEPA SW846-6020A	0.5		
Barrier Wall PDI	Soil	Total Metals	Arsenic	ARI	USEPA SW846-3050B followed by USEPA SW846-6010D/7471B	5.0	88	mg/kg
			Barium			0.60	700,000	
			Cadmium			0.20	3,500	
			Chromium			0.90	5.300,000 / 260 [5]	
			Lead			2.0	1,000	
			Mercury			0.025	1,050	
			Selenium			5.0	18,000	
			Silver			0.30	18,000	
		TCLP Metals	Arsenic	ARI	USEPA SW846-1311 followed by USEPA SW846-6010D/7470A	0.25	5.0	mg/L
			Barium			0.015	100	
			Cadmium			0.010	1.0	
			Chromium			0.025	5.0	
			Lead			0.10	5.0	
			Mercury			0.00010	0.20	
			Selenium			0.25	1.0	
			Silver			0.25	5.0	

Notes:

ICP: inductively coupled plasma; MS: mass spectrometry; N/A: not applicable; TBD: to be determined

[1] It may not be possible to achieve these reporting limits in all samples (e.g., samples requiring extra dilution beyond the target dilution, interferences).

[2] For the purposes of this Work Plan, the total metals criteria for soil samples are MTCA Standard Method C/Method A soil direct contact cleanup levels (Ecology 2001, 2023), the TCLP metals criteria are toxicity characteristic concentrations in WAC 173-303-090(8)(c), and the dissolved metals criterion for GW, PW, and SW samples is the MTCA Method B GW cleanup level with natural background adjustment.

[3] These analytes are being collected for geochemical purposes only.

[5] The first value is for Chromium VI and the second value is for Chromium III.

[4] TBD on a batch-specific basis at the time of analysis.

Table 5: Key Investigation Roles and Responsibilities

Role	Name	Contact Information	Key Investigation Responsibilities
Ecology Unit Supervisor and Site Manager	Andy Smith	ansm461@ecy.wa.gov 360-407-6316 (O)	▪ Review and approve Work Plan ▪ Field oversight as necessary
Port Project Manager for RTC Data Gaps Investigation	Scott Hooton	shooton@portoftacoma.com 253-383-9428 (O)	▪ Provide Port technical direction for RTC Data Gaps Investigation ▪ Communicate and coordinate with Ecology ▪ Communicate and coordinate within Port ▪ Manage team performance, budget, and schedule for RTC Data Gaps Investigation
PIONEER Project Manager for RTC Data Gaps Investigation	Troy Bussey	busseyt@uspioneer.com 360-570-1700 (O) 360-810-0640 (C)	▪ Prepare Expanded RTC Data Gaps Investigation Work Plan ▪ Communicate and coordinate with Port Project Manager for RTC Data Gaps Investigation activities ▪ Coordinate and provide guidance to On-Site Field Project Manager for RTC Data Gaps Investigation activities ▪ Evaluate and document results for RTC Data Gaps Investigation
Port Project Manager for Barrier Wall PDI	Brett Ozolin	bozolin@portoftacoma.com 253-241-0207 (O)	▪ Provide Port technical direction for Barrier Wall PDI ▪ Communicate and coordinate within Port ▪ Manage team performance, budget, and schedule for Barrier Wall PDI
DOF Project Manager for Barrier Wall PDI	Trevor Louviere	tlouviere@dofnw.com 206-502-1125 (O) 425-785-6322 (C)	▪ Prepare Barrier Wall PDI Work Plan ▪ Communicate and coordinate with Port Project Manager for Barrier Wall PDI activities ▪ Coordinate and provide guidance to On-Site Field Project Manager for Barrier Wall PDI activities ▪ Evaluate and document results for Barrier Wall PDI
On-Site Field Project Manager (DOF)	Dave Cooper	dcooper@dofnw.com 425-827-4588 (O) 206-660-3466 (C)	▪ Complete pre-mobilization coordination activities ▪ Supervise and overall administration of all Site field operations ▪ Prepare technical memo(s) documenting field implementation
Site Health and Safety Officer	Steve Frost	stephenfrost18@hotmail.com 206-214-8990 (O and C)	▪ Ensure appropriate implementation of Health and Safety Plan
Field Technical Staff (DOF)	To be determined		▪ Conduct variety of field implementation tasks
XRF Field Screening and GPS Coordinates (PIONEER)	Melisa Kegans	kegansm@uspioneer.com 360-570-1700 (O) 503-758-7363 (C)	▪ Conduct XRF field screening ▪ Obtain GPS coordinates for borings
Geophysical Survey (HydroGeophysics)	Nigel Crook	ncrook@hgiworld.com 206-669-3730 (C)	▪ Conduct geophysical survey and report results
HPT Licensed Driller (Cascade)	Brad Carlson	wcarlson@cascade-env.com 813-731-5916 (C)	▪ Advance direct-push HPT borings, operate HPT equipment, and produce HPT logs
Primary Licensed Driller	To be determined		▪ Advance all soil borings, except for HPT borings ▪ Install and develop MWs
Licensed Surveyor	To be determined		▪ Determine the horizontal coordinates and vertical elevations of the MW measuring points
Divers (Ballard Marine Construction)	Adam Litt	adam.litt@ballardmc.com 360-695-5163 (O) 360-518-4864 (C)	▪ Install and collect NSDSs for SW and PW samples ▪ Collect Intermediate Aquifer PPS samples
Primary Laboratory (ARI)	Kelly Bottem	kellyb@arilabs.com 206-695-6200 (O)	▪ Perform all analyses, except for analyses conducted by Brooks ▪ Perform associated laboratory quality control
Specialty Laboratory (Brooks)	Jeremy Maute	jeremy@brooksapplied.com 206-753-6116 (O)	▪ Perform all sequential extraction analyses ▪ Perform associated laboratory quality control
Data Quality Validator (QA/QC Solutions)	James McAteer	jjmcateer@msn.com 503-763-6948	▪ Perform independent data quality validation for all laboratory data from the primary laboratory
Data Management and Risk Assessment Support (PIONEER)	Chris Waldron	waldronc@uspioneer.com 360-570-1700 (O)	▪ Provide data management support as necessary ▪ Provide risk assessment support as necessary

Appendix A

Barrier Wall Pre-Design Investigation Work Plan

PORT OF TACOMA – FORMER ARKEMA MANUFACTURING SITE

TACOMA, WASHINGTON

June 28, 2023 – REVISION

Prepared for:
PORT OF TACOMA
Tacoma, Washington

Prepared by:
DALTON, OLMSTED, & FUGLEVAND, INC.
1001 SW Klickitat Way, Suite 200B
Seattle, Washington 98134

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ACRONYMS AND ABBREVIATIONS

ASTM ..... American Society of Testing and Materials

bgs ..... Below Ground Surface

CD ..... Consolidated Drained

COC ..... Constituent of Concern

CU ..... Consolidated Undrained

DOT ..... Department of Transportation

EPA ..... Environmental Protection Agency

GPR ..... Ground Penetrating Radar

NAVD88 ..... North American Vertical Datum of 1988

PCA ..... Proposed Containment Area

Port ..... Port of Tacoma

P&T ..... Pump and Treat

RCRA ..... Resource Conservation and Recovery Act

Site ..... Former Arkema Manufacturing Site

SPT ..... Standard Penetration Test

SPW ..... Sheet Pile Wall

TCLP ..... Toxicity Characteristic Leaching Procedure

USG ..... United States Gypsum

WAC ..... Washington Administrative Code

1.0 INTRODUCTION

The Port of Tacoma (Port) has requested preparation of this work plan to help assess subsurface conditions along the alignment of the proposed subsurface barrier wall for the Former Arkema Manufacturing Site (Site) shown on Figure 1. The objective of the barrier wall is to provide containment through control of groundwater within the barrier wall to minimize the release of site constituents to the adjacent Hylebos Waterway. The scope of work presented in this work plan will provide data allowing for design of the barrier wall.

1.1 Purpose

The purpose of the data collection scope identified in this work plan to provide design parameters for the subsurface barrier wall. Data collected under the work plan will provide the following:

- Subsurface geotechnical data;
- Subsurface utility location information;
- Waste characterization data for shallow soils in the proposed barrier wall alignment;
- Compatibility of mix design materials with site conditions; and
- Proposed mix design for barrier wall construction.

1.2 Site Location

The approximately 48-acre Site is a former chemical manufacturing facility that operated from 1927 to 1997 in the Tacoma Tideflats, adjacent to the Hylebos Waterway in Tacoma, Washington (Figure 1). All directions called out in this report will be referenced to the Site specified directions depicted on Figure 1. The addresses for the Site are 2901 and 2920 Taylor Way, Tacoma, Washington. The Site is bounded by the former United States Gypsum (USG) facility to the north (i.e., Site north), the Hylebos Waterway to the east, the Arkema Mound site to the south, and Taylor Way to the west. The proposed barrier wall alignment is shown on Figure 2, along with other pertinent existing site conditions.

1.3 Work Plan Organization

The work plan is organized as follows:

- Section 2: Site Background
- Section 3: Scope of Work and Procedures
- Section 4: Sample Nomenclature
- Section 5: Reporting
- Section 6: References

2.0 SITE BACKGROUND

The Site was used as a manufacturing facility and the products that were manufactured included chlorine, sodium hydroxide (caustic), sodium chlorate, hydrochloric acid, and sodium arsenite (Penite). Operations started in 1927 with the manufacturing of chlorine and caustic. Penite was manufactured between circa 1944 and the early 1970s. Penite was produced by combining hot caustic soda with arsenic trioxide (Malcolm Pirnie, 2006). The remaining chlorine-based manufacturing facility operations ceased in 1997, at which time the manufacturing facilities were dismantled and removed from the Site. The Port removed all remaining aboveground structures in 2008. Numerous subsurface features remain in place (e.g., utilities, vaults, injection wells, extraction wells, and piping associated with the former pump-and-treat [P&T] system for the main arsenic plume). A more detailed description and history of the site may be found in the Feasibility Study Data Gap Investigation Report (Pioneer, 2019).

2.1 Topography and Drainage

The Site consists of remanent building foundations, former rail alignments, and dilapidated pavement from the former manufacturing facility operations. Based on past environmental investigations and evaluations on the site, arsenic has been identified as the primary constituent of concern (COC) at the Site (Pioneer, 2019), particularly within the proposed containment area (PCA), and is known to be present to a much lesser degree within the 24-Acre Cap/Cover Redevelopment Area.

The Site is relatively flat in the PCA, with the shoreline sloping to the Hylebos Waterway. The elevation of the top of slope along the Hylebos Waterway (near the existing shoreline sheet pile wall) averages about elevation 15 feet (NAVD88). Contours range from elevation 13 feet to 18-feet within the PCA with most of the surface between elevation 14 feet and 16 feet, becoming higher in the area of the soil/sediment cap located on the south end of the PCA. No surface infrastructure remains in the portion of the Site being evaluated for the barrier wall; however, numerous below grade foundations, piping systems and miscellaneous buried objects remain in the area.

2.2 Geology

The regional geology is dominated by Quaternary ice age glacial deposits. In general, regional glacial deposits include sand and gravel aquifers associated with glacial outwash and low permeability glacial till deposits containing clay and silt. The Site is located within the tideflats of the Puyallup River delta. In general, the pre-development tideflats consisted of alternating layers of lower permeability silt/clay and sandy deposits. Sediment dredged from Commencement Bay and its tributaries, as well as other fill material, were used to raise the land elevation during the industrial development of the tideflats. The relevant lithologic units at the Site, from shallowest to deepest, include the following:

1. Fill (Upper Aquifer): The fill unit consists primarily of dredge sand and imported fill.
2. Upper Silt (First Aquitard): The upper native soils consist primarily of clayey silt to fine sandy silt, with fibrous organic material associated with former tideflat vegetation at the top of the unit.
3. Intermediate Sand (Intermediate Aquifer): The intermediate sand unit consists primarily of a native fine to medium sand with shell fragments and silt interbeds.

4. Lower Silt (Second Aquitard): The lower silt unit consists primarily of clayey silt to fine sandy silt.
5. Lower Sand (Deep Aquifer): The lower sand unit primarily consists of a fine to medium sand with silt interbeds.

2.3 Hydrogeology

The relevant hydrostratigraphic units at the Site, from shallowest to deepest, correspond to a specific lithologic unit and include the following:

1. Upper Aquifer: The Upper Aquifer is the saturated portion of the fill unit. The thickness of the Upper Aquifer is approximately eight to 12.5-feet. Upper Aquifer groundwater is typically encountered at depths of less than six feet below ground surface (bgs) in most portions of the Site, and is encountered at depths less than two-feet bgs within portions of the main arsenic plume. The PCA contains the core of the main arsenic plume
2. First Aquitard: The First Aquitard is the upper silt unit. The thickness of the First Aquitard is approximately seven to 14-feet. Thin and/or leaky portions of the upper silt have been identified in portions of the Site.
3. Intermediate Aquifer: The Intermediate Aquifer is the intermediate sand unit. The thickness of the Intermediate Aquifer is approximately 0.5 to 11-feet.
4. Second Aquitard: The Second Aquitard is the lower silt unit. The thickness of the Second Aquitard is approximately 9.5 to 19.5-feet.
5. Deep Aquifer: The Deep Aquifer is the lower sand unit. The thickness of the Deep Aquifer appears to be at least 20 feet thick.

In general the main arsenic plume and groundwater in all three aquifers flow east towards the Hylebos Waterway. There may also be localized groundwater flow in the Upper Aquifer and Intermediate Aquifer towards the north or south near a sheet pile wall (SPW) installed as part of the remedial activities (see Figure 2 for location). The Intermediate Aquifer and the Deep Aquifer are tidally influenced and can experience flow reversals. Tidal fluctuations and mixing occur seaward of the SPW in the Upper Aquifer, but are less noticeable in the Upper Aquifer landward of the SPW.

The Upper Aquifer, First Aquitard, and Intermediate Aquifers are the primary hydrostratigraphic units of interest because the overwhelming majority of the arsenic mass is located in these three units. The barrier wall is proposed to key into the Second Aquitard underlying the Intermediate Aquifer to provide containment for the three overlying units. The depth to the top of the Second Aquitard is typically 30 to 35 feet below current ground surface.

2.4 Constituents of Concern

The nine Site COCs are:

- Arsenic;
- Lead;
- Mercury;

- Copper;
- Nickel;
- Tetrachloroethylene (PCE);
- Trichloroethylene (TCE);
- Vinyl Chloride (VC); and
- Chloroform (CF).

As determined in previous documents and mentioned above, arsenic is the key COC for the Site and the barrier wall's primary function is to contain soils and groundwater with the highest arsenic concentrations on the Site and reduce the impacts of arsenic migration to the Hylebos Waterway.

3.0 SCOPE OF WORK & PROCEDURES

The following sections present work tasks and procedures for data collections and assessment.

3.1 Utility Locating

Existing utilities and remaining foundations are a major concern for construction of a barrier wall using slurry and trenching techniques. A thorough utility locate, and ground penetrating radar (GPR) scan will be conducted along the alignment of the barrier wall to identify potential obstructions and conduit pathways. The materials used for the pipelines (conductive vs. non-conductive) will be determined and lines investigated as to their extent within the area of planned containment. Already documented existing extraction wells, arsenic pump and treat extraction trenches and associated piping will also be identified and shown on the project plans.

3.1.1 SURFACE GEOPHYSICS

If conductive, utilities may be traced using conventional pipeline location methods. If non-conductive, the feature/pipeline location and extents will be investigated with cameras and conductive trace wire, if possible.

A variety of remote/electrical methods may be used depending on the utility anticipated or encountered by surface expression (e.g. manholes, hydrants, etc.).

- Direct Current (DC) Resistivity,
- Low-Frequency Electromagnetic (EM) Induction (i.e., loop-loop methods),
- VLF (Very Low Frequency EM),
- Metal detection equipment,
- Ground Penetrating Radar.

3.1.2 WALL ALIGNMENT TRENCHING

Following utility locating using conductive and non-conductive methods, a continuous trench using a small rubber-tired backhoe or excavator to clear utilities and locate foundations and other shallow obstructions along the entire alignment will be employed. The trench would be excavated to a general

depth of 3 feet, with exceptions to identify the top of deeper pipelines or anomalies identified by remote methods, up to a depth of 8 feet below ground surface.

- The dimensions of the trench will vary depending on the strength and stability of the trench walls and depth.
- Trenches will not be entered by any personnel.
- When starting an excavation, the backhoe operator will first remove the topsoil or cover (if any) and place it in a discrete mound at least 5 feet from the edge of the trench.
- The soils will be replaced in the trench at their original depths to the extent practicable so that the soil from the bottom of the trench will be placed on the bottom and the topsoil will be replaced on the top.
- The backhoe bucket will be used to backfill and compact the soil back into the trench.

3.1.2.1 Shallow Soil Sampling

During wall alignment trenching, composite soil samples will be collected for waste characterization purposes. Samples will be collected per Standard Operating Procedure 125 (SOP-125 in Appendix B of the Expanded RTC Data Gaps Investigation Work Plan), at the proposed boring locations (Figure 2) from ground surface to 3-feet below ground surface. Once the alignment trenching is complete and the composite soil samples from each location are collected, portions of each sample will be combined to create a single composite sample characteristic of materials to be generated from the installation trench required for the barrier wall construction. The individual composites from each of the boring locations will be submitted to the laboratory for archiving in the event additional analysis is necessary for waste characterization.

Analytical testing will be performed on the combined composite sample from shallow soils and will include:

- Resource Conservation and Recovery Act (RCRA) 8 Metals using Environmental Protection Agency (EPA) method 6020B; and
- Toxicity Characteristic Leaching Procedure (TCLP) using EPA 1311 for RCRA 8 Metals.

If analytical results indicate leachability, and the material will characterize as dangerous waste, then sample volume will be provided to Chemical Waste Management, Inc. (CWM) for internal treatability testing. CWM would determine the reagent quantity required to reduce leachability to below land disposal requirements. This will be required in advance of sending material to the facility for disposal and will define the disposal costs associated with material produced as part of installation of the barrier wall.

If analytical results indicate the material is below leachability criteria (Arsenic < 5 mg/L) and below the industrial Method C direct contact level (Arsenic = 88 mg/kg), the material will not be disposed of offsite and will be placed within the proposed barrier wall alignment for future capping.

3.1.3 UTILITY IDENTIFICATION

Remotely identified utilities will be painted on the ground as they are identified. These features will be mapped establishing horizontal coordinates using a DGPS[1], equipped with GIS mapping ability that will document the location of the utilities.

Utilities and foundation elements revealed by trenching will also be mapped using DGPS and photo documented.

3.2 Wall Alignment Borings

Based on available geotechnical information and the recommendation for use of the vibratory beam technology, an additional 15 borings (at roughly 150-foot spacing) to a depth of 40-feet are proposed directly along the barrier wall alignment to better define the following:

1. Depth to top of Second Aquitard
2. Depth to bottom of Second Aquitard
3. Density and gradation of materials with depth
4. Strength and consolidation characteristics with depth

Locations of the proposed borings are presented on Figure 2.

3.2.1 DRILLING

The borings will be advanced using a hollow-stem auger in accordance with Chapter 173-160 WAC. Soil sampling will be conducted on 2.5-foot intervals from 5 to 25-feet below ground surface, with continuous sampling thereafter to a final depth of 40 feet. If a boring is located in a known of suspected area of the site where the first aquitard is not present or thin, continuous sampling will be completed from 5 to 40-feet below ground surface.

Disturbed samples will be obtained in accordance with American Society for Testing and Materials (ASTM) D1586-11, Standard Test Method for Standard Penetration Test (SPT) and Split-barrel Sampling of Soils. This test and sampling method consists of driving a standard 2-inch outside diameter split barrel sampler a distance of 18 inches into the soil with a 140-pound hammer free falling a distance of 30 inches. The number of blows for each 6-inch interval is recorded. The number of blows required to drive the sampler the final 12-inches is considered the Standard Penetration Resistance (“N”) or blow count. If a total of 50 blows is recorded within one 6-inch interval, the blow count is recorded as “50 blows for the number of inches of penetration. The resistance, or “N” value, provides a measure of the relative density of granular soils or the relative consistency of cohesive soils.

Samples will be classified in the field as to material type using ASTM D2488 as a general guide. Visual observations of any observed staining or other indications of soil contamination will be noted. A field boring log will be prepared by the field geologist. Sampling will be conducted in accordance with Standard Operating Procedure 125 (SOP-125, provided in Appendix B of the Expanded RTC Data Gaps Investigation Work Plan).

[1] Trimble GeoXH GPS

Thin-walled tube (commonly referred to as a "Shelby Tube") samples will also be collected in accordance with ASTM D1587/D1587M-15, used for obtaining intact specimens of fine-grained soils for laboratory tests to determine engineering properties of soils (strength, compressibility, permeability, and density) per methods described in Section 3.2.1.4.

Odd numbered boring locations, e.g. DFO-B1, DOF-B3, etc., will be advanced first in an effort to identify depths of the Upper Aquifer, First Aquitard, Intermediate Aquifer, and Second Aquitard (Figure 3). This will allow for interpolation of each of these zones at the even numbered boring locations and increase accuracy of thin-walled tube sample depths. Existing boring logs proximal to the barrier wall alignment are provided as Appendix A for reference during implementation of this work plan.

3.2.1.1 Geotechnical Sample Analysis

Samples for physical testing will be collected from the wall alignment borings for geotechnical design considerations. Geotechnical testing will consist of the following:

1. Gradation Analyses by ASTM D6913-04– a total of 48 samples spaced throughout the alignment across the soil horizons. Select samples may include hydrometer analyses by ASTM D7928. Gradation analysis is necessary to verify field classification of soils for design.
2. Atterberg Limits by ASTM D4318 – a total of 16 samples collected the from aquitard horizons. This analysis is necessary to understand the variability within the two aquitards and inform the engineer on the soil's susceptibility for liquefaction.
3. Triaxial Tests by ASTM D4767 and ASTM D7181 – a minimum of 8 Consolidated Undrained (CU) and 4 Consolidated Drained (CD) strength tests of samples collected from each soil horizon.
4. Consolidation Tests by ASTM D2435 – a minimum of 8 consolidation tests with 2 collected from each major soil horizon.

Triaxial tests and consolidation testing is necessary understand site conditions in relation to maintaining an open slurry trench prior to material is initially set. Following wall installation, this data will inform the engineer on potential drag down forces exerted on the wall due to variable settlement induced by fluctuating groundwater elevations.

Subsurface zones targeted for physical testing and the distribution of samples anticipated are presented in Table 1. Geotechnical testing will be performed by HWA GeoSciences Inc. in Bothell, Washington.

3.2.1.2 Borehole Destruction/Borehole Abandonment

Abandonment of borings will be in accordance with the requirements of Chapter 173-160 WAC. The borehole will be filled by thoroughly mixing a sand-cement or cement-bentonite grout and pumping the grout to the bottom of the borehole through a tremie pipe until the borehole is filled to ground surface.

3.2.1.3 Decontamination

Drilling tools (augers, rods, samplers etc.) will be hot-water pressure washed between drilling locations. A cleaning area will be set-up on site or a decontamination trailer mobilized, that will allow cleaning water to be contained and collected. The water will be tested and disposed of in an appropriate fashion following completion of subsurface investigation.

During sampling, sampler tooling will be washed with a laboratory grade detergent and tap water and rinsed with tap water between each sampling run in accordance with Standard Operating Procedure 120 (SOP-120) provided in Appendix B of the Expanded RTC Data Gaps Investigation Work Plan. Wash and rinse water will be collected for proper disposal.

Personnel will follow decontamination procedures outlined in the site Health and Safety Plan.

3.2.1.4 Handling of Sampling Waste Materials

Drill cuttings will be segregated and placed on-site in plastic lined and covered piles for profiling. Once analytical data for the stockpile is available, the data will be assessed to determine if concentrations exceed the leachability criteria (Arsenic < 5 mg/L) and/or the industrial Method C direct contact level (Arsenic = 88 mg/kg). If the material is below these criteria, the material will be placed within the proposed barrier wall alignment for future capping. If the material exceeds either of these criteria, the material will be properly profiled and the material will be transferred to either a truck or roll-off bin for shipment and disposal at an approved disposal facility.

Water resulting from the decontamination of equipment and personnel, monitoring well development and sampling purge water, and other miscellaneous materials such as used tubing will be placed in DOT 55 gallon or other suitable containers and held for proper disposal.

3.3 Mix Design and Compatibility Testing

The objective for the mix design and compatibility testing is to develop a self-hardening slurry appropriate for use in the construction of a vibratory beam slurry wall at the Site in the presence of high pH and metals. The laboratory to perform this testing is TerraSense Geotechnical Laboratory in Totowa, New Jersey.

3.3.1 MIX DESIGN

Self-hardening slurry mixes are nominally based on a 5% Clay 20% Cement and mix design will utilize a slag cement as the cement component. As part of the proposed mix design, two types of clay additives will be evaluated for use: an attapulgite clay and sepiolite. Attapulgite has worked well as the clay component in past barrier wall projects in the Pacific Northwest. Attapulgite can be more difficult to source, so mix design should also include assessment using sepiolite (another relatively inert clay type), as it is more readily available and should perform similarly to Attapulgite. This mix design will provide the basis for on-site mixing to achieve the required hydraulic conductivity after construction. As part of this study, the compatibility characteristics of the proposed mix and the liquid contaminates will be studied to evaluate the long-term behavior of the mix. Laboratory efforts related to the mix design will assess:

- Performance of a basic compatibility test to select a potential clay mineral additive suitable for use with the Site water (high pH and high metal concentrations);
- Performance of unconfined compression testing on specimens prepared from self-hardening slurry mixes to evaluate set times and evaluate material hardening or degradation;
- Performance of flexible wall hydraulic conductivity tests using the selected clay mineral additive to confirm that the selected self-hardening slurry meets the desired coefficient of hydraulic conductivity in the wall; and

- Evaluation of likelihood of long-term compatibility problems between the mix and the Site groundwater.

No additional soil sampling or methods beyond the samples collected as described above for structural design use will be used as part of the compatibility testing. Prior to commencement of mix design testing the Port will provide the following to the laboratory:

- 2.5 gallons of Attapulgite;
- 2.5 gallons of Sepiolite;
- 5 gallons of Slag Cement; and
- 10 gallons of Site groundwater[2].

3.3.1.1 Clay Mineral Evaluation

Initial feasibility of using each of Attapulgite or Sepiolite clay mineral additives will be evaluated using a screening test. This test will compare the relative behaviors of the mineral when combined with the mix water (Totowa, New Jersey tap water will be used to represent the potable hydrant water expected to be used during construction) and with the high pH water present in the groundwater on site.

For each of the clay minerals, a standard slurry with a marsh funnel viscosity of approximately 40 will be prepared using the clay mineral and the proposed site mix waters (tap water). This slurry will be allowed to hydrate for at least 24 hours before use in the screening test. Basic slurry properties (Marsh Funnel Velocity, pH, and density) will be evaluated prior to use after the hydration period.

The sedimentation test provides an indication of the stability of the mineral slurry with the water and will be performed in accordance with ASTM D5890 modified. The test will consist of diluting a sample of the prepared slurry 1:1 by volume with water, with one dilution using tap water and the other using site groundwater. These samples are then allowed to settle overnight and observed for differences in settling behavior.

Based on these initial qualitative tests, the most suitable clay mineral will be selected for further testing.

3.3.1.2 Self-Hardening Slurry Evaluation

As the self-hardening slurries are formed from a combination of the cement and clay minerals, it is necessary to study these mixes as a combination of the ingredients. The clay mineral additive selected after the Clay Mineral Evaluation test will be used for all further testing. In total, three mixes will be studied, using variations of the water to determine if there is a deleterious effect of the groundwater. One mix will be prepared using mix water only (tap water), one with Site groundwater only, and one using a 50:50 mix of groundwater and mix water. Each mix will be visually monitored for greening, which indicates the initial set of the mixture, and other characteristics during initial material hardening.

[2] Groundwater collected for laboratory use related to mix design and compatibility will be collected from monitoring well 4D1-1 (Figure 2) due to the presence of high pH water and elevated levels of arsenic observed in the well. Groundwater sample collection will be in accordance with SOP 115 provided in Appendix B of the Expanded RTC Data Gaps Investigation Work Plan.

Each set will be evaluated for compressive strength using ASTM D4832 (Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders) at 14, 28, and 56 days after initial set of the mixture. Each mix will also be tested for hydraulic conductivity using ASTM D5084 (Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter) after a compressive strength of at least 25 psi is obtained during curing. The base hydraulic conductivity test will be performed on the tap water and 50:50 tap/groundwater mixes using tap water as the permeant, while the 100% Site groundwater mix will be tested using the groundwater as permeant. All specimens will be consolidated to an effective confining stress of 20 psi, which is about representative of the condition at the mid-height of the proposed barrier wall.

Results of the testing up to this point will be evaluated for satisfactory results before the next phase of testing is initiated.

3.3.2 COMPATABILITY TESTING

The compatibility testing evaluates the behavior of the selected design mixes when exposed to changing water conditions over time. Compatibility tests will be performed on the 100% tap water and 100% groundwater mixes (permeants). Once the hydraulic conductivity (ASTM D5084) has essentially stabilized using the initial permeant, permeation of the specimen will continue for 90 days but with the alternate water type from the mix water being used as the permeant. Variations in hydraulic conductivity with time are then primarily a function of the permeant only and indicative of the material reacting to the water change. Therefore, the relative variation of the hydraulic conductivity over time using the permeant, as compared to the value under the same conditions with the mix (tap) water. If an increase in hydraulic conductivity is noted, this may indicate that there is a potential incompatibility between the mix and the permeant. If this is noted, the mix may be considered as unacceptable and the test may be discontinued prior to reaching the desired pore volumes of flow.

Generally, compatibility tests on standard mixes are continued until approximately two to three pore volumes of permeant have passed through the specimen. Breakthrough of most contaminants usually occurs within the first pore volume, however up to two pore volumes may be required for breakthrough of contaminants that have been adsorbed on the soil. Passing of more than two pore volumes allows for the complete specimen length to have been exposed to all contaminants. Due to the unique chemistry of the self-hardening slurry mix where most of the water becomes part of the solid, estimation of the material porosity required for the determination of pore volume is not possible. Therefore, permeation is being performed over a set period of time to evaluate the time effect.

Mixes meeting the maximum hydraulic conductivity of $1x10^{-7}$ cm/sec requirement, that show stable or decreasing permeabilities with time, and for which compressive strengths are stable or increasing with aging may be considered for use in the field.

It should be recognized that differences between the laboratory samples and field samples, mixing techniques between the field and laboratory, and field stresses may result in hydraulic conductivities of the barrier wall varying from those obtained in the laboratory.

4.0 SAMPLE NOMENCLATURE

Each sample will be labeled to indicate media, sample location, sample date, and the top and bottom of the sample interval. Each sample will have a unique sample name generally as follows:

SO-DOFB1-072223-5-6.5 where:

- SO – Soil Sample (Groundwater sample will be GW)
- DOFB1 – DOF Boring Location B1
- 072223 – Sample Date – July 22, 2023
- 5 – Top of Sample Depth – 5-feet below ground surface
- 6.5 – Bottom of Sample Depth – 6.5-feet below ground surface.

This sample nomenclature matches nomenclature used previously on the site and is in accordance with Appendix D of the Expanded RTC Data Gaps Investigation Work Plan for the site.

5.0 REPORTING

Following completion of the scope of work provided above, a report will be prepared to summarize the findings of the subsurface investigation and the mix design and compatibility testing. The report will provide:

- Summary of the scope of work performed;
- Utility maps along the proposed barrier wall alignment;
- Recommendation for barrier wall mix design;
- Discussion of shallow soil sampling results related to waste disposal;
- Discussion of geotechnical soil testing results;
- Boring logs and Cross-sections along the barrier wall alignment to present subsurface geotechnical conditions for use during barrier wall design and preparation of technical specifications.

6.0 REFERENCES

Pioneer Technologies Corporation, 2019, Feasibility Study Data Gap Investigation Report, Former Arkema Manufacturing Site, Tacoma, Washington: Prepared for Port of Tacoma, Tacoma, Washington, July 2019.

Malcolm Pirnie, 2006, Evaluation of Media and Chemicals of Potential Concern, Exposure Pathways, and Clean Up Standards – Part 1 Arkema, Inc. Former Inorganic Chemical Plant Tacoma, Washington. July.

DOF DALTON OLMSTED FUGLEVAND

Tables

TABLE 1

TARGET INTERVALS FOR SAMPLE ANALYSIS [1]

PoT - Former Arkema Manufacturing Facility

Tacoma, Washington

Hydrostratigraphic Unit	Approximate Depth Interval [2] (feet bgs)	Geotechnical Analysis Method				
		Gradation Analysis	Atterberg Limits	Triaxial Compression		Consolidation
		ASTM D6913-04	ASTM D4318	ASTM D4767 (CU)	ASTM D7181 (CD)	ASTM D2435
Upper Aquifer	0 to 10	4	0	2	1	2
First Aquitard	10 to 20	4	4	2	1	2
Intermediate Aquifer	20 to 30	4	0	2	1	2
Second Aquitard	30 to 35	4	4	2	1	2

Abbreviations:

bgs = below ground surface

ASTM = American Society of Testing and Materials

CU = consolidated undrained

CD = consolidated drained

Notes:

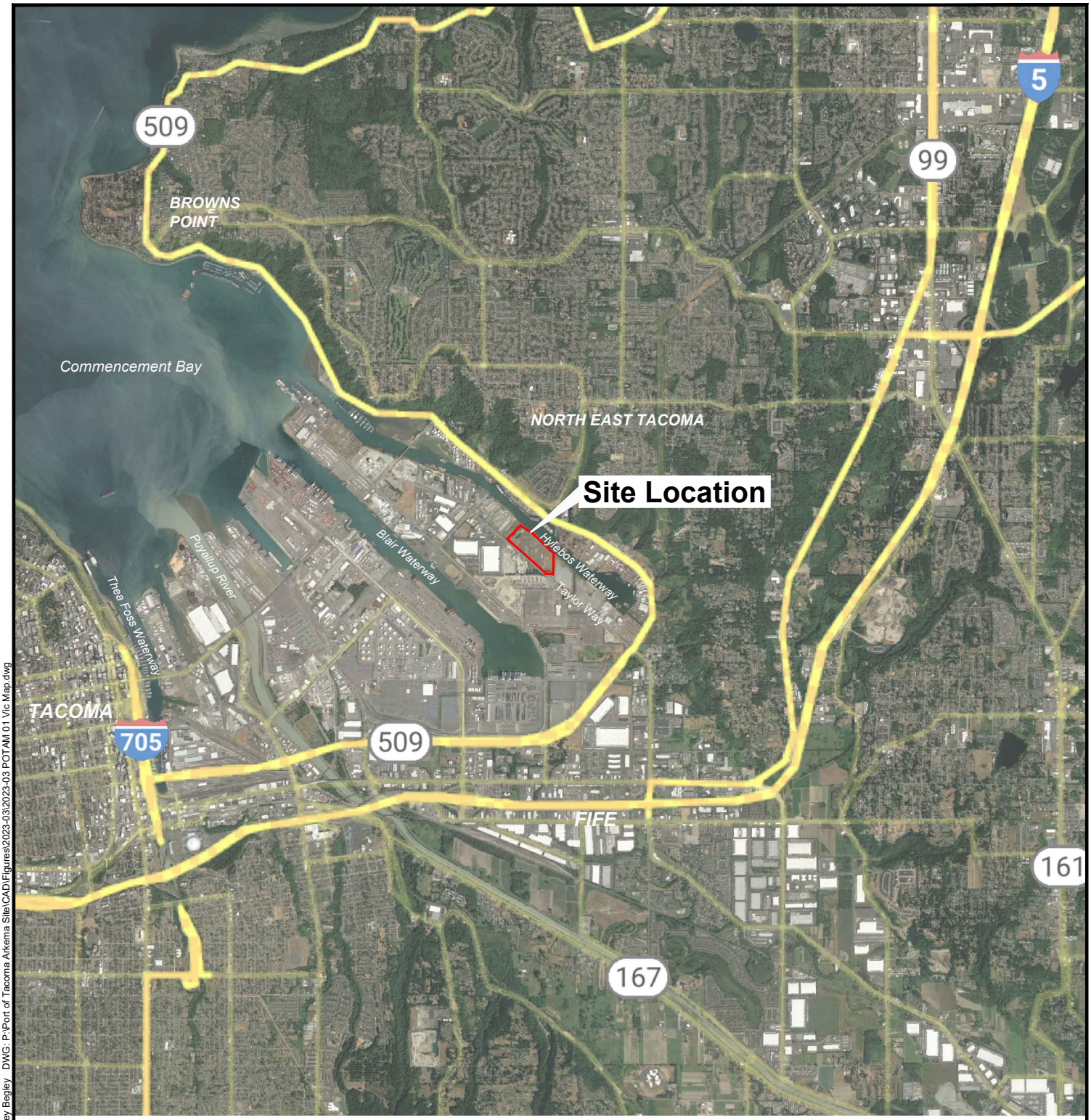
1. Numbers presented for each hydrostratigraphic unit indicate the number of tests assumed for that given unit. Locations and quantities of analyses may change due to field conditions.

2. Depth intervals listed are intended as targeted zones - hydrostratigraphic unit will be determined by visual idenification of soil type during drilling.

DOF DALTON OLMSTED FUGLEVAND

DOF DALTON OLMSTED FUGLEVAND

Figures



Aerial Source: Google Earth Pro, 08/14/2020.

Legend

Site Boundary

N

0 1

Scale in Miles

Port of Tacoma
2901 Taylor Way - Tacoma, WA

Barrier Wall Pre-Design Investigation Work Plan

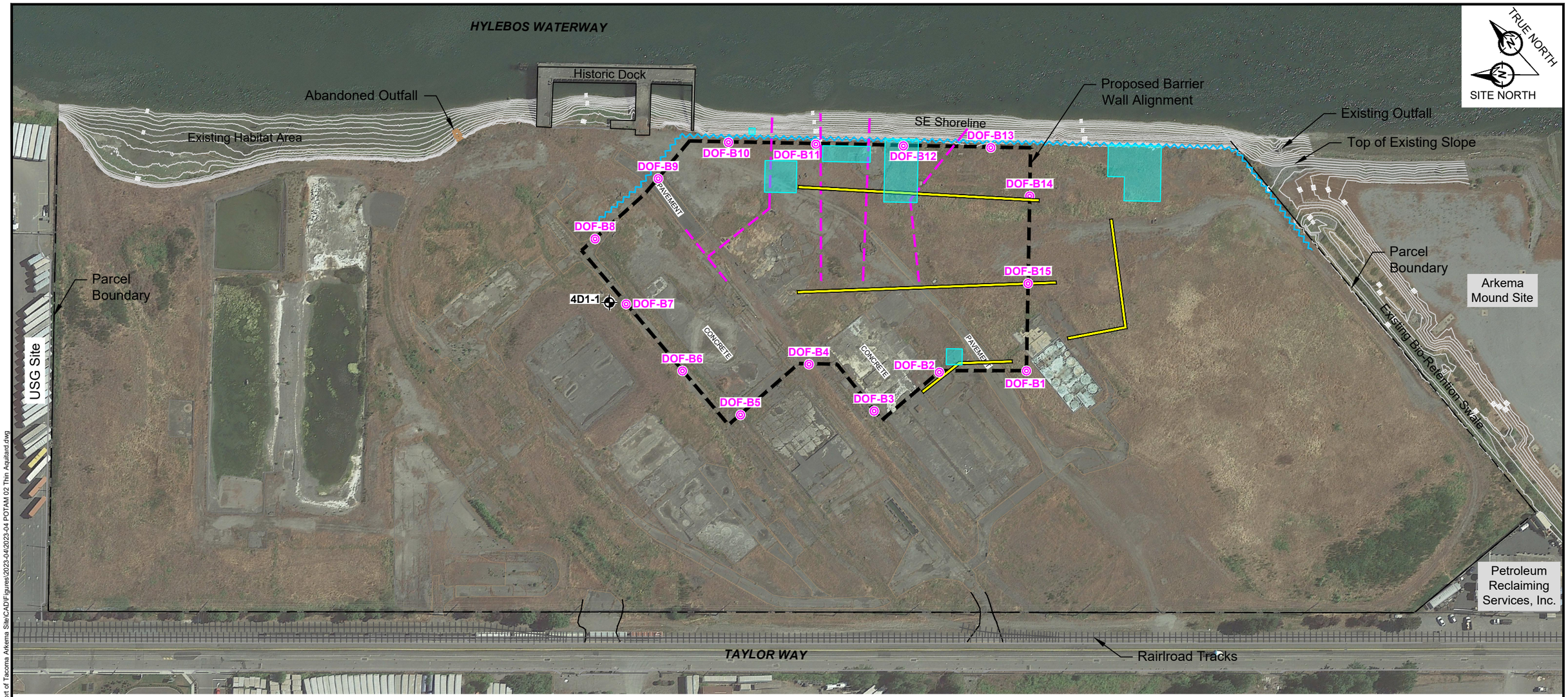
Site Location

DALTON OLMSTED FUGLEVAND

FIGURE 1

03/06/2023

PLOT TIME: 3/6/2023 5:38 PM MOD TIME: 3/6/2023 4:40 PM USER: Kelley Begley DWG: P:\Port of Tacoma Arkema Site\CAD\Figures\2023-03\2023-03 POTAM 01 Vic Map.dwg



Proposed Exploration Boring	X	Y
DOF-B1	1175275.4	710599.8
DOF-B2	1175167.9	710693.6
DOF-B3	1175045.9	710717.8
DOF-B4	1175017.9	710846.3
DOF-B5	1174879.1	710859.6
DOF-B6	1174856.6	710976.9
DOF-B7	1174861.4	711120.1
DOF-B8	1174895.0	711233.4
DOF-B9	1175038.0	711237.7
DOF-B10	1175163.3	711204.9
DOF-B11	1175267.8	711106.9
DOF-B12	1175372.4	711008.9
DOF-B13	1175476.9	710910.9
DOF-B14	1175471.1	710809.2
DOF-B15	1175373.3	710704.5

Legend

- Proposed Exploration Boring
- Proposed Barrier Wall
- Remnant Arsenic P&T Extraction Features
- Historical Sewage Line
- Parcel Boundary
- Existing Sheet Pile Wall
- Existing Fence
- Monitoring Well
- Thin or Leaky First Aquitard Location

Notes:

1. Vertical datum is NAVD88 (feet).
2. Horizontal datum is NAD83 Washington South (US feet).
3. Background reference image source: Google Earth Pro 2021

Port of Tacoma
2901 Taylor Way - Tacoma, WA
Barrier Wall Pre-Design Investigation Work Plan

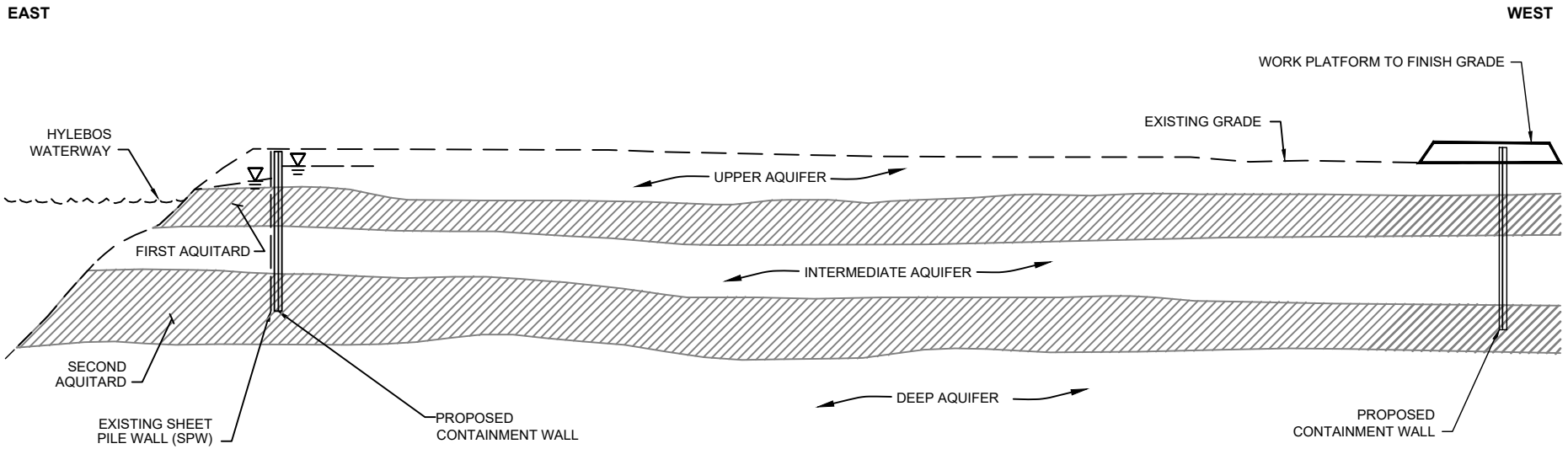
Site Plan and Boring Location Map

DOF DALTON OLMSTED FUGLEVAND

FIGURE 2

04/17/2023

PLOT TIME: 4/17/2023 11:47 AM MOD TIME: 4/17/2023 11:46 AM USER: Kelley Begley DWG: P:\Port of Tacoma Arkema Site\CAD\Figures\2023-04\2023-04 POTAM 02 Thin Aquitard.dwg



Not To Scale

Port of Tacoma - Arkema
Tacoma, Washington

ARKEMA Manufacturing Site

Barrier Wall
Geologic Section Schematic

DALTON OLMSTED FUGLEVAND

FIGURE
3

10/13/2022

DOF DALTON OLMSTED FUGLEVAND

Appendix A

Existing Boring Logs

Soil Classification System

MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL[1]	TYPICAL DESCRIPTIONS [2][3]
COARSE-GRAINED SOIL (More than 50% of material is larger than No. 200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (Little or no fines)		GW	Well-graded gravel; gravel/sand mixture(s); little or no fines
				GP	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)		GM	Silty gravel; gravel/sand/silt mixture(s)
				GC	Clayey gravel; gravel/sand/clay mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No. 4 sieve)	CLEAN SAND (Little or no fines)		SW	Well-graded sand; gravelly sand; little or no fines
				SP	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)		SM	Silty sand; sand/silt mixture(s)
				SC	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No. 200 sieve size)	SILT AND CLAY (Liquid limit less than 50)			ML	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity
				CL	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
				OL	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid limit greater than 50)			MH	Inorganic silt; micaceous or diatomaceous fine sand
				CH	Inorganic clay of high plasticity; fat clay
				OH	Organic clay of medium to high plasticity; organic silt
	HIGHLY ORGANIC SOIL			PT	Peat; humus; swamp soil with high organic content

OTHER MATERIALS	GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
PAVEMENT		AC or PC	Asphalt concrete pavement or Portland cement pavement
ROCK		RK	Rock (See Rock Classification)
WOOD		WD	Wood, lumber, wood chips
DEBRIS		DB	Construction debris, garbage

Notes:
1. USCS letter symbols correspond to symbols used by the Unified Soil Classification System and ASTM classification methods. Dual letter symbols (e.g., SP-SM for sand or gravel) indicate soil with an estimated 5-15% fines. Multiple letter symbols (e.g., ML/CL) indicate borderline or multiple soil classifications.
2. Soil descriptions are based on the general approach presented in the Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), outlined in ASTM D 2488. Where laboratory index testing has been conducted, soil classifications are based on the Standard Test Method for Classification of Soils for Engineering Purposes, as outlined in ASTM D 2487.
3. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:

Primary Constituent:	> 50%	"GRAVEL," "SAND," "SILT," "CLAY," etc.
Secondary Constituents:	> 30% and ≤ 50%	"very gravelly," "very sandy," "very silty," etc.
	> 15% and ≤ 30%	"gravelly," "sandy," "silty," etc.
Additional Constituents:	> 5% and ≤ 15%	"with gravel," "with sand," "with silt," etc.
	≤ 5%	"trace gravel," "trace sand," "trace silt," etc., or not noted.

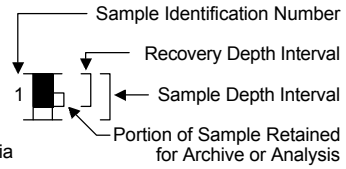
4. Soil density or consistency descriptions are based on judgement using a combination of sampler penetration blow counts, drilling or excavating conditions, field tests, and laboratory tests, as appropriate.

Drilling and Sampling Key

SAMPLER TYPE

Code	Description
a	3.25-inch O.D., 2.42-inch I.D. Split Spoon
b	2.00-inch O.D., 1.50-inch I.D. Split Spoon
c	Shelby Tube
d	Grab Sample
e	Single-Tube Core Barrel
f	Double-Tube Core Barrel
g	2.50-inch O.D., 2.00-inch I.D. WSDOT
h	3.00-inch O.D., 2.375-inch I.D. Mod. California
i	Other - See text if applicable
1	300-lb Hammer, 30-inch Drop
2	140-lb Hammer, 30-inch Drop
3	Pushed
4	Vibrocore (Rotosonic/Geoprobe)
5	Other - See text if applicable

SAMPLE NUMBER & INTERVAL



Field and Lab Test Data

Code	Description
PP = 1.0	Pocket Penetrometer, tsf
TV = 0.5	Torvane, tsf
PID = 100	Photoionization Detector VOC screening, ppm
W = 10	Moisture Content, %
D = 120	Dry Density, pcf
-200 = 60	Material smaller than No. 200 sieve, %
GS	Grain Size - See separate figure for data
AL	Atterberg Limits - See separate figure for data
GT	Other Geotechnical Testing
CA	Chemical Analysis

Groundwater

▽ Approximate water level at time of drilling (ATD)

▼ Approximate water level at time other than ATD

LANDAU ASSOCIATES

RRI-Blair Hylebos Peninsula Terminal Redevelopment Project Tacoma, Washington

Soil Classification System and Key

Figure A-1

RRI-B-14(S)

LAI Project No: 168005.030

Drilling Method: Mud Rotary
Ground Elevation (ft): 16.5 (MLLW)
Drilled By: Cascade Drilling Inc.
Logged By: DMN Date: 11/08/07

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Soil Profile	Groundwater
0	15	S-1	b2	31	PID=0		SP	Brown, gravelly, fine to medium SAND with trace silt (dense, damp to moist) **(FILL)** - cobble or small boulder?	
5	10	S-2	b2	11	PID=0 W = 24 GS		SP	Dark gray, fine to medium SAND with trace silt; medium to strong septic, H_2S or nitrate odor (medium dense, wet)	▽
		S-3	b2	11	PID=0 W = 26				
10	5	S-4	b2	3	PID=0 PID=0			- grades very loose	
		S-5	b2	2	ORG%9.3 W = 93 GS AL		MH	Gray, sandy SILT with abundant organics (very soft to soft, wet) **(ALLUVIUM)**	
15	0	S-6	b2	2	PID=0 W = 43 GS AL		ML	Gray, sandy SILT (very soft to soft, wet)	
20	-5	S-7	b2	6	PID=0 AL=NP W = 40 GS		ML	Gray, fine sandy SILT (medium stiff, wet)	
							PT	Brown, fibrous PEAT (soft, wet)	
25	-10	S-8A S-8B	b2	3	W = 143 GS		SM	Gray, silty, fine to medium SAND (very loose, wet)	
							ML	Gray SILT with trace sand (medium stiff, wet)	
30	-15	S-9	b2	6	PID=0 AL=NP W = 41 GS				
35									

Moisture Content (%) — Plastic Limit — Liquid Limit; 20 40 60 80
▲ SPT N-Value ▲ △ Non-Standard N-Value △; 10 20 30 40
× Fines Content (%) ×; 20 40 60 80

143

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

168005.03 2/16/09 \\EDMDATA\GINT\GINT7\PROJECTS\168005 REV 02.16.09.GPJ SOIL BORING LOG WITH GRAPH

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RRI-Blair Hylebos Peninsula Terminal Redevelopment Project Tacoma, Washington

Log of Boring RRI-B-14(S)

Figure A-14 (1 of 3)

RRI-B-14(S)

LAI Project No: 168005.030

Drilling Method: Mud Rotary
Ground Elevation (ft): 16.5 (MLLW)
Drilled By: Cascade Drilling Inc.
Logged By: DMN Date: 11/08/07

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Soil Profile
35	-20	S-10	b2	16	PID=0 AL=NP W = 35 GS	ML	Gray SILT with trace sand (medium stiff, wet) - grades with sand, very stiff at 35 ft bgs
						SM	Dark gray, silty, fine to medium SAND (medium dense, wet)
40	-25	S-11	b2	18	PID=0 W = 25 GS		
						SP-SM	Very dark gray, fine to medium SAND with silt and substantial shell fragments (medium dense, wet)
45	-30	S-12	b2	26	PID=0 W = 26 GS		
						SP-SM	Dark gray, fine to medium SAND with silt with trace organics (very loose, wet)
50	-35	S-13	b2	0	PID=0 W = 25 GS		
						SM	Dark gray, very silty, fine SAND (dense, wet)
55	-40	S-14	b2	46	PID=0 W = 31 GS		
						SM	Dark gray, silty, fine SAND with abundant shell fragments (very loose, wet)
60	-45	S-15	b2	2	PID=0		
						SM	Dark gray, silty, fine to medium SAND with trace shell fragments (dense, wet)
65	-50	S-16	b2	39	PID=0		
70							

Groundwater

Moisture Content (%): Plastic Limit 20 — 40 — 60 — 80 Liquid Limit
▲ SPT N-Value ▲ △ Non-Standard N-Value △: 10 20 30 40
× Fines Content (%) ×: 20 40 60 80

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

168005.03 2/16/09 \\EDMDATA\GINT\GINT7\PROJECTS\168005 REV 02.16.09.GPJ SOIL BORING LOG WITH GRAPH

LANDAU ASSOCIATES

RRI-Blair Hylebos Peninsula Terminal Redevelopment Project Tacoma, Washington

Log of Boring RRI-B-14(S)

Figure A-14 (2 of 3)

RRI-B-14(S)

LAI Project No: 168005.030

SAMPLE DATA | **SOIL PROFILE** | Groundwater | Moisture Content (%) (Plastic Limit – Liquid Limit) 20 40 60 80 | ▲ SPT N-Value ▲ △ Non-Standard N-Value △ 10 20 30 40 | × Fines Content (%) × 20 40 60 80

Drilling Method: Mud Rotary
Ground Elevation (ft): 16.5 (MLLW)
Drilled By: Cascade Drilling Inc.
Logged By: DMN Date: 11/08/07

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Soil Description
70	-55	S-17	b2	35	PID=0 W = 25 GS		SM	Dark gray, silty, fine to medium SAND with trace shell fragments (dense, wet)
75	-60	S-18	b2	40	PID=0			
80								
85								
90								
95								
100								
105								

Boring Completed 11/08/07. Total Depth of Boring = 76.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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RRI-Blair Hylebos Peninsula Terminal Redevelopment Project Tacoma, Washington

Log of Boring RRI-B-14(S)

Figure A-14 (3 of 3)

RRI-B-15(X)

LAI Project No: 168005.030

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): 16 (MLLW)
Drilled By: Cascade Drilling Inc.
Logged By: DMN Date: 11/07/07

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Soil Profile	Groundwater
0	15	S-1	h2	15	PID=0		GP	Brown to black, sandy GRAVEL with silt, trace roots (loose, moist to wet) **(FILL)**	▽
		S-2	h2	6	PID=0 GS		SP-SM	Dark brown to dark gray to black, fine to medium SAND with silt and trace gravel and abundant to trace shell fragments (very loose, wet)	
5	10	S-3	h2	3	PID=0 W = 38				
		S-4	h2	5	PID=0 W = 25				
10	5	S-5A S-5B S-5C	h2	2	PID=0		PT	Brown PEAT with gray, fine sand (very soft, wet)	
		S-6	c3		PID=0		ML/OL	**(ALLUVIUM)** Gray, fine sandy SILT with abundant roots and slight septic odor (very soft, wet)	
		S-7A S-7B	b2	4	PID=0		SP	Gray, fine SAND with substantial shell fragments (loose, wet)	
15	0	S-8A S-8B	b2	0	PID=0		ML	Gray, fine sandy SILT with substantial shell fragments (very soft, wet)	
							SP-SM	Gray, fine to medium SAND with silt (very loose, wet)	
20	-5	S-9A S-9B	b2	52	W = 22 GS		SP-SM	Dark gray, fine to medium SAND with silt (very loose to loose, wet) - blow count likely not representative	
							SM	Gray, silty, fine to medium SAND (dense, wet)	
25	-10	S-10	b2	3	W = 27 GS				
30									
35									

Moisture Content (%) — Plastic Limit — Liquid Limit; 20 40 60 80
▲ SPT N-Value ▲ △ Non-Standard N-Value △; 10 20 30 40
× Fines Content (%) ×; 20 40 60 80

52

Boring Completed 11/07/07. Total Depth of Boring = 26.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

RRI-Blair Hylebos Peninsula Terminal Redevelopment Project Tacoma, Washington

Log of Boring RRI-B-15(X)

Figure A-15

RRI-B-16(X)

LAI Project No: 168005.030

SAMPLE DATA | **SOIL PROFILE**

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): 17 (MLLW)
Drilled By: Cascade Drilling Inc.
Logged By: DMN Date: 12/19/07

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Soil Description	Groundwater
0	15						GP	Gravel access road	
							GP	Brown, fine to medium, sandy GRAVEL (moist to wet, loose)	
							SP-SM	**(FILL)**	
		S-1	b2	7	PID=0 W = 21			Dark gray, fine to medium SAND with silt (loose, wet)	
5	10	S-2	b2	5	PID=0 W = 23		SM	Brown, silty, fine to medium SAND with trace gravel (loose, wet)	▽
		S-3A S-3B	b2	0	PID=0		SM	Dark gray, silty, fine to medium SAND; moderate septic odor (very loose, wet)	
							ML	**(ALLUVIUM)**	
10	5	S-4	b2	0	PID=0			Dark gray, clayey, fine sandy SILT with abundant twigs, bark, and roots (very soft, wet)	
		S-5	c3						
		S-6	b2	0					
15	0								
20	-5	S-7A S-7B	b2	10			SP	Gray, fine to medium SAND with trace silt (medium dense, wet)	
25		S-8A S-8B	b2	13			ML	Gray, sandy SILT (stiff, wet)	
30									
35									

Moisture Content (%) — Plastic Limit — Liquid Limit
20 40 60 80
▲ SPT N-Value ▲
△ Non-Standard N-Value △
10 20 30 40
× Fines Content (%) ×
20 40 60 80

Boring Completed 12/19/07. Total Depth of Boring = 26.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

RRI-Blair Hylebos Peninsula Terminal Redevelopment Project Tacoma, Washington

Log of Boring RRI-B-16(X)

Figure A-16

RRI-B-33(X)

LAI Project No: 168005.030

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Soil Profile	Groundwater
0	15	S-1	h2	30	PID=0 W = 8 GS		SW-SM	Gray, very gravelly, fine to coarse SAND with silt (medium dense, moist) **(FILL)**	▽
		S-2	h2	31	PID=0 W = 35 GS		SM	Gray, silty, fine to medium SAND with abundant shell fragments (medium dense, wet)	
5	10	S-3	h2	3	PID=0 W = 41 GS		ML	Gray, fine sandy SILT (very soft, wet)	
		S-4	h2	8	PID=0 W = 30 GS		SM	Gray, silty, fine to medium SAND with shell fragments (loose, wet) - grades with silt	
10	5	S-5	c3				SP	Gray, fine to medium SAND (very loose, wet)	
		S-6A	h2	0	PID=0				
		S-6B					ML/OL	Dark gray to black, fine sandy SILT with substantial organics and a strong septic odor (very soft, wet) **ALLUVIUM**	
15	0	S-7	c3		GT W = 71 AL				
		S-8	b2	3	W = 38 GS		SM	Dark gray, silty, fine to coarse SAND with trace gravel; moderate septic odor (very loose, wet)	
20	-5	S-9	b2	13	PID=0 W = 28 GS		ML	Gray, fine sandy SILT with a moderate septic odor (stiff, wet)	
25		S-10	b2	17				- grades very stiff	
30									
35									

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): 17 (MLLW)
Drilled By: Cascade Drilling Inc.
Logged By: DMN Date: 11/07/07

Moisture Content (%) — Plastic Limit — Liquid Limit — 20 40 60 80
▲ SPT N-Value ▲ △ Non-Standard N-Value △ — 10 20 30 40
× Fines Content (%) × — 20 40 60 80

Boring Completed 11/07/07. Total Depth of Boring = 26.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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RRI-Blair Hylebos Peninsula Terminal Redevelopment Project Tacoma, Washington

Log of Boring RRI-B-33(X)

Figure A-32

RRI-B-118(B)

LAI Project No: 168005.030

Drilling Method: Mud Rotary
Ground Elevation (ft): 16.29 (MLLW)
Drilled By: Holocene Drilling
Logged By: RRR Date: 10/20/08

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Soil Profile	Groundwater
0	15	S-1	b2	6			GW-GM SM	Gray-brown, sandy GRAVEL with silt (medium dense, moist) **(FILL)** Dark gray, silty, fine to medium SAND (loose to medium dense, moist)	
5	10	S-2	b2	11	-200=28 W = 28 GS			- grades wet	▽
		S-3A S-3B	b2	5	W = 41 W = 104		CH	Gray, silty CLAY with abundant organics (very soft, wet) **(ALLUVIUM)**	
10	5	S-4	b2	0	W = 113 AL				
		S-5	b2	0	W = 74 AL				
15	0	S-6	h2	14			ML	Dark gray SILT with trace sand; non-plastic (stiff, wet)	
		S-7	c3						
20	-5	S-8	b2	11	W = 37 -200 = 96				
		S-9	b2	25	-200=23 W = 27 GS		SM	Dark gray, silty, fine SAND (medium dense, wet)	
25	-10						SM	Dark gray, very silty, fine SAND (loose to medium dense, wet)	
		S-10	c3						
30	-15						CH	Gray, silty CLAY with abundant organics (soft to medium stiff, wet)	
35		S-11	b2	2	W = 84 GT W = 70				

Moisture Content (%) — Plastic Limit — Liquid Limit
20 40 60 80

▲ SPT N-Value ▲
△ Non-Standard N-Value △
10 20 30 40

× Fines Content (%) ×
20 40 60 80

104

113

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

168005.03 2/16/09 \\EDMDATA\GINT\GINT7\PROJECTS\168005 REV 02.16.09.GPJ SOIL BORING LOG WITH GRAPH

LANDAU ASSOCIATES

RRI-Blair Hylebos Peninsula Terminal Redevelopment Project Tacoma, Washington

Log of Boring RRI-B-118(B)

Figure A-37 (1 of 3)

RRI-B-118(B)

LAI Project No: 168005.030

SAMPLE DATA | **SOIL PROFILE**

Drilling Method: Mud Rotary
Ground Elevation (ft): 16.29 (MLLW)
Drilled By: Holocene Drilling
Logged By: RRR Date: 10/20/08

Moisture Content (%) — Plastic Limit — Liquid Limit (20 40 60 80)
▲ SPT N-Value ▲ △ Non-Standard N-Value △ (10 20 30 40)
× Fines Content (%) × (20 40 60 80)

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Soil Description
35		S-12	c3		AL D = 63 W = 62	CH	
	-20	S-12A					
		S-12B	b2	9		SM	Dark gray, very silty, fine SAND (loose, wet)
		S-13	b2	4	W = 37 -200 = 95	ML	Dark gray SILT with trace sand; non-plastic (medium stiff, wet)
40	-25					SM	Dark gray, silty, fine to medium SAND (very loose, wet)
		S-14	b2	4	W = 28 -200 = 24		
45	-30					SP-SM	Dark gray, fine to medium SAND with silt (loose, wet)
		S-15A			W = 29 -200 = 13		
		S-15B	b2	7	W = 30 -200 = 57	ML	Dark gray, very sandy SILT (medium stiff, wet)
50	-35					SM/ML	Dark gray, interbedded very silty, fine to medium SAND/very sandy SILT (dense/hard, wet)
		S-16	b2	33	W = 33 -200 = 52		
55	-40					SP-SM	Dark gray, fine to medium SAND with silt (dense, wet)
		S-17	b2	46			
60	-45					SM	Dark gray, very silty, fine to medium SAND with trace shells (dense, wet)
		S-18	b2	33	W = 28 -200 = 34		
65	-50					SP-SM	Dark gray, fine to medium SAND with silt (medium dense, wet)
		S-19	b2	25	W = 27 -200 = 11		
70							

Groundwater

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

RRI-Blair Hylebos Peninsula Terminal Redevelopment Project Tacoma, Washington

Log of Boring RRI-B-118(B)

Figure A-37 (2 of 3)

RRI-B-118(B)

LAI Project No: 168005.030

SAMPLE DATA | **SOIL PROFILE**

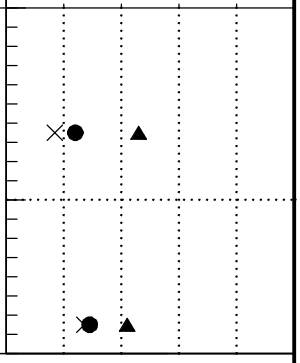
Drilling Method: Mud Rotary
Ground Elevation (ft): 16.29 (MLLW)
Drilled By: Holocene Drilling
Logged By: RRR Date: 10/20/08

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Soil Description	Groundwater
70	-55						SM	Dark gray, silty, fine to medium SAND (medium dense, wet)	
		S-20	b2	23	W = 24 -200 = 17				
75	-60						SM	Dark gray, silty, fine SAND with shells (medium dense, wet)	
		S-21	b2	21	W = 29 -200 = 27				
80									
85									
90									
95									
100									
105									

Moisture Content (%)
Plastic Limit — Liquid Limit
20 40 60 80

▲ SPT N-Value ▲
△ Non-Standard N-Value △
10 20 30 40

× Fines Content (%) ×
20 40 60 80



Boring Completed 10/20/08. Total Depth of Boring = 79.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

RRI-Blair Hylebos Peninsula Terminal Redevelopment Project Tacoma, Washington

Log of Boring RRI-B-118(B)

Figure A-37 (3 of 3)

RRI-B-119(B)

LAI Project No: 168005.030

Drilling Method: Mud Rotary
Ground Elevation (ft): 17.61 (MLLW)
Drilled By: Holocene Drilling Inc.
Logged By: RRR Date: 10/23/08

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Soil Profile
0	15	S-1	b2	10	W = 21		GM	Gray-brown, silty GRAVEL with sand (moist, medium dense)
							SP-SM	**(FILL)** Gray-brown, fine to medium SAND with silt (loose, moist)
5		S-2	b2	7	-200=6 W = 26 GS			
	10	S-3A S-3B	b2	21	W = 32 -200 = 25		SM	Dark gray, silty, fine to medium SAND (medium dense, wet)
10		S-4	b2	14	W = 52 -200 = 78		ML	Dark gray, sandy SILT; non-plastic (stiff, wet) **(ALLUVIUM)**
	5	S-5	b2	0	W = 82 AL		MH	Gray, clayey SILT with abundant organics (very soft, wet)
15		S-6	c3		AL=NP		ML	Dark gray, sandy SILT; non-plastic (very soft to soft, wet)
	0	S-7	b2	11	W = 27 -200 = 7		SP-SM	Dark gray, fine to medium SAND with silt, (medium dense, wet)
20		S-8	b2	25	W = 24 -200 = 7			
	-5	S-9A S-9B	b2	22	W = 35 -200 = 77		ML	Dark gray, SILT with sand; non-plastic (stiff, wet)
25		S-10	b2	12	W = 27 -200 = 35		SM	Dark gray, very silty, fine SAND (medium dense, wet)
	-10	S-11	b2	22	W = 27 -200 = 60		ML	Dark gray, very sandy SILT; non-plastic (very stiff, wet)
30								
	-15	S-12	b2	1	W = 53 AL		CH	Gray, silty CLAY with organics (soft to medium stiff, wet)
35					AL=NP		ML	

Groundwater

Moisture Content (%)
Plastic Limit — Liquid Limit
20 40 60 80

▲ SPT N-Value ▲
△ Non-Standard N-Value △
10 20 30 40

× Fines Content (%) ×
20 40 60 80

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

168005.03 2/16/09 \\EDMDATA\GINT\GINT7\PROJECTS\168005 REV 02.16.09.GPJ SOIL BORING LOG WITH GRAPH

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RRI-Blair Hylebos Peninsula Terminal Redevelopment Project Tacoma, Washington

Log of Boring RRI-B-119(B)

Figure A-38 (1 of 3)

RRI-B-119(B)

LAI Project No: 168005.030

SAMPLE DATA | **SOIL PROFILE** | Groundwater

Drilling Method: Mud Rotary
Ground Elevation (ft): 17.61 (MLLW)
Drilled By: Holocene Drilling Inc.
Logged By: RRR Date: 10/23/08

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Description
35		S-14	c3		GT		ML	Dark gray SILT with sand; non-plastic (stiff, wet)
					W = 32			
					D = 89			
		S-15	b2	10	W = 33			
	-20				-200 = 85			
40							SM	Dark gray, silty, fine to medium SAND (medium dense, wet)
	-25	S-16	b2	12	-200=18			
					W = 25			
45					GS			
							ML	Dark gray, very sandy SILT with shells; non-plastic (medium stiff, wet)
	-30	S-17	b2	1	W = 31			
					-200 = 64			
50		S-18	c3				SP-SM	Dark gray, fine to medium SAND with silt (loose, wet)
		S-19	b2	6	W = 26			
	-35				GS			
55							SM	Dark gray, silty, fine to medium SAND (dense, wet)
	-40	S-20	b2	32	W = 25			
					-200 = 15			
60							SP-SM	Dark gray, fine to medium SAND with silt (dense to very dense, wet)
	-45	S-21	b2	50				
65								
	-50	S-22	b2	49	W = 23			
					-200 = 10			
70								

Moisture Content (%)
Plastic Limit — Liquid Limit
20 40 60 80

▲ SPT N-Value ▲
△ Non-Standard N-Value △
10 20 30 40

× Fines Content (%) ×
20 40 60 80

50

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

168005.03 2/16/09 \\EDMDATA\GINT\GINT7\PROJECTS\168005 REV 02.16.09.GPJ SOIL BORING LOG WITH GRAPH

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RRI-Blair Hylebos Peninsula Terminal Redevelopment Project Tacoma, Washington

Log of Boring RRI-B-119(B)

Figure A-38 (2 of 3)

RRI-B-119(B)

LAI Project No: 168005.030

SAMPLE DATA | **SOIL PROFILE**

Drilling Method: Mud Rotary
Ground Elevation (ft): 17.61 (MLLW)
Drilled By: Holocene Drilling Inc.
Logged By: RRR Date: 10/23/08

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Soil Description	Groundwater
70							SP-SM	Dark gray, fine to medium SAND with silt (dense to very dense, wet)	
	-55	S-23	b2	51					
75							SM	Dark gray, silty, fine to medium SAND with trace seashell fragments (dense, wet)	
	-60	S-24	b2	36	W = 28 -200 = 19				
80								Boring Completed 10/23/08. Total Depth of Boring = 79.0 ft.	
85									
90									
95									
100									
105									

Moisture Content (%)
Plastic Limit — Liquid Limit
20 40 60 80

▲ SPT N-Value ▲
△ Non-Standard N-Value △
10 20 30 40

× Fines Content (%) ×
20 40 60 80

51

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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RRI-Blair Hylebos Peninsula Terminal Redevelopment Project Tacoma, Washington

Log of Boring RRI-B-119(B)

Figure A-38 (3 of 3)

RRI-B-120(B)

LAI Project No: 168005.030

Drilling Method: Mud Rotary
Ground Elevation (ft): 20.13 (MLLW)
Drilled By: Holocene Drilling
Logged By: RRR Date: 10/22/08

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Soil Profile	Groundwater
0	20	S-1	b2	10	W = 16		GM	Gray, silty GRAVEL with sand (loose, moist to wet) **(FILL)**	Groundwater Not Encountered
5	15	S-2	b2	2	W = 29 -200 = 24		SM	Gray, silty, gravelly, fine to coarse SAND (very loose, wet)	
		S-3	b2	3	W = 31 -200 = 26				
10	10	S-4	b2	17	W = 30 -200 = 13		SP-SM	Dark gray, fine to medium SAND with silt (medium dense, wet)	
		S-5	b2	6	W = 70 AL		MH	Gray, clayey SILT with abundant organics (soft to medium stiff, wet) **(ALLUVIUM)**	
15	5	S-6	b2	0	W = 104				
		S-7	c3		GT W = 58 AL D = 66		SP	Dark gray, fine to medium SAND (loose to medium dense, wet)	
20	0	S-8	b2	1	W = 43 AL		CL	Dark gray CLAY with silt (soft, wet)	
		S-9	b2	4	W = 32 -200 = 82		ML	Dark gray, sandy SILT; non-plastic (soft, wet)	
25	-5	S-10	b2	2	W = 35 -200 = 89		ML	Dark gray SILT with sand; non-plastic (soft, wet)	
		S-11	b2	8				- grades medium stiff	
30	-10						CL	Gray CLAY with silt (medium stiff, wet)	
		S-12	b2	5	W = 47			- abundant organics at 34'	
35									

Moisture Content (%) — Plastic Limit — Liquid Limit — 20 40 60 80
▲ SPT N-Value ▲ △ Non-Standard N-Value △ — 10 20 30 40
× Fines Content (%) × — 20 40 60 80

104

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

168005.03 2/16/09 \\EDMDATA\GINT\GINT7\PROJECTS\168005 REV 02.16.09.GPJ SOIL BORING LOG WITH GRAPH

LANDAU ASSOCIATES

RRI-Blair Hylebos Peninsula Terminal Redevelopment Project Tacoma, Washington

Log of Boring RRI-B-120(B)

Figure A-39 (1 of 3)

RRI-B-120(B)

LAI Project No: 168005.030

SAMPLE DATA | **SOIL PROFILE**

Drilling Method: Mud Rotary
Ground Elevation (ft): 20.13 (MLLW)
Drilled By: Holocene Drilling
Logged By: RRR Date: 10/22/08

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Description
35	-15	S-13	c2		GT W = 77 AL		CL	Gray CLAY with silt (medium stiff, wet)
		S-14	b2	4	W = 66 AL			
40	-20						SM	Dark gray, silty, fine to medium SAND (medium dense, wet)
		S-15	b2	10	W = 23 -200 = 27			
45	-25						SP-SM	Dark gray, fine to medium SAND with silt (medium dense, wet)
		S-16	b2	17	W = 30 -200 = 14			
50	-30						ML	Dark gray SILT with interbeds of fine sand; non-plastic (stiff, wet)
		S-17	b2	9	W = 36 -200 = 67			
55	-35						SP-SM	Dark gray, fine to medium SAND with silt (dense, wet)
		S-18	b2	35	W = 24 -200 = 11			
60	-40						SM	Dark gray, very silty, fine SAND (very loose, wet)
		S-19	b2	3				
65	-45	S-20	c3				SP-SM	Dark gray, fine to medium SAND with silt (dense to very dense, wet)
		S-21	b2	45	W = 21 -200 = 11			
70								

Groundwater: Groundwater Not Encountered

Moisture Content (%)
Plastic Limit — Liquid Limit
20 40 60 80

▲ SPT N-Value ▲
△ Non-Standard N-Value △
10 20 30 40

× Fines Content (%) ×
20 40 60 80

LL = 100

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

168005.03 2/16/09 \\EDMDATA\GINT\GINT7\PROJECTS\168005 REV 02.16.09.GPJ SOIL BORING LOG WITH GRAPH

LANDAU ASSOCIATES

RRI-Blair Hylebos Peninsula Terminal Redevelopment Project Tacoma, Washington

Log of Boring RRI-B-120(B)

Figure A-39 (2 of 3)

RRI-B-120(B)

LAI Project No: 168005.030

SAMPLE DATA | **SOIL PROFILE**

Drilling Method: Mud Rotary
Ground Elevation (ft): 20.13 (MLLW)
Drilled By: Holocene Drilling
Logged By: RRR Date: 10/22/08

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Soil Description	Groundwater
70	-50						SP-SM	Dark gray, fine to medium SAND with silt (dense to very dense, wet)	Groundwater Not Encountered
		S-22	b2	53					
75	-55						SM	Dark gray, very silty, fine to medium SAND (dense, wet)	
		S-23	b2	32	W = 27 -200 = 36				
80								Boring Completed 10/22/08. Total Depth of Boring = 79.0 ft.	
85									
90									
95									
100									
105									

Moisture Content (%)
Plastic Limit — Liquid Limit
20 40 60 80

▲ SPT N-Value ▲
△ Non-Standard N-Value △
10 20 30 40

× Fines Content (%) ×
20 40 60 80

53

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Log of Boring RRI-B-120(B)

Figure A-39 (3 of 3)

RRI-B-175(S)

LAI Project No: 168005.030

Drilling Method: Hollow-stem Auger
Ground Elevation (ft): 15.44 (MLLW)
Drilled By: Holocene Drilling
Logged By: RRR Date: 10/20/08

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Soil Profile
0	15						GW/ GM	Brown, silty GRAVEL with sand (medium dense, moist)
								(FILL)
							SP-SM	Dark gray, fine to medium SAND with silt (loose to medium dense, moist)
		S-1	b2	9				
5	10	S-2	b2	10				
		S-3A S-3B	b2	11				
10	5	S-4	b2	1	W = 90		PT	PEAT interbedded with clayey silt (very soft, moist)
								(ALLUVIUM)
		S-5	b2	2	W = 71 AL		CH	Brown, silty CLAY with abundant organics (very soft, wet)
15	0	S-6	h2	2			ML	Gray SILT with sand and organics; non-plastic (very soft, wet)
		S-7	b2	2				
20	-5	S-8	b2	20			SW-SM	Dark gray, fine to medium SAND with silt (medium dense to dense, wet)
		S-9	b2	48	W = 22 GS			
25								
30								
35								

Groundwater

Moisture Content (%) — Plastic Limit — Liquid Limit — 20 40 60 80
▲ SPT N-Value ▲ △ Non-Standard N-Value △ — 10 20 30 40
× Fines Content (%) × — 20 40 60 80

Boring Completed 10/20/08. Total Depth of Boring = 24.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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RRI-Blair Hylebos Peninsula Terminal Redevelopment Project Tacoma, Washington

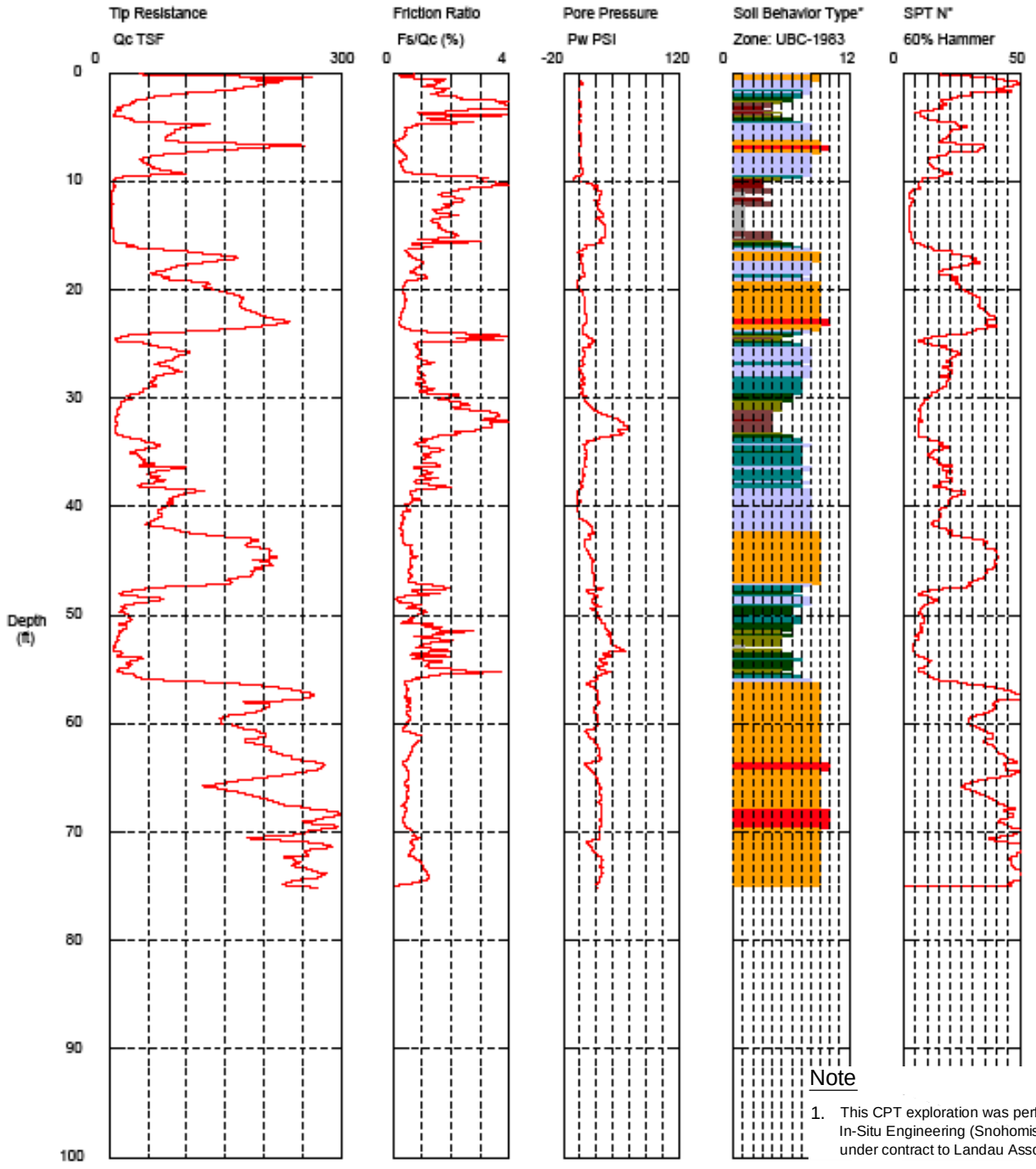
Log of Boring RRI-B-175(S)

Figure A-66

Landau Associates

Operator: Nowak
Sounding: CPT-4(S)
Cone Used: DSG1029

CPT Date/Time: 11/7/2007 12:27:10 PM
Location: Port of Tacoma Road Rail Infrastructure
Job Number: 0168002



Note

1. This CPT exploration was performed by In-Situ Engineering (Snohomish, WA) under contract to Landau Associates, Inc.

*Soil behavior type and SPT based on data from UBC-1983

Jacobs Civil, Inc. | \\Edmdata\projects\168\005\WIP\TPOT RRI 30% Data for GDR\CPT Logs\Figure C-3.dwg (A) "Figure C-3" 1/16/2009

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RRI-Blair Hylebos
Peninsula Terminal
Redevelopment Project
Tacoma, Washington

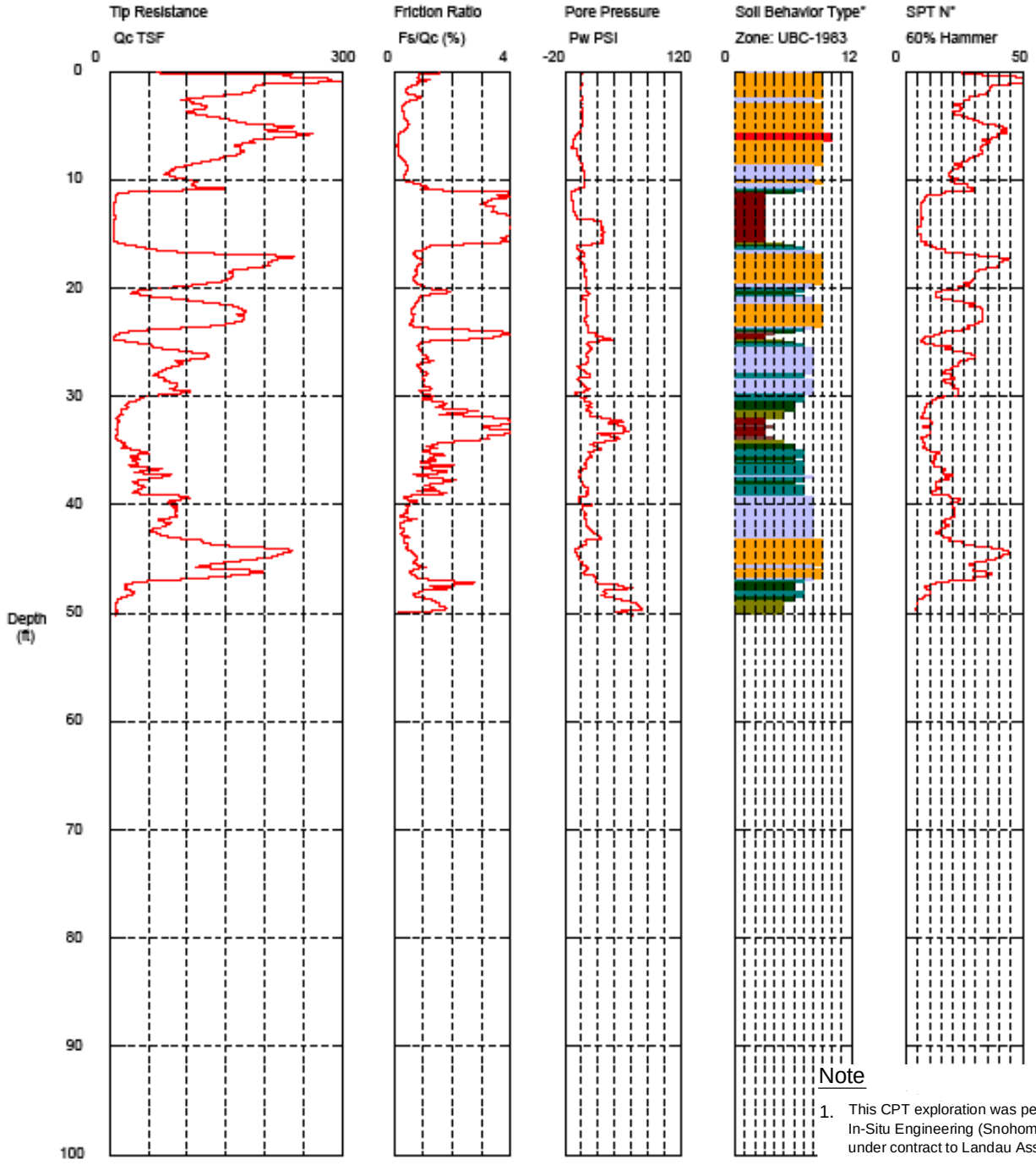
Log of CPT Sounding RRI-CPT-4(S)

Figure
C-3

Landau Associates

Operator: Dafni
Sounding: CPT-4(S)a
Cone Used: DSG1015

CPT Date/Time: 11/12/2007 11:12:54 AM
Location: Port of Tacoma Road Rail Infrastructure
Job Number: 0168002



Maximum Depth = 50.20 feet

Depth Increment = 0.164 feet

1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

End Area Ratio 'a' = 0.8

In Situ Engineering

*Soil behavior type and SPT based on data from UBC-1983

Note

1. This CPT exploration was performed by In-Situ Engineering (Snohomish, WA) under contract to Landau Associates, Inc.

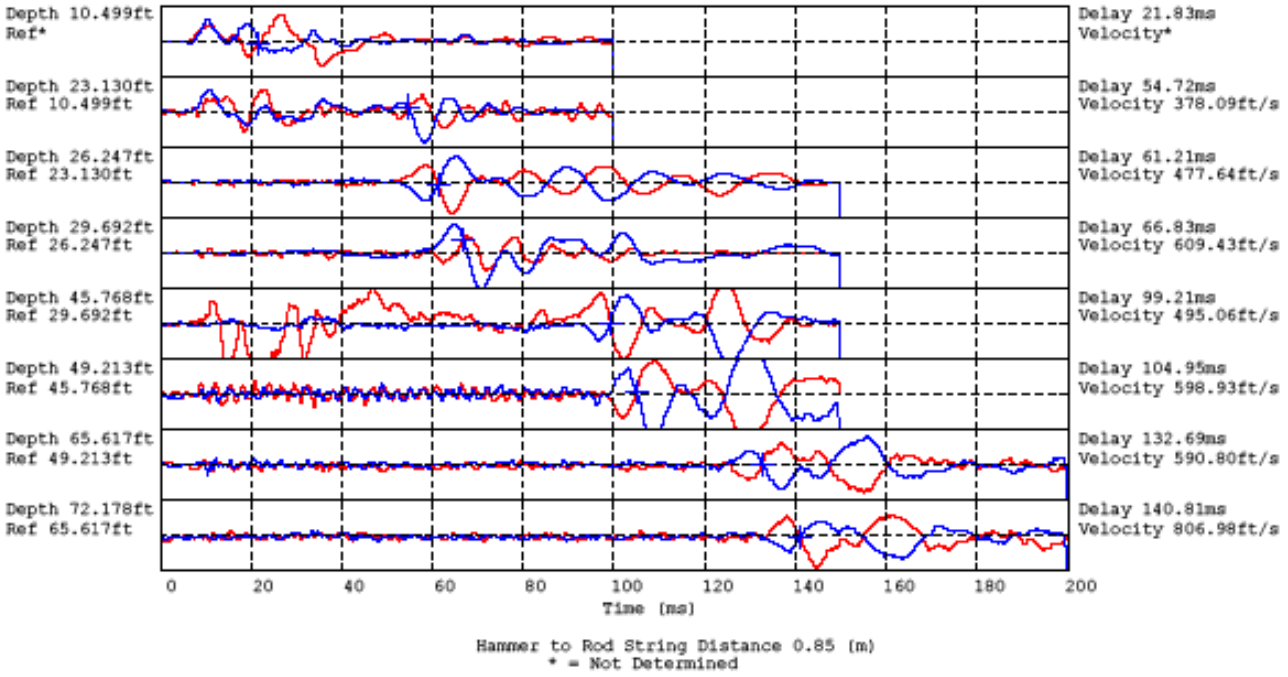
LANDAU ASSOCIATES

RRI-Blair Hylebos
Peninsula Terminal
Redevelopment Project
Tacoma, Washington

Log of CPT Sounding RRI-CPT-4A(S)

Figure
C-4

Landau Associates
Shear Wave Velocity Test - CPT-04(S)



Hammer to Rod String Distance 0.85 (m)
* = Not Determined

Note

1. This CPT exploration was performed by In-Situ Engineering (Snohomish, WA) under contract to Landau Associates, Inc.

Port of Tacoma - Job # 0168002

In Situ Engineering

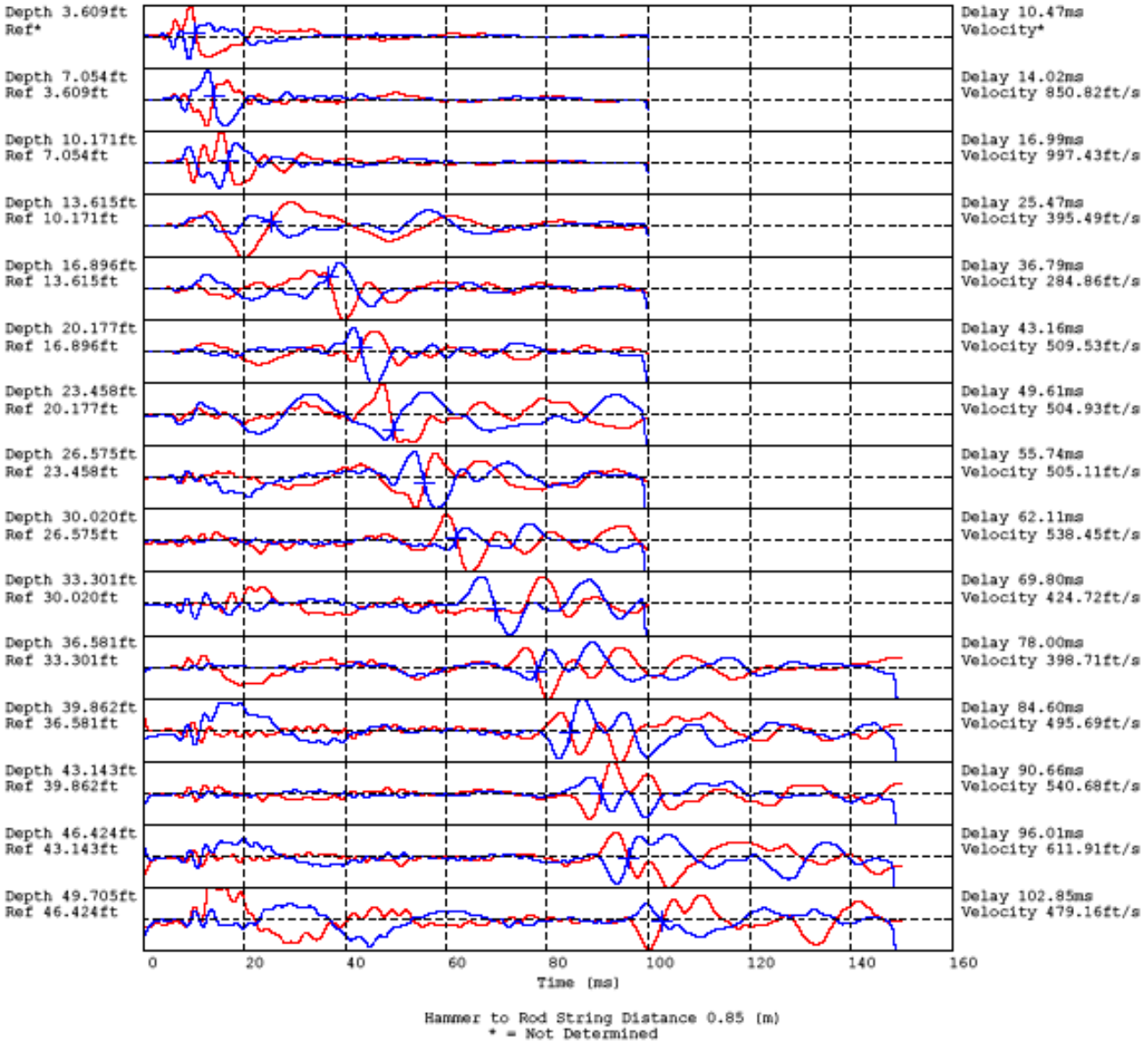
LANDAU ASSOCIATES

RRI-Blair Hylebos
Peninsula Terminal
Redevelopment Project
Tacoma, Washington

Shear Wave Velocity Measurements
RRI-CPT-4(S)

Figure
F-3

Landau Associates
Shear Wave Velocity Test - CPT-04(S)a



Hammer to Rod String Distance 0.85 (m)
* = Not Determined

Note

1. This CPT exploration was performed by In-Situ Engineering (Snohomish, WA) under contract to Landau Associates, Inc.

Port of Tacoma - Job # 0168002

In Situ Engineering

LANDAU ASSOCIATES

RRI-Blair Hylebos
Peninsula Terminal
Redevelopment Project
Tacoma, Washington

Shear Wave Velocity Measurements
RRI-CPT-4A(S)

Figure
F-4

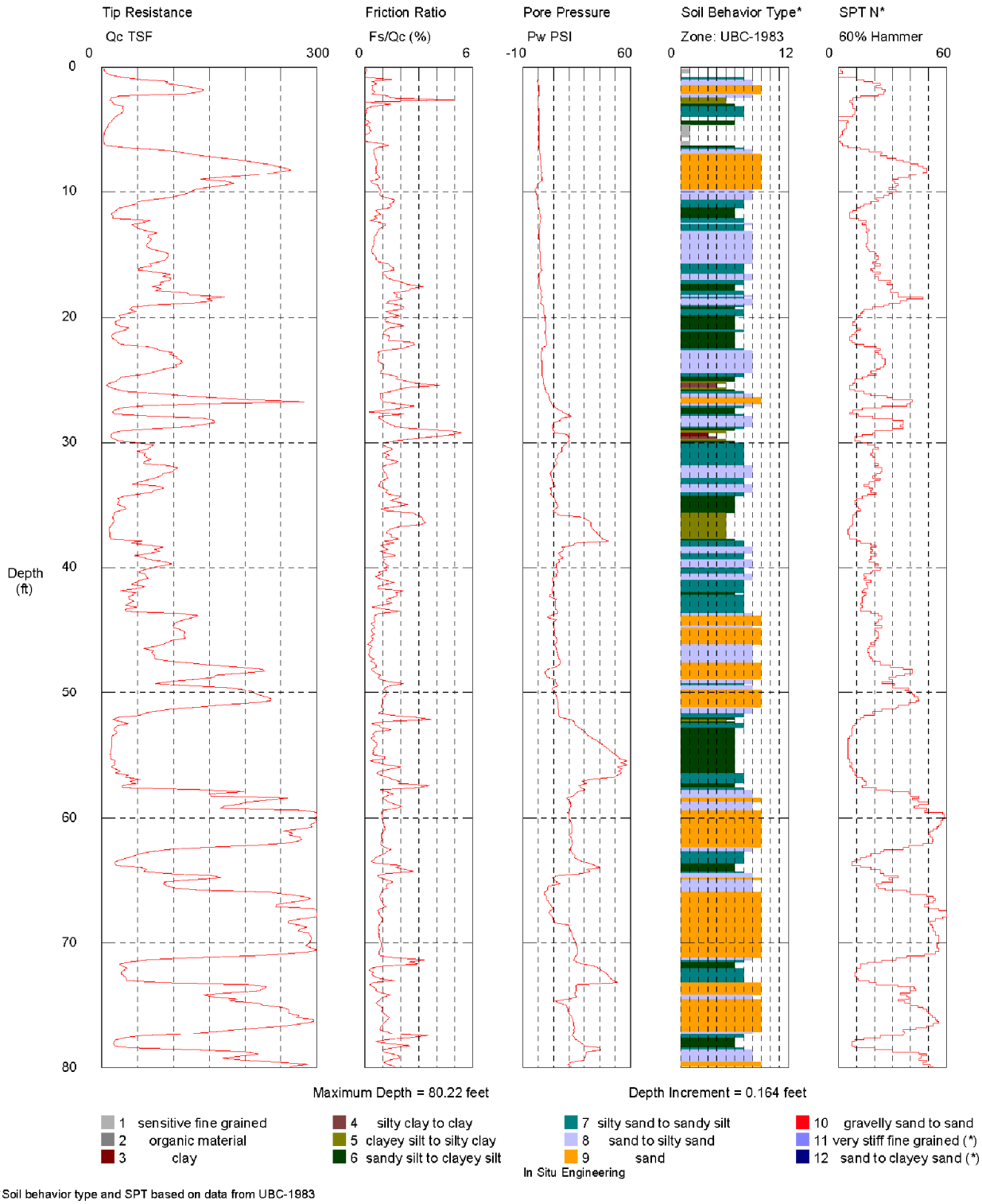
Note

1. This CPT exploration was performed by In-Situ Engineering (Snohomish, WA) under contract to Landau Associates, Inc.

Landau Associates

Operator: Nowak
Sounding: RRI-CPT-121(B)
Cone Used: DSG1029

CPT Date/Time: 11/3/2008 3:46:57 PM
Location: Port of Tacoma - Railroad Infrastructure
Job Number: 168005.150.153



*Soil behavior type and SPT based on data from UBC-1983

Jacobs Civil, Inc. | \\Edmdata\projects\168\005\WIP\TBoring Logs\CPT\CPT logs\Figure C-23.dwg (A) "Figure C-23" 1/27/2009

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RRI-Blair Hylebos
Peninsula Terminal
Redevelopment Project
Tacoma, Washington

Log of CPT Sounding
RRI-CPT-121(B)

Figure
C-23

RRI-P-107

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	
						Excavation Method: Geoprobe™	
						Ground Elevation (ft): 20.5 (MLLW)	
						Excavated By: Cascade Drilling Inc.	
						Logged By: DMN	
0	20					SP	Brown to light gray, fine to medium SAND with gravel (medium dense, damp)
			e3	PID=0 CA CA			**Collected composite soil sample RRI-P-107(0-4)C from 0 to 4 ft bgs.**
						SP/ SM	Mottled light gray, very silty, fine SAND; and Brown, fine to medium SAND with gravel (medium dense, moist)
5	15					SM	**Collected discrete soil sample RRI-P-107(2.5)D at 2.5 ft bgs.**
			e3	CA PID=0			- very loose from 3 to 4 ft bgs
							Brown to dark gray, silty, fine to medium SAND, trace gravel and silt inclusions (loose to medium dense, damp to moist)
							- loose from 5 to 6 ft bgs
						SP	**Collected composite soil sample RRI-P-107(4-7)C from 4 to 7 ft bgs.**
10	10		e3	PID=0 CA			**Collected groundwater sample RRI-P-107 from temporary well screened from 8-12 ft bgs.**
							Dark gray, fine to medium SAND, trace silt (very loose to medium dense, wet)
							- very loose from 8.5 to 11 ft bgs
			e3	PID=0			- encountered refusal at 12 ft bgs. Moved boring 1.5 ft west, drilled down to 12 ft bgs, and sampled from 12 to 16 ft bgs.
15	5						- loose from 11 to 16 ft bgs

▽ ATD groundwater seepage encountered at 8.5 ft.

Geoprobe Completed 12/18/07
Total Depth of Geoprobe = 16.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

RRI-Blair Hylebos Peninsula Terminal Redevelopment Project Tacoma, Washington

Log of Geoprobe RRI-P-107

Figure D-9

Appendix B

DOF STANDARD OPERATING PROCEDURE – 100

(DOF SOP-100)

Monitoring Well Installation Procedures

Revision Date: 12-13-2022

This SOP contains seven sections:

1.0 PURPOSE

The purpose of this SOP is to provide field personnel with an outline of the specific information needed to install and construct monitoring wells (also known as "*Resource Protection Wells*" by Ecology. The required equipment and documentation are also outlined for each of these procedures. The recommended monitoring well design, as presented in this SOP, assumes that the objective of the program is to obtain representative groundwater information and water quality samples from target groundwater zones.

2.0 REFERENCES

Chapter 173-160 WAC. Minimum Standards for Construction and Maintenance of Wells.

Chapter 173-160-400 WAC. Part Two - General Requirements for Resource Protection Well Construction and Geotechnical Borings

DOF. October 2022. Site Health and Safety Plan.

3.0 ASSOCIATED SOPS

SOP-105 – Monitoring Well Development
SOP-110 – Measuring Water and NAPL Levels and Total Depths
SOP-115 – Low-Flow Groundwater Sampling Procedure
SOP-120 – Equipment Decontamination Procedure
SOP-125 – Soil Sampling

4.0 EQUIPMENT AND MATERIALS

The following equipment/materials should be provided and maintained by DOF field staff :

- Copy of the relevant Work Plan including, at a minimum, the Field Sampling Plan, the Health and Safety Plan and the Quality Assurance Project Plan.
- Traffic control plan (as appropriate depending on well location).
- Personnel protective equipment as defined in the Health and Safety Plan.
- Calibrated photoionization detector (PID).
- Tape measure to locate the well to prominent site features and DGPS to determine horizontal coordinates.
- Weighted tape calibrated to 0.01 foot and of sufficient length to reach the bottom of the deepest bore hole.
- Electric water level indicator or immiscible phase probe for obtaining water level measurements to an accuracy of 0.01 foot.
- Field forms to document the as-built monitoring well construction.
- Stamp kit, permanent marker, or paint pen to mark the identification of the well on the monument (Note: the drilling contractor is responsible for providing an Ecology provided well tag to attach to the well monument).
- Well security locks.
- Sample containers and forms if soil samples are to be obtained during drilling (see DOF SOP-125)

The drilling contractor is responsible for providing the following, as necessary based on the work plan:

- Drilling and sampling equipment, cleaned prior to arriving at the project site (and after well construction).
- Decontamination equipment and fluids (e.g. steam cleaner, brushes, tap water).
- Materials to install the well per the work plan (e.g. pre-packaged well screens, riser pipe, monument, and sealing materials).
- Investigation derived waste containers such as DOT open-top drums.
- Department of Ecology provided well tags with unique identification numbers.

5.0 MONITORING WELL INSTALLATION PROCEDURE

Subsurface utilities will be identified prior to the start of any subsurface drilling. Field personnel will mark the proposed drilling locations on the ground. The utilities' underground location center (One Call) will be contacted, and a private utility locate will be conducted within the work areas to at least 20 feet beyond the limits of subsurface work, where possible. The intended drilling locations might be modified in the field if they interfere or appear to interfere with subsurface utilities.

Once mobilized to the site a tailgate health and safety meeting will be conducted, outlining the anticipated hazards and hazard mitigation with all workers. Work zone, traffic control components, and spill prevention measures will be set up.

5.1 Drilling Methodology

5.1.1 General Requirements

- No monitoring well or soil boring excavation may be used to withdraw or inject water for domestic, industrial, municipal, commercial, or agricultural purposes.
- No monitoring well or soil boring excavation may interconnect aquifers.
- Nested monitoring wells are prohibited.
- Cuttings, development water, and other investigation derived waste from well construction or geotechnical soil borings will be managed in a manner consistent with implementing regulations.
- Monitoring wells will be sealed in accordance with WAC 173-160-450 regardless of the method of installation.
- Completed wells will be tagged by the drilling contractor using Ecology provided well tags with unique identification numbers.
- Construction, alteration, reconstruction, and decommissioning of resource protection wells and geotechnical soil borings shall be done by an individual licensed (drilling contractor) under the provisions of chapter 173-162 WAC.
- The drilling contractor is required to file Resource Protection well reports with the Ecology water resources program upon completion.
- All drilling and sampling equipment will be decontaminated between boring locations.

5.1.2 Hollow-Stem Auger Drilling

Boreholes advanced by hollow-stem auger for monitoring well installation will typically be drilled using nominal 4¼ -inch inside diameter (ID), continuous flight hollow-stem augers, with an outside diameter (hole diameter) of 10-inches, operated from a truck or track-mounted drilling rig. Disturbed samples are obtained by using the Standard Penetration Test Procedure as described in ASTM:D 1586. Each drilling rig will be equipped with enough 3-inch OD split-spoons to collect samples for lithologic, chemical, or geotechnical analysis. The drilling equipment will be capable of driving a 3-inch OD split spoon sampler, circulating borehole fluids, and mixing grout.

5.1.3 Direct-Push Drilling

Boreholes advanced by Direct-push will typically be drilled using 2.25-inch diameter rods with core sample systems capable of retrieving 5-foot long, 1.5" diameter soil samples contained in disposable acrylic liners, continuously to depth.

In addition to the general requirements for Resource protection wells, monitoring wells that are installed using direct push technology will also comply with the following standards:

- Direct push wells shall not be constructed through more than one water bearing formation and the seal shall be from the top of the sand pack to land surface. Direct push wells shall not be greater than thirty feet in depth unless a variance is obtained.
- Prepacked screens or sand packed screens are used for all monitoring well installations. The sand pack or filter pack shall not extend more than three feet above the top or one foot below the bottom of the well screen. Pre-Pac screens for a standard 2-inch well are typically 3.4-inches in outside diameter consisting of 0.010" slotted SCH 40 PVC, surrounded by 20/40 grade sand, wrapped with #64 stainless steel wire mesh, and come in 5-foot lengths.
- The outside diameter of the bore hole shall be a minimum of one inch greater than the outside diameter of the well casing, typically 4.25" OD casing is used to install a standard 2-inch PVC Pre-Pac well.
- Slurry, or bentonite chip is added as the outer rods are pulled, maintaining a constant head within the annulus. Granular bentonite shall not be used in the sealed interval below the static water level due to the limited annulus diameter and potential for voids or bridging. Prepacked or slurry sealant is required below the water level. Any sealing method used must result in a continuous and effective seal meeting the minimum sealing standards per the WAC standards.

5.1.4 Sonic Drilling

Sonic Drilling advances tooling and continuous casing during drilling by high frequency resonant direct-drive, with very low risk of carrying-down contamination when compared to other methods, such as hollow-stem auger. Combinations of 4-inch diameter core barrel with 6-inch casing, or 6-inch core barrel with 8-inch casing are typically used. Continuous cores can be advanced from 5 to 10-foot intervals at a time. Other advantages include:

- Provides continuous core samples for observation/logging
- Reduces the possibility of cross contamination.
- Provides clean and effective wells by constructing wells inside the casing and the reduction/elimination of heaving sands/collapse of borehole.
- The ability of using larger diameter/telescoping or conductor casing to isolate problematic zones.
- Reduces the generation of drill cuttings (IDW) compared to hollow-stem auger.
- Capable of drilling to greater depths and through consolidated formations.

5.2 Monitoring Well Installation

Once a stable bore hole has been advanced to the desired depth in accordance with project-specific methods identified in the work plan, the installation of a well screen and riser will proceed as follows:

5.2.1 Materials Inspection and Cleaning

- Confirm sizing and specifications match project-specific work plan.
- Confirm materials are new and have been stored in clean packaging.
- Inspect all materials prior to assembly to ensure material integrity.

5.2.2 Bore Hole Preparation

- If viscous drilling fluids were introduced to the borehole, then the borehole should be flushed with clean tap water. This is done to remove viscous drill fluids from the bore hole which could prevent proper setting of well construction materials.
- Record the volume of water introduced into the bore hole and recovered from the bore hole during flushing.
- Confirm the total depth of the bore hole using a weighted tape and a constant datum such as the ground surface.
- Place a 6-inch to 1.0-foot-thick base layer of filter sand (or amount specified in project-specific work plan) at the base of the bore hole. Alternatively, the filter sand may be added directly between the rise pipe and the auger or casing. Verify the depth of the top of the sand base.

5.3.3 Monitoring Well Construction

- Quickly assemble the well within the bore hole by adding sections to the top of the column until the screened section is set at the desired depth. Care should be taken to prevent any materials from entering the well during down hole assembly.
- If well installation is being conducted using a push-probe, install a pre-packed screen assembly and riser pipe as required/described in Section 5.1.3. Special limitations on the surface seal are also required as described in Section 5.1.3. Any sealing method used must result in a continuous and effective seal meeting the minimum sealing standards per the WAC 173-160-451 standards.
- If well installation is being conducted using a hollow-stem auger or Sonic drilling rig, install a slotted screen assembly (typically 2-inch diameter SCH 40 PVC with machined slots ranging from 0.010 to 0.020 inch), riser pipe and filter pack (to surround the screen). Alternatively, the well may be constructed using a pre-packed screen assembly and riser pipe. The work plan should describe which screen installation method is being used
- Cap the well riser to prevent materials from entering the well during construction.

- Begin placing the chemically inert filter pack within the annular space between casing and screen riser pipe) surrounding the well screen and lower portion of the riser pipe while simultaneously removing the augers or casing.
- The filter pack should be added slowly to prevent bridging of the sand between the riser and the borehole or auger; when adding filter pack below the water table or to a deep well, a tremie pipe should be used.
- Add the filter sand until it extends no more than 2.0 feet inside the auger or casing, then pull the casing upward allowing the filter sand to flow from the bottom, filling the resultant annular space, maintaining a constant "head" of sand. Frequent depth measurements should be taken using a weighted tape to verify the effectiveness of this procedure. The augers or casings should not be extracted in greater than 2.0-foot increments to minimize the potential for native sediments to cave or slump into the annular space.
- Continue placing the filter pack until it extends above the screen for a distance equal to approximately 20% of the total screened interval, but not less than 2.0 feet above the top of the screen (or project-specific depth in work plan). Where there is a hydraulic connection between the zone to be monitored and the overlying strata, this upward extension of the filter pack should be minimized, subject to the construction described above, to prevent seepage from upper zones which may result in less than representative sampling.
- Place an annular sealant seal directly above the filter pack while continuing to remove the augers or casing. This seal, normally consisting of bentonite pellets or chips, should extend a minimum of 2.0 feet above the top of the filter pack or project-specific depth in work plan. This should prevent any (subsequent) migration of grout into the sand-pack, if used. Frequent depth measurements should be taken using a weighted tape to verify the efficiency of this procedure. It is generally a better idea to use bentonite in pellet form when placing this seal below the water table to avoid bridging.
- Pour water of a known chemistry over the bentonite pellets or chips if the seal is in the vadose (unsaturated) zone (i.e., above the water table) to hydrate the bentonite. Record the amount of water added during this procedure for corrected well water removal during well development.
- Fill the remaining annular space to land surface in a continuous operation with bentonite pellets or chip, neat cement, or neat cement grout, maintaining a constant head within the casing or auger to prevent the creation of voids. If neat cement, neat cement grout or bentonite slurry is used as the sealant, it shall be installed with a tremie tube and pumped from the top of the bentonite plug (above the filter pack) to land surface. Use only potable water to hydrate the mixture. The slurry should extend to approximately 3.0 to 5.0 feet below ground surface and all augers or casing should be withdrawn.
- Add concrete to surface and to secure monument. Maintain a sufficient thickness of concrete atop the bentonite seal to prevent future heaving or displacement of the well monument.

6.0 STANDARD SURFACE PROTECTION/FINISHING DESIGNS

Monitoring wells will be capped and protected by using either standard "flush mount" or "standpipe" monitoring well finishing procedures:

6.1 Standard Flush Mount Finish

This finishing design is used when monitoring wells are installed in high traffic areas or other areas where a low-profile design is needed. The standard flush mount finish is constructed as follows:

- In general, the protective casing shall extend at least six inches above the top of the well casing and be cemented at least two feet into the ground.
- The cover must be designed to withstand the maximum expected loading. Morris Industries three-bolt watertight manholes with either galvanized or steel skirts (or equivalent) are typically used.
- Secure the well casing with a watertight J-Plug.
- Fill the excavation evenly to a depth of approximately 8 inches below the ground surface and allow to settle and set (to shorten the setting time, the use of adding “quick-set” to the grout is acceptable).
- Center the approved, manhole-type cover equipped with a watertight gasket and skirt over the well casing. The top of the cover should be approximately a ¼ inch above the ground surface. The bottom few inches of the skirt should be seated in the cement.
- Add cement to the excavated area surrounding the cover until the cement is flush with the ground surface. Gently grade and smooth the cement from the edge to the cover, so that runoff is away from the well. **Trowel Finish** the cement to provide a durable and professional finish. Cone-off and allow to set.
- Permanently identify the well by labeling the cement pad, cover or lid.
- Secure well with an approved lock.

6.2 Standard Standpipe Finish

This finishing design is used when the flush finish design is not needed. The standard standpipe finish is constructed as follows:

- Center a 5.0-foot length of 4 or 5 inch inside diameter steel casing, with locking steel cap into the bore hole. This casing should be placed so that the locking lid rests approximately 2 inches above the top of the capped well riser and is seated within the concrete surface seal. Make sure there is ample space for the well casing cap or J-plug.
- Place filter sand in the annular space between the well riser and the steel casing to ground surface.
- Excavate a 2.5-foot square which measures approximately 4 inches deep around the edges and grades deeper toward the bore hole. Take care to minimize the deposition of soil into the annular space outside the steel casing.
- Using 1”x4” lumber, construct a 2.0-foot square wooden frame and insert the frame into the excavation. Situate the frame so that all edges are flush with the ground surface.

- Add cement to the excavated area, allowing the cement to flow into the annular spacing surrounding the steel casing, until the cement is flush with the ground surface. Gently grade and smooth the cement from the edge to the casing, so the runoff is away from the well. Trowel-finish the concrete for a more durable and professional finish.
- Cement three metal posts, at least three inches in diameter, in a triangular array around the casing and at least two feet from it. Each post shall extend at least three feet above and below the land surface.
- Permanently identify the well by labeling the cement pad, standpipe, and lid to the locking steel casing; and,
- Secure well with an approved lock.

7.0 DOCUMENTATION

Documentation of the monitoring well installation activities and well construction features should be documented on the soil sampling/well field log. The field log should be maintained in the project file.

Attachment – Soil Sample/Well Field Log

DALTON OLMSTED FUGLEVAND

Soil Sampling/Well Field Log

LOG OF

Sheet __ of __

PROJECT:	COORDINATES:	
LOCATION:	SURFACE ELEVATION:	
DRILLING CONTRACTOR:	DATE:	
DRILLING EQUIPMENT:	TOTAL DEPTH OF BORING:	
DRILLING METHOD:	LOGGED BY:	
SAMPLING METHOD:	RESPONSIBLE PROF.:	REG. NO.:
NOTES:		

DEPTH (feet)	SAMPLES				VISUAL SOIL DESCRIPTION	WELL CONSTRUCTION DETAILS, BORING SEALING AND/OR DRILLING REMARKS (Sketch Well Constuction Features)	
	Lab Sample	Sample Recovery	PID (ppm)	Sheen Test Result	Soil Group Name (USCS): color, moisture, density/consistency, grain size, other discriptors		
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

DEPTH (feet)	SAMPLES				VISUAL SOIL DESCRIPTION	WELL CONSTRUCTION DETAILS, BORING SEALING AND/OR DRILLING REMARKS
	Lab Sample	Sample Recovery	PID (ppm)	Sheen Test Result	Soil Group Name (USCS): color, moisture, density/consistency, grain size, other discriptors	
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						
40						
41						
42						
43						
44						
45						
46						
47						
48						
49						
50						

DEPTH (feet)	SAMPLES				VISUAL SOIL DESCRIPTION	WELL CONSTRUCTION DETAILS, BORING SEALING AND/OR DRILLING REMARKS
	Lab Sample	Sample Recovery	PID (ppm)	Sheen Test Result	Soil Group Name (USCS): color, moisture, density/consistency, grain size, other discriptors	
51						
52						
53						
54						
55						
56						
57						
58						
59						
60						
61						
62						
63						
64						
65						
66						
67						
68						
69						
70						

NOTES:

Equipment decon prior to install: _____

Drilling details: _____

_____

Screen details: _____

_____

Well details: _____

_____

Sand: Type: _____

Quantity: _____

Seal: Type: _____

Quantity: _____

Surface seal: _____

Monument: _____

DOF STANDARD OPERATING PROCEDURE – 105

(DOF SOP-105)

Monitoring Well Development

Revision Date: 12-13-22

This SOP contains seven sections:

1. PURPOSE

The purpose of this SOP is to provide field personnel with a set of guidelines to assure proper monitoring well development. According to EPA all monitoring wells should be developed to create an effective filter pack around the well screen, to rectify damage to the formation caused by drilling, to remove fine particulates from the formation near the borehole, and to assist in restoring the natural water quality of the aquifer in the vicinity of the well.

2. REFERENCES

U.S EPA. April 1992. Ground Water Forum, Monitoring Well Development Guidelines for Superfund Project Managers.

https://www.epa.gov/sites/production/files/2015-06/documents/welldevelp_0.pdf

DOF. October 2022. Site Health and Safety Plan.

3. ASSOCIATED SOPS

SOP-100 – Well Installation Procedure

SOP-120 – Equipment Decontamination Procedure

4. EQUIPMENT

The following equipment is necessary to properly develop a ground water monitoring well:

- A well key, hand drill, socket set, pad lock key, or other well access equipment.
- An electric water meter and oil/water interface probe or weighted tape calibrated to a hundredth of a foot, and sufficiently long to reach the bottom of the well.
- Well purging equipment (e.g. bailer, silicone line, PVC pipe, plug, pump, tubing, power supply, and extension cord), as needed.
- A solid surge block.
- A sufficient number of 55-gallon drums (including lids, gaskets, and fasteners) to contain all purge water, unless other water handling arrangements have been made.
- All required documentation including sample labels, field books, sampling forms, and chains-of-custody.
- Personal protective equipment as described in the Site Health and Safety Plan.
- Decontamination equipment as specified in the Work Plan.

5. DECONTAMINATION

All equipment that will come in contact with the well water will be decontaminated prior to arrival on site, relocation on site, and site exit. DOF Standard Operating Procedure -120 shall be followed.

6. WELL DEVELOPMENT PROCEDURES

Upon arrival at each well, the following procedures shall be followed:

- Suit up in appropriate personal protective equipment as described in the Site Health and Safety Plan.
- Brush any soil or vegetation and pump any standing water away from the well opening.
- Lay plastic sheeting around well to place equipment on and keep cords, tubing and pumps from touching the ground.
- Open the well cap.
- Measure and record the depth to LNAPL, water, DNAPL, and total depth of the well using a decontaminated oil/water interface probe or water level indicator (depending on the historical presence of NAPLs in the well). All LNAPL and DNAPL measurements are to be made in accordance with SOP-110. Measurements are to be made to the nearest one hundredth of a foot and recorded on the appropriate field form.
- Compute the unit purge volume using the following formula and the input values on the attached Well Volumes Sheet.

1 well volume (including annular space) = [x(total well depth – water level)] + [(y x 0.40)(total well depth – bottom of seal)]

where "x" is the Casing/Riser Volume per Unit Length, Internal (gal/ft), "y" is the Annular Volume per Unit Length (gal/ft), and 0.40 is a conservative estimate of the porosity of the sand pack.

6.1. New Well Development Procedure

- If a submersible pump is to be used for well development, gently lower the pump to the well bottom. If a non-submersible pump is used, lower the tubing to the bottom of the well.
- Determine the volume of water in the casing (including annular space). Begin to purge the well at a rate sufficient to remove fines, slowly run the pump up and down the well over the length of the screen. Completed turbidity testing after each successive casing volume is removed from the well.
- A minimum of three and maximum of five well volumes (including annular space) will be removed. If this is the first time the well has been developed and water was used in the drilling process, the volume of water introduced into the formation during well formation must also be removed during development. *Purging is completed once the following has occurred:*
  - *the minimum purge volume (three casing volumes) has been removed and turbidity <5 NTU; OR*
  - *the well runs dry; OR*
  - *five purge volumes and drilling process water volumes have been removed.*
- Measure total depth of well after development.
- Containerize all purge water in 55-gallon drums, unless other handling arrangements have been made.
- Record additional information such as unique odors or water color, and a description of the suspended particle content in the field notes and on appropriate field forms.
- Upon completion of development, both the well and the purge drums are to be properly sealed and secured.
- All drums are to be permanently labeled as follows:

  Well ID(s)
  Site Name
  Drum Contents
  Date
  Drum Number

- Close the well appropriately and record any well integrity concerns on the well development form.

6.2. Existing Well Development Procedure

- Remove pump from well (if installed).

- Attach one length of twine to the surge block or use a drill rig or tripod and lower it to the bottom of the well.
- Vigorously begin moving the surge block up and down in the well creating a surging action across the screened interval. This action will bring the finer grained materials into suspension.
- Remove the surge block.
- Determine the volume of water in the casing (including annular space). Begin to purge the well at a rate sufficient to remove fines, slowly run the pump up and down the well over the length of the screen. Completed turbidity testing after each successive casing volume is removed from the well.
- Repeat surging and purging to reduce silt presence in water and keep checking total depth measurements.
- A minimum of three and maximum of five well volumes (including annual space) will be removed. *Purging is completed once the following has occurred:*
    - *the minimum purge volume (three casing volumes) has been removed and turbidity <5 NTU; OR*
    - *the well runs dry; OR*
    - *five purge volumes and drilling process water volumes have been removed.*
- Measure total depth of well after development.
- Containerize all purge water in 55-gallon drums, unless other handling arrangements have been made.
- Record additional information such as unique odors or water color, and a description of the suspended particle content in the field notes and on appropriate field forms.
- Upon completion of development, both the well and the purge drums are to be properly sealed and secured.
- All drums are to be permanently labeled as follows:

    Well ID
    Facility Name
    Drum Contents
    Date
    Drum Number

- Close the well appropriately and record any well integrity concerns on the sampling form.

7. DOCUMENTATION

Documentation of monitoring well development activities should be document on the well development form.

ATTACHMENT – Well Development Field Form

DOF DALTON OLMSTED FUGLEVAND

Monitoring Well Development

Well No.

Facility:

Date:

Sampling Personnel:

Initial Headspace (ppm):

Purging Method:

Begin/End Water Level:

Equipment Used:

Gallons per linear foot

Bottom Depth Start/End:

2" = .163 | 4" = .653 | 6" = 1.47 | 8" = 2.61

Pump Intake Depth (ft) TOC:

Well Volume (including annular space) = [(casing volume)(total well depth - water level) + (annular volume)(totall well depth - bottom of seal)]

Well Volume: _____ gal

Total Vol. Purged: _____ gal

Water Quality Measurements

Time	Water Level	Purge Rate	Volume Removed	pH	Conductivity	Temperature	Dissoved Oxygen	ORP	Turbidity
				+/- 0.5 units	+/- 10%				<5 NTU
(24 hrs)	feet BTOC	(L/min)	L	pH Units	mS/cm µS/cm	^{0}C	mg/L	mV	(NTU)

Notes: _____

Signature _____ Date _____ No. of Bottles _____ Page ____ of _____

DOF STANDARD OPERATING PROCEDURE – 110

(DOF-SOP-110)

Measuring Water and NAPL Depths and Total Depths

Revision Date: 12-13-2022

This standard operating procedure (SOP) contains the following sections:

1. PURPOSE

The purpose of this SOP is to provide field personnel with the specific information needed to collect and document consistent and representative data on liquid levels in, and total depths of, monitoring wells and piezometers.

2. REFERENCES

U.S. EPA. May 2020. Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers. https://www.epa.gov/sites/production/files/201506/documents/gw_sampling_guide.pdf

DOF. October 2022. Site Health and Safety Plan.

3. ASSOCIATED SOPS

SOP-115 – Low-Flow Groundwater Sampling Procedure

SOP-120 – Equipment Decontamination Procedure

4. TERMINOLOGY

The following terminology is used in this SOP:

"NAPL" means nonaqueous-phase liquid. "DNAPL" and "LNAPL" mean dense and light NAPL (described below), respectively.

"Wells" means groundwater-monitoring wells and piezometers.

"Liquid levels" means the elevations of fluid interfaces in wells. These include the following:

The "LNAPL level" is the elevation of the air/LNAPL interface, if floating LNAPL is present.

The "water level" is either (1) the elevation of the air/water interface if LNAPL is absent, or (2) the elevation of the LNAPL/water interface if LNAPL is present.

The "DNAPL level" is the elevation of the water/DNAPL interface, if DNAPL is present.

MP – Measuring Point – The liquid level is measured as the depth of the interface from the well's measuring point.

5. EQUIPMENT AND SUPPLIES

The following equipment and supplies are necessary to accurately measure liquid levels and total depths:

- Equipment required to open the well monuments (e.g., padlock keys, well keys, hand drill, socket set, Allen wrenches or other tools).
- An electric water-level indicator and/or an electric oil/water interface probe. Each such instrument should have a chemically inert suspension line that is graduated in 0.01-foot increments and sufficiently long to reach the bottom of the well.
- Fully charged batteries for each battery-powered instrument.
- An accurate and reliable watch that has been properly set.

- In tidally influenced areas, a tide chart showing the times of tidal high or tidal low slack tides.
- Liquid level measurement form (see attachment).
- Health-and-safety equipment and supplies (e.g., personal protective equipment [PPE]) as described in the relevant site health-and-safety plan.
- Decontamination equipment and supplies as specified in SOP-120.

Although not essential, the following items are useful for verifying the correctness of field measurements:

- A construction (as-built) diagram for each well, showing the well's total depth and its screened interval.
- A table or graph (e.g., a well hydrograph) of field measurement results (liquid levels, total depth) from previous monitoring events, for each well.

6. PROCEDURES

6.1. Simultaneity of Measurements

If liquid-level measurements are to be completed at a group of wells at a site, then complete the entire set of measurements for the group within a single business day. In addition, if any of the wells at a site are screened in tide-influenced hydrogeologic units, then complete the set of measurements corresponding to those wells within a single one-hour period, or as short a time as feasible. In general, tidal influences decrease with distance from a shoreline. Measurements should made in tidally influenced wells beginning at slack tide (for either low or high tides) and proceed landward in as short a time as feasible.

6.2. Order of Completion

At each well, complete the liquid-level and total-depth measurements in the following order:

1. LNAPL level
2. Water level
3. DNAPL level/thickness
4. Total well depth

6.2.1. SPECIAL INSTRUCTIONS FOR WELLS WITH DEDICATED PUMPS

The instrument access ports on some dedicated pumps will not accommodate some probes (e.g., most oil/water interface probes). If so, the pump must be removed from the well to measure the DNAPL level and the total depth. At wells with dedicated pumps, complete the measurements in the following order:

1. Measure the water level.

2. Remove the pump from the well and place it in a clean plastic bag.
3. Allow the liquid levels to stabilize.
4. Measure the DNAPL level.
5. Measure the total depth.

6.3. Pre-Measurement Procedures

On arrival at each well, complete the following steps in the order listed:

1. Don appropriate PPE as described in the site health and safety plan.
2. Remove any debris (e.g., soil, vegetation, or refuse) and any standing water from the well opening, to prevent foreign matter from entering the well.
3. Open the well monument.
4. Vent the well by carefully removing the well cap. Record the time at which the well is initially vented to the atmosphere (i.e., the time at which the well cap is removed). If the gas in the well casing appears to have been over-pressurized or under-pressurized relative to the atmosphere, then note this in the field book.

   Caution (1): Never put your face, head, or any other body part over the well when venting it. If possible, vent the well gradually, so the cap does not become airborne.

   Caution (2): Handle monitoring wells with care at all times. If it is necessary to apply lift or torque to a well cap to remove it (e.g., if the casing is airtight and under a vacuum), then be extremely careful to prevent the well casing from being raised or rotated.
5. Wait at least 20 minutes from the time the well is vented, to allow the liquid levels in the well to equilibrate to the current atmospheric pressure, before measuring liquid levels. At some wells it may be necessary to vent for longer periods.

6.4. General Measurement Procedures

Each liquid level measurement involves lowering an instrument probe into the well, until the instrument emits the appropriate response, indicating the probe has reached the desired fluid interface in the well. Depending on the type (manufacturer and model) of instrument, the response may be audible (e.g., a tone is steadily or intermittently emitted), visible (e.g., an indicator light is steadily or intermittently illuminated), or both. The instrument may need to be grounded before use, consult the instrument's operating manual for details. The probe is attached to the body of the instrument by a flexible suspension line consisting of a graduated "tape" or coaxial cable that sheathes an electric conductor. After lowering the probe to the appropriate level in the well (see below), hold the upper end of the graduated tape against the well's MP and read the numeric value off the tape. Record the measurements to the nearest 0.01 foot below the well's MP. If the MP is not clearly marked (typically

by a notch cut into the top of the well riser), then measure all levels from the top of the north side of the riser or dedicated pump.

Duplicate each liquid-level and total-depth measurement in the field to ensure that the reading is accurate. Record all results (times, measured values, etc.) on the water-level field form.

6.5. Measuring LNAPL Levels

LNAPLs are NAPLs that are less dense than water. In the subsurface, free-phase LNAPL tends to accumulate on the water table. Free-phase LNAPL that enters a well tends to accumulate on the air/water interface. Some wells routinely contain LNAPL. Typically, the thicknesses of the LNAPL layers in such wells are measured at the same time the water levels are measured.

Use an oil/water interface detector for the measurement. Turn the detector on. Then slowly lower the probe into the well. In some cases, a very thin (~ 0.01 foot) layer of LNAPL may accumulate on the air/water interface in the well, so the probe must be lowered very slowly if the LNAPL layer is to be detected and accurately measured. The oil/water interface detector emits one type of response to indicate that the probe has contacted NAPL, and a different type of response to indicate that the probe has contacted water. First, lower the probe until the air/LNAPL interface is detected. Measure the depth to the interface. Record the result. Record "sheen" if the instrument detects an LNAPL layer whose thickness is less than 0.01 foot.

6.6. Measuring Water Levels

Measure water levels using either an oil/water interface detector or, if no LNAPL is present, using an electric water-level indicator.

6.6.1. MEASURING WATER LEVELS USING THE OIL/WATER INTERFACE DETECTOR

After measuring the depth to LNAPL in the well, and before retrieving the probe from the well, slowly lower the probe further into the well. When the LNAPL/water (or air/water) interface is detected, measure the depth to the interface. Record the result. Be aware that the probe may be coated with NAPL that may lead to a false NAPL bottom/Water level measurement or "thickness" reading. Once a water indication is achieved, raise the probe up to the bottom of the LANPL to double check that reading.

6.6.2. MEASURING WATER LEVELS USING THE ELECTRIC WATER-LEVEL INDICATOR

Turn the water-level indicator on. Manually adjust the sensitivity to a medium level. Slowly lower the indicator probe into the well until the indicator emits a short audible tone, indicating the probe has contacted the air-water interface. Measure the depth to the interface. Record the result.

6.7. Measuring DNAPL Levels

DNAPLs are NAPLs that are denser than water. In the subsurface, free-phase DNAPL tends to sink below the water table. Free-phase DNAPL that enters a well tends to sink to the bottom of the well, however some do achieve buoyancy within the water column. DNAPL levels are measured at some wells while

the water levels are measured. Use an oil/water interface detector to measure the DNAPL level as described below.

If the well does not have a dedicated pump, then after measuring the water level in the well, and before retrieving the probe from the well, slowly lower the probe further into the well. If the well does have a dedicated pump, then after the pump has been removed from the well and the liquid levels in the well have been allowed to stabilize, slowly lower the probe into the well.

When (if) the water/DNAPL interface is detected, measure the depth to the interface. Record the result.

6.8. Measuring Well Total Depths

For measuring well total depths, complete the following steps in the order listed:

1. Lower the instrument (water-level indicator, oil/water interface detector, or weighted tape) to the bottom of the well to measure the well's total depth.
2. Gently bounce the probe on the well bottom to determine when the probe is at the bottom of the well and take up the slack on the suspension line.
3. Measure the total depth. Record the result.

6.9. Post-Measurement Procedures

After the measurements have been made at a well, and the results have been recorded, complete the following steps in the order listed:

1. Retrieve the instrument suspension line and probe from the well, and simultaneously decontaminate the instrument suspension line and probe (see below).
2. If the well has a dedicated pump that was removed to complete the measurements, replace the pump.
3. Close (seal) and secure the well.
4. Record any well integrity concerns in the field book and on the water level/NAPL field form.

7. DECONTAMINATION

Decontaminate all equipment that may come in contact with the well water or NAPL, at the following times:

- prior to, or on, arrival at the site,
- on moving from one well to another, on site,
- immediately prior to exit from the site.

Follow the decontamination procedures given in DOF SOP-120.

8. DOCUMENTATION

Record all measurement results (liquid levels, total depth, and time of measurement) on the appropriate field form. Maintain the completed field form in the project file.

ATTACHMENT – Liquid Level Field Form

WATER LEVEL RECORD

Project Name:

Project Number:

Sheet ___of ___

Date:_____ Weather:_____

Sounder Type/Model_____

Field Rep: _____

DALTON OLMSTED FUGLEVAND

WELL ID	***Elevation Top of Casing*** (NAVD88)	***Height of Casing Above Ground*** (feet)	***Depth to LNAPL from Top of Casing*** (feet)	***LNAPL Thickness*** (feet)	***Depth to DNAPL from Top of Casing*** (feet)	***DNAPL Thickness*** (feet)	***Depth to Water from Top of Casing*** (feet)	***Time of Measurement***

Signature of Field Rep:_____

DOF STANDARD OPERATING PROCEDURE – 115

(DOF SOP-115)

Low-Flow Groundwater Sampling Procedure

Revision Date: 12-13-2022

This SOP contains seven sections:

1. PURPOSE

This SOP serves to provide field personnel with the specific information needed to consistently collect and document representative groundwater samples for laboratory analyses from monitoring wells using a low-flow groundwater sampling technique.

The purpose of low-flow groundwater sampling is to collect a groundwater sample that is representative of actual site conditions. Therefore, the purge rate is designed to be low enough to simulate actual groundwater flow and to pull water from a discrete zone near the pump intake into the pump rather than pulling groundwater from a large area around the well or outside of the screened area of the well. A low purge rate is also intended to reduce the possibility of stripping volatile organic compounds from groundwater and to reduce the likelihood of mobilizing colloids in the subsurface that are immobile under natural flow conditions.

2. REFERENCES

U.S. EPA. May 2020. Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers. https://www.epa.gov/sites/production/files/201506/documents/gw_sampling_guide.pdf

U.S. EPA. July 1996. Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells. https://www.epa.gov/sites/production/files/2017-10/documents/eqasop-gw4.pdf

3. ASSOCIATED DOF SOPS

SOP-110 - Measuring Water and NAPL Levels and Total Depths

SOP-120 - Equipment Decontamination Procedure

4. EQUIPMENT

The following equipment is recommended for properly sampling a groundwater monitoring well:

- Relevant work plan that includes a map of well locations, sampling plan, appropriate SOPs, well construction information, and a health & safety plan.
- A well key, hand drill, socket set, padlock key, or other well access equipment.
- An electric water-level indicator and/or oil/water interface detector calibrated. to 0.01 foot, and sufficiently long to reach the bottom of the well.
- A weighted tape measure for determining total depths of wells, when required.
- Well purging equipment (e.g., pump, pump controller, tubing, and power supply).
- A sufficient number of containers (e.g., 55-gallon drums with lids, labels, gaskets, and fasteners) to store purge water, unless other water handling arrangements have been made.
- Water-quality meter(s) that is calibrated and maintained in accordance with the manufacturer's recommendation using calibration solutions to measure, pH, specific conductivity, dissolved oxygen, and oxidation-reduction potential (ORP).
- Flow-through cell that is compatible with the multiparameter meter probe and is intended to reduce the affects to atmospheric conditions on the groundwater being purged and pumped.
- Turbidity meter that is calibrated and maintained in accordance with the manufacturer's recommendation using a calibration solution to measure turbidity.
- In-line disposable 0.45-micron filters, if necessary, for metals analyses when dissolved metals analysis is required.
- A sufficient number of sampling containers, including containers for regular samples and quality control samples (e.g., field blanks, equipment rinsate blanks, duplicates, trip blanks, and matrix spike/matrix spike duplicates).
- All required documentation including weatherproof sample labels, sampling forms, chain-of-custody (COC) forms, weatherproof pens and paper for sampling forms, and COC seals.
- Personal protective equipment (PPE) described in the site health and safety plan.

- Decontamination equipment as specified in DOF SOP-120.
- Water flow-rate measurement equipment (e.g., flow meter, or graduated container and stopwatch).
- Sampling support equipment and supplies (e.g., sample coolers, clean bagged ice, bubble wrap and VOC bottle holders, clear tape, plastic locking bags, razor knives, garbage bags, paper towels, deionized water, nitrile gloves, five-gallon buckets, clean fold out table for sample bottles and equipment, fabricated foam spill berm equivalent to 5-gallon bucket) as needed.

5. DECONTAMINATION

All reusable equipment that will contact the well and/or water samples will be decontaminated prior to its use, according to the procedures described in DOF SOP-120.

6. WELL SAMPLING PROCEDURES

6.1. Set Up

On arrival at each well, the following procedures shall be followed:

- Don appropriate PPE and safety vests as described in the site health and safety plan.
- Remove any soil or vegetation and standing water from the well monument casing. Check the well condition, making sure the flexible gasket seals are clean and intact. If applicable, also check the condition of the dedicated pump cap. Record any problems on the appropriate field forms.
- Place fabricated foam spill berm on the ground next to the well and place the sampling equipment and bottles on a clean fold out table to keep them from touching the ground.
- Remove the well cap,
- Set up the pump, flow-through cell, and water quality meter(s) in preparation for purging. Connect the discharge line from the pump to a flow- through cell. The discharge line from the flow-through cell must be directed to a container to contain the purge water during the purging and sampling of the well.
- Record the depth of the pump intake on the sampling form. The pump intake is set at the interval within the screen where the contamination is known to exist, the center of the screened interval, or the center of the saturated portion of the screened interval (for wells with screens not fully saturated). Check with the project manager if there is uncertainty regarding this issue. If the well doesn't have a dedicated pump, (e.g., well with dedicated tubing for use with a Peristaltic Pump) the tubing should be lowered into the well alongside of a weighted measuring tape or water-level indicator to ensure that the intake of the pump is set at the appropriate depth.
- Measure and record the depth to water using a decontaminated water-level indicator or oil/water interface detector to the nearest 0.01 foot, in accordance with SOP-110. Record the reading on the appropriate field form(s).

- Before purging, adjust the pumping rate to its lowest setting, and set the data logger in the flow-through cell to record readings every three to five minutes.

6.2. Purging Monitoring Wells

6.2.1. PURGING PROCEDURE

Measure the initial (static) water level in the well and record the measurement on the field form(s).

Start the pump at a flow rate of 200 to 500 mL/min. Maintain a steady flow rate while maintaining a drawdown of less than 0.33 foot (if possible). The flow rate can be measured using a graduated cup and a stopwatch.

To determine water-level stability, subtract the second water-level reading (not the static water-level reading) from the current water-level reading to determine the current drawdown.

After the flow rate is stable, record the water level and the flow rate every three to five minutes. Record water levels more frequently if the rate is being adjusted. A drawdown less than 0.33 foot is preferred but may not always be possible. If the drawdown exceeds 0.33 foot at low flow rates (<500 mL/min), lower the flow rate as practical (not to drop below 100 mL/min) to reduce the drawdown.[1]

Begin recording water-quality parameters after all water has been purged from the sample tubing, pump, and flow-through cell. Initiate water-quality testing for temperature, pH, specific conductivity, dissolved oxygen (DO), oxidation reduction potential (ORP), and turbidity. Record water-quality parameters every three to five minutes.

6.2.2. PURGING REQUIREMENTS

Sampling cannot begin until the drawdown is no greater than 0.33 foot[1], and all water- quality parameters are stable. Each water-quality parameter is considered stable when it satisfies the corresponding stability criterion specified in the table below.

[1] The 0.33-foot drawdown goal may be difficult to achieve under some circumstances due to geologic heterogeneities within the screened interval and may require adjustment based on site-specific conditions and personal experience. The water levels in water-table wells should not be allowed to drop below the pump intake. In all other cases, the water level should not be allowed to drop below the top of the well screen. If the water table drops below one of these minimum values, the pump should be turned off and the water level should be allowed to recover. See section 7.2.2, fifth bullet for more information.

Water-Quality Parameter	Stability Criterion
Turbidity	{X} < 5 NTU or RPO < 10 % for values {X} > 5 NTU
Dissolved Oxygen	delta $\leq$ 0.3 mg/L
Specific Conductivity	RPD $\leq$ 3%
ORP	delta < 10 mV
Temperature	delta < 3%
pH	delta < 0.1 unit

Where:

{X} = the last three water-quality readings

$$m = \text{mean} = \frac{\text{Max}\{X\} + \text{Min}\{X\}}{2}$$

$$\text{Delta} = \text{Max}\{X\} - \text{Min}\{X\}$$

$$\text{RPD} = \frac{\text{delta}}{m} \times 100\%$$

In some circumstances, the well may not stabilize according to the above criteria, but the well can be sampled if one of the following conditions occurs:

- Wells are unable to meet stability criteria due to equipment accuracy. The accuracy of the instruments will often limit the ability to achieve stabilization on a percentage basis. For example, if the ORP is consistently fluctuating between 1 and 15 mV, then delta = 14 mV, which is not within the requirements for stability. However, the accuracy of the instrument currently used is+/- 20 mV. Therefore, in this case the stability criterion would be considered satisfied within the range of accuracy of the equipment. This is particularly important when the water-quality parameter values are low.[2] Field personnel must consult the instrument's manual to determine its accuracy.
- Wells for which all water-quality parameters have stabilized may be sampled if it is clear that the drawdown will not stabilize before the water level drops below the minimum allowable value (i.e., pump intake, or top of screen if aquifer is confined).

[2] ORP may not always be an appropriate stabilization parameter, depending on site conditions. The project manager may designate wells that will not require ORP measurements.

- If collecting metals samples and all water-quality parameters except turbidity stabilize, it is acceptable to collect filtered and unfiltered metals samples without waiting for turbidity to stabilize or for one well volume to be purged. A filtered sample should be collected using a disposable 0.45 micron in-line filter. If there are no directions on the filter for rinsing, then a minimum of 0.5 liter of groundwater from the well should be run through the filter prior to collecting the sample.
- Water-quality parameters are not stable, but at least three well volume of water has been removed from the well. Calculate the volume of water in the casing and the screened interval as follows.

  The following equation is used to calculate the well volume:

  $V = V_{casing}$ (well depth - static water depth)

  where:
  V_{casing} = casing volume per unit length (e.g., ~0.17 gal/ft for two-inch casing)

- The water level drops below the minimum value (i.e., the pump intake, or the top of the screen if the aquifer is confined) during purging. In this case, the pump should be turned off and the well should be allowed to recover. As long as a minimum of two tubing volumes (including the tubing and pump) has been removed from the well, then the well should be sampled as soon as the water level has recovered sufficiently to collect volume of groundwater necessary for all samples. Use the following equations to determine the minimum volume of groundwater to be removed prior to sampling when this problem occurs:

  Minimum purge volume= 2 [500 mL + M (length of tubing in feet)]
  where M is the volume (in mL) contained in a one-foot length of tubing.
  For tubing of various inner diameters, M is equal to:

Inner Diameter	M (ml/foot tube)
1/8"	2.4
1/4"	9.7
1/2"	39

  This is acceptable even though the water-quality parameters have not stabilized and one well volume has not been removed.

Record on the field form if any monitoring wells did not meet the stabilization and drawdown criteria and describe the rationale for sampling the well at the time it was sampled.

6.3. Sampling Procedure

Do not stop pumping after-the purging requirements have been met. Don clean nitrile gloves. **Disconnect the sampling tube from the influent flow-through cell**. Collect each sample directly from

the disconnected tubing. Minimize the turbulence by allowing the groundwater to flow from the tubing gently down the inside of the container.

The sampling flow rate may remain at the established purge rate or may be adjusted slightly to minimize aeration, bubble formation, turbulent filling of sample bottles, or loss of volatiles due to extended residence time in tubing. Typically, flow rates less than 500 mL/min are appropriate.

When collecting the dissolved gas samples (e.g. volatile organic compounds, total petroleum hydrocarbons - gasoline range, or methane/ethane/ethane) the following procedures should be followed:

- The tubing should be completely filled with water to prevent the groundwater from being aerated as it flows through the tubing.
- A meniscus must be formed over the mouth of the vial to eliminate the formation of air bubbles and headspace prior to capping.

Samples do not have to be collected in a particular order unless unfiltered metals samples are collected, in which case they should be collected last.

Once a sample has been collected, a final set of field parameter measurements should be made to compare to the set of measurements made immediately prior to sample collection.

6.4. Post-Sampling Procedures

After all of the samples have been collected in containers that are labeled and appropriately treated with preservatives, the following tasks should be completed:

- Measure and record the depth to water to determine total drawdown. Record the estimated total volume of water purged from the well.
- If dedicated equipment is in place at the well, disconnect aboveground tubing and properly seal the well.
- If non-dedicated equipment is used, then remove the equipment. Discard disposable items and decontaminate reusable items according to SOP-120. It may be appropriate to collect rinsate blanks to confirm that the decontamination procedure is effective.
- Close and secure the well, and record any well integrity concerns (bolt tightness, etc.) on the sampling form.
- Rinse the water-quality meters with deionized water between wells.
- Report if any monitoring wells did not meet the stabilization and drawdown criteria with recommendation on how to conduct the sampling for the next sampling event.

7. DOCUMENTATION

Monitoring well sampling activities should be documented on the Monitoring Well Sampling Field Sheet. The sheets should be maintained in the project file.

ATTACHMENTS – Monitoring Well Sampling Field Sheet

	Monitoring Well Sampling Field Sheet		Well No.
			Site:
Date:	Sampling Personnel:		
Sampling Method: Low Flow			Begin-Water Level (ft):
Equipment Used:		**MP** = ☐ North Side TOC ☐ other: _____	End-Water Level (ft):
		1 Volume = 0.17 * (total well depth - water level)	Pump Intake Depth below MP:

Abbreviations: **MP**=Measuring Point **TOC**=Top of Casing **PPM**=Parts per Million **ft**=Feet **uS/cm**=microsiemens per centimeter **C**=Celsisus **mg/L**=milligrams per Liter **mV**=millivolts **mL/min**=milliliters per minute **NTU**=nephelometric turbidity units

Time	Water level	Purge Rate	pH	Conductivity	Temperature	Dissoved Oxygen	Redox Potential	Turbidity
(24 hour)	ft	(mL/min)	pH Units	uS/cm	^{0}C	mg/L	mV	(NTU)
	< 0.33 ft from 2nd reading	< 500 mL	< 0.1 unit	</= 3%	< 3%	</= 0.3 mg/L	< 10 mV	< 5 NTU **or** < 10% if >5 NTU

Notes: _____

DOF STANDARD OPERATING PROCEDURE – 120

(DOF SOP-120)

Equipment Decontamination Procedure

Revision Date: 12-13-22

This SOP contains eight sections:

1. PURPOSE

This SOP serves to provide field personnel with an outline of the procedure and frequency of decontaminating equipment that has come into contact with potentially contaminated soil, water or NAPL.

2. REFERENCES

U.S. EPA. June 2020. Field Equipment Cleaning and Decontamination.

https://www.epa.gov/sites/production/files/2016-01/documents/field_equipment_cleaning_and_decontamination205_af.r3.pdf

DOF. October 2022. Site Health and Safety Plan.

3. ASSOCIATED DOF SOPS

SOP-100 – Well Installation Procedures

SOP-105 – Monitoring Well Development

SOP-110 - Measuring Water and NAPL Levels

SOP-115 – Low-flow Groundwater Sampling Procedure

SOP-125 – Soil Sampling

4. EQUIPMENT

The following equipment is necessary to properly decontaminate equipment used to install wells, collect soil and groundwater samples, and make measurements in monitoring wells.

DOF Field Equipment

- De-ionized water and spray bottle.
- Alconox (or similar detergent) and spray bottle, paper towels/rags.
- If NAPL is expected to be present - citrus-based solvent (such as CitriSolv) and methanol
- Brushes
- PVC pipe, capped on one end, 5 feet long.
- A clean hose and tap water source.
- A labeled container for wastewater and a bucket to use for smaller volume prior to containing in larger container.
- Personal protective equipment as described in the Site Health and Safety Plan.

Contractor Provided Equipment

- Steam cleaner
- Brushes
- Containers to collect decontamination fluids

5. GENERAL DECONTAMINATION PROCEDURES

All reusable equipment that will come in contact with soil and/or groundwater during well installation and/or be used to acquire soil or groundwater samples will be decontaminated prior to arrival on site, relocation on site, and site exit. In addition, downhole probes, such as electric well sounders and interface probes used to assess the presence of NAPL, will be decontaminated between measurement locations.

If NAPL is not present:

- Wash the equipment with a solution of nonphosphate detergent (Alconox or equivalent) and water
- Rinse the equipment with tap water.
- Rinse the equipment with distilled or DI water.

If NAPL is present pay particular care to remove NAPL prior to next use.

- Rinse with Citrus-based solvent (CitriSolv)
- Rinse with Methanol
- Wash in Alconox solution
- Rinse with tap water and distilled or DI Water

6. SPECIFIC DECONTAMINATION PROCEDURES

6.1. Push-Probe – Soil Sampling/Well Installation

- Drilling and sampling equipment that contacts soil and/or groundwater will be cleaned using a steam cleaner before entering the site, before moving between locations, and before existing the site.
- Downhole samplers will be washed with a detergent solution and rinsed with tap water between sampling runs, if NAPL is not present. A steam cleaner and/or brushes will be used to remove visible soil and NAPL if present. Use a citrus based solvent, if necessary.
- Used decontamination fluids will be placed in containers for off-site disposal.

6.2. Hollow-Stem Auger – Soil Sampling/Well Installation

- Drilling and sampling equipment that contacts soil and/or groundwater will be cleaned using a steam cleaner before entering the site, before moving between locations, and before existing the site.
- Downhole samplers (such as split-spoon samplers) will be washed with a detergent solution and rinsed with tap water between sampling runs, if NAPL is not present. A steam cleaner and/or brushes will be used to remove visible soil and NAPL, if present. Use a citrus based solvent, if necessary.
- After soil sampling and well installations are complete, the augers will be steam cleaned using a detergent solution and be rinsed with tap water. Brushes will be used to remove visible soil and NAPL if present.
- Used decontamination fluids will be placed in containers for off-site disposal.

6.3. Sonic Drilling Rig – Soil Sampling/Well Installation

- Drilling and sampling equipment that contacts soil and/or groundwater will be cleaned using a steam cleaner before entering the site, before moving between locations, and before existing the site.

- Downhole samplers (such as core barrels) will be washed with a detergent solution and rinsed with tap water between sampling runs, if NAPL is not present. A steam cleaner and/or brushes will be used to remove visible soil and NAPL if present.
- After soil sampling and well installations are complete, the casings and core barrels will be steam cleaned using a detergent solution and be rinsed with tap water. Brushes will be used to assist in removing visible soil and NAPL if present. Use a citrus based solvent, if necessary.
- Used decontamination fluids will be placed in containers for off-site disposal.

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6.4. Non-Dedicated Submersible Pump Decontamination Procedure

After sampling or developing a well using a non-dedicated submersible pump, decontaminate the pump as follows:

- Use hose to spray off pump with tap water.
- Place pump into a capped approximately 5’ long, 3” diameter PVC pipe or similar container.
- Fill the PVC pipe with tap water and non-phosphate detergent.
- Run the pump until the pipe is empty, refilling it with tap water 3 times. The discharge decontamination water will be pumped into a 55-gallon drum or other container.
- Remove the pump and wash out the pipe using tap water from the hose.
- Place the pump in the pipe again and fill with tap water.
- Run the pump until it empties, then rinse it with water and refill the pipe with distilled or di-ionized water.
- Run the pump until the pipe empties three times with the distilled or deionized water.
- If NAPL is present, the pump and/or tubing will be dedicated to the individual well containing the NAPL.

7. DOCUMENTATION

Decontamination procedures associated with field sampling activities including those associated with soil and groundwater sampling, in-well measurements, and well installation should be documented on the appropriate field forms.

ATTACHMENT - None

DOF STANDARD OPERATING PROCEDURE – 125

(DOF SOP-125)

Soil Sampling

Revision Date: 12-13-2022

This SOP contains eight sections:

1. PURPOSE

This SOP serves to provide field personnel with the specific information needed to consistently collect and document representative soil samples for laboratory analyses. Soil samples may be collected using hand equipment (surface/near surface), push-probe, hollow-stem auger, or another type of drilling rig, or a backhoe.

2. REFERENCES

ASTM D2487, 2008. Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

ASTM D2488, 2008. Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)

ASTM, D1586, 2011. Standard Method for Penetration Test and Split-Barrel Sampling of Soils.

Chapter 173-160 WAC. Minimum Standards for Construction and Maintenance of Wells.

Chapter WAC 296-155-657. Protection of Employees in Excavations.

Site Characterization for Subsurface Remediation, EPA/625/4-91/026, November 1991

3. ASSOCIATED DOF SOPS

SOP-100 – Well Installation Procedures

SOP-120 - Equipment Decontamination Procedures

4. EQUIPMENT

4.1. For General Soil Sampling

- Relevant work plan that includes a map of sample locations, sampling plan (target sample intervals), and list of laboratory analyses to be completed.
- A photoionization detector (PID) to measure volatiles in sample bag headspaces (if such measurements are being made) and breathing zone.
- Spray water bottle and pan to complete sheen testing.
- Tape measure to determine sample depths and thicknesses, and to measure the sample location from prominent site features.
- DGPS to determine horizonal coordinates (to +/- 1.0 feet).
- A sufficient number of plastic bags and laboratory sample containers, including containers for regular samples and quality control samples (e.g., duplicates, trip blanks, and matrix spike/matrix spike duplicates). Requires coordination with laboratory.
- VOC sampling equipment per EPA Method 5035 (if VOC analyses are being conducted).
- Documentation including sample labels, sampling forms, chain-of-custody (COC) forms, weatherproof pens and paper for sampling forms, and COC seals (if needed).
- Personal protective equipment (PPE) described in the site health and safety plan.
- Decontamination equipment as specified in DOF SOP-120.

4.2. Specific to Surface/Near Surface Soil Sampling (Hand) or Backhoe

- Hand auger, post-hole digger, or hand driven barrel-type sampler (hand sampling).
- Clean stainless steel sampling spoons.
- Clean stainless steel or aluminum mixing bowls or pans.

4.3. Specific to Subsurface Soil Sampling

- Clean stainless steel sampling spoons.
- Clean stainless steel or aluminum mixing bowls or pans.
- The drilling contractor will normally provide the down-hole soil sampling equipment (e.g. split spoon sampler and other barrel-type samplers).

5. DECONTAMINATION

All reusable equipment that will contact soil will be decontaminated prior to its use, according to the procedures described in DOF SOP-120.

6. DESCRIBE AND TEST SOIL SAMPLES

6.1. Describe Soil Samples

Each soil sample or core should be described using ASTM-D2488 as a general guide. Evidence of contamination such as color, odor, oily soil, presence of industrial debris, etc. should be noted, as should the depth below ground surface of changes in lithology or material type. Observations should be documented in the field on the appropriate field form along with the sample location, including DGPS coordinates.

6.2. Test Headspace for VOCs

Place a portion of each sample into a 1-quart plastic bag (thin-walled sandwich bag). The bag should be no more than half full. Seal bag and allow to come to ambient temperature. Insert the probe of a calibrated PID into the bag and record the maximum meter reading on the appropriate field form. The PID will be calibrated with 100 ppm isobutylene gas as the beginning of each day. After each sample batch is tested, the PID will be checked against the 100-ppm gas standard. If the reading is more than 10 percent above or below the calibration gas standard, the instrument will be recalibrated.

6.3. Sheen Testing

Place a representative portion of the soil sample onto a small pan. Spray a small portion of water onto the sample so that the water pools on the sample. Observe the water surface for the presence of a sheen. Describe the sheen and its intensity using the following classification.

Sheen Classification

Sheen Classification	Description
No Sheen (NS)	No visible sheen on water surface
Light Sheen (LS)	Light colorless sheen, spread in irregular, not rapid; film dissipates rapidly
Moderate Sheen (MS)	Light to heavy film, may have some color or iridescence; spread is irregular to flowing, may be rapid; few remaining areas of no sheen on water surface.
Heavy Sheen (HS)	Heavy colorful film with iridescence; spread is rapid, and sheen flows off sample; entire water surface may be covered with sheen.

7. SOIL SAMPLING PROCEDURES

7.1. Representative Samples

The goal of soil sampling is to collect representative samples of a known depth interval. The work plan will note the target intervals which may be adjusted based on field observations. For example, if the target interval crosses two material types (e.g. sand over clay), care should typically be taken not to include the two material types in the sample. A discrete sample should be obtained of either the sand or clay, or both depending on the project objectives.

7.2. Surface/Near Surface Soil Samples – Hand Sampling

- If a backhoe is being used to excavate the sample holes, complete utility checks per Washington State Law. In many cases it may also be appropriate to retain a private locating surface to supplement the one-call "utilities" checks. In cases where sampling may occur close to buried utilities or if the locations are unsure, probing using a vac truck may be appropriate to confirm utilities are not present below the sampling location.
- Don appropriate PPE and safety vests as described in the site health and safety plan.
- Place plastic adjacent to the sample location and remove surface vegetation such as grass, duff, leaves, etc. Place removed material on plastic sheeting.
- Excavate sample hole to target depth. Place excavated soil on plastic sheeting. Describe and record soil removed from hole. Measure and record depth of hole.
- Collect sample(s) from the hole sidewall along the target sample interval(s), being careful not to include soil from above or below the sample interval. Place a portion of the sample in a 1-quart plastic bag for headspace analysis and a portion in a bowl/pan and collect a sample for VOC analysis,

if being performed. Mix the remainder of the bowl sample to a consistent color/texture and fill the labeled laboratory supplied containers, and place containers in a chilled cooler. Conduct sheen testing on the remaining portion of the sample.

- Backfill any remaining soil into the sample hole and restore surface.
- If samples are being collected using a backhoe, the bucket should be cleaned between sample locations. Materials encountered should be described as the backhoe excavation proceeds and representative samples obtained from the bucket taking care not to include soil that has come in contact with the bucket sidewalls. In no case should the excavation be entered if deeper than two feet.
- Once sampling is completed, backfill excavation with the excavated soil in reverse order of how the soil was removed from the excavation. The excavation should not remain open as it represents a potential hazard unless suitable barriers are in place to prevent unintended falls into the excavation.
- Measure the sample location using a tape measure from prominent site features and determine horizontal coordinates using a DGPS.
- Prepare chain-of-custody records and transport/ship the samples to the laboratory– ideally the same day or the day following collection.

7.3. Push-Probe Barrel Samples

- Complete the one-call utility checks per Washington State Law. In many cases it may also be appropriate to retain a private locating surface to supplement the one-call “utilities” checks. In cases where sampling may occur close to buried utilities or if the locations are unsure, probing using a vac truck may be appropriate to confirm utilities are not present below the sampling location.
- Don appropriate PPE and safety vests as described in the site health and safety plan.
- Drive the core barrel with acrylic liner through progressively deeper intervals. Core barrels are typically 5-feet long with the goal being to collect continuous cores to the target depth.
- Allow the driller to slice open the acrylic liner and record the sample recovery, leaving the core cradled in the liner.
- Collect samples for VOC analysis per EPA Method 5035. Typically from the mid-point of the target interval. At this time also collect a portion of the same sample interval into a 1-quart plastic bag for headspace analysis.
- Transfer the portion of the core sample target interval soil into a bowl/pan and mix to a consistent color/texture. Place a portion into the laboratory supplied labeled container. Place containers in a chilled cooler. Conduct sheen testing on the remaining portion of the sample. If a limited volume of sample is available, use a portion of soil from the headspace plastic bag for sheen testing.

- Once the final drilling depth is reached, samples have been obtained and a monitoring well is not to be installed, the driller will grout the hole in accordance with WAC 173-160. Document the sealing method on the field log.
- Measure the sample location using a tape measure from prominent site features and determine horizontal coordinates using a DGPS.
- Prepare chain-of-custody records and transport/ship the samples to the laboratory– ideally the same day or the day following collection.
- Collect and containerize any waste materials such as wash water or drill cuttings.
- Once the final drilling depth is reached and samples have been obtained, the driller will grout the hole in accordance with WAC 173-160. Document the sealing method on the field log.

7.4. Hollow-Stem Auger Samples

- Complete the one-call utility checks per Washington State Law. In many cases it may also be appropriate to retain a private locating surface to supplement the one-call "utilities" checks. In cases where sampling may occur close to buried utilities or if the locations are unsure, probing using a vac truck may be appropriate to confirm utilities are not present below the sampling location.
- Don appropriate PPE and safety vests as described in the site health and safety plan.
- Drive the split-spoon sampler through progressively deeper intervals. The normal split spoon samplers are 18-inches long and 2-inches in diameter. Typically sampling can occur every 2.5 feet, as the auger flights are 5-feet in length. Depending on the project objectives and the volume of sample necessary to complete the laboratory analyses, either a standard 1 ½ -inch diameter SPT or a modified "California" 3-inch diameter – 2-feet long sampler may be deployed.
- As each spoon is driven, record the blow counts to drive the sampler each 6" (Standard Penetration Test [SPT] if an 18-inch, 2-inch diameter sampler is used). If an oversized split spoon is used to obtain greater sample volume, the blow counts should also be recorded, although they do not correlate with the SPT test criteria without a correction factor being applied.
- As each split spoon is retrieved and opened, record the driven interval, sample recovery, and describe the materials retrieved. Between sample runs, wash the sampler with a detergent solution and tap water (typically the driller is set up to do this).
- Collect samples for VOC analysis per EPA Method 5035 (if VOC laboratory tests are being conducted), typically from the mid-point of the sampler. At this time also collect a portion of the same sample interval into a 1-quart plastic bag for headspace analysis.
- Transfer the portion of the core sample target interval soil into a bowl/pan and mix to a consistent color/texture. Place a portion into the laboratory supplied labeled container. Place containers in a

chilled cooler. Conduct sheen testing on the remaining portion of the sample. If a limited volume of sample is available, use a portion of soil from the headspace plastic bag for sheen testing.

- Measure the sample location using a tape measure from prominent site features and determine horizontal coordinates using a DGPS.
- Prepare chain-of-custody records and transport/ship the samples to the laboratory– ideally the same day or the day following collection.
- The augers and samplers should be cleaned between sampling locations. Typically, the driller is set up to do this using a steam cleaner, detergent solution, and tap water rinse.
- Collect and containerize any Investigation Derived Waste (IDW) such as wash water or drill cuttings.
- Once the final drilling depth is reached, samples have been obtained, and a well is not to be installed, the driller will grout the hole in accordance with WAC 173-160. Document the sealing method on the field log.

7.5. Sonic Core Barrel Samples

- Complete the one-call utility checks per Washington State Law. In many cases it may also be appropriate to retain a private locating surface to supplement the one-call "utilities" checks. In cases where sampling may occur close to buried utilities or if the locations are unsure, probing using a vac truck may be appropriate to confirm utilities are not present below the sampling location.
- Don appropriate PPE and safety vests as described in the site health and safety plan.
- Core barrels are typically either 4 or 6 inches in diameter and are used in combination with 6- or 8-inch diameter casing (4/6 or 6/8).
- Advance the core barrel ahead of the casing through progressively deeper intervals (typically 5-10 feet). Core barrels are typically 10-feet long with the goal being to collect continuous cores to the target depth.
- The core is extracted by withdrawing the barrel, tilting the drive-head/barrel at a slight angle from horizontal and gently vibrating the core into a clean tubular bag, being careful to maintain cohesion of the sample for an even extrusion. Care should be taken by the driller to limit the vibratory frequency of the extrusion so-as not to over disturb the sample.
- Lay-out the plastic tube bags containing the soil cores in order of recovery depth on a clean surface strong enough to retain the sample and avoid further disturbance and record the sample recovery length.
- Slice along the vertex of the plastic bag longitudinally to reveal the soil core. First collect samples for VOC analysis per EPA Method 5035. Typically from the mid-point of the target interval at the

center of the core, away from the outer rind. At this time also collect a portion of the same sample interval into a 1-quart plastic bag for headspace analysis.

- Transfer the portion of the core sample target interval soil into a bowl/pan and mix to a consistent color/texture. Place a portion into the laboratory supplied labeled container. Place containers in a chilled cooler. Conduct sheen testing on the remaining portion of the sample. If a limited volume of sample is available, use a portion of soil from the headspace plastic bag for sheen testing.
- Once the final drilling depth is reached, samples have been obtained and a monitoring well is not to be installed, the driller will grout the hole in accordance with WAC 173-160. Document the sealing method on the field log.
- Measure the sample location using a tape measure from prominent site features and determine horizontal coordinates using a DGPS.
- Prepare chain-of-custody records and transport/ship the samples to the laboratory– ideally the same day or the day following collection.
- Collect and containerize any waste materials such as wash water or drill cuttings.
- Once the final drilling depth is reached and samples have been obtained, the driller will grout the hole in accordance with WAC 173-160. Document the sealing method on the field log.

8. DOCUMENTATION

Soil sampling activities should be documented on the appropriate field forms. The forms should be maintained in the project file.

ATTACHMENTS – Soil Sampling Field Form (Log)

DALTON OLMSTED FUGLEVAND

Soil Sampling/Well Field Log

LOG OF

Sheet __ of __

PROJECT:	COORDINATES:	
LOCATION:	SURFACE ELEVATION:	
DRILLING CONTRACTOR:	DATE:	
DRILLING EQUIPMENT:	TOTAL DEPTH OF BORING:	
DRILLING METHOD:	LOGGED BY:	
SAMPLING METHOD:	RESPONSIBLE PROF.:	REG. NO.:
NOTES:		

DEPTH (feet)	SAMPLES				VISUAL SOIL DESCRIPTION	WELL CONSTRUCTION DETAILS, BORING SEALING AND/OR DRILLING REMARKS (Sketch Well Constuction Features)	
	Lab Sample	Sample Recovery	PID (ppm)	Sheen Test Result	Soil Group Name (USCS): color, moisture, density/consistency, grain size, other discriptors		
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

DEPTH (feet)	SAMPLES				VISUAL SOIL DESCRIPTION	WELL CONSTRUCTION DETAILS, BORING SEALING AND/OR DRILLING REMARKS
	Lab Sample	Sample Recovery	PID (ppm)	Sheen Test Result	Soil Group Name (USCS): color, moisture, density/consistency, grain size, other discriptors	
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						
40						
41						
42						
43						
44						
45						
46						
47						
48						
49						
50						

DEPTH (feet)	SAMPLES				VISUAL SOIL DESCRIPTION	WELL CONSTRUCTION DETAILS, BORING SEALING AND/OR DRILLING REMARKS
	Lab Sample	Sample Recovery	PID (ppm)	Sheen Test Result	Soil Group Name (USCS): color, moisture, density/consistency, grain size, other discriptors	
51						
52						
53						
54						
55						
56						
57						
58						
59						
60						
61						
62						
63						
64						
65						
66						
67						
68						
69						
70						

NOTES:

Equipment decon prior to install: _____

Drilling details: _____

_____

Screen details: _____

_____

Well details: _____

_____

Sand: Type: _____

Quantity: _____

Seal: Type: _____

Quantity: _____

Surface seal: _____

Monument: _____

Appendix C

Memo

PIONEER TECHNOLOGIES CORPORATION
5205 Corporate Ctr. Ct. SE, Ste. A
Olympia, WA 98503-5901
Phone: 360.570.1700
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www.uspioneer.com

To: Troy Bussey, Field Team Members

From: Stacy Munson

Date: July 18, 2016

Subject: XRF Field Screening Procedures, Former Arkema Manufacturing Site, Tacoma, Washington

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The purpose of this memo is to describe the field-portable X-Ray Fluorescence (XRF) unit procedures for real-time analysis of arsenic and other metals in soil at the former Arkema manufacturing site in the Port of Tacoma, Washington during Feasibility Study (FS) Data Gap Investigation field activities.

Introduction

The XRF sample preparation and analysis procedures were developed using United States Environmental Protection Agency (USEPA) Method SW846-6200 (USEPA 2007), the Innov-X Alpha/Delta XRF user instruction manuals (Olympus 2010), and the USEPA and Interstate Technology Regulatory Council (ITRC) Advanced Design Application & Data Analysis for Field-Portable XRF guidance (USEPA 2010). The Innov-X Alpha/Delta XRF unit (or equivalent) meets EPA SW846-6200 requirements and will be used to analyze samples.

XRF Unit Calibration

Calibration checks will be made on the XRF unit by the vendor supplying the unit, and before, during, and after field sample preparation and analysis. Calibration checks ensure that the precision, accuracy, and quantitation limits of the XRF unit are within quality assurance/quality control (QA/QC) standards. Standardization procedures details and frequency are presented in Table 1 and discussed below.

The vendor supplying the unit will be consulted to ensure it is factory-calibrated for analysis of arsenic and other metals in soil. A standard Alloy 316 energy calibration procedure will be performed before, during, and after all field sample preparation activities. Standard reference materials (SRMs) with the range of concentrations likely to be observed at the site will be utilized during calibration procedures in the field to ensure precision and accuracy in the data generated. Standard reference materials will be obtained from the XRF unit manufacturer, the vendor supplying the XRF unit, and/or the National Institute of Standards and Technology.

XRF Sample Preparation - Drying

Soil XRF analytical results can be biased low due to excess moisture because as soil moisture content increases, XRF-estimated metal concentrations will decrease. Therefore, soil samples will be dried to less than 20% moisture content in order to increase data quality (USEPA 2010).

Samples selected for XRF analysis will be placed into a dedicated convection-oven-safe metal pie pan (or equivalent) container and dried to less than 20% moisture in a convection oven before being homogenized and placed into a plastic bag for XRF analysis. A minimum of 5g of soil will be obtained for each sample. Moisture will be measured using a calibrated, decontaminated Decagon EC-5 (or equivalent) soil moisture probe and samples with moisture content greater than 20% will be dried further.

XRF Sample Preparation - Homogenizing

To ensure that soil XRF analytical results are not biased high or low, the soil samples will be sieved and homogenized to increase data quality. Dried samples will be passed through a decontaminated 1/4 in. (6.35 mm) sieve in order to remove large rocks and debris. The sample will be pushed through the screen using a decontaminated pestle. Large debris (e.g., sticks, roots, rocks, trash) that does not pass through the screen will be discarded. As samples pass through the 1/4 in. sieve, the samples will fall onto a piece of butcher or parchment paper. To homogenize the samples, the paper will be folded over by lifting alternating corners, one at a time, for a minimum of 20 corner lifts. Additionally, the mortar and pestle will be used to homogenize soils which may have adhered together while drying. Following homogenization the dried, sieved, homogenized samples will be placed in clear plastic sandwich bags for XRF analysis.

XRF Analysis Procedures

The drying and homogenizing sample preparation steps described above may be modified in the field, if other laboratory analyses are to be requested for a sample and drying activities would impact the soil matrix such that the analyses cannot be performed. In those cases, an initial homogenization and sample splitting step may be performed to preserve the original soil matrix conditions.

To ensure that quality arsenic and other metals analytical results are collected, the XRF unit will be secured in a "stand" that will hold it in place and reduce the chance for operator error. Square sample bags will be "shot" by the XRF four times, once in each quadrant. Two readings will be collected from diagonal quadrants, then the bag will be flipped over and readings will be collected from the other two quadrants. Each XRF analysis shot will be for 60 seconds. All readings (and the detection limits for those readings) will be recorded. Any sample with intra-quadrant readings with a difference greater than 40% will be re-homogenized and re-analyzed. If intra-quadrant analytical results still have a difference greater than 40%, it will be assumed that the variability was due to natural heterogeneity in soil.

The representative arsenic and other metals concentrations in a sample may be determined by calculating the 95% Upper Confidence Limit (UCL) on the mean using the four readings (USEPA 2010).

Following collection of XRF sample readings, the samples will be double-bagged. Additional analyses (if requested) will be documented on a chain-of-custody form and samples will be prepared for transport and submitted to the laboratory. Samples not identified for other analyses may still be sent to the laboratory for archive purposes.

XRF QA/QC Procedures

Data collection procedures and QA/QC procedures were identified to address XRF QA/QC metrics including bias, precision, accuracy, detection limits, quantitation limits, representativeness, and comparability. The QA/QC procedures presented in Table 1 will be performed at the frequency indicated and logged in the daily field notes. All QA/QC procedures that require XRF shots will be run for 60 seconds.

References

Olympus. 2010. User Manual. Delta Family: Handheld XRF Analyzers.

USEPA. 2007. SW-846 Test Method 6200: Field Portable X-Ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment.

USEPA. 2010. USEPA and Interstate Technology Regulatory Council (ITRC) Advanced Design Application & Data Analysis for Field-Portable XRF guidance.

Table 1: XRF QA/QC Procedures

Procedure Name	QA/QC Metric	Procedure Notes	Frequency				
			Every Sample	Beginning of Day	1 in 20 Samples	Every 4 Hours	End of Day
Sample Drying	Reduce bias by reducing soil moisture content to an acceptable level	Dry sample to less than 20% moisture content	X				
Sample Homogenization	Reduce bias by homogenizing sample	Sieve (1/4 in. or 6.35 mm) to achieve a uniform particle size and remove debris. Homogenize by folding the soil over on itself and mortar and pestle (as necessary).	X				
Default Instrument Calibration Procedure	Accuracy	Self-calibration is conducted during Innov-X Alpha/Delta startup using Standard Alloy 316 will be supplied by the XRF manufacturer.		X	X	X	X
Instrument Calibration Procedure Using Standard Reference Materials	Precision, Accuracy, and Quantitation Limits	SRMs will be sourced from standards agencies and arsenic and other metals concentrations will be consistent with Site conditions. Seven readings will be taken of all SRMs. SRM readings will be no greater than 20% different.		X	X	X	X
Determining Detection Limits	Detection Limits	Take readings of blank sample material (silicon dioxide sand) 7 times, find standard deviation, multiply by 3.143 to determine the minimum detection limits for arsenic and other metals and make sure they are less than action levels.		X			
XRF Shot Duration	Precision	Each XRF shot will be for 60 seconds.	X				
Number of XRF Shots per Sample	Accuracy	Four shots per sample	X				
Instrument Correction Factor for Elemental Interference	Quantitation Limit	Innov-X Alpha/Delta algorithm is run automatically.	X				
Sample Replicate Analysis	Precision and Representativeness	Take 3 readings from a sample at the same location on the baggie. All three sample results should be no greater than 40% different.			X		
Analytical Confirmatory Analysis	Comparability	Samples will be submitted for analytical analysis of total arsenic.			X		

Appendix D

Memo

PIONEER TECHNOLOGIES CORPORATION
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To: Arkema Team Members

From: PIONEER

Date: July 13, 2016

Subject: PIONEER Technologies Corporation Sample Number Schema

All:

The following sample number schema should be used on all PIONEER Technologies Corporation (PTC) projects:

MediaCode-SiteID-DateCode-TopDepth-BotDepth-(PTCTypeCode) – Be sure to use Dashes and Not Underscores

- Media Code = 2 Letter Code for Media Sampled At Location (see Table 1)
- Site ID = 1 to 10 Letter/Number Code for Site ID (with Dash between Site ID and Site ID # (e.g., MW-01)
- DateCode = 6 Number Code for Date (no slashes between monthdayyear)
- TopDepth = Optional but must have 1 decimal point max.
- BotDepth = Optional but must have 1 decimal point max.
- PTCSampTypeCode = Optional (see below)
    - (01) – For Field Duplicate/Replicate #1/Test Case #1
    - (02) – Replicate #2 or Test Case #2
    - (03) – Replicate #3 or Test Case #3
    - (04) – Replicate #4 or Test Case #4
    - (05) – Replicate #5 or Test Case #5
    - (06) – Replicate #6 or Test Case #6
    - (07) – Replicate #7 or Test Case #7
    - (08) – Replicate #8 or Test Case #8
    - (09) – Replicate #9 or Test Case #9
    - (10) – Leachate Sample
    - (20) – Dissolved Sample (i.e., filtered in the field or by the lab)

Note: PTCSampTypeCodes can be combined. For example, a PTCSampTypeCode of "(11)" indicates that the sample is a field duplicate of a leachate sample and a PTCSampTypeCode of "(21)" indicates that the sample is a field duplicate of a dissolved/filtered sample.

Examples:

- EF-EF-01-100112 – No Depth Interval
- EF-EF-01-100112-(01) – No Depth Interval & Field Duplicate Sample of EF-EF01-100112
- GW-MW-01-100112-10.5-20.5 – With Depth Intervals (10.5 to 20.5 feet)

- SO-SS-01-100112-0-0.5 – With Depth Intervals (0 to 0.5 feet)

Note: Examples of leachate and dissolved samples that require field duplicates or replicates:

- SO-SS-01-100112-0-0.5-(11) – Field Duplicate of Leachate sample with depth Intervals (0 to 0.5 feet).
- SO-SS-01-100112-0-0.5-(14) – Replicate #4 of Leachate sample with depth Intervals (0 to 0.5 feet).
- GW-MW-01-100112-10.5-20.5-(21) – Field Duplicate of Dissolved/Filtered groundwater sample with depth intervals (10.5 to 20.5 feet)
- GW-MW-01-100112-10.5-20.5-(23) – Replicate #3 Triplicate of Dissolved/Filtered groundwater sample with depth Intervals (10.5 to 20.5 feet).

Table 1 – PTC Media Codes for Sample Numbers

Media	Media Code for Sample Number	Description
Ambient Air	AA	Ambient Air
Asphalt	AS	Asphalt
Bituminous Coating	BC	Bituminous Coating
Brick	BR	Brick
Concrete	CO	Concrete
Dust	DT	Dust
Equipment Blank	EB	Equipment Blank
Effluent	EF	Effluent
Field Blank	FB	Field Blank
Field Spike	FS	Field Spike Sample
Groundwater	GW	Groundwater
Indoor Air	IA	Indoor Air
Influent	IN	Influent
Midpoint Between IN and EF	MD	Midpoint Between Influent and Effluent Samples
Other Liquid	OL	Non-specified Liquid
Other Solid	OS	Non-specified Solid
Performance Evaluation	PE	Performance Evaluation Sample
Perched Water	PP	Perched Water
Paint	PT	Paint, Paint Chips, Paint Flakes
Pore Water	PW	Sediment Pore Water
Sierra-Crete	SC	Sierra-Crete
Sediment	SD	Sediment
Stack Sample (Emissions)	SE	Stack Sample (Emissions)
Soil Gas	SG	Soil Gas, Soil Vapors, Sub-Slab Soil Gas
Sludge	SL	Sludge
Soil	SO	Soil
Seep Water	SP	Seep Water from Bank Samples
Surfacewater	SW	Surfacewater

Table 1 – PTC Media Codes for Sample Numbers		
Media	**Media Code for Sample Number**	**Description**
Trip Blank	TB	Trip Blank
Tap Water	TW	Tap Water, Drinking Water
Wood	WD	Wood Debris, Wood Waste
Waste Solid	WS	Investigation Derived Waste Solid
Waste Water	WW	Investigation Derived Waste Liquid
Treated Water	XW	Treated Water from Pilot Test, Treatability Study

Sincerely,

Chris Waldron

Appendix E

Health and Safety Plan
Expanded RTC Data Gaps Investigation Work
Former Arkema Manufacturing Plant
Port of Tacoma, Washington

Prepared for:
Port of Tacoma

DALTON OLMSTED FUGLEVAND

May 2023

Health and Safety Plan
Expanded RTC Data Gaps Investigation
Former Arkema Manufacturing Plant
Port of Tacoma, Washington

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Health and Safety Plan
Expanded RTC Data Gaps Investigation
Former Arkema Manufacturing Plant
Port of Tacoma, Washington

1. INTRODUCTION

This Health and Safety Plan (HASP) addresses the health and safety practices and controls that will be implemented by Dalton, Olmsted & Fuglevand Inc. (DOF) during their site characterization work at the Port of Tacoma's Arkema property. Activities addressed in this plan include investigation for the design for the Barrier Wall PDI and the investigation for the Expanded RTC Data Gaps.

The safety and health directives discussed herein apply only to DOF employees and their subcontractors engaged in the work activities mentioned above. Furthermore, this plan has been developed specifically for this project and should not be used in whole or in part for any other project unless such application is reviewed and approved by DOF management. This plan, however, will be updated as appropriate to account for changes in the scope of work and for new hazards discovered at the jobsite once work is underway.

Site work activities will comply with WAC 173-340-810 (of the Model Toxics Control Act) and applicable sections of WAC 296-843 and other relevant WISHA construction industry health and safety regulations. Where appropriate, specific WISHA standards will be referenced within the plan to highlight additional health and safety requirements not otherwise discussed. These standards are available on Washington L&I's Division of Occupational Safety and Health (DOSH) web-based homepage. The content of this plan and any relevant WISHA standards will be discussed with DOF project personnel before work begins. However, DOF management, its subcontractors, and its client do not guarantee the health or safety of any person entering this site. Because of the nature of this site and the many different activities occurring thereon, it is not possible to discover, evaluate, and provide protection for all possible hazards that may be encountered. Strict

adherence to the safety and health guidelines set forth herein will reduce, but not eliminate, the potential for injury at this site.

2. DESCRIPTION OF PROJECT

The Arkema property is currently contaminated with several chemical constituents that were released into the soil and groundwater from a chemical manufacturing plant that once occupied the site. To facilitate cleanup and development of the property it will be necessary to address identified site characterization data gaps by collecting new data on the site. These data collection efforts will involve a geophysical survey and collecting sediment, soil, surface water and groundwater samples. This field work will be implemented by DOF personnel and their subcontractors.

3. DOF PROJECT ORGANIZATION

DOF employees and their subcontractors working on site are expected to maintain vigilance at all times to ensure that the work is conducted in a safe and efficient manner. To provide an organizational structure that supports this objective, the following individuals are assigned specific responsibilities and lines of communication for the duration of this project.

3.1 On-site Field Project Manager (FPM)

The On-site Field Project Manager (FPM), David Cooper of DOF is responsible for overall administration of site field operations. His duties include directing DOF technical staff, coordinating the activities of on-site subcontractors, tracking budget, ensuring adequate resources are available to complete the work, resolving site safety and health issues as they arise, project planning, and maintaining communications between contractors, regulatory agencies, client, and off-site resources. The Field Project Manager reports directly to the Project Manager, Troy Bussey of Pioneer Technologies Corp. and indirectly to the Port of Tacoma project management.

3.2 Technical Lead

A technical lead may be assigned to each field team to supervise the well inventory and environmental sample collection work. The Technical Lead will also monitor compliance with applicable environmental regulations, WISHA standards, and other client-specific requirements. The Technical Lead will coordinate any DOF-related spill response activities that may be needed during the sampling work, inform site management of health and safety issues as they arise, document site activities, and verify that site personnel are adequately trained and qualified for the work. The Technical Lead reports directly to the FPM.

3.3 Site Health and Safety Officer

The FPM will act as DOF's Site Health and Safety Officer (SHSO) on the project. He is responsible for verification and overall compliance with this site health and safety plan (HASP). His duties include: 1) on site monitoring to determine appropriate levels and use of Personal Protective Equipment (PPE); 2) site surveillance, hazard identification, and health risk analysis; 3) implementation of procedures and programs to eliminate risk to site personnel including initiating changes to the HASP; 4) implementation of site control measures; 5) conducting and documenting daily health and safety briefings; 6) tracking health and safety issues in DOF field note book; 7) conducting incident investigations; 8) informing DOF site personnel of the contents of the HASP; 9) maintaining medical clearance letters and training documentation for site personnel; 10) conducting regular site safety inspections and; 11) exercising stop work authority when warranted by conditions. The Site Health and Safety Officer reports directly to DOF's Project Manager.

3.4 DOF Technical Staff

Each member of DOF's technical staff has the responsibility to report any unsafe or potentially hazardous situations to the FPM . They will maintain knowledge of the information, instructions, and emergency response actions contained in the HASP and comply with rules, regulations, and procedures established for the site. Site employees

are expected to stop work and contact their supervisor whenever they believe their work, or that of their coworkers, poses an uncontrolled hazard or unreasonable risk of injury or illness. Furthermore, each project participant is expected and encouraged to participate in the implementation of the environmental safety and health process through participation in meetings, incident reporting and investigations, inspections, hazard identification and hazard analyses.

3.5 Visitors

On occasion, appropriately authorized visitors may come to the site to observe the site characterization operations. Visitors may be from city, state, and federal regulatory and resource agencies that have a specific interest in the project. Before accessing the site, visitors will be briefed on the hazards of the site, contents of the HASP, site safety rules, hazard control measures, and required personal protective equipment. This orientation session will be documented on the Daily Site Briefing form. Visitors will also be expected to follow the direction of the FPM while on-site.

4. DOF WORK PLAN

As indicated in Section 1 above, DOF personnel will conduct activities which include investigation for the design for the Barrier Wall PDI and investigation for the Expanded RTC Data Gaps.

The investigation design for the Barrier Wall PDI activities include:

- Locating, identifying, and documenting utilities and other potential subsurface obstructions via surface geophysics and shallow trenching along the barrier wall alignment.
- Collecting one composite soil sample during shallow trenching along the barrier wall alignment and analyzing that sample for total metals and toxicity characteristic leaching procedure (TCLP) metals to evaluate on-site reuse and off-site disposal options for soil excavated from the trench.
- Advancing 15 soil borings along the barrier wall alignment and collecting geotechnical data (e.g., standard penetration tests, gradation analyses, Atterberg Limits, triaxial tests, consolidation tests).

- Evaluating different slurry mix design options.
- Completing compatibility testing for one or more slurry mix design options.

RTC Data Gaps Investigation activities include:

- Geophysical survey.
- Hydraulic profiling tool (HPT) borings.
- Plume core borings.
- Plume core Upper Aquifer groundwater samples.
- Plume core Intermediate Aquifer groundwater samples.
- Sequential extraction and pore water samples from plume core borings.
- Tidal fluctuation study.
- Shoreline Wedge borings.
- Shoreline Wedge Intermediate Aquifer groundwater samples.
- Sequential extraction and pore water samples from wedge boring.
- Surface Water and Intermediate Aquifer pore water and pushpoint samples.
- Additional plume core borings.
- Field x-ray fluorescence (XRF).

Push-probe or hollow-stem auger core sampling will be used to collect upland samples. Sediment samples potentially contaminated with arsenic will also be collected from the inter-tidal and subtidal region of the Hylebos Waterway that borders the eastern boundary of the Arkema property. This sampling will largely be conducted during low tides. Some sediment and pore water sampling will be conducted by commercial divers and some sediment samples may be collected from a boat. Note because of the very specialized nature of commercial diving, the divers will be responsible for preparing there own health and safety plan. This DOF plan will be supplemented to cover the over water sampling after a contractor has been selected. It is expected that sediments collected by the divers

and/or from a boat will not be highly contaminated and the primary health and safety issues will be associated with sampling over and in water.

5. SITE CHARACTERIZATION

This section presents an assessment of the chemical and physical hazards that may be encountered during the tasks specified in Section 4.0 of this HASP. Additional hazard control information can be found in the Activity Hazard Analyses table in Appendix A and in the listing of General Site Work Rules found in Appendix B. Site personnel will be informed of these hazards and the means that will be taken to control them prior to beginning work

5.1 Chemical Contaminants

Extensive environmental sampling of soil and groundwater has been conducted at the Arkema Site in the past by various environmental contractors. These samples were analyzed for a wide array of potential environmental pollutants, including metals, high and low molecular weight polycyclic aromatic hydrocarbons (PAHs), chlorinated and non-chlorinated volatile organic compounds, polychlorinated biphenyls (PCBs), pesticides, and petroleum hydrocarbons. It is highly unlikely, though, that most of these contaminants could present an exposure hazard to site personnel when compared that is, to WISHA's permissible exposure limits (PELs) where inhalation of the offending chemical agent is the exposure route of concern. This evaluation is based on the fact that the majority of site contaminants are relatively non-volatile (PCBs, lube oil) or for the most part consist of solids (metals, PAHs, pesticides, asbestos) and, at least with respect to the volatile organic and chlorinated compounds, are likely to be adsorbed onto the surface of the soil particles or are dissolved in the groundwater. The site is also well ventilated.

In addition, the majority of contaminants are present in soil and groundwater at relatively low concentrations. The volatile organic hydrocarbons detected in the site soils, for example, all have concentrations less than 1 ppm except for xylenes and isopropyl toluene, whose concentrations are 5 ppm and 8 ppm respectively. The maximum soil

concentrations of the PAH's were all less than 2 ppm while PCB levels were all less than 0.2 ppm.

Pesticide soil concentrations range from a high of 30,000 ppm for DDT to a low of 1900 ppm for DDE. And likewise, petroleum hydrocarbon soil levels are 4700 ppm (max.) for lube oil and 1800 ppm (min.) for gasoline. Even at these soil concentrations, though, airborne exposure levels could not reasonably be expected to exceed the PELs of these contaminants even under extreme ambient dust conditions (> 10 mg/m^3 total dust). The same can be said for all of the metals detected in the site soils except one – arsenic. Certain "hot spots" (Attachment A) in the waste disposal area contain arsenic in the site soils at a maximum concentration of 25,000 ppm while it's most common concentration throughout the site is less than 1,000 ppm. These hot spot areas are shown on Attachment A.

Several of the site contaminants present in the soil and groundwater, however, are substances which if exposed to the skin can to some degree be cutaneously absorbed into the body (see American Conference of Governmental Industrial Hygienists Threshold Limit Values with "Skin" notations) or produce other adverse dermal effects (i.e., dermatitis, skin cancer). These materials include PAHs, arsenic, nickel, mercury, antimony, and PCBs. Fortunately, the actual concentrations of these materials in these contaminated substrates are relatively low (ppm range) and, as such, are not likely to be hazardous from a skin absorption standpoint. Nonetheless, appropriate chemical protective clothing will be worn whenever the potential for significant dermal contact with these materials exists. Decontamination measures will also be instituted to further reduce contaminant contact and to minimize the spread of contamination in the work area.

A listing of current occupational exposure limits, primary toxicological effects, and relevant physical properties for each of the skin absorbable contaminates is presented in Table 5-1. It is important to note when reviewing this table that the physical and toxicological data contained therein are derived from studies on concentrated (pure) forms

of the contaminants and do not accurately represent the low level (ppm) exposure conditions which will be encountered by site personnel working on the project.

Table 5-1. Chemical Data

CHEMICAL	ACGIH TLV	WISHA PEL	ROUTES OF EXPOSURE	SYMPTOMS OF EXPOSURE	TARGET ORGANS	PHYSICAL DATA
Arsenic	10 ug/m^3	10 ug/m^3	Inhalation Ingestion Skin contact	Skin and eye irritation, resp. tract irritation, lung and skin cancer.	Kidneys, liver, skin, lungs, bone marrow, and lymph.	Sp.G.=3.74 BP= 869F MP=599F Reactivity: acids, bases, oxidizers, iron solutions, and zinc.
Antimony	0.5 mg/m^3	0.5 mg/m^3	Inhalation Ingestion Skin contact	Irritation of eyes, skin, nose, throat, mouth; cough, dizziness, headache, nausea, diarrhea, stomach cramps, insomnia, anorexia.	Eyes, skin, respiratory system, cardiovascular system.	Sp.G.=6.69 BP= 2975F MP=1166F Reactivity: acids, oxidizers,
Nickel	1.5 mg/m^3	1.0 mg/m^3	Inhalation Ingestion Skin contact	Resp. tract irritation, allergic contact dermatitis, conjunctivitis, asthma, lung and nasal cancer.	Skin, lungs, and sinuses,	Sp.G.=4.84 Reactivity: H_2O_2
Mercury	0.025 mg/m^3	0.1 mg/m^3	Inhalation Ingestion Skin contact	Resp. tract irritation, allergic contact dermatitis, asthma, skin and eye irritation, bronchitis, dyspnea, GI tract irritation, tremor, and weakness.	Central nervous system, kidneys, skin, lungs, and eyes.	Sp.G.=13.6 BP= 674 F Reactivity: Acetylene, ammonia, azides, calcium, sodium carbide, and copper
PAHs	0.2 mg/m^3 as coal tar pitch.	0.2 mg/m^3 as coal tar pitch volat.	Inhalation Ingestion Skin contact	Skin, eye, and respir. tract irritation, nervous system effects, skin cancer, teratogenesis.	Skin, eyes, respiratory tract, and nervous system.	Pyrene example: Sp.G.=1.27 BP=759F MP=313F Reactivity: acids and oxidizers.
PCBs	0.5 mg/m^3	0.5 mg/m^3	Inhalation Ingestion Skin contact	Eye irritation, liver damage, chloracne, Reproductive effects, potential human carcinogen.	Skin, eyes, liver, and reproductive system.	Sp.G.=1.38 BP=689 – 734 F VP=0.00006 Reactivity: Oxidizers.

LEL= Lower Explosive Limit F.Pt.=Flash Point VP=Vapor Pressure BP=Boiling Point
UEL= Upper Explosive Limit React.=Reactivity Sp.G.=Specific Gravity MP=Melting Pt.

5.2 Physical Hazards

Several physical hazards are anticipated to be associated with the planned work. These hazards included working around heavy equipment (i.e. drill rigs, backhoes), noise, thermal stress, slips, trips and falls, adverse contact with mechanical equipment and power tools, drilling, and physical injury from heavy lifting. A general discussion of the aforementioned hazards and the work practices that will be used to control them is presented below. A more detailed listing of hazard control strategies for specific tasks is included in the Activity Hazard Analysis (AHA) in Appendix A. This discussion is intended to point out the more obvious hazards reasonably anticipated on this project and assumes that any DOF subcontractor will be responsible for, and meet, all applicable OSHA/WISHA regulations and requirements to their work.

5.2.1 Noise

Noise levels in excess of 85 dBs are likely to exist near motorized equipment, such as, drill rigs and portable generators, operating in the work area. To evaluate and control this hazard, sound level measurements may be collected around each work area periodically throughout the duration of the project. If noise levels exceed 85 dBs and DOF personnel are exposed to these noise levels for the majority of their shift, then they will be required to wear hearing protection and comply with the hearing conservation requirements of WAC 296-817.

5.2.2 Slips, Trips and Falls

Tripping on equipment, uneven walking surfaces, and on debris left on the ground is likely to be a concern on this project. There are likely to be slip, trip, and fall hazards on-board the work boats from wet walkways, unsecured equipment left on deck, open hatches, and pitching and rolling actions of the vessels in rough water. These hazards may also exist on the dock where boats will be moored. In addition, there is a risk that workers could fall from equipment. Slip, trip, and fall hazards will be controlled by keeping the work area free of debris and other litter. Site workers will wear steel-toed safety boots and pay careful

attention to surface conditions to prevent trip and fall injuries. The work area will be inspected before the start of work each day to identify any hazards that could cause injury. The results of these inspections will be communicated to site personnel during the daily tailgate safety briefings. Workers will wear personal fall protection whenever they must work at heights 6 ft. or greater above the ground. These situations will be evaluated beforehand by the SSHO and an activity-specific fall protection plan will be drafted.

5.2.3 Thermal Stress

Because all site work will be conducted outside where temperature conditions vary, there is a risk that site workers could develop heat or cold stress. The likelihood of this occurring is dependent on environmental conditions, the level of work activity, and the personal control measures that are used to manage heat loads (work/rest cycles, use of clothing and/or cooling devices, hydration, etc.).

The planned soil and groundwater sampling work, however, is not likely to subject workers to significant heat stress risks unless low-permeability protective clothing is worn (i.e. Tyvek, raingear, etc.) during periods of warm weather. As such, modified Level D and Level C protective clothing will be worn only as necessary and for as short a time period as possible. In addition, workers will be encouraged to self-limit their exposures to heat stress conditions and have co-workers watch for signs and symptoms of heat strain in others. Shaded rest areas and chilled beverages will also be provided.

If visual monitoring indicates that a worker is suffering from heat stress, or if conditions/PPE requirements warrant, workers will be evaluated for heat strain by monitoring their heart rate, body core temperature, and heat strain symptomology. Excessive heat strain may be marked by one or more of the following measures, and an individual's exposure to heat stress will be discontinued when any of the following occur:

- Sustained heart rate is in excess of 180 beats per minute (bpm) minus the individual's age in years, for individuals with assessed normal cardiac performance, or

- Recovery heart rate at one minute after a peak work effort is greater than 110 bpm, or
- Body core temperature - as measured with an infrared ear drum scanner - is greater than 100.4°F, or
- There are symptoms of sudden and severe fatigue, nausea, dizziness, or lightheadedness.

Workers who appear to be disoriented or confused, or suffer inexplicable irritability, malaise, or flu-like symptoms will also stop work and rest in a cool location with rapidly circulating air and kept under skilled observation.

5.2.4 Drilling and Heavy Equipment Hazards

Light duty pickup trucks, backhoe and drill rigs will be used on site during the project. There is a potential for workers to be struck by these vehicles or to be injured by contact with exposed moving parts on mechanical equipment. To control these hazards, safe distances will be maintained between workers and mechanical equipment. Mobile equipment will be equipped with backup alarms and spotters will be utilized as necessary to direct equipment operators when moving and placing equipment. Personnel needing to approach heavy equipment while in operation will observe the following protocols:

- Make eye contact with the operator (and spotter).
- Signal the operator to cease heavy equipment activity.
- Approach the equipment and inform the operator of intentions.

All site workers will wear American National Standards Institute (ANSI) / International Safety Equipment Association (ISEA) 107-2004 Class II compliant reflective road vests when heavy equipment or vehicular traffic is in the vicinity. Workers will avoid standing in the blind areas behind vehicles, particularly when they are backing up.

The drilling subcontractor will ensure that the equipment they bring to the site is in proper working order and that all exposed, mechanical moving parts are appropriately

guarded. The driller will also follow such safe work practices as: conducting an underground utility search before drilling, parking their drill rig on level, stable ground with outriggers fully extended, keeping the drill rig's mast at least 15 ft. away from overhead power lines, not moving the rig while its mast is extended, keeping hands clear of the drilling auger, making sure emergency kill switches are operational, inspecting the drill rig before use, using only experienced drill rig operators, and shutting down and securing the drill rig when not in use.

Ambient dust conditions in the work area will be evaluated with a direct-reading, MiniRam dust monitor when using a backhoe to excavate soil from around the sheet pile wall. Action levels for these dust measurements are listed in Table 12-1. Full-shift personal exposure samples for arsenic will also be collected on representative members of the drilling crew when drilling under worst-case soil conditions in the Penite Pit. Results will be compared to arsenic's action (AL) level of 5 ug/m^3 and applicable sections of WISHA's arsenic standard (WAC 296-62-07347). Necessary exposure control measures will be implemented should the AL be exceeded. This exposure monitoring approach may be applied to other dust producing work activities on-site depending on site conditions and the level of work activity creating the dust hazard

To control dermal exposures to the contaminated drill cuttings, drill rig operators will wear the chemical protective clothing listed in Section 10.0.

5.2.6 Heavy Lifting

Site personnel will be cautioned not to lift or exert themselves beyond their physical ability and to apply proper ergonomic principles when doing their work. Each contractor on site will be responsible for monitoring the work practices of their employees to ensure that they are not over-exerting themselves or engaging in high risk, heavy lifting or repetitive motion activities. Mechanical lifting devices, such as, winches, pulleys, forklifts, hand carts, and dollies, should be used to lift and move equipment whenever feasible. Also, workers should enlist the help of others when lifting and moving

exceptionally heavy loads whenever the use of mechanical lifting devices is not feasible. As a matter of policy, DOF employees will not lift more than 50 lbs. individually. Other contractors on-site are encouraged to follow this rule, as well.

5.2.7 Hand and Power Tools

Heavy equipment operators may have occasion to use hand and power tools to operate or repair the equipment they bring to the site. They will ensure that their tools are inspected before use and are used in the proper manner by qualified individuals. Damaged tools must be tagged-out and removed from service. Only non-sparking or intrinsically safe tools must used in locations where sources of ignition may cause fire or explosion. Electrically powered tools using AC current must be GFCI protected. If portable generators are used to power tools and equipment, they must be placed outdoors, downwind and away from workers. Refueling will be done with the generator shut off. Internal combustion engines will be equipped with spark arresters.

5.2.8 Sediment Sampling From Boat

Operating boats or vessels on the water carries the risk of having a crew member fall overboard and possibly drown, striking or being struck by other vessels operating in the area, losing power or steering and drifting into hazardous areas (i.e. shore, marine facilities etc.) and encountering severe weather and dangerous seas, to name a few. The risk of a boating accident can be reduced by ensuring that boat operators are experienced; operating the vessel in compliance with Coast Guard rules and regulations; maintaining the vessel in good mechanical order; avoiding bad weather and dangerous seas; and ensuring emergency equipment is available on-board (i.e. life vests, life rings, life boats, fire extinguishers, communication equipment etc.)

To address these concerns, all work conducted from the sediment sampling boat will comply with all applicable Coast Guard regulations. Boats, will be operated by experienced crewmembers and all equipment will be inspected prior to use to ensure that it is in proper working order. The boat operator will be responsible for the safety of all personnel on the boat and for the integrity of the vessel and its safety equipment.

Prior to the start of field activities, the boat operator will give a detailed health and safety briefing on the location and use of all vessel safety equipment and the procedures for addressing on-board emergencies (i.e. fire, mechanical failure, man overboard situation, etc.) All sample boats will meet U.S. Coast Guard license and registration requirements and be equipped to safely support maximum rated crew and passenger sizes. The maximum number of passengers and weight shall be conspicuously posted on each vessel. The number of passengers shall not exceed the number of PFDs (personal flotation devices). Personnel working from the sample boat will be required to wear a Type II or equivalent PFD at all times. The sample boat will have at least one sound signaling device (air horn), a fire extinguisher, and at least one vessel mounted or hand held radio to communicate with shore-based support facilities and other vessels operating in the waterway. To avoid collision with other vessels operating in the area, boat operators will look for and avoid other vessels operating in the area at all times. Boating operations will be suspended during severe weather or rough seas.

5.2.9 Diving Operations

The placement and retrieval of pore water samplers and collection of sub-tidal sediment samples in the Hylebos Waterway will be conducted by commercial divers using surface-supplied air diving equipment. The diving contractor will be responsible for complying with all applicable requirements of WISHA's Commercial Diving Standard (WAC 296-37) and for providing a Safe Practices Manual before beginning work. This manual must include:

- Copy of WAC 296-37-520
- Safety procedures and checklists for diving operations;
- Assignments and responsibilities of the dive team members;
- Equipment procedures and checklists; and
- Emergency procedures for fire, equipment failure, adverse environmental conditions, and medical illness and injury.

In addition, the contractor will produce a Site-Specific Dive Plan for each diving operation that specifies the procedures that will be implemented, given current site

conditions, to comply with WISHA diving requirements and control health and safety hazards related to the diving work. Some of the more noteworthy regulatory requirements specified in the WISHA standard, as well as, other pertinent restrictions that must be addressed in the Dive Plan include the following:

- All surface-supplied air divers will be continuously tended and in 2-way voice communication with a surface dive team member. A standby diver will also be in attendance during the dives.
- No night diving will be allowed;
- No decompression diving, mixed gas diving, or diving conducted at depths greater than 100 feet are allowed.
- Decompression tables and a depth-time profiles, including when appropriate any breathing gas changes, will be maintained for each diver.
- No diving will be conducted in enclosed or physically confining spaces;
- No diving will be conducted against excessive currents (usually those exceeding 1 knot).
- No diving will take place if surface visibility is less than 300 feet.
- Dives must be terminated whenever communication is lost with the diver, diver fails to respond to a communication or diver requests that the dive be terminated.
- Divers must carry a reserve breathing gas supply.
- A list shall be kept at the dive location of the telephone or call numbers of an operational decompression chamber; accessible hospital; available physician; available means of transportation; and the nearest U.S. Coast Guard Rescue Coordination Center.
- A first aid kit appropriate for the diving operation must be available at the dive location along with an American Red Cross standard first aid handbook or equivalent and a manual bag-type resuscitator.

- To minimize hazards to the dive team, diving operations must be coordinated with other activities in the vicinity that could potentially interfere with the diving operation.

- A warning flag must be displayed at the dive site.

- Divers must be provided a means for entry into and exit from the water if the water cannot otherwise be accessed from the shore.

- Prior to diving, divers must be briefed on emergency procedures, communications, surface and underwater conditions and hazards, diving equipment and systems, breathing gas supplies and dive team assignments and fitness of dive team members.

- Dive team members must possess a nationally recognized diving certificate, have current certifications in first aid and CPR and be medically fit to perform their diving duties.

- A qualified person will be located at the dive site who will be in charge of all aspects of the diving operation affecting the safety and health of dive team members.

- Off-site communications for summoning emergency services will be available at the site.

5.2.10 Use of XRF Analyzer

A hand-held XRF analyzer will be used on-site to evaluate the metal content of the soil samples collected during the soil boring work. These instruments operate by generating a beam of X-rays that, when aimed at sample target, ionize the metal constituents of the sample causing the metal to fluoresce at very specific wavelengths which are then detected and identified by the instrument. Ionizing radiation can damage body tissues depending on the type and intensity of the radiation and duration of exposure. As such, several safety precautions will be taken to ensure project personnel are not injured when this instrument is being used. They include the following:

- Only properly trained and authorized personnel will be allowed to operate the instrument. They must have completed formal training in radiation safety and in safe instrument operating procedures. They will also be responsible for ensuring

that only authorized individuals have access to the equipment and that the instrument is secured, and locked when not in use.

- All reasonable measures, including labeling, operator training and certification, and the concepts of time, distance, & shielding, should be implemented to limit radiation exposure to as low as reasonably achievable (ALARA).

- Operators should minimize the time around the energized instrument, maximize the distance from the instrument window, and shoot into high density materials whenever possible.

- Restrict access to the location of instrument storage and use to limit potential exposure to ionizing radiation. Keep the instrument in a controlled location, where only trained and authorized users have access.

- Never point the instrument at a person, yourself, or hold a sample in your hand or point the instrument into the air when performing a test.

- Keep the test area clear of people for at least four to five feet in front of the analyzer. This no admittance zone should be a sufficient distance from the instrument's measurement window to allow ambient air to attenuate the x-ray beam. If necessary, use portable panels to shield others from radiation (for example, 1/8" stainless steel can attenuate the beam to background levels).

- When analyzing a sample, ensure that the probe (nose) of the instrument is firmly placed on the target and that no part of your body (including hands and/or fingers) is near the measurement window.

- Do not use the instrument if there is any chance that it is damaged or might leak radiation. In such a case, arrange for qualified personnel to perform a radiation safety test and repair any analyzer damage.

- If required by the operator's radiation safety program, the operator will wear a radiation dosimeter when using the XFR analyzer.

5.2.10 Dermal Contact with Contaminated Soil and Groundwater

Certain areas of the site contain significantly higher levels of contamination then the site in general. Such areas present a higher risk of dermal contact with the site contaminants depending on the nature and extent of the work activity (i.e. degree of contact with contaminated soil and groundwater). These areas will be identified before work begins and are illustrated on the attached site diagram, Attachment A. The SHSO will evaluate all work activities occurring within these work areas and determine if dermal contact with the soil and groundwater is excessive. If so, personnel working in these areas will be required to wear the chemical protective clothing specified in Section 10. They will also undergo decontamination before leaving the regulated area and they will wash their hands before eating, smoking or exiting the site.

6. SITE CONTROL MEASURES

6.1 Property Access and Site Security

Except for the shoreline that borders the Hylebos Waterway, the entire Arkema property is secured with cyclone fencing or other access controls. The fencing incorporates several gates with access roads that open to Taylor Way. DOF site management will control access to the work site by requiring all project personnel and visitors to check with site management and sign the Daily Site Briefing form for the day. These individuals will receive a site orientation briefing on site hazards, controls, emergency procedures, and general site rules, before they will be allowed to enter the jobsite. Visitors will be escorted by an authorized site representative at all times while on-site. They will also stay within designated walkways and behind fenced-off areas including work zones that have been secured with barricades, boundary tape or rope.

Regular site workers will receive site orientation training when first entering the site and attend daily site safety meetings thereafter. They will also follow the “buddy rule” (work with or in close proximity to another worker) when doing their work.

6.2 Regulated Work Areas

Because access to the Arkema site is controlled, and because there are no regular activities on the site, there is little chance of exposing the public to the anticipated work activity of soil/sediment/groundwater sampling. Consequently there generally will not be a requirement to establish additional regulated work areas while performing these activities. At soil/sediment/groundwater sampling locations were respirators are required, or where significant risk is associated with exposure to chemicals, then specific exclusion zones, contamination reduction zones, and support zones will be established as described below. These zones will be clearly marked and only properly trained and medically qualified personnel will be allowed to enter them. Smoking, eating, or drinking will only be allowed in the support zone.

6.2.1 Exclusion Zones

As required by site conditions, exclusion zones (EZs) will be placed around work areas as described below. As a minimum, EZs will be established around each drilling site and active groundwater monitoring and soil / sediment sampling location. EZs will be demarcated with warning tape or other equivalent means (for example cones, barricade, stanchions) and marked with warning signs. Only Hazardous Waste Operations and Emergency Response (HAZWOPER) trained and medically qualified workers wearing the necessary PPE as described in Section 10.0 will be allowed to enter the EZ. All site personnel will be accompanied by another crewmember when working in the EZ. Upon exiting the EZ, site workers will doff personal protective equipment (PPE) and wash their hands and face prior to eating, drinking, smoking or performing any other hand-to-mouth activity.

EZ locations will be altered to account for changing site conditions.

6.2.2 Contamination Reduction Zones

As required by site conditions, Contamination Reduction Zone (CRZ) will be established adjacent to each EZ to provide a secure area for decontaminating and removing the

protective clothing worn by those site workers working in the EZs. The CRZs will be equipped with the following equipment, as necessary.

- Chairs or benches for the workers to sit on when removing their clothing
- Wash buckets and brushes for cleaning protective clothing and tools
- First Aid Kit
- Bloodborne pathogen kit
- Air horn (or other emergency alert signal)
- Fire Extinguisher (ABC Type, at least five pound size)
- Spill Kit
- Eyewash station
- Hand wash station (or equivalent materials)
- Containers appropriate for containing used PPE
- Additional PPE components (for example, additional disposable gloves or hearing protection)

6.2.3 Support Zone

As required by site conditions, all areas outside of the exclusion and contamination reduction areas will be considered the support zone (SZ). The SZ will include equipment and material storage areas, employee break areas, temporary office facilities, etc. and will be considered open access for site personnel. No special access requirements other than the general security requirements will be required for access to the SZ.

7. COMMUNICATIONS

Communications at the jobsite will be by verbal command, hand signals, cell phone, or a combination of all three. DOF personnel will carry with them cellular telephones and a listing of emergency telephone numbers. These phone numbers are listed in Section 13 of this plan. Copies of these phone numbers will be available at each operational work area.

In the event of an emergency requiring evacuation, the Emergency Coordinator will verbally alert each contractor working on-site to immediately proceed to the designated staging location for a head count and for further instructions on exiting the site.

8. TRAINING AND RECORDKEEPING REQUIREMENTS

Site personnel directly involved in soil, sediment, surface water and groundwater sampling or other site workers who could potentially incur significant dermal or inhalation exposures to the site contaminants will have completed at least 40 hours of hazardous waste operations training, as required by 29 CFR 1910.120/1926.65. These individuals must also have received a minimum of three days of actual field experience under the direct supervision of a trained, experienced supervisor. Those personnel who completed the 40-hour training more than 12 months prior to the start of the project will have attended an 8-hour refresher course within the past 12 months. The Field Project Manager, Site Supervisor (including subcontractor supervisors), and the SHSO must have completed an additional 8 hours of hazardous waste site supervisor training.

A copy of the training completion certificates for each employee (including subcontractors) working in either the EZ or CRZ will be maintained at the project office. All personnel working on site will receive site orientation training that will include a discussion of each element of this HASP and all of its attachments. At least one site worker, who has current first aid/cardiopulmonary resuscitation (CPR) training, will be on site at all times when work is underway. The aforementioned training requirements and other mandatory training and certifications required for this project are summarized in Table 8-1.

Table 8-1 Summary of Training Requirements

Personnel	Requirements
SHSO, Field Project Manager, and Site Supervisors	• 40-Hour HAZWOPER, 3 days of supervised field experience training, current 8-hour refresher training • Bloodborne pathogens awareness • Fire extinguisher training [29 CFR 1910.157(g)]

Personnel	Requirements
	• 8 Hr. Site Supervisor Course (29 CFR 1910.120 p. (e)(8)) • First Aid/CPR training • Hearing protection training [29 CFR 1910.95(i),(k)] and hearing conservation program • Site- specific training (including hazcom training)
Technicians working in the EZ or CRZ (includes laborers, scientists, engineers, technicians, etc.)	• 40-Hour HAZWOPER, 3 days of supervised field experience training, current 8-hour refresher training • Hearing protection training [29 CFR 1910.95(i),(k)] and hearing conservation program • Bloodborne pathogens awareness • Fire extinguisher training [29 CFR 1910.157(g)] • Site specific training (including hazcom training)
General site workers **not** working in the EZ or CRZ (includes laborers, scientists, engineers, technicians, etc.)	• Hearing protection training [29 CFR 1910.95(i),(k)] and hearing conservation program • Bloodborne pathogens awareness • Fire extinguisher training [29 CFR 1910.157(g)] • Site specific training (including hazcom training)
Subcontractors and Visitors (not operating in an area where a potential for exposure to contamination exists)	• Site safety brief / safety awareness training

CPR = cardiopulmonary resuscitation

8.1 Site Specific Training

Prior to starting work, each employee will receive site specific health and safety training. The SHSO, or designee, will provide and document site-specific orientation training during the project site kickoff meeting and whenever new workers arrive on site. No site workers will be allowed to begin work on site until the site-specific training is completed and documented by the SHSO. This training will address this HASP and health and safety requirements and procedures pertinent to site operations.

As part of the site-specific orientation training, the following topics will be covered:

- Project introduction and orientation
- Potential site hazards (chemical, physical, and biological)

- Hazard Communication as per 29 CFR 1910.1200 (particularly arsenic hazard awareness training)
- Selection, use, and limitation of PPE
- Emergency procedures
- Contents of the HASP

8.2 Hazard Communication Training

Material Data Safety Sheets (MSDS) will be kept in Appendix C of this HASP for each hazardous chemical used during the project. These MSDSs will be made available to each employee on request. Employees will also be informed about any site operations involving the use of hazardous chemicals, the hazardous nature of the chemicals used, and the location of the MSDSs. Workers who are exposed to hazardous chemicals will be trained to recognized chemical contact hazards in the workplace, the physical properties and health hazards of hazardous chemicals, and the personal protective measures that will be taken to control exposures. All chemical containers used to store hazardous chemicals will also be marked or labeled with the name of the chemical and its hazard warning.

8.3 Emergency Response Training

Personnel on this project will not respond to off-site releases of hazardous materials, structural or major fires, or other catastrophic incidents. Project personnel will only respond to on-site incidents within their training and competency. On-site response training during initial orientation, as well as periodic drills and reviews at each work area will include:

- Employee alarm system
- Evacuation procedures, routes, meeting places, and accountability
- Control of fuel sources
- Fire extinguisher education (No employee is permitted to attempt to fight a fire beyond incipient stage.)

- Minor spill control/cleanup on site in accordance with the plan. This may include source control (e.g., shutoffs, repositioning containers); containment (e.g., drum overpacks, sorbent booms, earthen dikes); and non-emergency cleanup (e.g., sweeping, digging, pumping, and containerization of spills and residues).
- Rescue operations, as necessary

8.4 First Aid and CPR Training

At a minimum, one site worker per work shift will have received first aid and CPR training taught by a certified instructor and approved by an organization such as the American Red Cross. Persons trained in first aid and CPR shall have received instruction on bloodborne pathogens according to 29 CFR 1910.1030. Site-specific briefings will include information about bloodborne pathogen hazards, and the SHSO will keep a record of all site personnel having such training.

On-site medical emergencies will be handled as discussed in the Emergency Response Plan (Section 13). Type III, 16-unit first aid kits that comply with the criteria contained in ANSI Z308.1-1998 will be located on site and in each of the site vehicles, where possible. Bloodborne pathogen barrier kits containing latex gloves, CPR barrier, masks, and eye protectors will also be staged with the first aid kits. They will be inspected weekly and replenished as necessary.

8.5 Tools and Equipment

Any worker using a specific tool must have had training on the proper use of the tool. For tools having common use in construction activities, a visual observation by a supervisor is sufficient to document that worker is knowledgeable of general trade tools (screwdrivers, hammers, pliers, wrenches, etc.). Workers operating heavy equipment must have training or equivalent experience in operating that equipment Training in the operation of forklifts requires training specified in 29 CFR 1910.178, which includes

recertification on a periodic basis. A certificate of training in compliance with this regulation is required in the employee's training record.

8.6 Safety Meetings

Site safety briefings will be conducted prior to the start of work each day. During these sessions, each worker (subcontractors included) will be encouraged to share their observations, thoughts, and experiences on safety and health-related issues pertinent to the jobsite. This venue also allows site management to share important hazard communication topics with the workers, such as plan-of-the-day activities and associated hazards and controls, required use of PPE, decontamination procedures, emergency procedures, safe work practices, and HASP changes.

The SHSO will conduct these briefings at the start of each shift. Site briefings may be repeated during the day if new hazards arise, which must be communicated to site personnel, or if other workers arrive at the jobsite later in the day. It is at this meeting that site workers will review the AHA for the tasks to be performed that day. A Daily Site Briefing form will be used to document these meetings and will include a listing of topics discussed, hazards identified, recommended remedial controls, other pertinent issues, and the names of all attendees. The information gathered in these sessions will be used to correct any unsafe conditions or work practices at the jobsite and amend the SSHP as appropriate. Copies of Daily Site Briefing forms will be maintained in the project files. A copy of this form is included in Attachment C.

8.7 Recordkeeping Requirements

In accordance with the recordkeeping requirements of 29 CFR 1910 and 1926, and DOF's Health and Safety Program, the following health and safety documents will be generated and maintained at the jobsite or project office:

- Daily Tailgate Safety Briefings
- Medical clearance letters

- Training course certificates (i.e. 40Hr. Hazwoper, 8Hr. Refresher, First Aid/CPR, etc.)
- Respirator fit test forms
- Accident report and investigation forms.
- MSDS sheets
- DOF project field notebook
- HASP review declaration
- Weekly and monthly site inspection forms

Copies of these forms are included in Appendix C.

8.8 Inspections

The SHSO will conduct informal daily inspections of the jobsite. The results of these inspections will be recorded in the DOF project field notebook. Safety and health inspections will also be conducted each week by the Field Project Manager and every month by the Project Manager or their designee. Inspection results will be recorded on the "Project Inspection Checklist" found in Appendix C. Copies of the inspection reports will be kept on file for review by the PHSM.

Deficiencies noted during these inspections will be recorded in DOF's project field notebook . Each deficiency will be corrected by a designated authority according to a pre-assigned completion date. Copies of the inspection findings will be sent to the Project Manager for evaluation and correction of any deficiencies.

9. MEDICAL SURVEILLANCE

DOF site personnel and subcontractors who are exposed to hazardous substances on this project will participate in either DOF's Medical Surveillance program or in a comparable surveillance program chosen by their employer that meets the requirements of 29 CFR 1910.120(f). This program requires a complete pre-employment physical with associated laboratory tests and a drug screen. DOF site personnel must have passed this

examination and have a copy of their medical clearance on file at the site before they will be allowed to enter the EZ or CRZ. This clearance letter, applicable to both DOF and subcontractor personnel, must include the physician's opinion as to whether the employee has any detected medical conditions which would place the employee at increased risk of material impairment of the employee's health from work in hazardous waste operations or emergency response or from respirator use. It must also list any limitations upon the employee's assigned work.

An annual or biennial physical examination (as determined by the occupational health physician) is also required for all personnel participating in this program. Additional physical exams will be made available to program participants who terminate their employment with DOF or who are reassigned to a job position, which does not require participation in the program.

The medical examinations will be provided by a licensed physician, preferably one knowledgeable in occupational medicine, in accordance with 29 CFR 1910.120 (f)(5).

10. PERSONAL PROTECTIVE EQUIPMENT

Prior to the start of work, the SHSO will review the applicable work plans, site historical records, remedial investigation results, etc. and evaluate each major work activity to determine the appropriate level of PPE needed for the work. This evaluation will include a consideration of potential chemical, physical, and biological hazards present; work operations to be performed; potential routes of exposure; concentrations of contaminants present; and characteristics, capabilities, and limitations of PPE, including any hazards that the PPE may create or exacerbate (i.e., heat stress). Evaluation findings and recommendations for the project, to date, are listed in the AHA tables found in Appendix A.

The SHSO will also evaluate PPE usage at the jobsite on a daily basis and determine the necessary PPE for specific activities or portions of activities not included in the AHAs. If

necessary, the HASP will be amended to reflect new or modified PPE requirements. All PPE changes will be communicated to site personnel during the daily site briefings and hazard communication training sessions. At a minimum, though, all field activities will require the use of ANSI-approved hard hats, safety glasses, safety-toe footwear; short-sleeve shirts; and long pants and ANSI / International Safety Equipment Association (ISEA) 107-2004 Class II compliant reflective road vests.

Three different levels of PPE—Level D, modified Level D, and Level C —will be available for use during the planned project activities. The PPE components that make up these levels are listed below.

10.1 Level D

For activities not presenting a risk of significant contact with contaminated sediment, soil or groundwater, site personnel will wear Level D consisting of:

- Standard work clothing (long pants and short or long sleeve shirt), gloves (as appropriate), ANSI-approved hard hat and safety glasses
- Chemical-resistant boots or leather work boots with safety toe (as appropriate)
- Hearing protection as required
- ANSI/ISEA 107-2004 Class II reflective road vests where equipment traffic is present
- Leather work gloves

Site operations that are likely to result in minimal contact with contaminated soil and groundwater include operating mobile equipment, working in the SZ, and working in areas where airborne contaminant levels are below PELs. Personnel performing these tasks will wear Level D PPE unless the SHSO determines an upgrade is necessary.

10.2 Modified Level D

Modified Level D will be worn by those site personnel directly engaged in activities that could result in significant skin contact to contaminated sediment, soil, and groundwater. This includes the "hot spot" areas identified on Attachment A in the vicinity of the Former Penite Pit Areas discussed in section 5.1. Also, personnel assigned to assist in decontaminating these individuals will wear the same level of PPE. Modified Level D will consist of the following items:

- Disposable Tyvek coveralls or lightweight neoprene raingear or PolyTyvek coveralls if contact with liquid is possible.
- Nitrile gloves
- Rubber boots with steel toes or leather steel toe boots with chemical resistant boot covers.
- Hard hat
- Safety glasses
- Hearing protection as required
- ANSI/ISEA 107-2004 Class II reflective road vests worn on the outside of the coveralls in areas of equipment traffic.

Workers directly engaged in manually handling contaminated sediment, soil or groundwater (such as, drillers and sampling technicians) in the designated exclusion zones and those who repair equipment that is soiled have the greatest potential for contacting site contaminants.

10.3 Level C

Level C will be worn if the air monitoring results described in Section 12.0 indicate that an inhalation exposure hazard (in addition to a skin contact hazard) to volatile organic vapors or arsenic contaminated dust in excess of the specific action levels listed in Table 12-1 exist at the site. Level C will consist of the Modified Level D clothing specified above plus a full-face air purifying respirator (APR) equipped with organic vapor / HEPA

cartridges. Cartridges will not be used beyond their calculated end-of-service-life and at a minimum will be discarded at the end of each day.

Efforts will be made to eliminate airborne exposure hazards before resorting to the use of respiratory protection by, for example, allowing vapor emissions to dissipate before resuming work, using water to wet the ground to control dust release, and using exhaust fans to dilute potentially toxic or explosive atmospheres.

10.4 Respirator Use Requirements

All DOF personnel who must wear half-face air purifying respirators (APR) will receive a qualitative fit test in the exact same model, type, and size respirator to be used on the project prior to starting work. Fit test records will be kept on-file at the jobsite. Fit testing will be repeated every twelve months. Only medically qualified personnel will be allowed to use respiratory protective equipment. Medical clearance letters indicating the worker's ability to a wear respirator will be maintained at the jobsite.

Respirator users will also be trained in the selection, use, limitations, and maintenance of the respirators they have been assigned. This training is typically included in the worker's 40 Hr. Hazwoper training course and 8 Hr. Refresher training. Re-training on this subject, however, will be offered to anyone unfamiliar with the aforementioned topics.

Each respirator user on the project will be issued and fit tested in their own respirator which will be issued to them before work begins. They will be responsible for properly cleaning, inspecting, maintaining, repairing, and storing this equipment. Respirators will be cleaned in the manufacturer's recommended cleaning and disinfecting solution after each use. They will then be dried, placed in plastic bags and stored on-site for future use. Each storage bag will be identified with the respirator user's name. The Site Safety and Health Officer will conduct periodic inspections of all operations requiring the use of respirators to ensure the aforementioned respirator use requirements are being implemented.

10.5 PPE Use and Maintenance

Employees assigned to use PPE are required to inspect the equipment before and after each use, discard any equipment that is defective, clean and maintain the equipment according to manufacturer's recommendations, and store their PPE in a clean, secure area. Specific PPE inspection, cleaning, and maintenance procedures vary according to the type of equipment being used. Employees will be informed of these equipment-specific use and maintenance procedures prior to being assigned to their jobs. Training in PPE equipment inspection, cleaning, and maintenance protocols will be provided during the requisite 40-Hour Hazardous Waste Operations course and in the site-specific orientation training conducted by the SHSO. Employees will practice use and inspection of PPE before entering an EZ.

At the end of each shift, the SHSO will examine the inside of a representative sample of protective garments before they are discarded or cleaned to identify evidence of breakthrough. Such evidence would include any discoloration or staining of the clothing; thinning, blistering, or cracking of the clothing material; and the presence of torn seams and perforations. The SHSO will also note if the workers themselves have become contaminated while wearing the PPE. If, based on this examination, it is apparent that the PPE designated for the work is not adequately controlling worker exposures, the level of personal protection will be upgraded.

11. DECONTAMINATON

11.1 Personnel Decontamination

Decontamination for site personnel wearing Level D PPE will consist of having workers remove their hard hats, safety glasses, leather gloves, hearing protectors, and outer protective garments prior to leaving the site and storing them in a clean area for reuse the next day.

Site personnel engaged in activities requiring Modified Level D and Level C PPE will be required to wash their boots and remove their gloves when leaving the EZ. Disposable coveralls will be placed in a designated container for disposal. Workers will wash their hands and face before leaving the CRZ. Respirators, if worn, will be removed last and placed in plastic bags for later inspection, cleaning, and storage. Separate areas for storing street clothing and changing into and out of chemical protective clothing will be determined at the jobsite should level C or modified level C be required.

Personnel decontamination will be conducted in a CRZ situated adjacent to and contiguous with the EZ. A washtub will be placed in the CRZ for workers to use during the decontamination process. Scrub brushes and soap solution may be used to remove soil from clothing. Wash and rinse water will be managed and disposed of as discussed in the Site Work Plan.

The SHSO will ensure that the above-mentioned decontamination procedures are effectively controlling the spread of contamination in the work area by periodically inspecting the recently cleaned clothing and equipment for evidence of residual contamination. The work area also will be examined to detect any sign of contamination outside of the work zones. Should it become apparent that contamination is being dispersed into clean areas of the site, work activities will cease until more effective decontamination methods can be devised.

11.2 Equipment Decontamination

Decontamination of hand tools and heavy machinery will be performed prior to leaving the site or at the conclusion of site activities. Equipment will be cleaned of gross materials using hand tools and brushes and will then be sprayed with water, as necessary. To the greatest extent possible, rinsates will be maintained within the consolidation area or containments. General cleaning of equipment and tools where contact with contaminated materials has not occurred will not be considered decontamination and will

not require containment of rinsates. Generation of dust will be minimized to the greatest extent possible.

12. AIR MONITORING

Ambient air measurements for volatile organic vapors will be collected in the breathing zone of site workers when sampling monitoring wells and collecting soil core samples in areas that are known to be contaminated with volatile organic hydrocarbons. The purpose of this monitoring is to ensure that: 1) vapor levels do not pose an inhalation hazard to site personnel, 2) the appropriate level of PPE is being used, and 3) potentially explosive environments do not exist.

Organic vapor levels will be measured with an organic vapor analyzer, such as a PID or FID. As indicated in Table 12-1, total organic vapor levels equal to or less than background will be considered acceptable. Vapor levels in excess of this limit will require that work temporarily stop until vapors dissipate, effective engineering controls are implemented, or workers wear Level C PPE.

Collecting soil borings within the data-gap evaluation area is the only other work activity that presents a noteworthy contaminated dust exposure hazard. However, because relatively small amounts of soil are unearthed and handled during the drilling process, dust exposure levels are expected to be low. Past personal exposure monitoring on drilling personnel collecting soil borings at the site in 2012 and field soil analysis operations with an XRF analyzer in 2017 showed exposure results well below the Action Level and Permissible Exposure Limit for arsenic. Similar exposure monitoring conducted on drilling and sampling personnel within the former Penite Pit Area in 2017 also showed identical results.

Air sampling for arsenic will be conducted as per the National Institute for Occupational Safety and Health (NIOSH) Sampling and Analytical Method 7300. Exposure monitoring samples will be sent to an American Industrial Hygiene Association (AIHA)

accredited laboratory, NVL Laboratories, Inc. in Seattle, Washington for analysis. Air monitoring results will be recorded in the site field logbook and will be made available for review by all site personnel. Personnel will be notified of any levels of concern verbally upon receipt of the results or through discussions during the next daily safety meeting. Employees who had their personal exposures to arsenic measured will receive a written letter with their test results. This letter will be delivered no later than five days after receipt of air monitoring results.

Calibration and maintenance of monitoring equipment will be done by the SHSO in compliance with the manufacturer's specifications and will be performed prior to daily monitoring. Calibration records will be kept in the project health and safety files. All direct reading air sampling results from the previous day will be discussed with the site crews at the morning tailgate safety meeting.

The above-mentioned instrument readings will be compared to the actions levels listed in Table 12-1.

Table 12-1 Air Monitoring Action Levels

Monitoring Instruments	Activity	Action Level	Site Action
Organic Vapor Analyzer (PID or FID)	• Drilling soil borings. • Constructing groundwater monitoring wells. • Purging and sampling wells. • Working in VOC contaminated soils	≤ background > background but ≤ 10 ppm. >10 ppm	• Continue working • Wear Level C PPE or stop work until vapors are ≤ background. • Discontinue work • Shut down equipment • Evacuate area • Call Project Manager

Personal exposure monitoring for arsenic	• Drilling soil borings. • Constructing groundwater monitoring wells. • Other significant dust generating activities.	≤ 0.005 mg/m^3 As > 0.005 mg/m^3 As but ≤ 0.01 mg /m^3 As > 0.01 mg/m^3 As but ≤ 0.03 mg/m^3 As >0.03 mg/m^3 As	Wear Modified Level D Medical Monitoring Biological Monitor. Hazcom Training Decontamination and Change areas Wear Level C Comply with WAC 296-62-07347. Suspend work and call PHSM.
Combustible Gas / H_2S Indicator	Drilling soil borings and installing wells in slag pile.	< 10% LEL > 10% LEL < 20 ppm H_2S ≥ 20 ppm H_2S	Continue or resume working Stop work, shut down equipment, isolate ignition sources, evacuate immediate work area. Inert auger as appropriate to control explosive atmosphere. Continue or resume working Evacuate immediate work area.
MiniRam Dust Monitor	Sheet pile wall soil excavation and inspection.	< 2.5 mg/m^3 > 2.5 mg/m^3 but < 5.0 mg/m^3. > 5.0 mg/m^3.	Continue working Implement dust control measure and/or have site personnel wear Level C PPE. Stop work and evacuate site.

13. EMERGENCY RESPONSE

There is a possibility that DOF personnel or their contractors could experience a medical emergency in the normal course of their work or, perhaps, spill fuels and lubricants used to service their equipment. For these emergencies, the following emergency response plan has been drafted. It will be discussed with all project personnel during their initial site orientation training. A copy of the Emergency Response Plan (this section) and a map to the emergency medical facility (Appendix E) will be readily available in each work area.

A listing of emergency response contacts for this project is presented in following table:

13-1. Emergency Response Contacts	
Site Address: 2901 Taylor Way Tacoma, WA	
Hospital:	
St. Joseph's Medical Center 1717 South J Street Tacoma, WA 98405	(253) 426-4100
EMT/Ambulance	911
Pierce County Sheriff's Dept.:	
Emergency	911
Business	(253) 798-4721
Tacoma Fire Dept.:	
Emergency	911
Business	
US Coast Guard	(206) 217-6000 or VHF chnl 16
DOF Field Project Manager, Dave Cooper	Cell: (206) 660-3466
DOF Emergency Coordinator, Dave Cooper	Cell: (206) 660-3466
Pioneer Project Manager, Troy Bussey	Cell: (360) 528-3057
Port of Tacoma Security (after hours)	(253) 383-9472
Port of Tacoma Security (Agnes TooToo)	Cell: (253) 571-8872
National Response Center	800-424-8802
Dept. of Ecology	800-258-5990

13.1 Emergency Coordinator

DOF's Technical Lead will be the designated emergency coordinator responsible for implementing this emergency response plan. This person will notify emergency

responders during a medical emergency (ambulance, hospital, etc.) or spill incident and ensure that the client and all affected project contractors are made aware of any emergencies occurring on-site. DOF's Technical Lead will initiate emergency evacuation procedures, as appropriate, and ensure that injured DOF employees are given emergency medical treatment and are transported to the hospital for follow-up treatment.

The emergency coordinator will conduct an inspection of emergency response equipment every month. This equipment includes fire extinguishers, first aid kits, and spill control equipment. As part of the daily site walk-through, he/she will pay close attention to potential fire hazards, spill potentials, and individual work practices. Emergency response equipment will be stored at an easily accessible location in the work area. Monthly fire extinguisher checks will be documented, either on the fire extinguisher or in the SHSO logbook.

13.2 Site Evacuation

Should a serious or catastrophic situation arise on site, such as but not limited to, an uncontrollable fire, airborne release of flammable or toxic chemical, hazardous liquid spill, significant injury to site personnel, and major earthquake or explosion, the jobsite will be evacuated. Site personnel will be notified of an evacuation through direct communication.

If an evacuation is necessary, all site personnel will proceed immediately to the entry gate to the site on Taylor Way. The emergency coordinator will be informed of the emergency and a head count of all assembled site personnel will be taken. Once everyone is accounted for, they will evacuate further to a safe area designated during site orientation training and the emergency coordinator will assess the situation and outline the actions to be taken.

During the emergency, the emergency coordinator will:

- Ensure injured personnel are given first aid treatment, as appropriate.
- Shut down equipment that could cause a hazard or act as an ignition source;
- Notify applicable emergency response services.
- Prohibit unauthorized personnel from entering the evacuated area by calling Port of Tacoma Security.
- Provide emergency equipment as appropriate; and
- Notify the project manager and client of the incident.

13.3 Environmental Incident (Spill)

Each contractor working on-site will be responsible for containing, controlling, and cleaning up any spills they create. Except for collecting environmental samples, DOF will not be engaged in any work activities that could result in the significant release of hazardous materials into the environment. Spills associated with drilling activities would likely result from the release of diesel fuel, lubricants, or hydraulic fluid into the water from the refueling or maintenance of their equipment. Should such an event occur, the Technical Lead will isolate the spill area; identify the nature and hazardous properties of the spilled material (i.e. reference MSDS sheets); notify site management of the situation; don appropriate personal protective equipment and; contain and control the spill using plugs, patches, containment boom and absorbants, etc.

A small spill, less than 5 gallons, will be handled by the responsible contractor. For spills greater than 5 gallons, the responsible contractor or DOF will call the local emergency response hazmat team (Fire Dept.) for assistance. The heavy equipment contractor will have on hand appropriate spill control equipment consisting of sorbent pads, sorbent boom, vermiculite, duct tape, large plastic bags, shovel, and one 55-gallon drum (or two 35-gallon drums). This spill kit will also include personal protective equipment, such as, disposable PolyTyvek coveralls or lightweight PVC raingear, nitrile gloves, PVC boot

covers, and chemical protective goggles. This equipment will be staged at each major work area.

Any spills that occur in the water will be reported to the appropriate regulatory authorities (i.e. Coast Guard, EPA, Dept. of Ecology, etc.) They will direct on-site cleanup resources and efforts.

13.4 Explosion

In the event of an explosion, all non-essential personnel will be evacuated from the site and the work area will be secured. No one will be allowed to re-enter the site, except to possibly save a life, until cleared by the emergency coordinator. If adjacent properties are threatened by the explosion, local emergency response authorities will be called to evaluate the situation and possibly initiate an evacuation of the surrounding community.

13.5 Personal Injury

In the event of serious personnel injury (fatality, patient unconscious, possibility of broken bones, severe bleeding, burns, blood loss, shock, or trauma), the first person on-scene will immediately:

- Administer first aid if qualified; if not qualified, seek out a person qualified to administer first aid; and
- Notify the emergency coordinator of the name of the individual involved, their location, and the nature of injury.

The emergency coordinator, upon receipt of notification of the injury, will immediately:

- Notify emergency medical services and give the appropriate patient information and their location.
- Assist the injured party as deemed appropriate.

- Designate someone to accompany the injured party to the hospital and to provide chemical data sheets to the emergency medical team.
- Notify DOF's project manager.
- Complete an injury report (see Appendix C.)

If the emergency coordinator determines that emergency medical services are not necessary (minor injury such as sprain or abrasion, patient is conscious and can be moved), he/she may direct someone to transport the patient by vehicle to the hospital. A hospital route map will be located in DOF's field vehicle which will be present at each major work area.

13.6 Adverse Weather

Weather conditions in Washington State are typically punctuated by severe winds and rain. In the event of adverse weather, the SHSO working with the site superintendent will determine if work can continue without sacrificing the health and safety of field personnel. Some of the items to be considered prior to determining if work should continue are:

- Extreme cold and wind,
- Heavy precipitation,
- Limited visibility, and
- Potential for accidents.

13.7 Emergency Equipment

The following emergency response equipment will be stored at DOF's field vehicle:

- First aid kits for 5 people,
- 2-pound ABC fire extinguishers,
- Portable, emergency eyewash.

- Cellular phones and/or radios.

This equipment will be inspected monthly by the FPM. It will be cleaned, inspected, and replenished immediately after each use.

Postings related to the Emergency Response Plan will be placed in the DOF field vehicle, sediment sampling boat, or each major work area. The following information from the Emergency Response Plan will be highlighted on these postings:

- Emergency telephone numbers for fire, ambulance, hospitals, police
- Location of fire extinguishers and emergency equipment
- Map to the hospital.

14. HEALTH AND SAFETY PLAN CERTIFICATION

By their signature, the following undersigned certify that this plan has been read, or otherwise communicated to them. They further certify that they completely understand this plan and will follow its procedures for the protection of the health and safety of all persons entering this site.

NAME	**DATE**
_____	_____
_____	_____
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_____	_____
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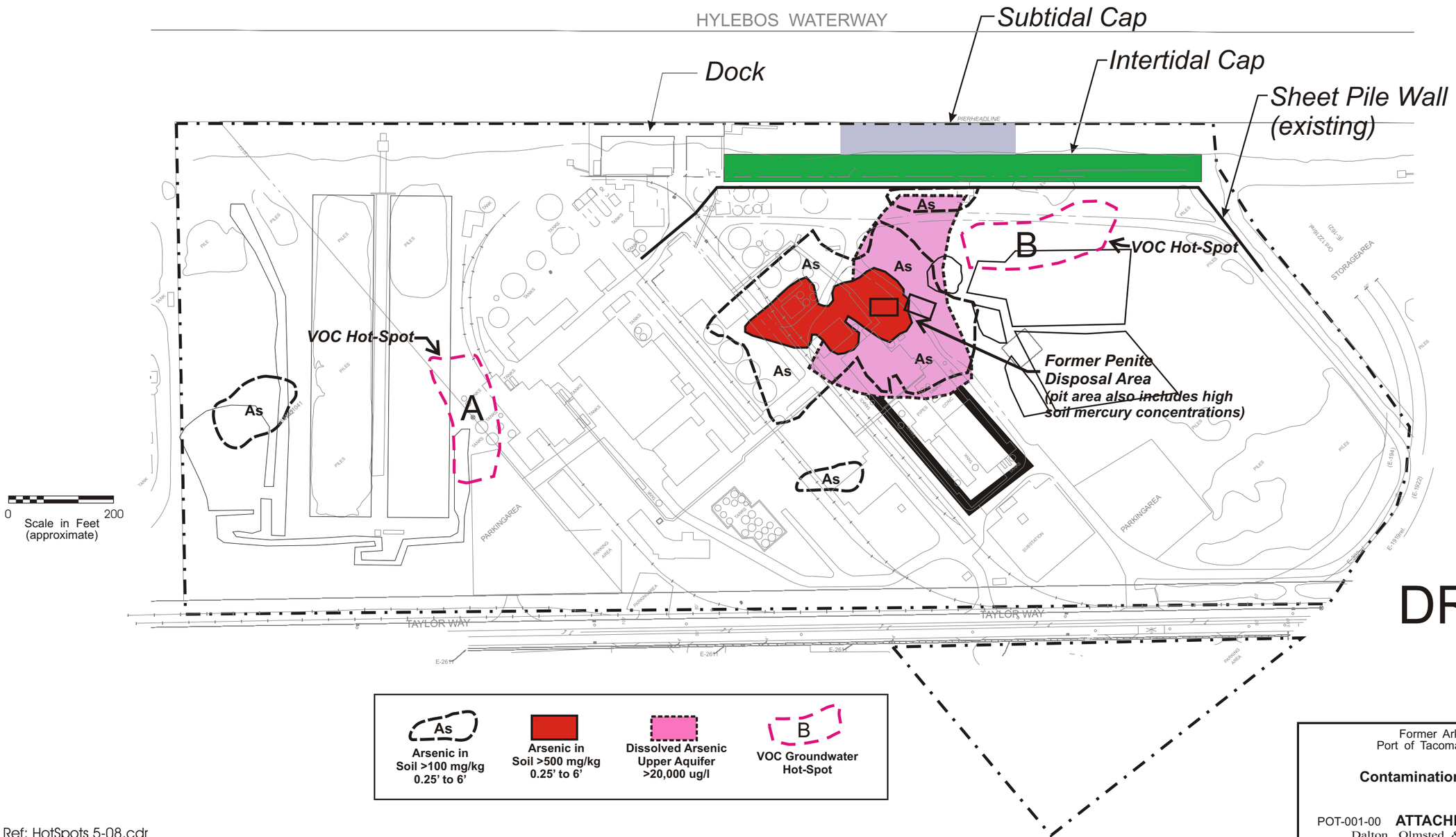

DRAFT

Ref: HotSpots 5-08.cdr

Former Arkema Site
Port of Tacoma, Washington

Contamination Hot Spots

POT-001-00 **ATTACHMENT A** March 2008
Dalton, Olmsted & Fuglevand, Inc.

APPENDIX A

AHA TABLES

ACTIVITY HAZARD ANALYSIS

Project / Location: Former Arkema Facility, Tacoma, WA.	**Estimated Start Date:** March 2008	**Phase of Work:** Mobilization
Analysis Performed By: Steve Frost	**Date:** 2-2-08	**Analysis Approved By:**
PRINCIPAL STEPS	**POTENTIAL SAFETY / HEALTH HAZARDS**	**RECOMMENDED CONTROLS**
Site Preparation (i.e. establishing control zone around work area, removing surface obstructions, identifying and securing overhead and underground utilities.), including using portable power tools.	Contact with traffic operating near work area.	• Establish traffic lanes around work area using signs, flags, barricade tape, etc. • Install Jersey barriers or equivalent as appropriate. • Ensure vehicles parked in the work area are chocked and have their parking brakes set.
	Back strain from lifting and moving materials stored in work area.	• Use mechanical lifting devices when feasible. • Do not lift more than 50 lbs. per individual. • Have others help lift excessively heavy loads. • When lifting, maintain ergonomically correct lifting posture.
	Cuts and scrapes from handling and moving materials.	• Ensure loads to be handled are free of sharp edges and points. • Wear leather gloves and long sleeved shirts.
	Electrocution from relocating surface and overhead electrical utilities	• De-energize and lockout/tagout surface electrical utilities in the immediate work area that will not be used and could be accidentally disturbed by the construction work. • Ensure temporary electrical wiring is protected from contact by vehicles and equipment. • Have licensed electrical conduct all electrical disconnects.
	Being struck by mobile equipment operating within the work area.	• Ensure mobile equipment has backup alarms • Make eye contact with operator before approaching vehicle. • Have ground crews wear high intensity road vests. • Use spotters to direct traffic as appropriate. • Inspect vehicles and equipment for mechanical integrity daily.

	Slips and trips from uneven or obstructed walking surfaces in the work area.	• Clear work area and walkways of debris. • Cover holes, pits, or other openings in walking surface. • Wear high traction, steel toed boots. • Provide adequate illumination of the work area.
	Heat stress from working outside	• Monitor temperatures and establish work/rest schedules as per SHSP. • Provide shaded rest areas and cold beverages for workers. • Train workers in thermal stress recognition, treatment, and controls.
	Excessive noise exposure	• Monitor noise levels with sound level meter • Demarcate areas where noise levels exceed 85dBs • Post noise hazard warning signs in high noise areas • Post copy of OSHA's noise standard • Have workers wear hearing protection when working in high noise areas.
	Struck by, caught in or between	• Wear leather work gloves and long sleeved work shirts. • Inspect power tools for damage or defects before and after each use. • Ensure all guards are in place. • Use tools only as designed. • Receive proper training in tool use.
	Struck by flying debris	• Wear impact-resistant, ANSI-approved safety glasses with sideshields • Wear face protection in addition to safety glasses for electric or pneumatic grinding, chipping, abrasive saw metal cutting, chain saw and brush cutter work
	Sprains/strains and vibration-induced musculoskeletal disorders	• Do not use heavy tools over shoulder height. • Where tool use is necessary on a continuous or repetitive basis take frequent breaks to rest muscles and joints, particularly if working in awkward positions • Use lightest tool acceptable for application • Use anti-vibration gloves for repetitive use of high velocity or high impact tools, such as impact wrenches, reciprocating saws, etc.

	Electrical contact	• Ensure electrical power tools are connected to ground fault circuit interruptors • Do not use electrical power tools in wet environments. • Use only heavy duty extension cords and inspect daily to ensure insulation and plug connections are intact.
Driving pickup trucks and delivery vehicles	Workers injured while driving vehicles	• Follow all driving rules and regulations. Always wear seat belts whenever vehicle is in motion. Licensed drivers only may drive vehicles. • Wear high-visibility reflective vests at all times in work areas.
	Struck by or against vehicles	• Make eye contact with operators of vehicles. • Understand and review posted hand signals. Traffic barricades, signs, flags, and backup spotters will be used during field activities, as necessary.
Connecting Temporary Power to Site Trailer	Electrocution	• Shut-off and lockout/tagout primary electrical power sources when making electrical connections to office trailer. • Have licensed electrician make all electrical connections. • Check grounding, continuity, and polarity of all electrical service outlets. • Make sure trailer is properly grounded. • Ensure circuit breaker switches are labeled.
	Fall from heights	• Use personal fall protection when working 6 ft or higher above ground. • Secure all ladders when in use. • Use manlifts when feasible to access elevated work locations

EQUIPMENT TO BE USED	INSPECTION REQUIREMENTS	TRAINING AND CP REQUIREMENTS
Pickup trucks Forklifts Ladders Power drills and saws Hand tools Level D PPE Personal fall protection as needed	Daily vehicle and equipment inspection. Inspect ladders before use Inspect personal fall protection equipment before use	OSHA compliant forklift training Ladder safety training Use of PPE Use of personal fall protection and content of OSHA fall protection standard as needed.

ACTIVITY HAZARD ANALYSIS

Project / Location: Former Arkema Facility, Tacoma, WA	**Estimated Start Date:** March 2008	**Phase of Work:** Monitoring Well Inventory and Sampling
Analysis Performed By: Steve Frost	**Date:** 2-2-08	**Analysis Approved By:**

PRINCIPAL STEPS	POTENTIAL SAFETY / HEALTH HAZARDS	RECOMMENDED CONTROLS
Park vehicle at well.	Vehicle contact	Use spotters when positioning vehicle if needed. Ensure vehicle's backup lights are operational.
	Location could create a traffic hazard.	Locate vehicle in an area that will not obstruct traffic.
Unload equipment and materials from vehicle.	Back strain from heavy lifting	Use proper lifting techniques such as keeping the back straight, lifting with legs, limiting twisting, and getting help when moving bulky/heavy materials and equipment. Use hand truck if needed. For loads greater than 50 pounds, use two people to lift.
Move equipment and materials to designated well location.	Handling of equipment could cause strain to worker.	Use care when walking so that there are no sudden jerks or mis-steps that can cause the worker to strain to maintain control of the equipment. Get assistance from other workers if needed. For loads greater than 50 pounds, use two people to carry.
	Slip, trip, and fall hazards could be present.	Maintain good housekeeping in work area. Mark or remove all identified trip, slip, and fall hazards from sampling area. Maintain proper illumination in work area.
	Worker could be struck by vehicles.	Wear high-visibility reflective vests at all times in work areas. Make eye contact with operators of vehicles. Post an observer, as needed, when well is close to busy streets. Use traffic controls or barricades, if necessary, to keep traffic away from workers.
	Thermal Stress	Provide cold beverages and shaded rest areas for work crews. Establish work/rest schedules based on WBGT readings and physiological monitoring. Train workers in thermal stress signs, symptoms, treatments, and controls. Ensure all workers have been enrolled in a medical surveillance program and they are physically fit to work in temperature conditions existing at jobsite. Ensure no one works alone. Have workers keep track of each other and report any symptoms of thermal stress to supervisor immediately.

Inspect condition of well and remove well cap.	Back strain from heavy lifting	Use proper lifting techniques such as keeping the back straight, lifting with legs, limiting twisting, and getting help if cover is too heavy or it is too difficult to handle because cover is wedged or impaired. If cover is on hinges, ensure that cover is secured in upright position by latching or tie-off to prevent cover from closing on worker.
	Adverse contact with hand tools.	Inspect all tools for damage before use. Do not use damaged tools (mark and tag "out of service"). Select hand tools to minimize following stressors: chronic muscle contraction or steady force; extreme or awkward finger/hand/arm positions; repetitive forceful motions; or excessive gripping, pinching, or pressing with hands and fingers.
	Release of volatile vapors	Test air in breathing zone with organic vapor analyzer. Continue work only if vapor concentrations are at or below background.
	Cuts to hands and fingers	Wear leather gloves.
Measure depth to groundwater.	Dermal contact with contaminated groundwater	Wear nitrile gloves and neoprene, steel-toed boots. Wear disposable Poly-Tyvek coveralls if there is a potential for work clothing to become significantly contaminated with groundwater.
Set up sampling equipment.	Polyethylene sheeting can be slippery.	Wear boots with traction. Use caution when maneuvering on or around polyethylene sheeting, especially if sheeting is wet.
	Worker could be exposed to pinch points.	Use care when setting up equipment. Wear leather gloves if necessary.
Purge well.	Dermal contact with contaminated groundwater	Wear nitrile gloves and neoprene, steel-toed boots Wear disposable Poly-Tyvek coveralls if there is a potential for work clothing to become significantly contaminated with groundwater. Wash hands before leaving exclusion zone
	Back strain from heavy lifting	Use proper lifting techniques such as keeping the back straight, lifting with legs, limiting twisting, and getting help to lift heavy loads.

	Thermal Stress	Provide cold beverages and shaded rest areas for work crews. Establish work/rest schedules based on WBGT readings and physiological monitoring. Train workers in thermal stress signs, symptoms, treatments, and controls. Ensure all workers have been enrolled in a medical surveillance program and they are physically fit to work in temperature conditions existing at jobsite. Ensure no one works alone. Have workers keep track of each other and report any symptoms of thermal stress to supervisor immediately.
	Electrical contact	Ensure electrical equipment (i.e. pumps) is connected to ground fault circuit interruptors Use only heavy duty, water resistent, extension cords and inspect daily to ensure insulation and plug connections are intact.
Collect groundwater samples.	Muscle strain.	Maintain steady pace and follow rest periods given on job. Select a position during sampling to minimize following stressors: chronic muscle contraction or steady force; extreme or awkward positions; repetitive forceful motions; or excessive gripping, pinching, or pressing.
	Dermal contact with contaminated groundwater	Wear nitrile gloves and neoprene, steel-toed boots Wear disposable Poly-Tyvek coveralls if there is a potential for work clothing to become significantly contaminated with groundwater. Decontaminate exteriors of sample containers. Avoid spills. Ensure spill cleanup supplies are available. Wash hands before leaving exclusion zone
	Thermal Stress	Provide cold beverages and shaded rest areas for work crews. Establish work/rest schedules based on WBGT readings and physiological monitoring. Train workers in thermal stress signs, symptoms, treatments, and controls. Ensure all workers have been enrolled in a medical surveillance program and they are physically fit to work in temperature conditions existing at jobsite. Ensure no one works alone. Have workers keep track of each other and report any symptoms of thermal stress to supervisor immediately.

	Electrical contact	Ensure electrical equipment (i.e. pumps) is connected to ground fault circuit interruptors Use only heavy duty, water resistent, extension cords and inspect daily to ensure insulation and plug connections are intact.
Replace well cap	Worker could experience strain from use of tools.	Inspect all tools for damage before use. Do not use damaged tools. Mark and tag "out of service". Select hand tools to minimize the following stressors: chronic muscle contraction or steady force; extreme or awkward finger/hand/arm positions; repetitive forceful motions; or excessive gripping, pinching, or pressing with hands and fingers.
	Worker could get hand caught between cover and top when replacing cover.	Use care when replacing well cover. Wear leather gloves when handling covers.
Decontaminate all reusable materials and equipment.	Lifting of equipment and materials could cause strain to worker.	Use proper lifting techniques such as keeping the back straight, lifting with legs, limiting twisting, and getting help when moving bulky/heavy materials and equipment. Use hand truck if needed. For loads greater than 50 pounds, use two people to lift.
	Dermal contact with contaminants.	Avoid spills. Ensure that spill cleanup supplies are available. Wear required PPE as specified in the SHSP. Remove PPE properly and wash hands.
	Decontamination area may become slippery.	Visually inspect work areas and mark, barricade, or eliminate slip, trip, and fall hazards as feasible. Maintain proper illumination in all work areas. If decontaminating on plastic sheeting, use caution since plastic sheeting is extremely slippery. Wear boots with good traction.
Pack samples for shipment.	Manually moving materials and equipment could cause strains.	Use proper lifting techniques such as keeping the back straight, lifting with legs, limiting twisting, and getting help when moving bulky/heavy materials and equipment. Use hand truck when handling more than one box at a time. Try to pack shipping boxes so that each box does not exceed 50 pounds. For loads greater than 50 pounds, use two people to carry.
	Contents of sample containers could leak, causing exposure to worker and possibly to people handling shipping box.	Ensure that each container top is securely tightened. Pack each container in a manner to prevent damage to container during handling of shipping box and during transportation. Ensure boxes meet required packaging standards based on mode of transportation used for shipping.
EQUIPMENT TO BE USED	**INSPECTION REQUIREMENTS**	**TRAINING AND CP REQUIREMENTS**
Pickup trucks Hand tools	Daily vehicle and equipment inspection. Outlets – prior to use during site inspection	OSHA compliant forklift training Use of PPE

Modified Level D PPE Personal fall protection as needed Temporary power supplies including GFCIs, extension cords, cord and plug-operated tools	GFCI – prior to use during site inspection Extension cords and cords and plugs on equipment – daily by users	Use of personal fall protection and content of OSHA fall protection standard as needed. General electrical safe work practices training provided during site orientation. Only licensed electricians will install, repair, and maintain electrical equipment and current carrying parts of electrically supplied tools and equipment.

ACTIVITY HAZARD ANALYSIS

Project / Location: : Former Arkema Facility, Tacoma, WA	**Estimated Start Date:** March 2008	**Phase of Work:** Installing groundwater monitoring wells.
Analysis Performed By: Steve Frost	**Date:** 2-2-08	**Analysis Approved By:**

PRINCIPAL STEPS	POTENTIAL SAFETY / HEALTH HAZARDS	RECOMMENDED CONTROLS
Site Preparation (i.e. establishing control zone around work area, removing surface obstructions, identifying and securing overhead and underground utilities.)	Contact with traffic operating near work area.	• Establish traffic lanes around work area using signs, flags, barricade tape, etc. • Have workers wear traffic vests • Ensure vehicles parked in the work area are chocked and have their parking brakes set.
	Back strain from lifting and moving materials stored in work area.	• Use mechanical lifting devices when feasible. • Do not lift more than 50 lbs. per individual. • Have others help lift excessively heavy loads. • When lifting, maintain ergonomically correct lifting posture.
	Cuts and scrapes from handling and moving materials.	• Ensure loads to be handled are free of sharp edges and points. • Wear leather gloves and long sleeved shirts.
	Electrocution from relocating surface and overhead electrical utilities	• De-energize and lockout/tagout surface electrical utilities in the immediate work area that will not be used and could be accidentally disturbed by the excavation or need to be relocated. • Ensure temporary electrical wiring is protected from contact by vehicles and equipment.
	Being struck by mobile equipment operating within the work area.	• Ensure mobile equipment has backup alarms • Make eye contact with operator before approaching vehicle. • Have ground crews wear high intensity road vests. • Secure area around mobile equipment. • Use spotters to direct traffic as appropriate. • Inspect vehicles and equipment for mechanical integrity daily. • Ensure forklift operators are trained

	Slips and trips from uneven or obstructed walking surfaces in the work area.	• Clear work area and walkways of debris. • Cover holes, pits, or other openings in walking surface. • Wear high traction, steel toed boots. • Provide adequate illumination of the work area.
Operating Drill Rig	Contact with underground utilities and overhead powerlines.	• Conduct an underground utility search before drilling. • Maintain a minimum 15 ft. clearance from overhead power lines. • Review site design drawings • Use non-intrusive utility detection equipment (i.e. magnetometers, ground penetrating radar, etc.) as necessary to locate utilities. • Identify shut off valves and switches to all utilities traversing site before drilling. • De-energize and lockout / tagout utilities passing in, through, or near drilling site if feasible. • Evacuate site if utilities are damaged. Shut off ignition sources. • Use hand shovels and/or air lances to excavate soils when drilling near active utilities.
	Equipment rollover	• Ensure outriggers on drill rig are extended and placed on solid ground. • Ensure drill rig operates on level ground. • Ensure equipment is equipped with roll over protection and seat belts. • Do not move drill rig when drill mast is deployed in vertical position.

	Dermal and inhalation contact with contaminated soil and groundwater	• Wear modified Level D PPE as appropriate. • Wear leather work gloves (over nitrile gloves) that are left in the work area and which are disposed of regularly. • Wash hands and face before each break and before leaving the jobsite. • Undergo decontamination before leaving work area. • Ensure workers are informed and trained in recognition and control of petroleum contact hazard. • Conduct air monitoring near breathing zone of drillers with organic vapor analyzer. • Keep cab of drill rig and support vehicles clean. • Have a portable eyewash available at the jobsite. • Wear Level as indicated by air monitoring
	Struck by drill rig	• Ensure drill rig has backup alarms • Make eye contact with operator before approaching equipment. • Have ground crews wear high intensity road vests. • Secure area around drill rig • Use spotters to direct movement of equipment as appropriate. • Inspect drill rig for mechanical integrity daily. • Ensure operators are trained and experienced
	Thermal stress from working outside	• Evaluate temperature in work area, have work crews wear appropriate clothing. • Comply with thermal stress controls discussed in Section 6. • Have crews take frequent breaks in temperature controlled break room to either warm up or cool down. • Provide water or hot or cold beverages as needed. • Ensure workers are aware of thermal stress symptoms, treatments, and preventative measures.
	Contact with moving mechanical parts.	• Ensure all moving mechanical parts on the drill rig that are accessible to workers are guarded. • Ensure emergency kill switches on drill rig are operational. • Stay a safe distance away from auger. Do not touch auger while drilling. • Do not wear loose clothing around equipment.

	Excessive noise exposure	• Have personnel working near heavy equipment wear hearing protection. • Monitor noise levels in work area with a sound level meter as appropriate. • Post noise hazard warning signs, enroll workers in hearing conservation program, and post copy of OSHA noise standard if noise levels exceed 85 dBs.
	Back strain from heavy lifting	• Do not lift equipment (particularly auger flites) that weighs more than 50 lbs. individually. Have others help. • Use mechanical lifting devices whenever feasible. • Maintain proper posture when lifting (i.e. back straight, lift with legs, keep load close to body, don't twist, etc.) • Size up load before lifting • Clear path when carrying loads. • Wear leather gloves to avoid cuts and scrapes.
Installing Well Casing	Back strain from heavy lifting	• Do not lift equipment that weighs more than 50 lbs. individually. Have others help. • Use mechanical lifting devices whenever feasible. • Maintain proper posture when lifting (i.e. back straight, lift with legs, keep load close to body, don't twist, etc.) • Size up load before lifting • Clear path when carrying loads. • Wear leather gloves to avoid cuts and scrapes.
	Thermal stress from working outside	• Evaluate temperature in work area, have work crews wear appropriate clothing. • Comply with thermal stress controls discussed in SHSP. • Have crews take frequent breaks in temperature controlled break room to either warm up or cool down. • Provide water or hot or cold beverages as needed. • Ensure workers are aware of thermal stress symptoms, treatments, and preventative measures.

	Adverse contact with portable power tools (i.e. cuts, scrapes, puncture, electrocution, noise).	• Wear leather work gloves and long sleeved work shirts. • Inspect power tools for damage or defects before and after each use. • Ensure all guards are in place. • Use tools only as designed. • Receive proper training in tool use. Wear impact-resistant, ANSI-approved safety glasses with sideshields • Wear face protection in addition to safety glasses for grinding, chipping, sanding or sawing. • Monitor noise in work area with sound level meter. • Have workers wear hearing protection when noise levels exceed 85 dBA. • Use quieter equipment, if possible. Do not use heavy tools over shoulder height. • Where tool use is necessary on a continuous or repetitive basis take frequent breaks to rest muscles and joints, particularly if working in awkward positions • Use lightest tool acceptable for application • Use anti-vibration gloves for repetitive use of high velocity tools, such as reciprocating saws, etc. • Ensure electrical power tools are connected to ground fault circuit interrupters • Do not use electrical power tools in wet environments. • Use only heavy duty extension cords and inspect daily to ensure insulation and plug connections are intact.
	Dermal and inhalation exposure to pvc glues and solvents.	• Wear nitrile gloves when cleaning and gluing pvc piping. • Glue and clean pvc pipe only in well ventilated areas. • Eliminate all ignition sources in work area when using pvc glues and solvents. • Have MSDS sheet for pvc glues and solvents available for workers to review before beginning work.

	Contact with bentonite grout and cement	• Wear modified level D PPE. • Use water spray to control dust emissions. • Do not wear non-chemical protective clothing (i.e. standard work clothing) that is contaminated with cement or bentonite. • Wash skin if it becomes contaminated with cement or bentonite. • Wear chemical protective goggles when mixing cement and bentonite. • Stage emergency eyewash in work area.
	Excessive noise exposure	• Have personnel working near heavy equipment wear hearing protection. • Monitor noise levels in work area with a sound level meter as appropriate. • Post noise hazard warning signs, enroll workers in hearing conservation program, and post copy of OSHA noise standard if noise levels exceed 85 dBs.
	Dermal contact with contaminated soil and groundwater	• Control dust emissions with water spray • Wear modified Level D PPE as appropriate. • Wear leather work gloves (over nitrile gloves) that are left in the work area and which are disposed of regularly. • Wash hands and face before each break and before leaving the jobsite. • Undergo decontamination before leaving work area. • Ensure workers are informed and trained in recognition and control of petroleum contact hazard. • Have a portable eyewash available at the jobsite.
EQUIPMENT TO BE USED	**INSPECTION REQUIREMENTS**	**TRAINING AND CP REQUIREMENTS**
Drill rig Portable power tools	Daily drill rig inspection. Daily tool inspection	Equipment operators must trained in the type of equipment they are operating. Tool operators must be trained in the inspection and use of their tools.

ACTIVITY HAZARD ANALYSIS

Project / Location: Former Arkema Facility, Tacoma, WA	**Estimated Start Date:** March 2008	**Phase of Work:** Collecting Soil and Sediment Samples
Analysis Performed By: Steve Frost	**Date:** 2-2-08	**Analysis Approved By:**

PRINCIPAL STEPS	POTENTIAL SAFETY / HEALTH HAZARDS	RECOMMENDED CONTROLS
Securing work area	Struck by vehicles and mobile equipment operating in area.	Demarcate work area (i.e. rope, barricade tape, signage, etc.) Use spotters to direct traffic away from work area. Wear high visibility traffic vests. Maintain proper illumination
	Slip, trip, and fall	Inspect work area for slip, trip, and fall hazards Cover all surface openings Remove surface obstructions Wear high traction steel-toed work boots. Do not work at heights greater than 6 ft. without fall protection.
Unload equipment and materials from vehicle.	Back strain from heavy lifting	Use proper lifting techniques such as keeping the back straight, lifting with legs, limiting twisting, and getting help when moving bulky/heavy materials and equipment. Use hand truck if needed. For loads greater than 50 pounds, use two people to lift.
Move equipment and materials to designated sampling location.	Handling of equipment could cause strain to worker.	Use care when walking so that there are no sudden jerks or mis-steps that can cause the worker to strain to maintain control of the equipment. Get assistance from other workers if needed. For loads greater than 50 pounds, use two people to carry.
	Slip, trip, and falls.	Maintain good housekeeping in work area. Mark or remove all identified trip, slip, and fall hazards from sampling area. Maintain proper illumination in work area.
	Worker could be struck by vehicles.	Wear high-visibility reflective vests at all times in work areas. Make eye contact with operators of vehicles. Post an observer, as needed, when well is close to busy streets. Use traffic controls or barricades, if necessary, to keep traffic away from workers.

	Thermal Stress	Provide cold beverages and shaded rest areas for work crews. Establish work/rest schedules based on ambient temps, work load and physiological monitoring. Train workers in thermal stress signs, symptoms, treatments, and controls. Ensure all workers have been enrolled in a medical surveillance program and they are physically fit to work in temperature conditions existing at jobsite. Ensure no one works alone. Have workers keep track of each other and report any symptoms of thermal stress to supervisor immediately.
Collect soil or sediment samples	Back strain from heavy lifting	Use proper lifting techniques such as keeping the back straight, lifting with legs, limiting twisting, and getting help if cover is too heavy or it is too difficult to handle because cover is wedged or impaired. If cover is on hinges, ensure that cover is secured in upright position by latching or tie-off to prevent cover from closing on worker.
	Adverse contact with hand tools.	Inspect all tools for damage before use. Do not use damaged tools (mark and tag "out of service"). Select hand tools to minimize following stressors: chronic muscle contraction or steady force; extreme or awkward finger/hand/arm positions; repetitive forceful motions; or excessive gripping, pinching, or pressing with hands and fingers.
	Release of volatile vapors from VOC contaminated areas	Test air in breathing zone with organic vapor analyzer. Continue work only if vapor concentrations are at or below background.
	Cuts to hands and fingers	Wear leather gloves.
	Dermal contact with contaminated soil or sediment	Wear nitrile gloves and neoprene, steel-toed boots. Wear disposable Tyvek coveralls. Undergo decontamination before leaving work area. Wash hands and face before leaving site.
	Tidal engulfment when sampling sediments in waterway	Collect samples only at low tide. Confirm tide schedule. Stay at least 6 ft. from water's edge. Ensure clear access and egress from sampling area Ensure sediment surface is firm enough to support weight

	Thermal Stress	Provide cold beverages and shaded rest areas for work crews. Establish work/rest schedules based on WBGT readings and physiological monitoring. Train workers in thermal stress signs, symptoms, treatments, and controls. Ensure all workers have been enrolled in a medical surveillance program and they are physically fit to work in temperature conditions existing at jobsite. Ensure no one works alone. Have workers keep track of each other and report any symptoms of thermal stress to supervisor immediately.
Decontaminate all reusable materials and equipment.	Lifting of equipment and materials could cause strain to worker.	Use proper lifting techniques such as keeping the back straight, lifting with legs, limiting twisting, and getting help when moving bulky/heavy materials and equipment. Use hand truck if needed. For loads greater than 50 pounds, use two people to lift.
	Dermal contact with contaminants.	Avoid spills. Ensure that spill cleanup supplies are available. Wear required PPE as specified in the SHSP. Remove PPE properly and wash hands.
	Decontamination area may become slippery.	Visually inspect work areas and mark, barricade, or eliminate slip, trip, and fall hazards as feasible. Maintain proper illumination in all work areas. If decontaminating on plastic sheeting, use caution since plastic sheeting is extremely slippery. Wear boots with good traction.
Pack samples for shipment.	Manually moving materials and equipment could cause strains.	Use proper lifting techniques such as keeping the back straight, lifting with legs, limiting twisting, and getting help when moving bulky/heavy materials and equipment. Use hand truck when handling more than one box at a time. Try to pack shipping boxes so that each box does not exceed 50 pounds. For loads greater than 50 pounds, use two people to carry.
	Contents of sample containers could leak, causing exposure to worker and possibly to people handling shipping box.	Ensure that each container top is securely tightened. Pack each container in a manner to prevent damage to container during handling of shipping box and during transportation. Ensure boxes meet required packaging standards based on mode of transportation used for shipping.
EQUIPMENT TO BE USED	**INSPECTION REQUIREMENTS**	**TRAINING AND CP REQUIREMENTS**
Pickup trucks Hand tools Modified Level D PPE Personal fall protection as needed	Daily vehicle and equipment inspection Before each use. Before each use. Before each use.	OSHA compliant forklift training Tool-specific training Use of PPE Use of personal fall protection

ACTIVITY HAZARD ANALYSIS

Project/Location: Former Arkema Facility, Tacoma, WA.	**Estimated Start Date:** September 2017	**Phase of Work:** Deployment of pore water samplers and collection of sediment samples.
Analysis Performed By: S. Frost	**Date:** 8-29-17	**Analysis Approved By:**
PRINCIPAL STEPS	**POTENTIAL SAFETY/HEALTH HAZARDS**	**RECOMMENDED CONTROLS**
Boarding boat	Slip, trips, and possibly falling into water	- Secure boat firmly to dock - Clear walkways of equipment and other trip hazards - Use gangway as appropriate. Ensure gangway has guardrails as appropriate. - Passengers and crew must wear PFDs while accessing dock area and boat. - Grab handholds on boat when boarding. - Be vigilant for physical hazards. - Maintain work areas in safe and orderly manner. - Unloading areas will be level and even if feasible. - Watch for wet walking surfaces. Use caution. - Use handholds and wear dive booties or other high traction footwear as appropriate.
Operating small boat	Falling overboard and drowning.	- Ensure boat has guardrails as appropriate. - Ensure no standing or leaning over edge of boat. - Rehearse man overboard drill. - Ensure water rescue is available. - Vessel must have at least one throwable PFD (Type IV PFD) with 90 feet of line attached. - All personnel on board must wear PFDs. - Crewmembers must wear PFDs.
	Colliding with other boats operating in area.	- Maintain vigilance and ensure boat has proper running lights. - Notify other site contractors of work location. - Comply with Coast Guard right-of-way rules. - Use horn to signal or warn other boats as appropriate. - Suspend work during bad weather or poor visibility. - Have experienced boat crews operate vessel.
	Vessel mechanical failure or on-board emergency (fire, loss of power, breach of hull, etc.).	- Inspect vessel for mechanical integrity before each use. - Communicate fire and emergency evacuation procedures to all boat occupants. - Ensure radio communications with Coast Guard are available. - Have emergency telephone/radio numbers available. - Ensure emergency life boats, life rings, and vests are available. - Verify presence and working order of fire extinguishers.

	Heavy lifting.	- Limit lifting to 50 lbs./person or less. - Use proper lifting techniques. - Use mechanical equipment when feasible.
	Thermal stress.	- Wear thermally insulated clothing as appropriate. - Wear raingear when needed. - Take frequent warm-up breaks in heated boat cabin or car, as appropriate. - Review thermal stress treatments and controls with personnel. - Monitor level of work activity and ambient temperature conditions. - Have water available to drink. - Work in shaded areas as appropriate.
	Slip, trips, and possibly falling into water	- Clear walkways of equipment and other trip hazards - Passengers and crew must wear PFDs while operating boat. - Be vigilant for physical hazards. - Maintain work areas in safe and orderly manner. - Unloading areas will be level and even if feasible. - Watch for wet walking surfaces. Use caution. - Use handholds and wear dive booties or other high traction footwear as appropriate.
	Noise	- Wear hearing protection if noise levels exceed 85 dbs. - H&S Officer will determine need for hearing protection.
	Adverse weather	- Use sunscreen as necessary - Terminate boating operations during thunderstorms or other severe weather. - Comply with thermal stress treatments and controls found in Sec. 5.2.3 of HASP. Increase fluid intake during hot weather.
	Grounding and contacting objects in the water	- Use caution in shallow areas - Use depth meter and visual observation to avoid collision with objects and striking bottom. - Reference nautical charts and tide charts to ascertain depths. - Be certain of position at all times.
Underwater diving to deploy pore water samplers and collect sediment samples.	Uncertain of work practices and procedures	- Follow approved site-specific dive plan. - Comply with WAC 296-37. - Use only experienced, commercial divers and boat operators for work. - Have safe dive practices manual available at jobsite. - Do not dive during high seas, strong currents, or poor visibility.

	Becoming disoriented	- Always dive with a buddy. - Deploy buoys with tether lines at each dive location. Use tether lines to guide divers to surface. - Do not disturb sediments when diving - Tether divers when using surface supplied air. - Designate surface standby/rescue divers. - Have diver follow tether line back to surface in the event of disorientation or loss of communications. - Use underwater two-way communication system. - Do not dive during high seas or strong currents. - Divers will maintain visual or tactile contact with each other at all times.
	Cut off from air supply	- Have all divers carry emergency air supply. - Surface immediately when air supply fails. - Buddy breath as necessary - Deploy standby diver to assist as necessary.
	Losing communications with surface	- Terminate dive if communications with dive tender is lost or any problems arise. - Have diver follow tether line back to surface in the event of disorientation or loss of communications. - Use underwater two-way communication system.
	Being struck by boats operating in the area	- Display “Diver Down” flag and have dive tenders warn divers of boat traffic in the area.
	Decompression sickness, drowning, and arterial gas embolism.	- Do not allow decompression dives. Monitor depth and down times. - Post emergency telephone numbers and radio frequencies in dive boat. Verify that emergency medical, transport, and decompression (hyperbaric chamber) services are available. - Utilize experienced divers - Provide diving physicals - Conduct training on equipment - Procure top quality equipment - Follow approved written procedures - Check cylinder pressure and equipment before each dive. - Display dive flag on boat. Have dive supervisor and standby diver onboard at all times. - Avoid diving in areas with low visibility - Avoid areas with heavy boat traffic. - Maximum diving depth is 100 ft.

	Underwater entrapment or entanglement	- Do not enter areas that could entrap or entangle divers. Carry knife. - Designate surface standby/rescue divers.
	Dive-related medical emergencies	- Designate surface standby/rescue divers. - Post emergency telephone numbers and radio frequencies in dive boat. Verify that emergency medical, transport, and decompression (hyperbaric chamber) services are available. - Ensure all divers are first aid/CPR trained. - Have first aid kit available at dive site.
	Equipment failure	- Inspect dive equipment before use.
	Poor weather	- Use sunscreen as necessary - Terminate diving and boating operations during thunderstorms or other severe weather. - Comply with thermal stress treatments and controls found in Sec. 5.2.3 of HASP. Increase fluid intake during hot weather.
	Contact with hazardous marine fauna	- Be aware of surroundings. Look for hazardous fauna and avoid it. - Approach debris, rock piles, and other crevices with caution. - Dive in pairs at all times. - Avoid diving in murky water and always have a Dive Supervisor and Standby Diver on the boat.
	Handling compressed air cylinders	- All cylinders will have current hydrostatic tests and visual inspections. - Cylinders will be properly stowed and secured when not in use. - Regulators, manifolds, and valves will be handled with care.
	Inhaling compressed air contaminants such as carbon monoxide, elevated levels of carbon dioxide, oil mist, and other contaminants.	- Procure dive air from a facility that meets all federal and state requirements. - Test air before use. - Compressed air must meet standards published in Navy Diving Manual.
	Cuts and scrapes on hands from handling equipment..	- Divers should wear leather gloves when handling equipment. - Round off all sharp edges and corners on equipment..

	Reduced visibility from disturbed sediments.	- Divers should not disturb sediments when inspecting equipment - Be sure marker buoys have been attached to equipment. - Dive only when visibility conditions are good.
Handing sampling equipment to divers from the boat while the divers are in the water.	Back strain from heavy lifting	- If feasible, use vessel crane or davit to lift and lower equipment from boat into water. - If not feasible, have multiple crew members assist in lowering equipment into water. - Attach lifting sling and lines to equipment to facilitate handling as appropriate.
	Striking divers with equipment when it is lowered into water.	- Use tag lines on equipment as appropriate when moving equipment with cranes / davits. - Do not suspend load/equipment over divers when they are in the water. - Lower load into water and have divers disengage lifting line/sling from load. Divers should adjust their buoyancy to compensate for additional weight of load before detaching lifting lines. - Ensure load is reasonable buoyant in water so as not to sink rapidly and possibly pull divers underwater. - If load in not buoyant, lower equipment to bottom of waterway using lifting line from boat.
	Cuts and scrapes on hands from handling equipment	- Crewmembers and divers should wear leather gloves when handling equipment.
Installing support stakes in sediment to hold equipment	Cuts and scrapes on hands from pushing stakes into sediments.	- Divers should wear leather gloves when driving stakes. - Round off all sharp edges and corners on stakes.
	Reduced visibility from disturbed sediments.	- Divers should not disturb sediments when installing equipment
EQUIPMENT TO BE USED	***INSPECTION REQUIREMENTS***	***TRAINING AND CP REQUIREMENTS***
Motor boat	Inspect boat before each day's use.	Experienced boat operator (USCG license; training certification documenting that they are proficient in the handling of the boat they will operate (written and operational); boating safety course meeting the criteria of the USCG Auxiliary, NASBLA, or equivalent). Use properly registered/licensed vessel.
First aid kit, bloodborne pathogen kit, and DANS O_2 and AMBU bag	Dive supervisor will inspect prior to bringing on-site.	All dive personnel will have current first aid/cpr training. At least two individual qualified to administer first aid/cpr will be qualified to use DANS O_2 and AMBU bag.

GPS unit	Dive Supervisor checks each day prior to operations.	An experienced operator will use.
Type II or higher PFDs to be worn	Inspected daily by Dive Supervisor and boat operator	All users of PFDs will be instructed in their use by the Dive Supervisor and/or boat operator.
Type IV PFDs (safety ring)	Inspected daily by Dive Supervisor and boat operator	All users of PFDs will be instructed in their use by the Dive Supervisor and/or boat operator.
Flare gun	Inspected initially before start of work by Dive Supervisor and boat operator and monthly thereafter.	Personnel will be instructed on proper emergency notification procedures and use of emergency equipment by Dive Supervisor and/or boat operator.
Air horn	Inspected and tested initially before start of work by Dive Supervisor and boat operator and monthly thereafter.	Personnel will be instructed on proper emergency notification procedures and use of emergency equipment by Dive Supervisor and/or boat operator.
Cellular telephone	Dive supervisor and boat operator will check operation of cell phones each morning.	Personnel will be instructed on proper emergency notification procedures and use of emergency equipment by Dive Supervisor and/or boat operator.
Fire extinguishers	Inspected initially before start of work and monthly thereafter.	Fire extinguisher trained and qualified person as per OSHA requirements. Dive supervisor will have this training.
Diving equipment	Before and after each use.	Commercial diving certificates. First Aid/CPR certification and 40-hour HAZWOPER.
Personal protective equipment (Mod. Level D)	Before and after use.	Specific training in selection, use, limitations, inspection and maintenance of PPE by qualified instructor.
Emergency eyewash	Before use	N/A
Sediment monitoring equipment	Before deployment.	N/A

APPENDIX B

GENERAL SITE WORK RULES

GENERAL SITE WORK RULES

1. All DOF personnel must attend weekly site briefings and other scheduled meetings.
2. Any individual taking prescribed drugs shall inform the site health and safety officer of the type of medication and any possible adverse side effects that could effect the health and well being of the worker while they are performing their jobs. The SHSO will decide if the employee can safely work on-site while taking the medication.
3. The personal protective equipment specified by the SHSO and in the Site Safety and Health Plan(s) shall be worn by all DOF site personnel. This includes hard hats, safety glasses, and steel-toed boots, as a minimum.
4. Facial hair (beards, long sideburns or mustaches) which may interfere with a satisfactory fit of a respirator mask is not allowed on any person who may be required to wear a respirator.
5. All personnel must sign the site log when visiting the jobsite.
6. Personnel must follow proper decontamination procedures.
7. Eating, drinking, chewing tobacco or gum, smoking and any other practice that may increase the possibility of hand-to-mouth contact is prohibited in regulated areas of the jobsite.
8. All lighters, matches, cigarettes and other forms of tobacco are prohibited in regulated areas of the jobsite.
9. All signs and demarcations shall be followed. Such signs and demarcation shall not be removed except as authorized by the site superintendent.
10. No one shall enter a permit-required confined space without approval from the site superintendent and site health and safety officer.
11. All personnel must use the Buddy System when working in regulated areas.
12. All personnel must follow the work-rest regimens and other practices required by the heat stress program.
13. All personnel must follow lockout/tagout procedures when working on equipment involving moving parts or hazardous energy sources.
14. No person shall operate equipment unless trained and authorized. No one may enter an excavation greater than four feet deep unless authorized by the Competent Person.

Excavations must be sloped or shored properly. Safe means of access and egress from excavations must be maintained.

15. Ladders and scaffolds shall be solidly constructed, in good working condition and inspected prior to use. No one may use defective ladders or scaffolds.
16. Fall protection or fall arrest systems must be in place when working at elevations greater than six feet for temporary working surfaces and four feet for fixed platforms.
17. Safety belts, harnesses and lanyards must be selected by the SHSO. The user must inspect the equipment prior to use. No defective personal fall protection equipment shall be used. Personal fall protection equipment that has been shock loaded must be discarded.
18. Hand and portable power tools must be inspected prior to use. Defective tools and equipment shall not be used.
19. Ground fault interrupters shall be used for cord and plug equipment used outdoors or in damp locations. Electrical cords shall be kept out of walkways and puddles unless protected and rated for the service.
20. Improper use, mishandling, or tampering with safety and health equipment and samples is prohibited.
21. Horseplay of any kind is prohibited.
22. Possession or use of alcoholic beverages or controlled substances on-site is forbidden.
23. All incidents, no matter how minor must be reported immediately to the site superintendent. .
24. All personnel shall be familiar with the Site Emergency Response Plan.
25. All personnel will report any unsafe conditions or practices to site management immediately upon discovery.

The above Work Rules are not all inclusive and it is the responsibility of each employee to comply with all applicable regulations set forth by WISHA, DOF management, the site safety and health plan, the client, DOF, the SHSO and the controlling contractor's work rules and health and safety requirements.

APPENDIX C

HEALTH AND SAFETY FORMS

SITE SAFETY BRIEFING

- Dalton, Olmsted & Fuglevand, Inc.-

Date: _____ Time: _____ Location: _____

Shift: _____ Person Conducting Briefing: _____

1. HEALTH AND SAFETY CONCERNS *(i.e. use of PPE, chemical, physical, or biological hazards, unsafe conditions, unsafe work practices, communication problems, safety equipment, training issues, etc.)*:

2. RECENT INCIDENTS *(i.e. near misses, first aid cases, serious injuries, environmental spills, etc.)*:

3. HAZARD CONTROL MEASURES *(i.e. PPE changes, new site control requirements, recommended work practices, etc..)*:

2. OTHER ISSUES:

3. ATTENDEES (Print Name):

1.	12.
2.	13.
3.	14.
4.	15.
5.	16.
6.	17.
7.	18.
8.	19.
9.	20.
10.	21.
11.	22.

THIS IS YOUR RECORD -- KEEP IN YOUR FILE

SUPERVISOR'S REPORT OF AN ACCIDENT

Name of Injured Employee:_____ Date of Report _____

Age	Length of Employment At plant	On job	Department	Section

☐ Head	☐ Hands	☐ Wounds	☐ Amputation	☐ Death	☐ Lost Time
☐ Eyes	☐ Legs	☐ Strain & Sprain	☐ Burns	☐ First Aid Only	
☐ Trunk	☐ Toes	☐ Hernia	☐ Foreign Body		
☐ Arms	☐ Internal	☐ Fracture	☐ Skin (occupational)	☐ Due to Delayed Medical Treatment	
Remarks:_____		Remarks:_____		Remarks:_____	

Date of Injury	Hour	Department	Exact Location

Eyewitnesses _____

Describe accident: Include the machine, equipment, object or substance involved . . . . . All Details . . . . . Use back space if necessary

CAUSE: Mark basic cause [X] Mark contributing cause, if any [O]

UNSAFE CONDITIONS

1 ☐ Inadequately Guarded
2 ☐ Unguarded
3 ☐ Defective Tools, Equipment, or Substance
4 ☐ Unsafe Design or Construction
5 ☐ Hazardous Arrangement
6 ☐ Unsafe Illumination
7 ☐ Unsafe Ventilation
8 ☐ Unsafe Clothing
9 ☐ Insufficient Instruction

UNSAFE ACTS

1 ☐ Operating Without Authority
2 ☐ Operating at Unsafe Speed
3 ☐ Making Safety Devices Inoperative
4 ☐ Using Unsafe Equipment or Equipment Unsafely
5 ☐ Unsafe Loading, Placing, Mixing
6 ☐ Taking Unsafe Position
7 ☐ Working on Moving or Dangerous Equipment
8 ☐ Distraction, Teasing, Horse Play
9 ☐ Failure to use Personal Protective Devices

Why was the unsafe act committed? _____ Why did the unsafe condition exist? _____

Any physical disabilities? _____

Number of previous disablng injuries _____

GUIDES TO CORRECTIVE ACTION

Based on the cause checked above, I am taking the following corrective action:

UNSAFE ACT

☐ 1 Stop the Behavior
☐ 2 Study the Job
☐ 3 Instruct (tell--show--try--check)
☐ 4 Follow Up
☐ 5 Enforce

UNSAFE CONDITION

☐ 1 Remove
☐ 2 Guard
☐ 3 Warn
☐ 4 Supervisory Training

If Supervisor Can't Handle, Then

5 Recommend To:
(a) ☐ Own Boss, OR
(b) ☐ Safety Committee, OR
(c) ☐ Maintenance Dept., OR
(d) ☐ _____

6 Follow Up

What I am actually doing to prevent similar injuries_____

What further recommendations? _____

SIGNATURES

_____ Immediate Supervisor or Foreman

_____ Received by Plant Manager or Superintendent

DEPARTMENT OF LABOR AND INDUSTRIES
WISHA SERVICES DIVISION

1. Describe the accident in your own words just as you saw it happen. Describe the surroundings or setting before the accident and the position of the injured party in relation to the surroundings, then describe the steps in proper sequence leading to the accident that happened. If possible attach a picture or make a drawing.

2. Describe any near accidents you have observed in the past week.

3. Report any unsafe procedures you have observed in the past week. (Physical hazards are classed as unsafe procedures as well as human acts.)

Safety and Health Inspection Check List

A = Adequate at time of inspection
B = Needs immediate attention

A	B	
		1. JOB SITE INFORMATION
☐	☐	WISHA and other job site warning posters posted
☐	☐	Scheduled safety meetings held and documented
☐	☐	Adequate employee training – general and specific
☐	☐	Medical services, first aid equipment, stretchers and a qualified first aider available
☐	☐	Emergency telephone numbers posted (medical services, fire department, police)
		2. HOUSEKEEPING AND SANITATION
☐	☐	Working areas generally neat
☐	☐	Waste and trash regularly disposed
☐	☐	Enclosed chute provided when material dropped outside of building from over 20 feet
☐	☐	Lighting adequate for all work tasks
☐	☐	Projecting nails removed or bent over
☐	☐	Oil and grease removed from walkways and stairs
☐	☐	Waste containers provided and used
☐	☐	Sanitary facilities adequate and clear
☐	☐	Potable water available for drinking
☐	☐	Disposable drinking cups and container for used cups provided
		3. FIRE PREVENTION
☐	☐	Fire protection program developed
☐	☐	Fire instructions provided to personnel
☐	☐	Proper type and number of fire extinguishers, identified, checked and accessible
☐	☐	Phone number of fire department posted
☐	☐	Hydrants clear, access open
☐	☐	NO SMOKING signs posted and enforced where needed
☐	☐	Temporary heating devices safe. Adequate ventilation provided
		4. ELECTRICAL INSTALLATIONS
☐	☐	Adequate wiring, well insulated, grounded, protected from damage
☐	☐	Assured grounding program followed (OR)
☐	☐	Ground fault circuit interrupters used
☐	☐	Terminal boxes equipped with required covers
		5. HAND TOOLS
☐	☐	Proper tools being used for each job
☐	☐	Safe carrying practices used
☐	☐	Company and employees' tools regularly inspected and maintained

Safety and Health Inspection Check List – continued

A = Adequate at time of inspection
B = Needs immediate attention

A	B	
		6. POWER TOOLS
☐	☐	Good housekeeping where tools are used
☐	☐	Tools and cords in good condition
☐	☐	Proper grounding of all tools (OR)
☐	☐	Double insulated tools used
☐	☐	Proper instruction in use provided
☐	☐	All mechanical guards in use
☐	☐	Tools neatly stored when not in use.
☐	☐	Right tool being used for the job at hand
☐	☐	Wiring properly installed
		7. POWDER-ACTUATED TOOLS
☐	☐	All operators licensed
☐	☐	Tools and charges protected from unauthorized use
☐	☐	Competent instruction and supervision provided
☐	☐	Tools used only on recommended materials
☐	☐	Flying hazards checked by backing up, removal of personnel, or use of captive stud tool
		8. LADDERS
☐	☐	Ladders inspected and in good condition
☐	☐	Ladders properly secured to prevent slipping, sliding or falling
☐	☐	Side rails extended 36" above the top of landing
☐	☐	Job-built ladders properly constructed
☐	☐	Stepladders fully open when in use
☐	☐	Metal ladders not used around electrical hazards
☐	☐	Ladders not painted
☐	☐	Ladders properly stored
☐	☐	Ladder safety feet in use
		9. HEAVY EQUIPMENT
☐	☐	Inspection and maintenance records up to date
☐	☐	Lights, brakes, warning signals operative
☐	☐	Wheels chocked when necessary
☐	☐	Haul roads well maintained and properly laid out
☐	☐	Equipment is properly secured when not in use
☐	☐	Shut-off devices on hose air lines, in case of hose failure
☐	☐	Noise arrestors in use
☐	☐	ROPS in place

Safety and Health Inspection Check List – continued

A = Adequate at time of inspection
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A	B	
		10. SCAFFOLDING
☐	☐	Erection properly supervised
☐	☐	All structural members meet safety factors
☐	☐	All connections secure
☐	☐	Scaffold tied in to the structure when required
☐	☐	Working areas free of debris, snow, ice and grease
☐	☐	Foot sills and mud sills provided
☐	☐	Workers protected from falling objects
☐	☐	Scaffolds plumb and square, with cross-bracing
☐	☐	Guard rails, intermediate rails, and toeboards in place
☐	☐	Adequate, sound planking provided
☐	☐	Scaffold equipment in good working order
☐	☐	Ropes and cables in good condition
		11. MOTOR VEHICLES
☐	☐	Roadways or walkway hazards effectively barricaded
☐	☐	Barricades illuminated or reflectorized at night
☐	☐	Traffic control devices used when appropriate
☐	☐	Inspection and maintenance records up to date
☐	☐	Operators qualified for vehicles in use
☐	☐	Local and state vehicle laws and regulations observed
☐	☐	Brakes, lights, warning devices operative
☐	☐	Weight limits and load sizes controlled
☐	☐	Personnel transported in a safe manner
☐	☐	All glass in good condition
☐	☐	Back-up signals provided
☐	☐	Fire extinguishers installed where required
☐	☐	SLOW MOVING VEHICLE signs used when required
		12. HOISTS, CRANES AND DERRICKS
☐	☐	Cables and sheaves regularly inspected
☐	☐	Slings and chains, hooks and eyes inspected before each use
☐	☐	Equipment firmly supported
☐	☐	Outriggers used if needed
☐	☐	Power lines inactivated, removed, or at a safe distance
☐	☐	Proper loading for capacity at lifting radius. Rated load capacities posted?
☐	☐	All equipment properly lubricated and maintained
☐	☐	Signalpersons where needed
☐	☐	Signals posed, understood, and observed
☐	☐	Inspection and maintenance logs maintained
☐	☐	Hazard signs posted and visible to operator

Safety and Health Inspection Check List – continued

A = Adequate at time of inspection
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A	B	
		13. BARRICADES
☐	☐	Floor and wall openings planked over or barricaded
☐	☐	Roadways or walkway hazards effectively barricaded
☐	☐	Barricades illuminated or reflectorized at night
☐	☐	Traffic control devices used when appropriate
		14. HANDLING AND STORAGE OF MATERIALS
☐	☐	Materials properly stored or stacked
☐	☐	Passageways clear
☐	☐	Stacks on firm footings, not too high
☐	☐	Materials protected against weather conditions
☐	☐	Trash chutes safeguarded and properly used
☐	☐	Dust protection observed
☐	☐	Traffic controlled in the storage area
		15. EXPLOSIVES
☐	☐	Qualified operators and supervision during all explosives operations
☐	☐	Proper transport vehicles as required by Department of Transportation and WISHA
☐	☐	State and local laws and regulations observed
☐	☐	Storage magazines constructed per regulations
☐	☐	Cases opened ONLY with wooden tools
☐	☐	NO SMOKING signs posted and observed where appropriate
☐	☐	Detonators tested before each shot
☐	☐	All personnel familiar with signals; signals properly used at all times
☐	☐	Inspection after each shot
☐	☐	Proper protection and accounting for all explosives at all times
☐	☐	Proper disposition of wrappings, waste, and scrap
☐	☐	Nearby residents advised of blasting and danger
☐	☐	Radio frequency hazards checked
		16. WELDING AND CUTTING
☐	☐	Operators qualified
☐	☐	Screens and shields used when needed
☐	☐	Goggles, welding helmets, gloves, clothing used as required
☐	☐	Equipment in safe operating condition
☐	☐	Electrical equipment grounded
☐	☐	Power cables and hoses protected and in good repair
☐	☐	Fire extinguishers of proper type nearby
☐	☐	Surrounding area inspected for fire hazards
☐	☐	Flammable materials protected or removed
☐	☐	Gas cylinders secured upright
☐	☐	Cylinder caps in use

Safety and Health Inspection Check List – continued

A = Adequate at time of inspection
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A	B	
		17. FLAMMABLE GASES AND LIQUIDS
☐	☐	All containers approved and clearly identified
☐	☐	Proper storage practices observed
☐	☐	Fire hazards checked
☐	☐	Proper types and number of extinguishers nearby
☐	☐	Proper method for moving cylinders used
		18. EXCAVATION AND SHORING
☐	☐	Adjacent structures properly shored
☐	☐	Excavation shored, shielded, or sloped as required
☐	☐	Roads and sidewalks supported and protected
☐	☐	Material stored away from excavations
☐	☐	Excavation barricades and lighting adequate
☐	☐	Equipment a safe distance from edge of excavation
☐	☐	Ladders provided
☐	☐	Equipment ramps adequate
☐	☐	Observer(spotter) provided during trenching operations
		19. STEEL ERECTION
☐	☐	Fall protection provided with safety nets, planked floors, or personnel restraint devices
☐	☐	Hard hats worn as required
☐	☐	Tools and materials secured from falling
☐	☐	Fire hazards at rivet, forge, and welding operations eliminated
☐	☐	Floor openings covered or barricaded
☐	☐	Ladders, stairs, or other safe access provided
☐	☐	Daily inspection of hoisting apparatus
☐	☐	Employees prohibited from riding the ball or loads
		20. PERSONAL PROTECTIVE EQUIPMENT MONITORED BY SUPERVISORS
☐	☐	Hard hats available on-site; worn when overhead hazards exist
☐	☐	Eye protection
☐	☐	Face shields
☐	☐	Written respirator program; respirators fit-tested; replacement cartridges; cleaning and maintenance
☐	☐	Helmets and hoods
☐	☐	Hearing protection – noise monitoring; written program
☐	☐	Foot protection
☐	☐	Rubber or plastic gloves, aprons, and sleeves for chemical protection
☐	☐	Electrician's rubber gloves and protectors

Safety and Health Inspection Check List -- continued

A = Adequate at time of inspection
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A	B	
		21. HIGHWAY CONSTRUCTION
☐	☐	Laws and ordinances observed
☐	☐	Competent flaggers properly instructed and dressed; area posted
☐	☐	Adequate traffic control devices used throughout construction area
☐	☐	Equipment cleared from right-of-way
☐	☐	Adequate marking and maintenance of detours approaching construction area
☐	☐	Dust controlled
☐	☐	Adequate lighting for night crews
☐	☐	**22. CONCRETE CONSTRUCTION**
☐	☐	Forms properly installed and braced
☐	☐	Adequate shoring, plumbed and cross-braced
☐	☐	Shoring remain in place until strength is attained
☐	☐	Proper curing period and procedures followed
☐	☐	Heating devices checked for fire safety
☐	☐	Mixing and transport equipment supported; traffic planned and routed
☐	☐	Adequate runways and ramps provided for concrete placement equipment
☐	☐	Employees protected from cement dust
☐	☐	Hard hats, boots, gloves, eye protection, and skin protection worn at all times
☐	☐	Nails bent over or removed and stripped material removed from area
		23. LIFTING AND BACK SAFETY
☐	☐	Team lifting used for heavy or awkward loads
☐	☐	Mechanical lifting devices used when appropriate
☐	☐	Back care training provided to all employees
☐	☐	Bent-knee lifting used by workers
☐	☐	Work hardening program used for returning time-loss employees
☐	☐	Employees do "warm up" exercises before strenuous work
		24. HAZARD COMMUNICATION PROGRAM
☐	☐	Chemical inventory list developed and maintained
☐	☐	Containers properly labeled
☐	☐	Material Safety Data Sheets collected and available
☐	☐	Adequate employee information and training provided
☐	☐	Written program available

Safety and Health Inspection Check List – continued

A = Adequate at time of inspection
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A	B	
		25. MASONRY
☐	☐	Scaffolding procedures meet at least minimum requirements
☐	☐	Masonry saws properly equipped and grounded, dust protection provided
☐	☐	Hoisting equipment in safe operating condition and used by qualified personnel
☐	☐	Limited access zone established
☐	☐	Walls over 8 feet in height adequately braced
		26. CONFINED SPACE
☐	☐	Written confined space program
☐	☐	Competent instruction and supervisors provided
☐	☐	Hot work permits obtained, if needed, prior to entry and work
☐	☐	Evaluation and monitoring – sampling devices adequate, calibrated, and used
☐	☐	Ventilation adequate, testing and monitoring during operation
☐	☐	Respirators, standby person , harnesses/lifelines at the site
☐	☐	**27. DEMOLITION**
☐	☐	Written demolition plan
☐	☐	Protection of adjacent structures
☐	☐	Material chutes used. Floor openings for material disposal barricaded
☐	☐	Sidewalk and other public protection provided
☐	☐	Clear opening space for trucks and other vehicles
☐	☐	Adequate access ladders or stairs maintained
		28. PILE DRIVING
☐	☐	Stored piles properly secured
☐	☐	Unloading only by properly instructed workers
☐	☐	Steam lines, slings, etc., in safe operating condition
☐	☐	Piledriving rigs properly supported
☐	☐	Cofferdams maintained and inspected
☐	☐	Adequate pumping available

(Customize the checklist above for adding any additional areas or equipment and deleting the information that does not apply to your business.)

APPENDIX D

MSDS SHEETS

MATERIAL SAFETY DATA SHEET

ALCONOX®

Prepared to U.S. OSHA, CMA, ANSI, Canadian WHMIS, Australian WorkSafe, Japanese Industrial Standard JIS Z 7250:2000, and European Union REACH Regulations

SECTION 1 - PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME:	**ALCONOX®**
CHEMICAL FAMILY NAME:	Detergent.
PRODUCT USE:	Critical-cleaning detergent for laboratory, healthcare and industrial applications
U.N. NUMBER:	Not Applicable
U.N. DANGEROUS GOODS CLASS:	Non-Regulated Material
SUPPLIER/MANUFACTURER'S NAME:	Alconox, Inc.
ADDRESS:	30 Glenn St., Suite 309, White Plains, NY 10603. USA
EMERGENCY PHONE:	**TOLL-FREE in USA/Canada** 800-255-3924
	International calls 813-248-0585
BUSINESS PHONE:	914-948-4040
DATE OF PREPARATION:	May 2011
DATE OF LAST REVISION:	February 2008

SECTION 2 - HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: This product is a white granular powder with little or no odor. Exposure can be irritating to eyes, respiratory system and skin. It is a non-flammable solid. The Environmental effects of this product have not been investigated.

US DOT SYMBOLS

Non-Regulated

CANADA (WHMIS) SYMBOLS

EUROPEAN and (GHS) Hazard Symbols

Signal Word: **Warning!**

EU LABELING AND CLASSIFICATION:

Classification of the substance or mixture according to Regulation (EC) No1272/2008 Annex 1
EC# 205-633-8 This substance is not classified in the Annex I of Directive 67/548/EEC
EC# 268-356-1 This substance is not classified in the Annex I of Directive 67/548/EEC
EC# 231-838-7 This substance is not classified in the Annex I of Directive 67/548/EEC
EC# 231-767-1 This substance is not classified in the Annex I of Directive 67/548/EEC
EC# 207-638-8 Index# 011-005-00-2
EC# 205-788-1 This substance is not classified in the Annex I of Directive 67/548/EEC

GHS Hazard Classification(s):

Eye Irritant Category 2A

Hazard Statement(s):

H319: Causes serious eye irritation

Precautionary Statement(s):

P260: Do not breath dust/fume/gas/mist/vapors/spray
P264: Wash hands thoroughly after handling
P271: Use only in well ventilated area.
P280: Wear protective gloves/protective clothing/eye protection/face protection/

Hazard Symbol(s):

[Xi] Irritant

Risk Phrases:
R20: Harmful by inhalation
R36/37/38: Irritating to eyes, respiratory system and skin

Safety Phrases:
S8: Keep container dry
S22: Do not breath dust
S24/25: Avoid contact with skin and eyes

HEALTH HAZARDS OR RISKS FROM EXPOSURE:

ACUTE: Exposure to this product may cause irritation of the eyes, respiratory system and skin. Ingestion may cause gastrointestinal irritation including pain, vomiting or diarrhea.

CHRONIC: This product contains an ingredient which may be corrosive.

TARGET ORGANS: ACUTE: Eye, respiratory System, Skin CHRONIC: None Known

SECTION 3 - COMPOSITION and INFORMATION ON INGREDIENTS

HAZARDOUS INGREDIENTS:	CAS #	EINECS #	ICSC #	WT %	HAZARD CLASSIFICATION; RISK PHRASES
Sodium Bicarbonate	144-55-8	205-633-8	1044	33 - 43%	HAZARD CLASSIFICATION: None RISK PHRASES: None
Sodium (C10 – C16) Alkylbenzene Sulfonate	68081-81-2	268-356-1	Not Listed	10 – 20%	HAZARD CLASSIFICATION: None RISK PHRASES: None
Sodium Tripolyphosphate	7758-29-4	231-838-7	1469	5 - 15%	HAZARD CLASSIFICATION: None RISK PHRASES: None
Tetrasodium Pyrophosphate	7722-88-5	231-767-1	1140	5 - 15%	HAZARD CLASSIFICATION: None RISK PHRASES: None
Sodium Carbonate	497-19-8	207-638-8	1135	1 - 10%	HAZARD CLASSIFICATION: [Xi] Irritant RISK PHRASES: R36
Sodium Alcohol Sulfate	151-21-3	205-788-1	0502	1 – 5%	HAZARD CLASSIFICATION: None RISK PHRASES: None
Balance of other ingredients are non-hazardous or less than 1% in concentration (or 0.1% for carcinogens, reproductive toxins, or respiratory sensitizers).					

NOTE: ALL WHMIS required information is included in appropriate sections based on the ANSI Z400.1-2004 format. This product has been classified in accordance with the hazard criteria of the CPR and the MSDS contains all the information required by the CPR, EU Directives and the Japanese Industrial Standard *JIS Z 7250: 2000*.

SECTION 4 - FIRST-AID MEASURES

Contaminated individuals of chemical exposure must be taken for medical attention if any adverse effect occurs. Rescuers should be taken for medical attention, if necessary. Take copy of label and MSDS to health professional with contaminated individual.

EYE CONTACT: If product enters the eyes, open eyes while under gentle running water for at least 15 minutes. Seek medical attention if irritation persists.

SKIN CONTACT: Wash skin thoroughly after handling. Seek medical attention if irritation develops and persists. Remove contaminated clothing. Launder before re-use.

INHALATION: If breathing becomes difficult, remove victim to fresh air. If necessary, use artificial respiration to support vital functions. Seek medical attention if breathing dificulty continues.

INGESTION: If product is swallowed, call physician or poison control center for most current information. If professional advice is not available, do not induce vomiting. Never induce vomiting or give diluents (milk or water) to someone who is unconscious, having convulsions, or who cannot swallow. Seek medical advice. Take a copy of the label and/or MSDS with the victim to the health professional.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: Pre-existing skin, or eye problems may be aggravated by prolonged contact.

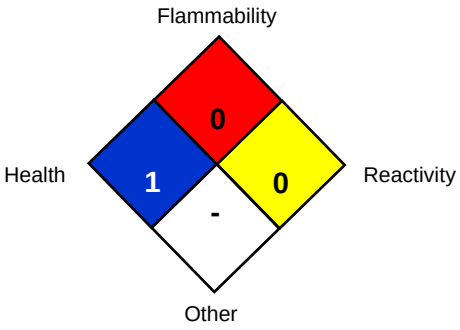
RECOMMENDATIONS TO PHYSICIANS: Treat symptoms and reduce over-exposure.

SECTION 5 - FIRE-FIGHTING MEASURES

FLASH POINT: Not Flammable
AUTOIGNITION TEMPERATURE: Not Applicable
FLAMMABLE LIMITS (in air by volume, %): Lower (LEL): NA Upper (UEL): NA
FIRE EXTINGUISHING MATERIALS: As appropriate for surrounding fire. Carbon dioxide, foam, dry chemical, halon, or water spray.

UNUSUAL FIRE AND EXPLOSION HAZARDS: This product is non-flammable and has no known explosion hazards.
Explosion Sensitivity to Mechanical Impact: Not Sensitive.
Explosion Sensitivity to Static Discharge: Not Sensitive
SPECIAL FIRE-FIGHTING PROCEDURES: Incipient fire responders should wear eye protection. Structural firefighters must wear Self-Contained Breathing Apparatus and full protective equipment. Isolate materials not yet involved in the fire and protect personnel. Move containers from fire area if this can be done without risk; otherwise, cool with carefully applied water spray. If possible, prevent runoff water from entering storm drains, bodies of water, or other environmentally sensitive areas.

NFPA RATING SYSTEM



HMIS RATING SYSTEM

HAZARDOUS MATERIAL IDENTIFICATION SYSTEM

HEALTH HAZARD (BLUE)	1
FLAMMABILITY HAZARD (RED)	0
PHYSICAL HAZARD (YELLOW)	0

PROTECTIVE EQUIPMENT			
EYES	RESPIRATORY	HANDS	BODY
	See Sect 8		See Sect 8

For Routine Industrial Use and Handling Applications

Hazard Scale: **0** = Minimal **1** = Slight **2** = Moderate **3** = Serious **4** = Severe * = Chronic hazard

SECTION 6 - ACCIDENTAL RELEASE MEASURES

SPILL AND LEAK RESPONSE: Personnel should be trained for spill response operations.
SPILLS: Contain spill if safe to do so. Prevent entry into drains, sewers, and other waterways. Sweep, shovel or vacuum spilled material and place in an appropriate container for re-use or disposal. Avoid dust generation if possible. Dispose of in accordance with applicable Federal, State, and local procedures (see Section 13, Disposal Considerations).

SECTION 7 - HANDLING and STORAGE

WORK PRACTICES AND HYGIENE PRACTICES: As with all chemicals, avoid getting this product ON YOU or IN YOU. Wash thoroughly after handling this product. Do not eat, drink, smoke, or apply cosmetics while handling this product. Avoid breathing dusts generated by this product. Use in a well-ventilated location. Remove contaminated clothing immediately.

STORAGE AND HANDLING PRACTICES: Containers of this product must be properly labeled. Store containers in a cool, dry location. Keep container tightly closed when not in use. Store away from strong acids or oxidizers.

SECTION 8 - EXPOSURE CONTROLS - PERSONAL PROTECTION

EXPOSURE LIMITS/GUIDELINES:

Chemical Name	CAS#	ACGIH TWA	OSHA TWA	SWA
Sodium Bicarbonate	144-55-8	10 mg/m³ Total Dust	15 mg/m³ Total Dust	10 mg/m³ Total Dust
Sodium (C10 – C16) Alkylbenzene Sulfonate	68081-81-2	10 mg/m³ Total Dust	15 mg/m³ Total Dust	10 mg/m³ Total Dust
Sodium Tripolyphosphate	7758-29-4	10 mg/m³ Total Dust	15 mg/m³ Total Dust	10 mg/m³ Total Dust
Tetrasodium Pyrophosphate	7722-88-5	5 mg/m³	5 mg/m³	5 mg/m³
Sodium Carbonate	497-19-8	10 mg/m³ Total Dust	15 mg/m³ Total Dust	10 mg/m³ Total Dust
Sodium Alcohol Sulfate	151-21-3	10 mg/m³ Total Dust	15 mg/m³ Total Dust	10 mg/m³ Total Dust

Currently, International exposure limits are not established for the components of this product. Please check with competent authority in each country for the most recent limits in place.

VENTILATION AND ENGINEERING CONTROLS: Use with adequate ventilation to ensure exposure levels are maintained below the limits provided below. Use local exhaust ventilation to control airborne dust. Ensure eyewash/safety shower stations are available near areas where this product is used.

The following information on appropriate Personal Protective Equipment is provided to assist employers in complying with OSHA regulations found in 29 CFR Subpart I (beginning at 1910.132) or equivalent standard of Canada, or standards of EU member states (including EN 149 for respiratory PPE, and EN 166 for face/eye protection), and those of Japan. Please reference applicable regulations and standards for relevant details.

RESPIRATORY PROTECTION: Based on test data, exposure limits should not be exceeded under normal use conditions when using Alconox Detergent. Maintain airborne contaminant concentrations below guidelines listed above, if applicable. If necessary, use only respiratory protection authorized in the U.S. Federal OSHA Respiratory Protection Standard (29 CFR 1910.134), equivalent U.S. State standards, Canadian CSA Standard Z94.4-93, the European Standard EN149, or EU member states.

EYE PROTECTION: Safety glasses. If necessary, refer to U.S. OSHA 29 CFR 1910.133 or appropriate Canadian Standards.

HAND PROTECTION: Use chemical resistant gloves to prevent skin contact.. If necessary, refer to U.S. OSHA 29 CFR 1910.138 or appropriate Standards of Canada.

BODY PROTECTION: Use body protection appropriate to prevent contact (e.g. lab coat, overalls). If necessary, refer to appropriate Standards of Canada, or appropriate Standards of the EU, Australian Standards, or relevant Japanese Standards.

SECTION 9 - PHYSICAL and CHEMICAL PROPERTIES

PHYSICAL STATE:	Solid
APPEARANCE & ODOR:	White granular powder with little or no odor.
ODOR THRESHOLD (PPM):	Not Available
VAPOR PRESSURE (mmHg):	Not Applicable
VAPOR DENSITY (AIR=1):	Not Applicable.
BY WEIGHT:	Not Available
EVAPORATION RATE (nBuAc = 1):	Not Applicable.
BOILING POINT (C°):	Not Applicable.
FREEZING POINT (C°):	Not Applicable.
pH:	9.5 (1% aqueous solution)
SPECIFIC GRAVITY 20°C: (WATER =1)	0.85 – 1.1
SOLUBILITY IN WATER (%)	>10% w/w
COEFFICIENT OF WATER/OIL DIST.:	Not Available
VOC:	None
CHEMICAL FAMILY:	Detergent

SECTION 10 - STABILITY and REACTIVITY

STABILITY: Product is stable
DECOMPOSITION PRODUCTS: When heated to decomposition this product produces Oxides of carbon (COx)
MATERIALS WITH WHICH SUBSTANCE IS INCOMPATIBLE: Strong acids and strong oxidizing agents.
HAZARDOUS POLYMERIZATION: Will not occur.
CONDITIONS TO AVOID: Contact with incompatible materials and dust generation.

SECTION 11 - TOXICOLOGICAL INFORMATION

TOXICITY DATA: Toxicity data is available for mixture:

CAS# 497-19-8 LD50 Oral (Rat)	4090 mg/kg
CAS# 497-19-8 LD50 Oral (Mouse)	6600 mg/kg
CAS# 497-19-8 LC50 Inhalation (Rat)	2300 mg/m³ 2H
CAS# 497-19-8 LC50 Inhalation (Mouse)	1200 mg/m³ 2H
CAS# 7758-29-4 LD50 Oral (Rat)	3120 mg/kg
CAS# 7758-29-4 LD50 Oral (Mouse)	3100 mg/kg
CAS# 7722-88-5 LD50 Oral (Rat)	4000 mg/kg

SUSPECTED CANCER AGENT: None of the ingredients are found on the following lists: FEDERAL OSHA Z LIST, NTP, CAL/OSHA, IARC and therefore is not considered to be, nor suspected to be a cancer-causing agent by these agencies.
IRRITANCY OF PRODUCT: Contact with this product can be irritating to exposed skin, eyes and respiratory system.
SENSITIZATION OF PRODUCT: This product is not considered a sensitizer.
REPRODUCTIVE TOXICITY INFORMATION: No information concerning the effects of this product and its components on the human reproductive system.

SECTION 12 - ECOLOGICAL INFORMATION

ALL WORK PRACTICES MUST BE AIMED AT ELIMINATING ENVIRONMENTAL CONTAMINATION.
ENVIRONMENTAL STABILITY: No Data available at this time.
EFFECT OF MATERIAL ON PLANTS or ANIMALS: No evidence is currently available on this product's effects on plants or animals.

EFFECT OF CHEMICAL ON AQUATIC LIFE: No evidence is currently available on this product's effects on aquatic life.

SECTION 13 - DISPOSAL CONSIDERATIONS

PREPARING WASTES FOR DISPOSAL: Waste disposal must be in accordance with appropriate Federal, State, and local regulations, those of Canada, Australia, EU Member States and Japan.

SECTION 14 - TRANSPORTATION INFORMATION

US DOT; IATA; IMO; ADR:

THIS PRODUCT IS NOT HAZARDOUS AS DEFINED BY 49 CFR 172.101 BY THE U.S. DEPARTMENT OF TRANSPORTATION.
PROPER SHIPPING NAME: Non-Regulated Material
HAZARD CLASS NUMBER and DESCRIPTION: Not Applicable
UN IDENTIFICATION NUMBER: Not Applicable
PACKING GROUP: Not Applicable.
DOT LABEL(S) REQUIRED: Not Applicable
NORTH AMERICAN EMERGENCY RESPONSE GUIDEBOOK NUMBER (2004): Not Applicable
MARINE POLLUTANT: None of the ingredients are classified by the DOT as a Marine Pollutant (as defined by 49 CFR 172.101, Appendix B)

U.S. DEPARTMENT OF TRANSPORTATION (DOT) SHIPPING REGULATIONS:
This product is not classified as dangerous goods, per U.S. DOT regulations, under 49 CFR 172.101.

TRANSPORT CANADA, TRANSPORTATION OF DANGEROUS GOODS REGULATIONS:
This product is not classified as Dangerous Goods, per regulations of Transport Canada.

INTERNATIONAL AIR TRANSPORT ASSOCIATION (IATA):
This product is not classified as Dangerous Goods, by rules of IATA:

INTERNATIONAL MARITIME ORGANIZATION (IMO) DESIGNATION:
This product is not classified as Dangerous Goods by the International Maritime Organization.

EUROPEAN AGREEMENT CONCERNING THE INTERNATIONAL CARRIAGE OF DANGEROUS GOODS BY ROAD (ADR):

This product is not classified by the United Nations Economic Commission for Europe to be dangerous goods.

SECTION 15 - REGULATORY INFORMATION

UNITED STATES REGULATIONS

SARA REPORTING REQUIREMENTS: This product is not subject to the reporting requirements of Sections 302, 304 and 313 of Title III of the Superfund Amendments and Reauthorization Act., as follows: None

TSCA: All components in this product are listed on the US Toxic Substances Control Act (TSCA) inventory of chemicals.

SARA 311/312:

Acute Health: Yes Chronic Health: No Fire: No Reactivity: No

U.S. SARA THRESHOLD PLANNING QUANTITY: There are no specific Threshold Planning Quantities for this product. The default Federal MSDS submission and inventory requirement filing threshold of 10,000 lb (4,540 kg) may apply, per 40 CFR 370.20.

U.S. CERCLA REPORTABLE QUANTITY (RQ): None

CALIFORNIA SAFE DRINKING WATER AND TOXIC ENFORCEMENT ACT (PROPOSITION 65): None of the ingredients are on the California Proposition 65 lists.

CANADIAN REGULATIONS:

CANADIAN DSL/NDSL INVENTORY STATUS: All of the components of this product are on the DSL Inventory

CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA) PRIORITIES SUBSTANCES LISTS: No component of this product is on the CEPA First Priorities Substance Lists.

CANADIAN WHMIS CLASSIFICATION and SYMBOLS: This product is categorized as a Controlled Product, Hazard Class D2B as per the Controlled Product Regulations

EUROPEAN ECONOMIC COMMUNITY INFORMATION:

EU LABELING AND CLASSIFICATION:

Classification of the mixture according to Regulation (EC) No1272/2008. See section 2 for details.

AUSTRALIAN INFORMATION FOR PRODUCT:

AUSTRALIAN INVENTORY OF CHEMICAL SUBSTANCES (AICS) STATUS: All components of this product are listed on the AICS.

STANDARD FOR THE UNIFORM SCHEDULING OF DRUGS AND POISONS: Not applicable.

JAPANESE INFORMATION FOR PRODUCT:

JAPANESE MINISTER OF INTERNATIONAL TRADE AND INDUSTRY (MITI) STATUS: The components of this product are not listed as Class I Specified Chemical Substances, Class II Specified Chemical Substances, or Designated Chemical Substances by the Japanese MITI.

INTERNATIONAL CHEMICAL INVENTORIES:

Listing of the components on individual country Chemical Inventories is as follows:

Asia-Pac:	Listed
Australian Inventory of Chemical Substances (AICS):	Listed
Korean Existing Chemicals List (ECL):	Listed
Japanese Existing National Inventory of Chemical Substances (ENCS):	Listed
Philippines Inventory if Chemicals and Chemical Substances (PICCS):	Listed
Swiss Giftliste List of Toxic Substances:	Listed
U.S. TSCA:	Listed

SECTION 16 - OTHER INFORMATION

PREPARED BY: Paul Eigbrett Global Safety Management, 10006 Cross Creek Blvd. Suite 440, Tampa, FL 33647

Disclaimer: To the best of Alconox, Inc. knowledge, the information contained herein is reliable and accurate as of this date; however, accuracy, suitability or completeness is not guaranteed and no warranties of any type either express or implied are provided. The information contained herein relates only to this specific product.

ANNEX:

IDENTIFIED USES OF ALCONOX® AND DIRECTIONS FOR USE

Used to clean: Healthcare instruments, laboratory ware, vacuum equipment, tissue culture ware, personal protective equipment, sampling apparatus, catheters, tubing, pipes, radioactive contaminated articles, optical parts, electronic components, pharmaceutical apparatus, cosmetics manufacturing equipment, metal castings, forgings and stampings, industrial parts, tanks and reactors. Authorized by USDA for use in federally inspected meat and poultry plants. Passes inhibitory residue test for water analysis. FDA certified.

Used to remove: Soil, grit, grime, buffing compound, slime, grease, oils, blood, tissue, salts, deposits, particulates, solvents, chemicals, radioisotopes, radioactive contaminations, silicon oils, mold release agents.

Surfaces cleaned: Corrosion inhibited formulation recommended for glass, metal, stainless steel, porcelain, ceramic, plastic, rubber and fiberglass. Can be used on soft metals such as copper, aluminum, zinc and magnesium if rinsed promptly. Corrosion testing may be advisable.

Cleaning method: Soak, brush, sponge, cloth, ultrasonic, flow through clean-inplace. Will foam—not for spray or machine use.

Directions: Make a fresh 1% solution (2 1/2 Tbsp. per gal., 1 1/4 oz. per gal. or 10 grams per liter) in cold, warm, or hot water. If available use warm water. Use cold water for blood stains. For difficult soils, raise water temperature and use more detergent. Clean by soak, circulate, wipe, or ultrasonic method. Not for spray machines, will foam. For nonabrasive scouring, make paste. Use 2% solution to soak frozen stopcocks. To remove silver tarnish, soak in 1% solution in aluminum container. RINSE THOROUGHLY—preferably with running water. For critical cleaning, do final or all rinsing in distilled, deionized, or purified water. For food contact surfaces, rinse with potable water. Used on a wide range of glass, ceramic, plastic, and metal surfaces. Corrosion testing may be advisable.

SAFETY DATA SHEET

Nitrogen

Section 1. Identification

GHS product identifier : Nitrogen

Chemical name : nitrogen

Other means of identification : nitrogen (dot); nitrogen gas; Nitrogen NF, Nitrogen FG

Product use : Synthetic/Analytical chemistry.

Synonym : nitrogen (dot); nitrogen gas; Nitrogen NF, Nitrogen FG

SDS # : 001040

Supplier's details : Airgas USA, LLC and its affiliates
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

24-hour telephone : 1-866-734-3438

Section 2. Hazards identification

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture : GASES UNDER PRESSURE - Compressed gas

GHS label elements

Hazard pictograms :

Signal word : Warning

Hazard statements : Contains gas under pressure; may explode if heated.
May displace oxygen and cause rapid suffocation.

Precautionary statements

General : Read and follow all Safety Data Sheets (SDS'S) before use. Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand. Close valve after each use and when empty. Use equipment rated for cylinder pressure. Do not open valve until connected to equipment prepared for use. Use a back flow preventative device in the piping. Use only equipment of compatible materials of construction.

Prevention : Not applicable.

Response : Not applicable.

Storage : Protect from sunlight when ambient temperature exceeds 52°C/125°F. Store in a well-ventilated place.

Disposal : Not applicable.

Hazards not otherwise classified : In addition to any other important health or physical hazards, this product may displace oxygen and cause rapid suffocation.

Section 3. Composition/information on ingredients

Substance/mixture : Substance

Chemical name : nitrogen

Other means of identification : nitrogen (dot); nitrogen gas; Nitrogen NF, Nitrogen FG

CAS number/other identifiers

CAS number : 7727-37-9

Product code : 001040

Ingredient name	%	CAS number
Nitrogen	100	7727-37-9

Any concentration shown as a range is to protect confidentiality or is due to batch variation.

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact : Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Get medical attention if irritation occurs.

Inhalation : Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband. In case of inhalation of decomposition products in a fire, symptoms may be delayed. The exposed person may need to be kept under medical surveillance for 48 hours.

Skin contact : Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion : As this product is a gas, refer to the inhalation section.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact : Contact with rapidly expanding gas may cause burns or frostbite.

Inhalation : No known significant effects or critical hazards.

Skin contact : Contact with rapidly expanding gas may cause burns or frostbite.

Frostbite : Try to warm up the frozen tissues and seek medical attention.

Ingestion : As this product is a gas, refer to the inhalation section.

Over-exposure signs/symptoms

Eye contact : No specific data.

Inhalation : No specific data.

Skin contact : No specific data.

Ingestion : No specific data.

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician : In case of inhalation of decomposition products in a fire, symptoms may be delayed. The exposed person may need to be kept under medical surveillance for 48 hours.

Section 4. First aid measures

Specific treatments : No specific treatment.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use an extinguishing agent suitable for the surrounding fire.

Unsuitable extinguishing media : None known.

Specific hazards arising from the chemical : Contains gas under pressure. In a fire or if heated, a pressure increase will occur and the container may burst or explode.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
nitrogen oxides

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Contact supplier immediately for specialist advice. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Avoid breathing gas. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders : If specialised clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions : Ensure emergency procedures to deal with accidental gas releases are in place to avoid contamination of the environment. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill : Immediately contact emergency personnel. Stop leak if without risk.

Large spill : Immediately contact emergency personnel. Stop leak if without risk. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Contains gas under pressure. Avoid contact with eyes, skin and clothing. Avoid breathing gas. Empty containers retain product residue and can be hazardous. Do not puncture or incinerate container. Use equipment rated for cylinder pressure. Close valve after each use and when empty. Protect cylinders from physical damage; do not drag, roll, slide, or drop. Use a suitable hand truck for cylinder movement.

Section 7. Handling and storage

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Conditions for safe storage, including any incompatibilities : Store in accordance with local regulations. Store in a segregated and approved area. Store away from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10). Keep container tightly closed and sealed until ready for use. Cylinders should be stored upright, with valve protection cap in place, and firmly secured to prevent falling or being knocked over. Cylinder temperatures should not exceed 52 °C (125 °F).

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Ingredient name	Exposure limits
Nitrogen	Oxygen Depletion [Asphyxiant]

Appropriate engineering controls : Good general ventilation should be sufficient to control worker exposure to airborne contaminants.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: safety glasses with side-shields.

Skin protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Body protection : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection : Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance

Physical state : Gas. [Compressed gas.]

Color : Colorless.

Molecular weight : 28.02 g/mole

Molecular formula : N2

Boiling/condensation point : -196°C (-320.8°F)

Melting/freezing point : -210.01°C (-346°F)

Critical temperature : -146.95°C (-232.5°F)

Odor : Odorless.

Odor threshold : Not available.

pH : Not available.

Flash point : [Product does not sustain combustion.]

Burning time : Not applicable.

Burning rate : Not applicable.

Evaporation rate : Not available.

Flammability (solid, gas) : Not available.

Lower and upper explosive (flammable) limits : Not available.

Vapor pressure : Not available.

Vapor density : 0.967 (Air = 1) Liquid Density@BP: 50.46 lb/ft3 (808.3 kg/m3)

Specific Volume (ft^3/lb) : 13.8889

Gas Density (lb/ft^3) : 0.072

Relative density : Not applicable.

Solubility : Not available.

Solubility in water : Not available.

Partition coefficient: n-octanol/water : 0.67

Auto-ignition temperature : Not available.

Decomposition temperature : Not available.

SADT : Not available.

Viscosity : Not applicable.

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.

Chemical stability : The product is stable.

Possibility of hazardous reactions : Under normal conditions of storage and use, hazardous reactions will not occur.

Conditions to avoid : No specific data.

Incompatible materials : No specific data.

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Hazardous polymerization : Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 10. Stability and reactivity

Irritation/Corrosion
Not available.

Sensitization
Not available.

Mutagenicity
Not available.

Carcinogenicity
Not available.

Reproductive toxicity
Not available.

Teratogenicity
Not available.

Specific target organ toxicity (single exposure)
Not available.

Specific target organ toxicity (repeated exposure)
Not available.

Aspiration hazard
Not available.

Information on the likely routes of exposure : Not available.

Potential acute health effects

Eye contact : Contact with rapidly expanding gas may cause burns or frostbite.

Inhalation : No known significant effects or critical hazards.

Skin contact : Contact with rapidly expanding gas may cause burns or frostbite.

Ingestion : As this product is a gas, refer to the inhalation section.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : No specific data.

Inhalation : No specific data.

Skin contact : No specific data.

Ingestion : No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects
Not available.

General : No known significant effects or critical hazards.

Carcinogenicity : No known significant effects or critical hazards.

Section 11. Toxicological information

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Numerical measures of toxicity

Acute toxicity estimates

Not available.

Section 12. Ecological information

Toxicity

Not available.

Persistence and degradability

Not available.

Bioaccumulative potential

Product/ingredient name	$LogP_{ow}$	BCF	Potential
Nitrogen	0.67	-	low

Mobility in soil

Soil/water partition coefficient (K_{OC}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Empty Airgas-owned pressure vessels should be returned to Airgas. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Empty containers or liners may retain some product residues. Do not puncture or incinerate container.

Section 14. Transport information

	DOT	TDG	Mexico	IMDG	IATA
UN number	UN1066	UN1066	UN1066	UN1066	UN1066
UN proper shipping name	NITROGEN, COMPRESSED	NITROGEN, COMPRESSED	NITROGEN, COMPRESSED	NITROGEN, COMPRESSED	NITROGEN, COMPRESSED
Transport hazard class(es)	2.2 	2.2 	2.2 	2.2 	2.2 

Section 14. Transport information

Packing group	-	-	-	-	-
Environment	No.	No.	No.	No.	No.
Additional information	**Limited quantity** Yes. **Packaging instruction** **Passenger aircraft** Quantity limitation: 75 kg **Cargo aircraft** Quantity limitation: 150 kg	Product classified as per the following sections of the Transportation of Dangerous Goods Regulations: 2.13-2.17 (Class 2). **Explosive Limit and Limited Quantity Index** 0.125 **Passenger Carrying Road or Rail Index** 75	-	-	**Passenger and Cargo Aircraft**Quantity limitation: 75 kg **Cargo Aircraft Only** Quantity limitation: 150 kg

"Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product."

Special precautions for user : **Transport within user's premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code : Not available.

Section 15. Regulatory information

U.S. Federal regulations : **TSCA 8(a) CDR Exempt/Partial exemption**: This material is listed or exempted.
United States inventory (TSCA 8b): This material is listed or exempted.

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Not listed

Clean Air Act Section 602 Class I Substances : Not listed

Clean Air Act Section 602 Class II Substances : Not listed

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

No products were found.

SARA 304 RQ : Not applicable.

SARA 311/312

Classification : Sudden release of pressure

Composition/information on ingredients

Name	%	Fire hazard	Sudden release of pressure	Reactive	Immediate (acute) health hazard	Delayed (chronic) health hazard
Nitrogen	100	No.	Yes.	No.	No.	No.

Section 15. Regulatory information

State regulations

Massachusetts : This material is listed.

New York : This material is not listed.

New Jersey : This material is listed.

Pennsylvania : This material is listed.

International regulations

International lists

National inventory

Australia : This material is listed or exempted.

Canada : This material is listed or exempted.

China : This material is listed or exempted.

Europe : This material is listed or exempted.

Japan : Not determined.

Malaysia : Not determined.

New Zealand : This material is listed or exempted.

Philippines : This material is listed or exempted.

Republic of Korea : This material is listed or exempted.

Taiwan : This material is listed or exempted.

Canada

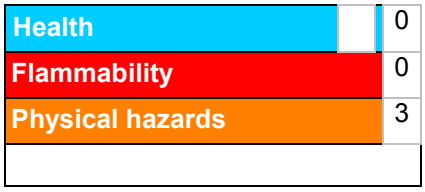
WHMIS (Canada) : Class A: Compressed gas.

CEPA Toxic substances: This material is not listed.
Canadian ARET: This material is not listed.
Canadian NPRI: This material is not listed.
Alberta Designated Substances: This material is not listed.
Ontario Designated Substances: This material is not listed.
Quebec Designated Substances: This material is not listed.

Section 16. Other information

Canada Label requirements : Class A: Compressed gas.

Hazardous Material Information System (U.S.A.)



Caution: HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks Although HMIS® ratings are not required on SDSs under 29 CFR 1910. 1200, the preparer may choose to provide them. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered mark of the National Paint & Coatings Association (NPCA). HMIS® materials may be purchased exclusively from J. J. Keller (800) 327-6868.

The customer is responsible for determining the PPE code for this material.

National Fire Protection Association (U.S.A.)

Section 16. Other information

Procedure used to derive the classification

Classification	Justification
Press. Gas Comp. Gas, H280	Expert judgment

History

Date of printing : 5/26/2016

Date of issue/Date of revision : 5/26/2016

Date of previous issue : 8/7/2015

Version : 0.02

Key to abbreviations : ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL 73/78 = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations

References : Not available.

Indicates information that has changed from previously issued version.

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

Material Safety Data Sheet: Oxygen Absorber

1. Identification of the substance/preparation and the company

Substance: Oxygen Absorber
Application: Oxygen Scavenger
Company:

IMPAK Corporation
13700 South Broadway
Los Angeles, CA 90061

2. Composition/Information of ingredients

Iron Powder (Fe)
Weight %: N/A
CAS No.: --
Hazard symbols: --
R-phrased: --

Index No.: --
EINECS No.: --

Active Carbon (C)
Weight %: N/A
CAS No.: --
Hazard symbols: --
R-phrases: --

Index No.: --
EINECS No.: --

Salt
Weight %: N/A
CAS No.: --
Hazard symbols: --
R-phrased: --

Index No.: --
EINECS No.: --

Vermiculite Granule
Weight %: N/A
CAS No.: --
Hazard symbols: --
R-phrases: --

Index No.: --
EINECS No.: --

3. Hazards Identification

Not Available

4. First-aid measures

May cause eye irritation/possible skin irritation upon prolonged direct contact with black powder, when the packet is broken and the contents are spilled.
Eye Contact: Immediately rinse with water for 15 minutes
Ingestion: Induce vomiting, drink water, and call physician immediately

5. Fire-fighting measures

This product is not combustible. If ignited can be extinguished with CO_2 foam or a water sprayer.

6. Accidental release measures

If product is released or spilled sweep off and place in disposal can.

7. Handling and Storage

Handling

Keep out of reach of children

Storage

Store in a dry place with cool, or normal room temperature

8. Exposure controls/personal protection

If large amounts of contents are spilled from packets, safety goggles recommended.

9. Physical and chemical properties

Form:	Black powder
Physical State	Powder
Odor:	odorless
PH Value	not available
Melting point:	Not available
Boiling point	not known
Solubility	Insoluble for iron powder and active carbon, soluble for salt
Vapor density:	not known
Vapor pressure	not known

10. Stability and reactivity

Chemical Stability: Avoid to expose packet in the air for a long time. When the master bag is open, iron will start chemical reaction with oxygen in the air, and form iron oxide in the packet
Incompatibility: Strong Acids
Hazardous Decomposition: Iron oxide
Hazardous Polymerization: Will not occur

11. Toxicological Information

None toxic with Oral LD_{50}
NTP- Not known

12. Ecological information

Not Available.

13. Disposal Considerations

Sweep off and place in disposal can
Dispose of in compliance with all federal, state, and local laws and regulations.

14. Transport information

GGVSE: --	UN: --	PG: --	
RID/ADR: --	UN: --	PG: --	
Warning sign: Hazard No. --	UN No.: ----		
ADNR: --	UN: --	PG: --	
GGVsee/IMDG Code: --	UN: --	PG: --	MPO: --
ICAO-TI/IATA-DGR: --	UN: --	PG: --	

Declaration for land shipment: --
Declaration for sea shipment: --
Declaration of shipment by air: --
Other information: Not dangerous cargo. Keep separated from foodstuffs

15. Regulatory information

Not Available

16. Other Information

Not Available

An ISO9001 Certified Company

Material Safety Data Sheet
Zinc Acetate Solutions

Section 1 - Chemical Product and Company Identification

MSDS Name:
Zinc Acetate Solutions
Catalog Numbers:
LC27080, LC27100
Synonyms:
None
Company Identification:
LabChem Inc
200 William Pitt Way
Pittsburgh, PA 15238
Company Phone Number:
(412) 826-5230
Emergency Phone Number:
(800) 424-9300
CHEMTREC Phone Number:
(800) 424-9300 or
(011) 703-527-3887

Section 2 – Composition, Information on Ingredients

CAS#	Chemical Name:	Percent
7732-18-5	Water	balance
5970-45-6	Zinc acetate, dihydrate	10-22

Section 3 - Hazards Identification

Emergency Overview

Appearance: *Clear, colorless solution*
Caution. *May cause eye irritation.*
Target Organs: *Eyes.*

Potential Health Effects

Eye:
May cause eye irritation.
Skin:
May cause skin irritation.
Ingestion:
May cause irritation of the digestive tract.
Inhalation:
May cause respiratory tract irritation.
Chronic:
Chronic exposure may cause kidney damage.

Section 4 - First Aid Measures

Eyes:
Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical aid.

Skin:
Flush skin with plenty of soap and water for at least 15 minutes while removing contaminated clothing and shoes. Get medical aid.

Ingestion:
Do not induce vomiting. If victim is conscious and alert, give 2-4 cupfuls of milk or water. Get medical aid immediately.

Inhalation:
Remove from exposure and move to fresh air immediately. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical aid.

Notes to Physician:
Treat symptomatically and supportively.

Section 5 - Fire Fighting Measures

General Information:
As in any fire, wear a self-contained breathing apparatus in pressure-demand, MSHA/NIOSH (approved or equivalent), and full protective gear.

Extinguishing Media:
For small fires, use dry chemical, carbon dioxide, water spray or alcohol-resistant foam.

Autoignition Temperature:
No information found.

Flash Point:
No information found.

NFPA Rating:
CAS# 7732-18-5: Health- 0, Flammability- 0, Instability- 0.
CAS# 5970-45-6: Health- 2, Flammability- 1, Instability- 0.

Explosion Limits:
Lower: n/a Upper: n/a

Section 6 - Accidental Release Measures

General Information:
Use proper personal protective equipment as indicated in Section 8.

Spills/Leaks:
Absorb spills with inert absorbent (vermiculite, sand, fuller's earth) and place in suitable containers labeled for later disposal.

Section 7 - Handling and Storage

Handling:

Wash thoroughly after handling. Do not get in eyes, on skin, or on clothing. Do not ingest or inhale.

Storage:

Store capped at room temperature. Protect from heat and incompatibles.

Section 8 - Exposure Controls, Personal Protection

Engineering Controls:

Facilities using or storing this material should be equipped with an eyewash and safety shower. Provide local exhaust or general dilution ventilation.

Exposure Limits:

Chemical Name:	ACGIH	NIOSH	OSHA
Water	None of the components are on this list	None of the components are on this list	None of the components are on this list
Zinc acetate, dihydrate	None of the components are on this list	None of the components are on this list	None of the components are on this list

OSHA Vacated PELs:

None.

Personal Protective Equipment

Eyes:

Wear appropriate protective eyeglasses or chemical safety goggles as described by OSHA's eye and face protection regulations in 29 CFR 1910.133. Do not wear contact lenses when working with chemicals.

Skin:

Wear appropriate protective gloves to prevent skin exposure.

Clothing:

Wear appropriate protective clothing to prevent skin exposure.

Respirators:

Follow the OSHA respirator regulations found in 29 CFR 1910.134. Always use a NIOSH-approved respirator when necessary.

Section 9 - Physical and Chemical Properties

Physical State:	Clear liquid
Color:	Colorless
Odor:	Slight acetic
pH:	5-7
Vapor Pressure:	No information found.
Vapor Density:	No information found.
Evaporation Rate:	No information found.
Viscosity:	No information found.
Boiling Point:	No information found.
Freezing/Melting Point:	No information found.
Decomposition Temperature:	No information found.
Solubility in water:	Soluble

Specific Gravity/Density: 1.0 – 1.2
Molecular Formula: No information found.
Molecular Weight: No information found.

Section 10 - Stability and Reactivity

Chemical Stability:
Stable under normal temperatures and pressures.
Conditions to Avoid:
Incompatible materials, excess heat.
Incompatibilities with Other Materials:
Strong oxidizing agents.
Hazardous Decomposition Products:
Carbon monoxide, carbon dioxide, zinc oxides.
Hazardous Polymerization:
Has not been reported.

Section 11 - Toxicological Information

RTECS:
CAS# 7732-18-5: ZC0110000.
CAS# 5970-45-6: ZG8750000.
LD50/LC50:
CAS# 7732-18-5:
Oral, rat: LD50 = >90 mL/kg.
CAS# 5970-45-6:
Oral, mouse: LD50 = 287 mg/kg
Oral, rat: LD50 = 794 mg/kg.
Carcinogenicity:
CAS# 7732-18-5: Not listed as a carcinogen by ACGIH, IARC, NIOSH, NTP, OSHA, or CA Prop 65.
CAS# 5970-45-6: Not listed as a carcinogen by ACGIH, IARC, NIOSH, NTP, OSHA, or CA Prop 65.
Epidemiology:
No information found
Teratogenicity:
No information found
Reproductive:
No information found
Mutagenicity:
No information found
Neurotoxicity:
No information found

Section 12 - Ecological Information

No information found

Section 13 - Disposal Considerations

Dispose of in accordance with Federal, State, and local regulations.

Section 14 - Transport Information

US DOT

Shipping Name: Not regulated.
Hazard Class:
UN Number:
Packing Group:

Section 15 - Regulatory Information

US Federal

TSCA:

CAS# 7732-18-5 is listed on the TSCA Inventory.
CAS# 5970-45-6 is not on the TSCA Inventory; however, its anhydrous form is on the inventory and so this hydrate is exempt from TSCA Inventory requirements (40CFR270.3(u)(2)).

SARA Reportable Quantities (RQ):

Zinc Acetate, Anhydrous (CAS No. 557-34-6): 1000 lbs. (453.6 kg)

CERCLA/SARA Section 313:

This material contains Zinc acetate dihydrate (CAS# 5970-45-6, 10-22%), listed as Zinc compounds, which is subject to the reporting requirements of Section 313 of SARA Title III and 40 CFR Part 373.

OSHA - Highly Hazardous:

None of the components are on this list.

US State

State Right to Know:

Zinc acetate, anhydrous, can be found on the following state Right-to-Know lists: California, New Jersey, Florida, Pennsylvania, Massachusetts.

California Regulations:

None.

European/International Regulations

Canadian DSL/NDSL:

CAS# 7732-18-5 is listed on Canada's DSL List.
CAS# 5970-45-6 is listed on Canada's DSL List.

Canada Ingredient Disclosure List:

CAS# 7732-18-5 is not listed on Canada's Ingredient Disclosure List.
CAS# 5970-45-6 is not listed on Canada's Ingredient Disclosure List.

Material Safety Data Sheet
Zinc Acetate Solutions

Section 16 - Other Information

MSDS Creation Date: February 14, 1998
Revision Date: February 17, 2011

Information in this MSDS is from available published sources and is believed to be accurate. No warranty, express or implied, is made and LabChem Inc. assumes no liability resulting from the use of this MSDS. The user must determine suitability of this information for his application.

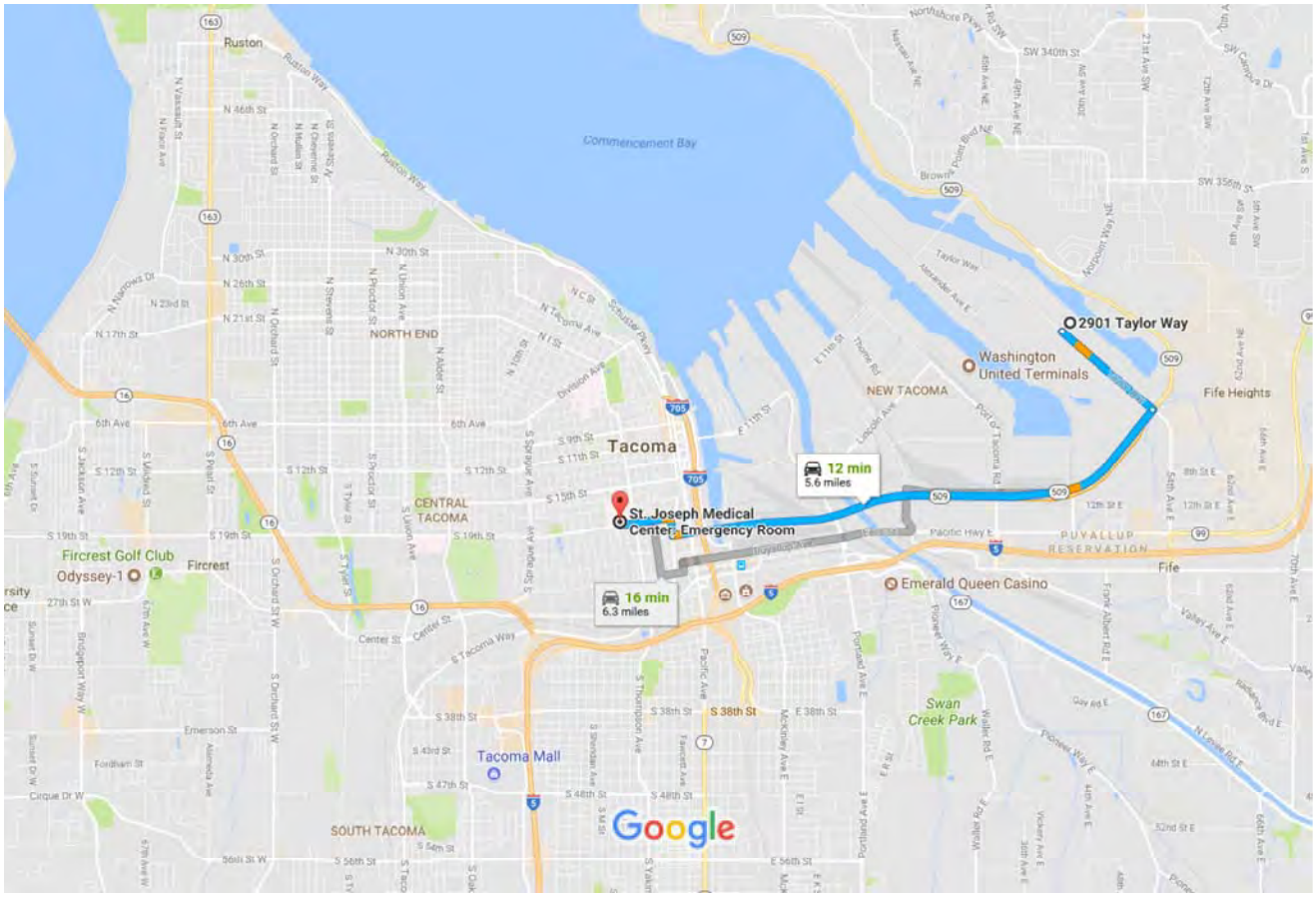
APPENDIX E

HOSPITAL ROUTE MAP

Google Maps

2901 Taylor Way, Tacoma, WA to St. Joseph Medical Center: Emergency Room

Drive 5.6 miles, 12 min



Map data ©2017 Google United States 2000 ft

via WA-509 S — 12 min

Fastest route, the usual traffic — 5.6 miles

via Puyallup Ave — 16 min

6.3 miles