Final Remedial Investigation Work Plan

Parcel 15 (Portac) Investigation

Ecology Facility Site No. 1215 / Cleanup Site No. 3642

April 2016

Prepared for

Port of Tacoma and

Portac, Inc.

Prepared by

GSI
Water Solutions, Inc.

S.S. PAPADOPULOS & ASSOCIATES, INC.

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Abbreviations and Acronyms

µg/L	micrograms per liter
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
bml	below mudline
CFR	*Code of Federal Regulations*
cm	centimeter
CSM	conceptual site model
CUL	MTCA's Cleanup Levels
Ecology	Department of Ecology, Washington State
EIM	Environmental Information Management, Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FS	Feasibility Study
GSI	GSI Water Solutions, Inc.
Log Yard	former log yard area at the Site
MTCA	Model Toxics Control Act, Washington State
Order	Agreed Order
ORP	oxidation-reduction potential
PAH	polycyclic aromatic hydrocarbon
PCP	pentachlorophenol
pH	negative log of the hydrogen ion concentration in solution
Port	Port of Tacoma
Portac	Portac, Inc.
PSL	preliminary screening levels
QAPP	Quality Assurance Project Plan
QA	quality assurance
RCC	roller-compacted concrete
RCW	Revised Code of Washington
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RIWP	Remedial Investigation Work Plan
SAP	Sampling Analysis Plan
Sawmill	former sawmill area at the Site
Site	Parcel 15 – Former Portac sawmill and log yard
SMS	Sediment Management Standards, Washington State
SR	State Route
SSPA	S.S. Papadopulos & Associates
TEE	Terrestrial Ecological Evaluation
TOC	total organic carbon
TPH	total petroleum hydrocarbons

Abbreviations and Acronyms (continued)

VCP	Ecology's Voluntary Cleanup Program
VOC	volatile organic compound
WAC	Washington Administrative Code
WES	Whitman Environmental Services

1 Introduction

This *Remedial Investigation Work Plan* (RIWP) was prepared by GSI Water Solutions, Inc. (GSI), and S.S. Papadopulos & Associates, Inc. (SSPA), on behalf of the Port of Tacoma (Port) and Portac, Inc. (Portac), in accordance with the requirements of the 2016 Agreed Order (Order) No. DE11237 between the State of Washington Department of Ecology (Ecology), the Port, and Portac, pursuant to the Washington State Model Toxics Control Act (MTCA; Revised Code of Washington [RCW] 70.105D), MTCA regulations (Washington Administrative Code [WAC] Chapter 173-340), and Washington's Sediment Management Standards (SMS; WAC 173-204).

1.1 Background

Parcel 15 (the Site[1]) consists of an approximately triangular parcel of about 52 acres of land owned by the Port. The Site is located in an industrial area between Interstate 5 and Commencement Bay, in Tacoma, Washington, as shown in Figure 1. Portac and its predecessors leased the Site from the Port beginning in 1974 and vacated the Site in 2009. The Site consists of two functionally distinct historical areas: the former sawmill area (Sawmill) in the southwestern part of the property, and the former log yard area (Log Yard) occupying the remainder of the Site.

Historical industrial activities conducted on the Site adversely impacted upland soil, groundwater, and surface water in the adjacent Wapato Creek. Environmental investigations and cleanup under Ecology oversight have been ongoing since the late 1980s and are described in Section 2 of this RIWP and summarized below.

During construction of the Log Yard, slag from the former ASARCO smelter was used as ballast (e.g., road base) to stabilize surface soils. An investigation conducted by Ecology, under authority of RCW 90.48 in the 1980s, showed that metals (e.g., arsenic, copper, lead, and zinc) were leaching from the slag and being discharged into surface water. Historical analysis of upland soil and fill containing slag indicate that metals (e.g., arsenic) were present at concentrations that would exceed current MTCA soil cleanup levels. In addition, historical groundwater monitoring did not confirm that current MTCA cleanup levels were met at a conditional point of compliance, as would be required under current MTCA rules. Current MTCA rules require confirmational monitoring and institutional controls.

Pursuant to a 1988 Order on Consent (under RCW 90.48), Portac and the Port agreed to cap the Log Yard to abate metals contamination of surface water runoff discharging to adjacent Wapato Creek. Although the primary purpose for capping the Log Yard was to mitigate surface water metals contamination, the action also was expected to mitigate groundwater contamination by preventing surface water infiltration through the slag and associated leaching of metals. Site groundwater is hydraulically connected with, and flows into, Wapato Creek. Wapato Creek in turn flows into the Blair Waterway of Commencement Bay in Puget Sound.

In addition to capping the Log Yard, Portac and the Port conducted groundwater monitoring for 3 years (1990 to 1992) after capping was completed. Historical analysis of groundwater, collected on

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[1] For the purpose of this RIWP, the Site encompasses the Log Yard and Sawmill and is based on the Site Boundary shown in Exhibit A of the Order. The final site definition will be developed after completion of the remedial investigation/feasibility study (RI/FS).

the Log Yard, indicate that metals (e.g., arsenic) were present at concentrations that would exceed current MTCA groundwater cleanup levels. Inspection and maintenance of the cap is required under the 1988 Order on Consent (Section VI (4)).

In 2009, Portac entered into Ecology's Voluntary Cleanup Program (VCP) to address the presence of contaminants (e.g., pentachlorophenol [PCP]) in soil and groundwater in the Sawmill. As described in Section 2.2.3, Portac implemented soil removals to address areas of identified contaminants. At the conclusion of those actions and after multiple rounds of groundwater sampling, PCP remained at concentrations above current MTCA groundwater cleanup standards in a single groundwater monitoring well.

1.2 Purpose and Objectives

The RIWP was developed to comply with a requirement of the Order between Ecology, and the Port and Portac. The primary objective of the Order is to develop a remedial investigation/feasibility study (RI/FS) that will determine what remedial actions are required to comply with current MTCA regulations. Specifically, Ecology is requiring a groundwater evaluation to determine whether capping of the fill containing slag is a sufficiently protective remedy to satisfy current MTCA cleanup standards. The Order requires Portac and the Port to complete an RI and prepare an FS. The RI/FS is to include both the capped Log Yard and the Sawmill (a portion of which also is known as the "VCP area").

Existing data were reviewed and summarized in the *Data Gaps Memorandum* (GSI, 2016). Data and figures from previous Site investigations were extracted from earlier reports and are provided by media in the attachments to the *Data Gaps Memorandum*. Sections 2 through 4 of this work plan provide the following information presented in the *Data Gaps Memorandum:* Site setting, previous investigations and existing data, and data needs for completion of an RI/FS consistent with the requirements WAC 173-340-350.

The purpose of this RIWP is to describe the RI investigation activities that will be completed to address the data gaps presented in the *Data Gaps Memorandum*. Specifically, the primary objectives of this RIWP are to:

- Develop and describe RI investigation activities to collect, develop, and evaluate sufficient information regarding the Site to allow completion of the RI/FS and to support the selection of a cleanup action under WAC 173-340-360 through 173-340-390.
- Develop and describe sufficient RI investigations to characterize the distribution of hazardous substances present at the Site and the potential threat(s) to human health and the environment. These investigations will address the following requirements of WAC 173-340-350 - *Remedial Investigation and Feasibility Study*:
    - Surface water and sediments
    - Soil
    - Geology and groundwater system characteristics
    - Current and future Site land use
    - Natural resources and ecological receptors
    - Hazardous substance sources.

The approach presented in this RIWP is designed with the intent of collecting sufficient information to support technically sound risk-based management decisions. The first phase of the RI consists of a comprehensive upland and in-water sampling plan and focuses on addressing the objectives listed above.

Because additional data may be generated during the RI that impacts the current understanding of the Site, the investigation approach or methods presented in this RIWP may be refined or modified to incorporate new information (e.g., drilling methods, sampling methodologies). Changes to the approach presented in this RIWP will be discussed with Ecology before implementation and subsequently submitted in writing to Ecology per Section VIII.J of the Order.

1.3 Document Organization

This RIWP summarizes operational, investigative, and regulatory history at the Site based on review of existing documents. It also presents a preliminary conceptual site model (CSM) and identifies data needs and data gaps that will be addressed through the RI sampling efforts described in this RIWP.

The RIWP is organized into the following sections:

- Section 1 – Provides an introduction to the project and objectives.
- Section 2 – Summarizes the pre-industrial development and the operational and regulatory history of the Log Yard and Sawmill.
- Section 3 – Summarizes the geologic and hydrogeologic Site setting and physical features.
- Section 4 – Provides a description of the preliminary CSM.
- Section 5 – Discusses identified data gaps and summarizes the proposed RI sampling approach to address the data gaps.
- Section 6 – Describes the RI sampling efforts by sampling event, location, and media.
- Section 7 – Summarizes the project schedule and RI reporting requirements.
- Section 8 – References.

Additional details on sampling and analytical procedures, project organization, and health and safety are provided in the following appendices:

- Appendix A - Sampling and Analysis Plan (SAP) – This includes the Field Sampling Plan (FSP) and the Quality Assurance Project Plan (QAPP)
- Appendix B - Health and Safety Plan (HSP)

2 Site History

This section describes the pre-industrial development of the Site and vicinity (Section 2.1) and the operational and regulatory history of the Sawmill and Log Yard (Section 2.2). Additional information about the hydrogeologic site setting and physical features is provided in Section 3.

2.1 Pre-Industrial Development and Land Use

The Site is situated within the Puyallup River Estuary and lowlands, which were largely undeveloped until construction of the U.S. Naval Station and the Port began in the early 1900s. Growth in the Tacoma tide flats was further stimulated in response to World War I and World War II. Additional information regarding development of the Puyallup River Estuary can be found in the *Draft Puyallup River Watershed Assessment* (Puyallup River Watershed Council, 2014).

Aerial photographs were compiled and reviewed to gain a better understanding of historical land use at the Site. Copies of these photographs are provided in Attachment A of the *Data Gaps Memorandum* for 1935, 1940, 1944, 1950, 1969, 1973, 1985, 1990, 2002, 2006, 2009, 2011, 2012, and 2015. A summary of historical events and observations from aerial photos is provided in Table 1.

Review of historical aerial photographs indicates that the Site was used for agricultural purposes from at least the 1930s through about 1950. At that time, Wapato Creek ran in a northwesterly direction through the Site. The orientation of this former channel is shown on a 1940 aerial photograph in Figure 2. Between 1959 and 1965, the Site and surrounding area received extensive fill. The fill likely originated from the Blair Waterway, which was extended in 1965. As part of filling and regrading, Wapato Creek was rerouted parallel to Alexander Avenue, along the western boundary of the Site. Review of the 1969 aerial photo shows the disturbed surface of the Site following filling of the Site and rerouting of the creek.

The Site remained undeveloped until the early 1970s, when Portac's predecessor, West Coast Orient Lumber Mill, constructed the Log Yard and Sawmill on the Site between the fall of 1974 and spring of 1975. The history of these operations is described in the following section.

2.2 Operational and Regulatory History

Portac and its predecessors leased the Site beginning in 1974 and vacated the premises in 2009. The Port owned the Site during the operation of the Site as a log yard and sawmill and maintains current ownership. Figure 3 shows the general layout of the former Site features on an aerial photograph from 1985. The Sawmill was situated in the southwestern portion of the property while the Log Yard occupied the remainder of the Site. The operational and regulatory history for each of these areas since development began in the 1970s is described separately in Sections 2.2.1 and 2.2.3. The central drainage ditch, which separated the Log Yard and the Sawmill, is discussed in Section 2.2.2. A summary of previous environmental investigations and sampling events is provided in Table 2 and supporting tables and figures are provided by sampling media in Attachments D through G of the *Data Gaps Memorandum*. A summary of identified source areas, Site-associated contaminants, and associated remedial activities (if applicable) is provided in Table 3 and the locations of the source areas are shown in Figure 3.

2.2.1 Log Yard

The Log Yard was constructed in 1974 on the northern and eastern portion of the Site (Figure 3). The portion of the Log Yard north of the central drainage ditch was unpaved and used for log storage while the southeastern portion was paved and used for lumber storage (HC, 1988b).

The U.S. Environmental Protection Agency (EPA) and Ecology discovered metals that were elevated in surface water above acute marine toxicity standards, in Wapato Creek, while conducting investigations in the Commencement Bay Area in the 1980s. The source of metals was identified as slag from the ASARCO copper smelter, which was placed to stabilize the Log Yard surface sometime during the mid-1970s. Subsequent environmental investigations conducted by Hart Crowser, Inc. (HC, 1988b and 1992), on behalf of the Port, indicated that the predominant contamination migration pathway for metals to Wapato Creek was stormwater runoff via overland flow, the onsite central drainage ditch, and subsurface drainage pipes. The configuration of the historical stormwater conveyance system is shown in Figure 3. Groundwater discharge was not considered to be a significant source of metals to surface water because the water table was reported to be deeper than the fill containing slag.

An environmental cap was placed over this area, subject to a 1988 Order on Consent (DE 88-S326) executed between Ecology, the Port and Portac under RCW 90.48 (this Order on Consent pre-dated the MTCA regulations). The cap consisted of gravel ballast and two layers of roller-compacted concrete (RCC) and was graded to direct surface water runoff to catch basins that carried water to Wapato Creek via underground piping of lined ditches (HC, 1988b.) The configuration of the current stormwater conveyance system is shown in Figure 4. The cap was selected as a remedy that would provide containment of the ASARCO slag and wood debris and prevent them from coming into contact with stormwater and subsequently impacting adjacent surface waters. The current area of the cap is approximately 29.4 acres (Figure 4).

The Log Yard area cap was installed by Portac and the Port as a jointly funded action under the 1988 Order on Consent. Subsequent stormwater and groundwater monitoring activities required by the 1988 Order on Consent have been completed. Since installation, Portac and the Port have performed periodic inspections and maintenance, primarily in the form of filling cracks. A summary of past cap inspections and cap maintenance was provided by the Port and is provided in Attachment H of the *Data Gaps Memorandum*.

The Log Yard is currently used by Port customers for parking and storage of new automobiles before transfer to dealerships.

2.2.2 Central Drainage Ditch

The *Portac Log Sort Yard Remediation Plan* (1988 Remediation Plan; HC, 1988b) discusses historical Site drainage features as described below. During operations, stormwater from about two thirds of the Log Yard area drained to Wapato Creek via an open drainage ditch (i.e., central drainage ditch), that flowed through the middle of the Site (Figure 3). Drainage in the southern portion of the Log Yard (where logs were stored) was conveyed through shallow perforated pipes. Stormwater in the southeastern corner of the Log Yard (i.e., the paved lumber storage area) was collected in subsurface piping and also routed to the central drainage ditch. Although not explicitly stated, the existing drainage figure provided in the 1988 Remediation Plan also indicates that surface drainage from the Sawmill entered the central drainage ditch, just east of the machine shop (Figure 3). The northern portion of the Log Yard drained to four catch basins along the northern property line and discharged to Wapato Creek via subsurface piping (Figure 3).

Section 7.2 of the 1988 Remediation Plan indicates that a PCP cleanup was occurring along the central drainage ditch, but that those cleanup efforts likely would not be completed at the same time of the capping of the Log Yard in the late 1980s. To provide space for the PCP cleanup to occur, the cap was set back about 50 feet from the central drainage ditch. The 1988 Remediation Plan indicates that a new trench was to be dug parallel to the central drainage ditch and either lined or equipped with a drainage pipe. Stormwater discharging to the former central drainage ditch was to be rerouted into the new trench and paved following completion of the PCP cleanup.

In late 1988, Portac removed approximately 900 tons of soil from the central drainage ditch. The work was performed by Crowley Environmental Services and was overseen by Rittenhouse-Zeman & Associates (RZA, 1988a, 1988b). Sampling was performed on the remaining ditch soils to document the adequacy of soil removal. The soils were managed by offsite disposal at Waste Management's Arlington, Oregon, permitted landfill. In parallel with this work, RZA also conducted testing for PCP in surface sediments along Wapato Creek (RZA, 1988c) adjacent to and upstream of the Site. The maximum concentration of PCP detected in that study was 10 micrograms per kilogram (µg/kg) dry weight. Other samples adjacent to the Site were non-detect for PCP. Test reports that documented the ditch cleanout were provided to Ecology, and Ecology summarized its review of the work in a letter dated February 8, 1989 (Ecology, 1989). Following the Ecology-approved ditch cleanup, the ditch was backfilled and the cap was extended over 0.51 acre at the Site, to its current location (Port, 1989).

2.2.3 Sawmill

Portac began operating the 22-acre Sawmill in 1974. Sawmill operations involved the use of PCP, a wood-treating preservative, which was used as a water-based solution and applied to lumber as it passed through spray booths at the facility between approximately 1976 and 1980 (WES, 2009e). The locations of the spray booth areas in the Mill Building and Planer Building are shown in Figure 3 and the history of usage is further described in the *Lumber Mill Demolition and Environmental Cleanup and Testing Report* (WES, 2009e). In 1980, Portac installed a dip tank to replace the spray booths. The rectangular steel tank (about 30 feet long, 6 feet wide, and about 6 feet deep) was located at the north end of the storage building where lumber was bundled before shipping. In 1986, Portac switched from using PCP to a different sap stain control solution, Kop-Coat NP-1.

A large centralized hydraulic system operated much of the equipment in the Sawmill building. There were two hydraulic pump rooms located in the northeastern part of the mill (see hydraulics area on Figure 3). Reportedly, there were several spills related to the pumps and hydraulic lines during the life of the mill. The spills were on concrete floors and were thought to be well contained. However, petroleum-contaminated soil was encountered during demolition beneath the former concrete floor slabs.

In 2008, Portac demolished the Sawmill portion of the Site in anticipation of vacating the premises. During demolition activities, Portac conducted an environmental site assessment and discovered detectable concentrations of PCP and petroleum in soil and groundwater beneath the Sawmill, and elevated levels of arsenic in groundwater in the area of the former dip tank. Portac voluntarily undertook cleanup actions in areas identified by the environmental site assessment and other conditions identified during the demolition of the structures. Closure actions taken by Portac during demolition included removal of the dip tank, excavation of PCP and/or petroleum impacted soils, confirmation sampling of the sidewalls and bases of the excavated areas, waste characterization of soils for disposal, installation of monitoring wells at locations where PCP spray equipment was used in the past, remediation of arsenic in slag and soil in the former ramp area adjacent to the Log Yard, and investigation of other potential sources of environmental contaminants. Additional details regarding the environmental site characterization and cleanup are provided in the *Lumber Mill Demolition and Environmental Cleanup and Testing Report* (WES, 2009e). A summary of environmental investigations and sampling events is provided in Table 2 and a brief description of the remedial action taken in each source area is provided in Table 3.

A paved earthen ramp that was used as a pathway to transport logs from the adjacent storage yard into the Sawmill was removed as part of the closure and demolition of the Sawmill. The log ramp was located near the central portion of the property adjacent to the capped Log Yard (Figure 3) and had a layered construction of asphalt (22 to 27 inches thick), crushed gravel (12 to 18 inches thick), fill containing slag material (1 to 5 feet thick), and a 6-inch-thick lay of sand and gravel (WES, 2009b). A cross section of the log ramp area prepared by Whitman Environmental Services (WES) is provided in Attachment B of the *Data Gaps Memorandum*. During removal of the log ramp, 2,473 tons of wood waste, slag, and soil containing elevated concentrations of arsenic were removed and disposed of offsite at the permitted LRI Landfill in Graham, Washington (WES, 2009b). Despite excavation beyond the planned final grade at the ramp area, the base of the excavation still contained visible slag. Based on Site conditions and a meeting among Portac, Ecology, and the Port on September 24, 2008, it was agreed that no further excavation would be conducted. The area was backfilled and regraded using stockpiled soils, crushed concrete, and asphalt, and then paved with an approximately 4-inch-thick layer of asphalt in November 2008 (WES, 2009b).

All of the Sawmill buildings have been removed and Portac has terminated its lease agreement with the Port. Since 2009, Portac has been working with the Port and Ecology under the VCP to resolve MTCA liabilities for soil and groundwater contamination issues associated with the Sawmill operations. While remediation of the Sawmill under the VCP is mostly complete, Ecology has requested that additional confirmational monitoring and other activities be conducted to complete the remediation of the Sawmill contamination.

3 Physical Site Setting

3.1 Site Location

The Site is located at 4215 State Route (SR) 509 – North Frontage Road, Tacoma, Washington (Figure 1 and Figure 4). The Site is roughly triangular and bounded by East 4th Street (northern boundary), Alexander Avenue East (western boundary), and North Frontage Road (SR 509) (southeastern boundary). Wapato Creek is situated between Alexander Avenue East and the western edge of the property and empties into the Blair Waterway through a culvert under East 4th Street. The Blair Waterway is in the southern portion of Commencement Bay, which is a natural harbor in the southeastern portion of the Puget Sound.

3.2 Geology

The Site is located within the Puget Sound Lowland, which is a complex basin formed in response to tectonic, glacial, and volcanic activity. The soils of the Puget Sound Lowlands reflect a highly complex sequence of glacial and interglacial deposits that occurred during the Pleistocene Ice Age. The last advance of glacial ice (about 14,000 years ago) scoured out some of the older deposits, resulting in troughs that became exposed and/or filled with water as the glaciers retreated north of the Straights of San Juan de Fuca. At that time, sea level was about 200 feet lower than today and the Puyallup Trough began to collect sediment from the Puyallup River. The Puyallup River Delta has grown irregularly in response to changes in sea level, river discharge, and sediment availability. The interbedded layers of silts and sand are reflective of the highly variable nature of the propagation of this delta into shallow water. A more detailed description of the geologic history is provided in the following documents:

- *Geology Study of the Port of Tacoma* (HC, 1976)
- *Puyallup River Watershed Assessment* (Puyallup River Watershed Council, 2014)

The subsurface lithology and geology at the Site has been investigated and described in previous Site reports. Copies of available soil boring and monitoring well logs are provided in Attachment B of the *Data Gaps Memorandum*. These logs were relied upon to create Site-specific cross sections depicting the subsurface lithology. For the purpose of this RIWP, the subsurface lithology at the Site is divided into the following units:

- **Fill Containing Slag** – Near-surface material placed since industrial development of the Site began in 1974 (e.g., includes a mixture of sand, silt, slag, and bark fill material and the overlying surface finishing and capping materials).
- **Dredged Sediment Fill** – This represents the silty sand material that likely originated from sediment that was dredged during construction of the adjacent Blair Waterway and deposited onto the Site and surrounding area between 1959 and 1965.
- **Native Silt and Sand Alluvium** – The natural deposits from the Puyallup River Wetlands consists of a mixture of interbedded silt, sand, and clay and may be hard to distinguish from the overlying dredged sediment fill.

The surficial and subsurface conditions for the Log Yard and Sawmill are discussed separately below.

3.2.1 Log Yard

During construction and/or use of the Log Yard, ballast material was used to fill and grade it for stability. The ballast material was produced as a by-product of smelting operations at a nearby ASARCO facility. Section 4.1.2 of the 1988 Remediation Plan notes three types of fill units (fines, rock, and bark) that contain combinations of sand, silt, bark, rock, and slag. The finer-grained surficial layer was approximately 1 to 2 feet thick and was underlain by a second predominantly slag and fill soils/wood debris layer. The 1988 Remediation Plan states that there may be more than 40,000 tons of slag below the surface (HC, 1988b). The reported thickness of the fill containing slag was 1 to 6 feet.

As discussed in Section 2, the Log Yard was capped to eliminate infiltration of surface water runoff into the fill containing slag, which is now overlain by a gravel base course and the RCC cap and asphalt overlay. The thickness of the cap and underlying fill materials was investigated and refined as part of the *2014 Log Yard Soil Testing Report* (AEQA, 2014). While thicknesses vary across the Log Yard, the average thickness of each unit in the capped area is reported as follows:

- RCC cap and asphalt overlay: 15 inches combined average thickness
- Gravel base course: 26 inches
- Fill containing slag: Average thickness of fill containing slag is 37.6 inches

A geologic cross section was generated using available soil boring and monitoring well logs across the Log Yard at the location shown in Figure 5. As shown in Figure 6, the surface of the cap contains a few gently sloping ridges and valleys with approximately 2 feet of elevation difference between them to promote drainage. The RCC (approximately 13 inches thick) and gravel base thickness (approximately 29 inches) are fairly consistent across this cross section line, except on the eastern edge where the RCC layer is a bit thicker (17 inches) and the gravel base is a bit thinner (19 inches). The thickness of the fill containing slag averaged 35 inches across this cross section line and most of the fill were reported to be a mixture of wood and slag. The thickest slag layers along this cross section line were reported in borings AQ-24 (57 inches), AQ-26 (65 inches), and PORTAC-09 (66 inches). In borings AQ-24 and AQ-26, the lower 12 inches of the fill unit were noted to contain predominantly slag. The boring log for PORTAC-09 noted that gravel with slag was observed above and below the wood/slag layer.

3.2.2 Sawmill

The geology in the Sawmill is similar to that in the Log Yard with the exception that (1) ASARCO slag was not reported to be used as ballast in this portion of the Site (with the exception of the log ramp area), and (2) the surface is not capped with RCC. The surface currently consists of areas with pavement, concrete, and gravel. Conceptual geologic cross sections that were presented in other reports are provided in Attachment B of the *Data Gaps Memorandum*. As shown on those cross sections, the subsurface geology in the Sawmill also consists of interbedded silt and sand units that resulted from the native deltaic setting and the addition of dredged fill materials.

3.3 Hydrology

Annual precipitation in the area ranges from 30 to 40 inches near Tacoma (Ecology, 2011c). Most of this precipitation occurs during the fall and winter months (October to March).

Wapato Creek drains 3.5 square miles of land from north of the City of Puyallup, the City of Fife, and the Port to the Blair Waterway and Commencement Bay in the City of Tacoma (WDOT, 2006).

Wapato Creek receives a substantial amount of runoff directly from adjacent agricultural, residential, commercial, and industrial lands in the Cities of Puyallup and Fife. Wapato Creek has been greatly altered from its natural condition, and riparian cover along most of the system is sparse to nonexistent.

3.4 Hydrogeology

Twelve groundwater monitoring wells (B-1R, B-2R, B-3R, B-4, B-5R, B-6R, MW-1, MW-2r, MW-3, MW-4, MW-5, MW-6R), and the shallow perched wells HC-1 and HC-2 are present on the Site, at the locations shown in Figure 4. Table 4 provides a summary of the existing well installation dates and well construction details (e.g., casing diameter and material, screened interval, and description of surface completion), as recorded on the original well logs. As shown in Table 4, six monitoring wells were installed in 1987 as part of the groundwater assessment (HC, 1988b). The remaining six monitoring wells were installed as part of the 2008/2009 VCP and site closure activities for the Sawmill. Environmental investigations that involved groundwater sampling are indicated in Table 2. Attachment B of the *Data Gaps Memorandum* provides copies of monitoring well logs, most of which include construction information. Well construction logs are unavailable for two wells (HC-1 and HC-2), which historically contained perched water. Attachment C of the *Data Gaps Memorandum* provides tables with historical water level measurements in Site monitoring wells and figures from previous Site reports that interpreted groundwater flow direction.

GSI conducted an assessment of the existing monitoring wells on November 9, 2015, to evaluate the condition of the wells, collect coordinates using a Trimble GeoExplorer 2008 Global Positioning Unit, and to measure depth to water and total well depth at each location. Methane gas readings were also collected upon opening each well. The results of the well assessment are included on Table 4. Monitoring wells B-4 and B-2R were not found during the well assessment. It was later confirmed that monitoring well B-4 was abandoned in 1991. No documentation confirming abandonment of B-2R was found, but the 1988 Portac Paving Plan contains some plans with the B-2R location crossed out, which suggests that this well may have been abandoned and paved over during cap construction. Those plans also include a well monument installation diagram indicating that the existing well casings would be extended or cut to accommodate construction of the cap on the Log Yard. In comparing the total depths of the wells measured in 2015 to the depths noted on the well logs, it appears that the casings of wells B-6R, B-3R, and B-1R were extended approximately 3 feet during construction of the cap in the late 1980s.

Shallow perched water was observed in the bark/fill containing slag layer during the investigations in the 1980s. This was attributed to infiltration of precipitation and surface water runoff that was directed to shallow subsurface drains that collected water from throughout the Log Yard and directed it toward the central drainage ditch. Since installation of the cap and associated stormwater drainage system, infiltration through the fill containing slag has been controlled. The *Log Yard Soil Testing Report* (AQEA, 2014), confirmed that the fill containing slag is not saturated and that continued leaching of metals from the fill containing slag is unlikely (see Section 4 for further discussion). The 2015 well assessment confirmed that well HC-1 was dry. And while approximately 1 foot of water was observed in the bottom of well HC-2, it is unknown if that water represents perched groundwater or is indicative of standing water in the sump of the well. The presence of water in this well will be further assessed as part of the RI.

The shallow water-bearing zone occurs in silts and sands that underlie the Site. Groundwater levels were measured in Wells B-1 through B-6 (see Figures 4 and 5) during multiple events between 1987 and 1992. Those measurements indicate that groundwater depths range from approximately 8 to 15 feet below ground surface (bgs) with the deepest depths (lowest groundwater table) observed in monitoring well B-5R, located adjacent to Wapato Creek. The April 1988 groundwater levels were selected as a representative high water level from this monitoring period and measurements from the central monitoring wells (B-5R, B-6R, and B-3R) and Wapato Creek were used to delineate the groundwater level shown on the geologic cross-section in Figure 6. As shown, groundwater flow is west toward Wapato Creek. Groundwater flow directions and gradients near the creek vary in response to water levels in the creek, which vary seasonally and with tides in Commencement Bay. The maximum anticipated range of water levels in Wapato Creek and adjacent groundwater are estimated in Figure 6.

Based on Hart Crowser's 1988 evaluation of seasonal and tidal fluctuations, the maximum tidal fluctuation in monitoring well B-5R, adjacent to Wapato Creek was 2 feet (see Appendix G of HC [1988b]). That report indicates that the other wells did not respond to tidal fluctuations, presumably because of the low permeability of the shallow water-bearing zone and/or distance from Wapato Creek. The report concluded that tidal influence on groundwater is limited to within about 100 feet of Wapato Creek (HC, 1988b). Monitoring well B-5R sits on the banks of the former channel of Wapato Creek (see Figure 2) and this could be an area of higher hydraulic conductivity. The seasonal fluctuations in groundwater elevations are about 2 to 4 feet with a maximum shift of 4 to 5 feet (HC, 1988b). The highest groundwater elevations occur in early spring (March and April) and the lowest occur in later summer/early fall (August and September) (HC, 1988b).

With the addition of the new monitoring wells (MW-1 through MW-6) in 2008 and 2009, additional information was obtained about groundwater levels on the Sawmill portion of the Site. Groundwater monitoring was conducted as part of the VCP activities between 2008 and 2013. Groundwater contour maps from the associated site closure and monitoring reports are provided in Attachment C of the *Data Gaps Memorandum*. In general, the historical groundwater monitoring data indicated varied groundwater flow directions (e.g., west, southwest, east, and northwest) depending on the season, tides, and location on the property (HC, 2012). However, groundwater flow directions generally were toward Wapato Creek.

4 Preliminary Conceptual Site Model

This section describes the preliminary CSM. As described in EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988), the purpose of a CSM is to describe what is known about potential contaminant sources, migration pathways, exposure routes, and receptors at a site.

The CSM is an iterative, 'living representation' of a site that summarizes and helps project teams visualize and understand available information (EPA, 2011). The primary components of a CSM describe the potential sources, release mechanisms, and transport pathways of contaminants present at the Site, and identify how potential human or ecological receptors may be exposed to site contaminants via exposure media (e.g., soil, groundwater, sediment) and exposure routes (e.g., direct contact, ingestion). The CSM will be refined throughout the RI/FS process as additional information and data are collected and evaluated. The CSM helps to identify and prioritize potential data needs, as well as helping to identify potential site cleanup needs.

Figures 7 and 8 are graphical representations of the preliminary CSM reflecting historical (pre-cap) and current (post-cap) conditions, respectively. Figures 7 and 8 relay the relationship among potential sources (in conjunction with Figure 3), release mechanisms, and transport media and mechanisms. Each of these categories is discussed in the following sections.

4.1 Sources

The potential source areas were identified and discussed in previous Site investigations and documents, and are summarized in Section 2 and Table 3. The locations of potential source areas are shown in Figure 3. These source areas include (1) areas where hazardous substances were placed (e.g., the slag ballast in the Log Yard) or stored (e.g., the above ground fuel tank), or (2) areas where historical activities may have resulted in the release of contaminants to the environment (e.g., the spray booths, dip tank, etc.). Several historical source areas have undergone remediation. A summary of former potential source areas and their associated contaminant usage is as follows:

- Machine Shop – Petroleum products, metals. Soil was tested in 2009 for volatile organic compounds (VOCs), metals, and total petroleum hydrocarbons (TPH). VOCs and TPH were not detected; metal concentrations did not exceed MTCA Method A cleanup levels (WES, 2009e). Therefore, no cleanup was performed and this area is not considered an ongoing source.
- Fuel Storage Area – Petroleum products. Soil was tested in 2009 for VOCs and TPH. Results did not exceed MTCA Method A cleanup levels (WES, 2009e). Therefore, no cleanup was performed and this area is not considered an ongoing source.
- Mill Hydraulic Equipment Area – Petroleum products. Soil from this area was excavated and disposed of offsite. This area is no longer considered an ongoing source (WES, 2009e).
- Central Drainage Ditch – Secondary source of PCP and TPH. Impacted ditch soil was excavated, the ditch was backfilled, and the cap was extended to cover the remediated area (RZA, 1988a, 1988b, 1988c; Port, 1989). This area is no longer considered an ongoing source.

- Former Log Ramp – Metals from slag were used to construct the ramp. The log ramp has been demolished, soil removal has occurred, and a cap is in place in this area (WES, 2009b). This area is no longer considered an ongoing source.
- Planer Spray Booth – PCP. Soil excavation has occurred in this area and it is no longer considered an ongoing source (WES, 2009e).
- Log Yard (northern portion of the Site) – Metals from use of slag across this portion of the Site. A concrete cap currently covers this area (HC, 1988b, 1988d). This area remains a source although it has been capped to control surface water and groundwater impacts.
- Former Dip Tanks – PCP. Soil excavation has occurred in this area (WES, 2009e). Additional information is required to determine the current status of this area.
- Spray Booth and Mill Spray Area -- PCP. Soil excavation has occurred in this area and it is no longer considered an ongoing source (WES, 2009e).

4.2 Site-Associated Contaminants

Site-associated contaminants were identified during previous investigations, based on analytical testing and screening against various screening levels (e.g., MTCA) and include: PCP, TPH, polycyclic aromatic hydrocarbons (PAHs), and metals. Dioxins are commonly present in PCP formulations and potentially could be present.[2] In addition, methane gas is identified as a Site-associated contaminant. Methane, a naturally occurring gas, may be present below the Log Yard cap as a result of decomposition of the wood waste associated with the fill containing slag or decomposition of naturally occurring organics (e.g., tide flat deposits).

Given that some of the available data for the Site may no longer be representative of current conditions, and screening levels used in past investigations may no longer be applicable to the Site, a re-screening of useable analytical data may be conducted as part of the RI. Proposed preliminary screening levels (PSLs) are discussed in Section 4.5.

4.3 Contaminant Migration Pathways

The results of the previous Site investigations identify soil and groundwater as the media of concern. Historical and current contaminant migration pathways are discussed by media in the following sections. Contaminant fate and transport is discussed in Section 4.4.

4.3.1 Soil

Potential migration pathways for contaminants in Site soil include:

- Stormwater infiltration and subsequent leaching of contaminants in soil to groundwater
- Stormwater or wind erosion of contaminated surface soil and subsequent transport to Wapato Creek
- Migration of methane gas through unsaturated soils beneath the cap.

Before installation of the cap (Figure 7), infiltration or precipitation through the fill containing slag and subsequent discharge of stormwater to Wapato Creek (via either the central drainage ditch,

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[2] PCP was used in a water-based solution as an anti-sap stain reagent. Dioxins are identified as a potential Site-associated contaminant because of the historical PCP use onsite. Dioxins may have been an impurity byproduct/contaminant in the PCP used onsite.

subsurface drains shown in Figure 2, or direct overland flow) served as a direct pathway for metals migration to surface water and potentially groundwater. Installation of the cap on the Log Yard in the late 1980s cut off surficial and shallow subsurface stormwater drainage through the fill containing slag (Figure 8). Because the Log Yard has been capped, surface soil migration through wind erosion, stormwater runoff, and leaching are no longer considered to be significant release mechanisms on the Log Yard portion of the Site.

As part of the VCP cleanup activities on the Sawmill, impacted surface soils from the source areas identified in Figure 3 and Table 3 have been removed. Furthermore, portions of the Sawmill have been regraded and/or paved so wind erosion or stormwater runoff are not anticipated to be substantial transport mechanisms in this area.

Tables and figures presenting the results of previous soil and stormwater investigations are included in Attachments E and G of the *Data Gaps Memorandum*, respectively.

4.3.2 Groundwater

Potential migration pathways for contaminants in Site groundwater include:

- Migration of Site-associated contaminants in groundwater to porewater and subsequently to surface water in Wapato Creek or to offsite groundwater
- Migration of contaminants in groundwater via infiltration into portions of the existing storm drain system (Figure 4) and subsequent transport to Wapato Creek
- Sorption/precipitation of groundwater contaminants onto sediments in Wapato Creek

The release of contaminants in the subsurface to groundwater is controlled by the contaminant chemical properties (e.g., solubility, partitioning coefficients) and by processes such as infiltration, leaching, dissolution, and adsorption. For example, if water comes into contact with the fill-containing slag underlying the Log Yard, metals may leach out of the slag and have the potential to be transported to groundwater and subsequently to Wapato Creek.

Infiltration of precipitation through contaminated subsurface Site soils (if any remain after completed soil removals) in unpaved portions of the Sawmill have the potential to leach contaminants, such as PCP (which is soluble in water), to groundwater and subsequently to Wapato Creek through advective flow. Any groundwater impacts are anticipated to be shallow given the fine-grained and relatively impermeable nature of the silty substrate underlying much of Site (at a depth of approximately 10 feet bgs). Tables and figures presenting the results of previous groundwater investigations are included in Attachments C and D of the *Data Gaps Memorandum*.

Additional information is needed to evaluate whether discharge of pollutants in groundwater to Wapato Creek is a significant transport mechanism. Current groundwater quality and the hydrogeologic characteristics governing flow (e.g., gradient, tidal and seasonal effects, and potential preferential flow paths) will be evaluated during the RI.

4.3.3 Sediment/Porewater

After contaminants reach the aquatic environment, they may mix with surface water or sorb to sediment that can be suspended and be redeposited through tidal fluctuations, flood events, and/or anthropogenic activities. Sediment deposition rates and changes in the elevation of the riverbed in Wapato Creek over time have not been quantified for the Site; however, the Site is considered to be depositional in nature given the fine-grained nature of the sediment, the small size of the watershed, the low surface-water flow velocities, and the lack of marine vessel and recreational use adjacent to the Site.

The interstitial water contained within surface sediment is referred to as porewater, and is a potentially relevant exposure media within the biologically active zone (upper 10 centimeters [cm] of sediment). Site-associated contaminants, if discharged to Wapato Creek, may partition to sediments, porewater, or surface water. The partitioning process depends on the geochemistry of the sediment matrix and the groundwater, as well as the type of contaminant (see Section 4.4). Porewater may become contaminated by impacted groundwater from an upland source that discharges through clean sediment. The environmental conditions along this groundwater migration pathway and the potential for cross-media transport (groundwater, sediment, porewater) in excess of cleanup standards was identified as a data gap (see Section 5) that warranted further evaluation during the RI.

As noted in Table 2, sediment samples from Wapato Creek were collected in 1988 and 2009. No exceedances of sediment criteria used at the time of the investigation were noted. Tables and figures presenting the results of previous sediment investigations are included in Attachment F of the *Data Gaps Memorandum*.

4.3.4 Surface Water

If Site-associated contaminants are discharged to surface water in Wapato Creek (e.g., from stormwater, groundwater, air deposition, or resuspension of contaminated bedded sediments), they may be present in surface water as suspended particulates or dissolved contaminants. Suspended particulates are likely to be redeposited in nearby quiescent areas and dissolved contaminants may either remain in the water column, become adsorbed to particulates, or precipitate. Contaminants in the dissolved phase may be bioavailable to aquatic organisms and enter the food chain.

Surface water testing was performed for slag-associated metals following construction of the Log Yard cap. Although limited, the data showed that water quality within Wapato Creek had recovered to background levels. Additional testing of surface water will be conducted as part of the RI to determine if Site-associated discharges (particularly for arsenic) are adversely affecting water quality within Wapato Creek. Tables and figures presenting the results of previous surface water investigations are included in Attachment F of the *Data Gaps Memorandum*.

4.4 Contaminant Fate and Transport

Based on the results of previous investigations and the current CSM, arsenic is the Site-associated contaminant with the greatest potential to discharge to Wapato Creek through the groundwater migration pathway. PCP also was detected in groundwater, but to date, groundwater testing has shown the area of contamination to be confined to the uplands (i.e., the contamination was bounded by wells with low or non-detected PCP concentrations). The fate and transport processes associated with these contaminants are summarized below and will be evaluated further based on new data obtained during the RI. Recent (2010 to present) PCP and arsenic concentrations are shown on Figures 9 and 10, respectively. Since no recent arsenic data is available over much of the Log Yard, Figure 11 also shows historical concentrations and the respective sample dates for reference.

4.4.1 Pentachlorophenol

PCP was used at the Sawmill as an anti-sap stain in a water-based solution. PCP migration is retarded by organic matter in soil and it naturally degrades. In soil, the major degradation pathway for PCP occurs by microbial degradation. High organic matter and moisture content, median temperatures, and high pH enhance microbial breakdown of PCP in soil.

The fate and transport of PCP in the environment are primarily influenced by the pH of the media and exposure to sunlight. Generally, PCP is considered relatively immobile in the environment. However, if the pH of soil and groundwater is elevated and the soil conditions are not conducive to natural degradation or adsorption, or if excessive amounts of PCP were released, transport may occur such that it reaches either groundwater or surface water.

PCP is subject to microbial degradation in groundwater. This degradation can occur during either aerobic or anaerobic conditions. Degradation of PCP in surface water occurs primarily through photo-degradation. When exposed to direct sunlight, the degradation process may be rapid. Photo-degradation rates decrease with increasing depth in the water column. The pH of the water also affects the photo-degradation rate. Half-lives in surface waters have been shown to range from less than an hour (20 minutes) to days, in part dependent on the exposure to sunlight. In aerobic aquatic environments, PCP may also be degraded by microbes.

4.4.2 Arsenic

Arsenic at the Site is associated with the slag used as ballast in the Log Yard. Historical leaching of the slag resulted in groundwater, stormwater, and surface water impacts including historical surface water impacts in Wapato Creek. The fate and transport of arsenic in groundwater, surface water, sediments, and porewater are strongly controlled by Site geochemistry (e.g., the oxidation state of the water). Under relatively oxidizing conditions (Eh > 0.0 V), arsenic is adsorbed to iron and manganese oxyhydroxides (EPA, 2007). By contrast, under more-reducing conditions (where Fe- and Mn-oxyhydroxide minerals are unstable), dissolved arsenic concentrations can be higher. Finally, during highly reducing conditions, arsenic can precipitate as a sulfide mineral (e.g. orpiment, As_2S_3) or co-precipitate with iron sulfides.

Arsenic may be attenuated in groundwater (and porewater) at the Site as a result of adsorption to Fe- and Mn-oxyhydroxides (although the formation of sulfides or mixed-iron Fe(II,III) minerals, such as green rust, is possible). The extent that arsenic adsorption occurs will largely depend on groundwater/porewater pH (at more alkaline conditions, arsenic is adsorbed less), the abundance of adsorbing minerals (which, as discussed above, depends on the oxidation state of the groundwater and porewater), and the concentration of competing ions for adsorption.

Understanding geochemical conditions in groundwater, porewater, and surface water within the transition zone is considered a data gap (see Section 5).

4.5 Preliminary Screening Levels

PSLs are selected for the Site for the purposes of screening for indicator hazardous substances. In accordance with MTCA, PSLs for Site-associated contaminants are selected by media and site uses. MTCA’s Cleanup Levels (CULs) are risk-based concentrations that are protective of generic exposure scenarios for a given site use. An explanation of PSL selection is provided below for each medium that may be impacted by Site-associated contaminants.

4.5.1 Soil

Human Health. The Site is currently zoned industrial and is expected to be used only for industrial purposes in the future. The Site meets MTCA characteristics for an industrial site, and public access is restricted by fences, signs, and security patrols around the property. The only people who might come into contact with contaminants in soil at the Site are industrial workers. Therefore, MTCA Method A and MTCA Method C (WAC 173-340) levels for industrial use were selected as PSLs to screen soil for direct contact exposure scenarios.

Because groundwater at the Site does not have existing potable uses (see Section 4.5.2), CULs for residual saturation or soil leaching to groundwater for potable uses will not be used as PSLs. However, based on empirical groundwater and surface water data, soil leaching will be incorporated into the screening for the groundwater and surface water exposure pathways.

Ecological. The Site consists of an industrial plot of land adjacent to Wapato Creek. PSLs for potential ecological exposures to contaminants that may be in the creek are discussed in Section 4.5.3. Terrestrial habitat on the upland portion of the Site is extremely limited. The Site is mostly paved, with only small patches of ruderal vegetation present. Given that the Site is fully developed, there are no ecological receptors exposed to contaminants in Site soil, and the upland Site is expected to qualify for an exemption from a Terrestrial Ecological Evaluation (TEE) under MTCA (WAC 173-340).

Background. In addition to the above PSLs, MTCA states that CULs should not be lower than natural background concentrations. Therefore, natural background concentrations for soil are provided for comparison in the PSL tables of Appendix A.

4.5.2 Groundwater

Groundwater at the Site currently is not used as a potable supply and likely will not be used in the future for the following reasons:

- The Site is located within City of Tacoma municipal water service area.
- Drinking water wells are not located in the vicinity of the Site.
- Proximity of the Site to marine waters.
- Shallow depth of groundwater.
- Susceptibility and potential low yield of the water-bearing zone.

The highest beneficial use is likely discharge to marine waters. Per MTCA requirements, documentation will be provided in the RI showing that the groundwater under the Site is not suitable for potable uses, primarily because of salinity.

Human Health. Groundwater at the Site is not potable, therefore, MTCA CULs related to drinking water do not apply to the Site. However, contaminants in groundwater may migrate to the adjacent Wapato Creek, impacting biota, such as fish, that may be consumed by humans. Therefore, National Toxics Rule (40 CFR 131) criteria for human consumption of fish in marine waters were selected as PSLs for screening groundwater. PSLs for surface water are discussed in Section 4.5.3.

Ecological. Contaminants in groundwater at the Site may migrate to surface water in the adjacent Wapato Creek, impacting ecological receptors in the creek. Washington State Water Quality Criteria (acute and chronic) for the protection of marine aquatic life (WAC 173-201A) will be used as PSLs for the screening of groundwater. Surface Water PSLs are discussed in Section 4.5.3.

Background. As mentioned in Section 4.5.1, MTCA states that CULs should not be lower than natural background concentrations. Therefore, available natural background concentrations for marine water are provided for comparison in the PSL tables of Appendix A, and will be the lowest PSL applied to the groundwater data.

4.5.3 Surface Water/Porewater

Contaminants may migrate from groundwater and be present in porewater or surface water.

Human Health. A beneficial use of groundwater is recharge to marine waters, while there is no documented fishery in Wapato Creek, it is possible that people may consume fish that use Wapato Creek during some life stages. MTCA Method B Values for Surface Water (cancer and non-cancer endpoints) (WAC 173-340) were selected as PSLs for porewater and surface water. PSLs also will include the National Toxics Rule (40 CFR 131) criteria for protection of human health from marine water fish consumption.

Ecological. Aquatic ecological receptors may be impacted by contaminants in porewater and surface water that have migrated from groundwater at the Site. PSLs for ecological receptors in porewater and surface water are applicable or relevant and appropriate requirements (ARARs) for the protection of marine aquatic life, including Washington State Surface Water Regulations (acute and chronic).

Background. As with groundwater, the available natural background concentrations for marine water are provided for comparison in the PSL tables of Appendix A, and will be the lowest PSL applied to the surface water/porewater data.

4.5.4 Sediment

Contaminants may migrate from groundwater and be present in sediments in Wapato Creek. Therefore, PSLs are selected that are protective of potential exposures to creek sediment.

Human Health. There is no existing shellfish harvesting area within Wapato Creek. While there is no documented fishery in Wapato Creek, it is possible that people may consume fish that use Wapato Creek during some life stages. Protection of human health from seafood consumption is addressed in Section 4.5.3.

Ecological. Ecological receptors may come in contact with contaminants in the sediment/porewater of Wapato Creek. Washington State Marine Sediment Quality Standards (WAC 173-204-562) Sediment Cleanup Objectives are selected as PSLs for sediment.

Background. The available natural background concentrations for marine sediment are provided for comparison in the PSL tables A-10 and A-11 of the SAP (Appendix A).

5 RI Data Needs and Proposed RI Approach

The purpose of the RI is to investigate the nature and extent of contamination caused by the release of hazardous substances at the Site (i.e., Site-associated contaminants) and collect data to support the selection of an appropriate cleanup action for the Site. Many of the RI data needs have been satisfied during previous investigations completed on the Site, as discussed in the *Data Gaps Memorandum*. However, the *Data Gaps Memorandum* also identified potential Site-associated contaminants and migration pathways where additional data are needed to assess the presence and significance of these contaminants. Specifically, the *Data Gaps Memorandum* identified additional data needed within the following categories to provide sufficient information to enable Ecology to select a cleanup action for the Site in accordance with RCW 70.105D.050(1), SMS (WAC 173-204-562), and MTCA (WAC Chapter 173-340-350):

- Environmental setting
- Geology and hydrogeology
- Nature and extent of contamination
- Contaminant fate and transport

This section presents the proposed approach for completing the RI to address the identified data gaps and complete the RI/FS. The RI approach addresses the major components of EPA RI/FS guidance, including *Guidance for Conducting Remedial Investigation and Feasibility Study under CERCLA* (EPA, 1988) and WAC 173-340-350. The data and information derived from previous investigations will be supplemented by data that will be collected during the RI.

The RI approach focuses on developing a comprehensive understanding of current Site environmental conditions and potential impacts associated with Site contaminants. Four Site-wide sampling events (Events 1 through 4) will be conducted to evaluate concentrations of Site-associated contaminants in multiple media (groundwater, surface water, porewater). Concurrent with the first sampling event, additional soil chemistry data and Wapato Creek sediment chemistry data will be collected to supplement existing Site data. Samples collected during Event 1 will provide comprehensive groundwater, porewater, surface water, sediment, and soil chemistry data across the Site and within Wapato Creek. These data will be used to supplement existing Site information and evaluate arsenic fate and transport mechanisms. The first event (designated Event 1) is planned for May 2016 with the subsequent three events (Events 2 through 4) targeting different times of the year to evaluate potential seasonal effects on water quality and surface water and groundwater interactions.

A summary of specific sampling locations by media and sub-area (Log Yard, Sawmill, and Wapato Creek) is provided in Section 6. Additional details on sampling and analytical techniques and quality assurance procedures are provided in the SAP (Appendix A), which includes the FSP and QAPP.

A summary of the RI sampling approach by data gaps category is provided below. Table 5 provides a summary of RI/FS data needs, existing information, data gaps, and the work that will be conducted as part of the RI to address the identified data gaps. Figure 12 shows the location of proposed RI sample locations relative to existing features and previous sampling locations. Information developed during implementation of the RIWP will be used to update and refine the CSM.

5.1 Environmental Setting

Data gaps related to characterization of the Site environmental setting include the following:

- Information to confirm topography, depths of existing drainage features, and locations/elevations of monitoring wells or other RI sampling locations.
- Anticipated future land uses, including potential groundwater use and human and ecological uses of Wapato Creek.

Work conducted for the RI will include the following activities to address these data gaps:

- **Topographic Survey.** Targeted surveys will be conducted as part of Event 1 to fill gaps in existing survey data and to document the locations and elevations of newly placed groundwater monitoring wells. This will include surveying to confirm:
    - Locations of new monitoring wells
    - Temporary borings and test pits
    - Stormwater features (e.g., catch basins, invert pipes, outfalls)
    - Wapato Creek elevations (along sampling transects only) and Wapato Creek sampling locations (e.g., sediment samples, porewater samples, stilling well)

  The survey information will be used during the RI to prepare Site maps, revise the CSM, document sample locations, and perform the stormwater analysis.
- **Future Land-Use Evaluation.** The Port will be consulted to discuss current and anticipated long-term land uses. An updated description will be provided in the RI report.
- **Current Human and Fish/Wildlife Use Evaluation.** Further evaluation of existing and newly collected data will be conducted following implementation of the RIWP. The RI Report will contain a description of human and ecological uses of Wapato Creek.

5.2 Geology and Hydrogeology

Identified data gaps related to the Site's geologic and hydrogeologic setting include the following:

- The depth and type of fill placed in the former channel of Wapato Creek and the former drainage ditch
- Data to refine the understanding of groundwater flow (directions, gradients, and migration pathways) along the northern site boundary and tidal influences on groundwater flow near Wapato Creek
- Supplemental hydrogeologic data to refine estimates of hydraulic conductivity

The following data-collection efforts will be conducted during implementation of the RIWP to address these data gaps:

- **Former Drainage Channel(s) Fill Evaluation.** One shallow soil boring (TB-9) is targeted for collection within the former channel of Wapato Creek and the central drainage ditch (Figure 12). Soil from this boring will be logged to document depth and type of fill and the depth of former drainage channel and/or Wapato Creek beds. Soil samples will be collected from the artificial fill, the base of the former channel, and the native sediments. In addition to Site-associated contaminants, analysis of these samples will include grain size, total organic carbon (TOC), and total solids. This information may be useful in evaluating whether this area may be a preferential flow path for Site groundwater.

- **Groundwater Levels and Flow Direction Assessment.** Manual water level measurements will be collected from all new monitoring wells and from existing monitoring wells and piezometers during each of the four RI sampling events. Site-wide groundwater contour maps will be developed from these data to better evaluate groundwater elevations and flow directions under both high water and low water conditions.

- **Short-term Tidal Study to Evaluate Groundwater Levels and Flow Directions.** A stilling well will be installed in Wapato Creek and equipped with a transducer for a period of at least 73 hours so that tidal fluctuations can be better understood. Transducers will also be installed in new and existing wells within the nearshore study area (within approximately 300 feet of the creek bank). Transducers will collect continuous (every 5 minutes) water level, temperature, and conductivity measurements. The groundwater and surface water elevations will be evaluated to better understand tidal influences on groundwater flow directions, gradients, and geochemistry.

- **Supplemental Hydrogeologic Testing.** The water level information collected during the tidal study combined with grain-size data and information about flow rates and drawdown obtained during development and sampling of groundwater monitoring wells will be used to estimate the hydraulic properties of the shallow water-bearing zone (e.g., hydraulic conductivity and groundwater flow direction and flux).

Updated descriptions of groundwater flow directions, gradients, and migration pathways within the Site and adjacent to Wapato Creek will be included in the RI Report. Details on the sampling and analytical procedures to fill the data gaps mentioned above are provided in the SAP (Appendix A).

5.3 Nature and Extent of Contamination

Data gaps in understanding of the nature and extent of contamination at the Site relate to characterization of the current groundwater quality within the capped area of the Log Yard and in the former Sawmill (i.e., uncapped). Specific data gaps identified include the following:

- The current nature and extent of arsenic contamination in groundwater beneath the Log Yard cap
- The extent of arsenic contamination in groundwater along the northwestern and northern boundaries the Site
- The current groundwater concentrations of arsenic along the migration pathway between upland fill containing slag and Wapato Creek
- Soil properties between the cap and Wapato Creek
- The potential presence of residual PCP in soil and groundwater in the former dip tank area

To address these data gaps, the RIWP includes the following data-collection efforts:

- **Onsite Source Characterization.** Soil and groundwater samples from source areas will be sampled and analyzed to determine the current concentrations of Site-associated contaminants present onsite. To address the identified data gaps, an adequate number of soil and groundwater samples will be collected and analyzed to define the extent of Site-associated contaminants present above applicable PSLs. This includes collecting data to fill data gaps associated with the following source areas:

  - **ASARCO slag-associated metals contamination:** The current nature and extent of arsenic in groundwater beneath the Log Yard and in the nearshore transition zone is not known.
  - **Former dip tank:** It is not known whether residual PCP contamination is present in soil and groundwater near the dip tanks in the Sawmill. Additional sampling will be conducted to confirm current concentrations of PCP, dioxins/furans, and heavy metals.

- **Offsite Source Characterization.** Research will be conducted, as necessary, to better understand contributions of regional contaminant sources, such as fallout of arsenic from the ASARCO smelter. These potential sources will be considered during development of the RI and interpretation of empirical testing data. Depending on the findings of this review and measured arsenic concentrations at the Site, supplemental evaluations of specific media may be warranted.
- **Groundwater Contamination Characterization.** The RI groundwater investigation approach focuses on a data collection program to develop a thorough understanding of groundwater contamination and contaminant mobility. Groundwater data are needed to define the nature and extent of contamination on the Site and along the northern and northwestern boundaries of the Site. Seven new and one replacement groundwater monitoring wells will be installed, and groundwater quality samples will be collected from the new and existing wells at the Site and analyzed to define the extent of Site-associated contaminants present above applicable PSLs. The RI will characterize current contaminant concentrations using a combination of groundwater grab samples from temporary soil borings and samples collected from groundwater monitoring wells to obtain a "snapshot” of arsenic and other contaminant concentrations at a single point in time. Samples will be analyzed for Site-associated contaminants, with additional geochemical testing conducted in the nearshore area to better understand arsenic mobility through the transition zone and support development of the FS.

  The results of the groundwater investigation will be used to:

  - Refine the physical (i.e., geologic and hydrogeologic) CSM.
  - Delineate groundwater concentrations above appropriate PSLs.
  - Assess the natural quality of Site groundwater (i.e., fresh, saline, brackish).
  - Understand the fate and transport of Site-associated contaminants in groundwater.
  - Support development of the FS.

  The spatial distribution of groundwater sample locations were selected to meet the defined objectives for the RI and are based on historical sample results and identified Site-associated contaminants migration and risk exposure pathways (i.e., the preliminary CSMs).

- **Soil Contamination Characterization.** As discussed in Section 3, soil contamination at the Site is expected to be limited in vertical and horizontal extent. Soil samples will be collected from the saturated zone of monitoring well and temporary borings to better understand arsenic concentrations and fate and transport mechanisms. Additional samples will be collected and analyzed from onsite source areas, as mentioned above and in Section 6.

  The spatial distribution of soil and groundwater sample locations were selected to meet the defined objectives for the RI and are based on historical sample results and identified contaminant migration and risk exposure pathways (i.e., the preliminary CSM). The results of the RI sampling will be used to:

  - Verify the CSM and historical findings.
  - Refine the physical (i.e., geologic and hydrogeologic) CSM.
  - Delineate concentrations above appropriate PSLs.
  - Support development of the FS.

- **Porewater, Sediment, and Surface Water Characterization.** Collocated porewater, sediment, and surface water samples will be collected from Wapato Creek to aid interpretation of the groundwater-to-surface-water pathway, and evaluate potential human health impacts of sediments, from bioaccumulation of arsenic in fish, clams, etc. and consumption by humans in Wapato Creek. Focused porewater and sediment sampling, surface water level measurements, and surface water quality monitoring will be performed during the RI. The results of the Wapato Creek sampling program will be used to:

  - Characterize the salinity of the aquatic system.
  - Verify and refine the CSM.
  - Identify whether Site-associated contaminants are present in surface water, sediments, and porewater.
  - Assess whether surface water, sediment, or porewater concentrations are greater than applicable PSLs.
  - Support the FS.

- **Stormwater Characterization.** Information about the stormwater system operations and maintenance activities will be reviewed and documented as part of the RI Report. Supplemental surveys will be performed to better understand the potential for the stormwater conveyance system to intersect a shallow water-bearing zone and act as a groundwater migration pathway to Wapato Creek. During field work, a reconnaissance will be conducted to evaluate the presence of dry weather flow from the stormwater outfalls. If stormwater discharge locations are identified, opportunistic stormwater samples may be collected and analyzed.

Updated descriptions of contaminant nature and extent and the potential significance of migration pathways will be evaluated further and described in the RI Report.

5.4 Contaminant Fate and Transport

Data gaps related to fate and transport of contaminants at the Site include the following:

- The extent and concentrations of arsenic in groundwater and porewater
- Additional information to document the geochemical properties of soil and groundwater in the nearshore transition zone
- Additional data to determine if Site-associated discharges (particularly for arsenic) are adversely affecting water quality within Wapato Creek
- Soil vapor data to document possible subsurface methane concentrations related to decomposition of capped wood waste in the former Log Yard

The following data-collection activities will be conducted as part of the RI to address these data gaps:

- **Nearshore Geochemical Evaluation.** Groundwater data collection has been limited to the upland area of the Site. Porewater within the sediment bioactive zone (zero to 10 cm below mudline [bml]) and groundwater within the nearshore transition zone have not been analyzed. Additional groundwater, porewater, sediment, and surface water data will be collected to (1) quantify the concentrations of Site-associated contaminants in the nearshore area, (2) document concentrations of Site-associated contaminants within and below the bioactive sediment zone, (3) determine if water quality within Wapato Creek is adversely impacted by discharges of Site-associated contaminants, and (4) obtain geochemical data to better understand the processes that may affect the attenuation or transport of arsenic along the groundwater-to-surface-water pathway.
- **Methane Monitoring.** Due to the potential risks associated with methane generation from decomposing wood waste within the fill containing slag, borings will be monitored during drilling and the headspace of new and existing monitoring wells will be screened for accumulation of combustible vapors prior to sampling.

Fate and transport processes will be evaluated further using new and existing data, and will be described in the RI Report.

5.5 Other

The *Data Gaps Memorandum* also identified two additional areas of information needed to be able to adequately characterize the nature and extent of Site-associated contaminants and to support the selection of an appropriate cleanup action for the Site: (1) information on regional and background metal concentrations in various media and (2) site-specific arsenic geochemistry that may influence arsenic attenuation in along Site-associated migration pathways. These are discussed below.

5.5.1 Background and Regional Conditions

During the evaluation of potential risks to human health and the environment and before the development of Site-specific remediation levels or cleanup levels, an evaluation of potential sources of contaminants driving unacceptable risks will be conducted. Some contaminants may be present at the Site from offsite sources. For example, dust from the ASARCO smelter was deposited in the vicinity of the Site and is a documented historical contaminant source of arsenic and lead. This deposition resulted in higher arsenic concentrations in surface soils within the smelter depositional area (i.e., plume). Regional or project-specific background conditions may be relevant to certain media or cleanup standard selections. Evaluation of background conditions and regional influences will be performed in accordance with EPA guidance (EPA, 2002a) and Ecology documents (Ecology, 1994, 2005, 2011a, 2011b, and 2015c).

Available regional data will be reviewed to assess potential background metal concentrations (e.g., arsenic) in soil, groundwater, surface water, sediment, and porewater. Depending on the findings of this review and measured arsenic concentrations at the Site, supplemental evaluations of specific media may be warranted.

5.5.2 Arsenic Geochemistry

Arsenic fate and transport in groundwater, surface water, and porewater is briefly described in Section 4.4.2. The RI is designed to assess the geochemistry within the shallow water-bearing zone; the groundwater/surface water transition zone, and in Wapato Creek surface water. Differences in the relative water levels between the shallow water-bearing zone and surface water will dictate both the direction and magnitude of water flux across the groundwater/surface water transition zone. Chemical gradients (e.g., salinity, Site-associated contaminants) develop across the groundwater/surface water transition zone due to the inherent differences in groundwater and surface water chemistry. Contaminant transport across the groundwater/surface water transition zone is regulated by the chemistry of redox-sensitive elements, such as carbon, iron, nitrogen, and sulfur. This will impact the chemical composition of water and sediments within this zone and, therefore, contaminant mobility. A contaminant may remain mobile across the groundwater/surface water transition zone, become immobilized on sediments within or adjacent to the boundaries of the transition zone, or undergo transformation in water to products with lower/greater toxicity. Development of an understanding of the processes that control contaminant mass distribution within the boundaries of the Site investigation underpins the risk evaluation and the design of intervention strategies to minimize risk (EPA, 2005). The RI will include collection of soil, sediment, groundwater, porewater, and surface water data to support the evaluation of the geochemical processes controlling arsenic mobility. Specifically, data will be collected to:

- Define the chemical composition of groundwater discharging into Wapato Creek and how it varies spatially and temporally.
- Evaluate the specific processes that result in the partitioning of arsenic in soil and sediment.
- Evaluate the stability of arsenic in soil/sediment.

Chemical data will be collected during the RI characterization to evaluate Site-specific arsenic attenuation via adsorption and mineral precipitation. Data will be collected in a phased approach at selected locations and will include the following types of data:

- General groundwater/porewater chemistry (e.g., pH, and major cations and anions)
- Groundwater/porewater redox chemistry including iron (Fe(II)/Fe(III)) and arsenic (As(III)/As(V)) redox-sensitive element speciation
- Solid-phase arsenic concentrations
- Solid-phase arsenic speciation (e.g., relative adsorbed fraction)
- Solid-phase mineralogy (e.g., Fe-oxyhydroxide concentrations)
- Batch adsorption tests

Specialized sequential extraction and batch adsorption tests will be performed on select soil and sediment samples within the nearshore transition zone.

Shallow sediment samples (zero to 10 cm bml and 40 to 50 cm bml) and soil samples (nearshore wells) from immediately below the water table will be collected along three transects adjacent to the Log Yard to help define the chemical processes that control the distribution of arsenic across the sediment-water interface. Soil and sediment testing at various locations across the system redox gradient will be performed to characterize arsenic speciation and anticpated mineralogy through specialized arsenic sequential extraction tests (procedure provided in the SAP presented in Appendix A). The objective of the sequential extraction tests is to develop a sense of the degree to which arsenic is partitioned to soil and sediment. The sequential extraction test consists of a series of single-step chemical extractions to assess the relative stability of arsenic, iron, and manganese under various conditions and better understand the solid-phase partitioning of arsenic in Site soil and sediments. The test results will provide information regarding weakly adsorbed and strongly adsorbed arsenic, amorphous iron oxides, and iron sulfides.

Soil and sediment samples will also be used to perform batch adsorption tests (procedure also provided in the SAP in Appendix A). The purpose of the batch adsorption tests is to estimate the adsorption/desorption behavior of arsenic and to obtain a sorption value that can be used to predict partitioning under a variety of environmental conditions.

The results of the geochemical studies will be used to:

- Refine the CSM.
- Evaluate Site geochemical processes in the groundwater/surface water transistion zone (i.e., hyporheic zone).
- Understand arsenic fate and transport along the groundwater to surface water pathway
- Assess the stability of arsenic adsorbed to sediment and soil.
- Support the evaluation of FS alternatives.

6 RI Sampling Activities

This section summarizes the investigations planned for the RI. As described in Section 1, this RIWP is intended to meet the requirements of the Order for an RI. Data collection activities presented in this RIWP are focused on supporting the upcoming FS and selection of a remedial decision for the Site.

As stated in EPA's RI/FS guidance (EPA, 1988), the goal of the RI is not to remove all uncertainty about Site conditions. Rather, it is to gather sufficient information to support an informed risk management decision regarding which remedy appears to be most appropriate for the Site. This section and the SAP, presented in Appendix A, describe specific details of the planned investigations, such as investigation locations; number of soil borings and/or monitoring wells to be installed; number of samples of soil, surface water, groundwater, and other applicable media to be collected; and the analytical program.

Proposed RI sampling locations are shown in Figure 13. As discussed in Section 5, the sampling will be conducted during four separate events (Events 1 through 4). Event 1 will entail drilling, construction, and sampling of groundwater monitoring wells; collection of soil and groundwater samples from temporary borings; test pit explorations; porewater sampling; and surface water sampling, sediment sampling, and a tidal study in adjacent Wapato Creek. Events 2 through 4 will be conducted at approximately 3-month intervals following Event 1 and will be limited to groundwater, porewater, and surface water sampling.

Sampling in Wapato Creek will be performed under the Port's Programmatic Sediment Sampling permits. No other permits are anticipated to be required for the RI activities.

Samples from each media collected during Events 1 through 4 will be submitted for laboratory analysis of Site-associated contaminants. Laboratory analyses for the soil and sediment samples collected during Event 1 are summarized in Table 6. The analytical program for groundwater, porewater, and surface water for Events 1 through 4 is provided in Table 7. The analytical approach for the RI entails analysis of a "Standard Analytical Suite" to assess arsenic concentrations and redox chemistry across the Site. In addition, a more comprehensive suite of analyses will be conducted on samples from locations within the nearshore transition zone (the "Nearshore Study Areas" outlined in Figure 13) to evaluate general chemistry and geochemical conditions that affect arsenic fate and transport. Additional constituents, such as PCP, will be analyzed in historical source areas in the Sawmill

Analysis of soil samples collected from the borings and test pits will focus on the saturated zone, the zone with most relevance for evaluation of the groundwater migration pathway. However, soil samples from the unsaturated zone and the capillary fringe also will be collected and will be archived for potential future analysis.

The planned sampling activities are summarized below by event and Site area. Details of the sampling techniques and laboratory analytical procedures are provided in the SAP (see Appendix A).

6.1 Event 1

6.1.1 Log Yard

Sampling in the Log Yard will be focused along three transects, for purposes of assessing the groundwater migration pathway. These transects are aligned along existing car storage aisle ways and extend into the adjacent Wapato Creek, as shown in Figure 13. Event 1 sampling activities in the Log Yard are summarized below (sampling at the Wapato Creek locations is summarized in Section 6.1.3).

6.1.1.1 Monitoring Wells

In advance of Event 1 sampling activities, a total of seven new monitoring wells (MW-7 through MW-13; see Figure 13) will be installed along the three transects to augment the existing monitoring well network.

During drilling of the wells, continuous soil cores will be collected, logged, and the depth to water will be identified. Soil samples will be collected on approximately 2- to 3-foot centers (described in SAP, see Section 2.4 of Appendix A) and include collection of archival samples from the unsaturated zone, the capillary fringe, and the saturated zone. One soil sample will be collected from approximately 1 to 2 feet below the water table in each of the seven new monitoring well borings and submitted for the Standard Analytical Suite, which includes arsenic, iron, TOC, and total solids. Soil samples collected from the five new wells located within the nearshore study area (Figure 13 and Table 6) will also be analyzed for the expanded Geochemical Suite, which includes sulfide, grain-size, sequential extraction, batch adsorption, and arsenic speciation tests. Additional information on the analytical methods is provided in the QAPP (described in the SAP, see Section 3 of Appendix A). Table 6 lists the laboratory analyses for the soil samples from the well borings.

All new and existing monitoring wells will be developed prior to groundwater sampling. Manual water levels will be collected in all new and existing wells, and in piezometers (NLR-Portac-16, -17, and -18) to assess the current depth to groundwater and groundwater flow direction. Field measurements will be taken at each sampling location for temperature, pH, specific conductance, oxidation-reduction potential [ORP], and dissolved oxygen (DO). The headspace of each well will also be monitored for methane gas upon initial opening.

Groundwater samples will be collected from each of the seven new wells and three existing wells (B-1R, B-6R, and B-3R) during Event 1. Shallow wells, HC-1 and HC-2, which were historically installed to monitor perched water in the fill-containing slag will be redeveloped and evaluated to assess whether these wells contain perched water or stagnant water trapped in the bottom of the wells. If recoverable quantities of water can be obtained, these wells will also be sampled. The groundwater samples will submitted to the laboratory for analysis of the Standard Analytical Suite, which for groundwater includes total and dissolved arsenic, total and dissolved organic carbon, dissolved sulfide, dissolved iron, and dissolved manganese. Additionally, the five new monitoring wells within the nearshore area (Figure 13 and Table 7) will be analyzed for the expanded Geochemical Suite, which includes major cations/anions, alkalinity, dissolved nitrate and nitrite, and iron speciation. Arsenic speciation will also be performed on groundwater samples with dissolved arsenic concentrations greater than or equal to 36 µg/L.

6.1.1.2 Temporary Borings

Eight targeted temporary (direct-push method) borings (TB-1 through TB-8; see Figure 13) will be advanced along the three sampling transects and along the northern property boundary to supplement arsenic concentration data in soil and groundwater.

The soil sampling procedures and analytical program for the temporary borings are identical to those described above for the new monitoring wells. The boring will be logged and archival samples will be collected from the unsaturated zone, capillary fringe, and unsaturated zone (described in the SAP, see Section 2.4 of Appendix A). One soil sample from each boring (collected from the uppermost saturated zone) will be submitted for laboratory analysis of the Standard Analytical Suite. Soil from the three borings within the nearshore study area will also be analyzed for the expanded Geochemical Suite (see Table 6 and Figure 13).

A groundwater grab sample will be collected from each temporary boring and submitted for laboratory analysis, as listed in Table 7. Field measurements will be taken for temperature, pH, specific conductance, ORP, and DO.

6.1.2 Sawmill

RI activities in the Sawmill are targeted to supplement existing data collected during previous investigations completed under the VCP and address the identified data gaps discussed in Section 5. Two supplemental soil testing areas were identified in the Data Gaps Memorandum: the former dip tank area and the former drainage ditch (former Wapato Channel) in the central portion of the Site (see Figure 13). The planned Event 1 activities in this area include replacing one of the existing monitoring wells (MW-5), groundwater sampling from the existing (including replacement) monitoring wells, collecting soil samples from test pits near the former dip tank, and collecting soil and groundwater samples from a temporary boring placed in the former drainage ditch. These activities are summarized below and described in detail in Appendix A. Laboratory analyses for the soil samples and groundwater samples collected from this area are identified in Table 6 and Table 7, respectively. In addition to these activities, surface water, porewater, and sediment samples will be collected in Wapato Creek, immediately adjacent to the former dip tank area; the Event 1 sampling activities in Wapato Creek are described in Section 6.1.3.

6.1.2.1 Monitoring Wells

In advance of Event 1 sampling, existing monitoring well MW-5 has a damaged vault and casing, and will be abandoned and replaced (as MW-5R). The damaged surface monument on existing monitoring well MW-6R will also be removed and replaced. The monitoring well network that will be used to evaluate groundwater levels, groundwater gradients, and water quality in the Sawmill is shown in Figure 13.

During drilling of the replacement well MW-5R, the soil core will be logged and the depth to water will be identified to the extent practicable. Sampling intervals are described the SAP (see Section 2.4 of Appendix A) and include collection of archival samples from the unsaturated zone, the capillary fringe, and the saturated zone. One soil sample will be collected from approximately 1 to 2 feet below the water table and submitted for the Standard Analytical Suite, which includes arsenic, iron, TOC, and total solids (Table 6).

All replacement (MW-5R) and existing (MW-1; MW-2R; MW-3, MW-4; MW-6R; and B-5R) wells will be developed prior to sampling. Manual water levels will be collected in the new and existing wells to assess the current depth to groundwater and groundwater flow direction. Field measurements will be taken for temperature, pH, specific conductance, ORP, and DO. The headspace of each well will also be monitored for methane gas upon opening.

Groundwater samples will be collected from the seven groundwater monitoring wells and submitted to the laboratory for analysis of the Standard Analytical Suite plus PCP (Table 7.) The five monitoring wells within the nearshore area close to the former dip tank (Figure 13) will also be analyzed for the expanded Geochemical Suite, which includes major cations/anions, alkalinity, dissolved nitrate and nitrite, and iron speciation. Arsenic speciation will also be performed on those groundwater samples with dissolved arsenic concentrations greater than or equal to 36 μg/L.

6.1.2.2 Temporary Borings

Soil and groundwater samples will be collected from one temporary (direct-push method) boring (TB-9) within the former drainage ditch (see Figure 13). The soil core will be logged to identify the presence of the former drainage ditch and/or Wapato Creek channel. If encountered, soil samples will be collected from the artificial fill, the base of the channel, and the underlying native sediment and submitted for analysis of the Standard Analytical Suite plus grain-size (Table 6). One additional sample from the fill and the saturated zone will be collected for archival.

Field measurements will be taken in groundwater at TB-9 for temperature, pH, specific conductance, ORP, and DO. A groundwater grab sample will be collected from this boring and submitted to be analyzed for the Standard Analytical Suite plus PCP.

6.1.2.3 Former Dip Tank Area Test Pits

Two test pits/trenches (TP-1 and TP-2) will be excavated near the location of the former dip tank to identify the edge of former remedial excavation and to collect soil samples approximately 3 to 5 feet beyond edge of the former cleanup area. The planned locations of TP-1 and TP-2 are shown in Figure 13. Soil samples from these test pits will be collected from the near-surface (approximately 0.5 to 1.5 feet bgs) and saturated soil zones (approximately 1 to 2 feet below the observed water level; or a maximum depth of 9 to 10 feet bgs). Two soil samples from each test pit will be submitted to the laboratory for analysis of the Standard Analytical Suite plus PCP. Dioxins/furan analysis will also be conducted on the shallow soil sample from each test pit. Additional samples will be archived for potential supplemental testing.

6.1.3 Wapato Creek Sediment and Porewater Sampling and Short-Term Tidal Study

As discussed above, the RI sampling in the Log Yard will include locations along three sampling transects, delineated for purposes of assessing the groundwater migration pathway from the upland portion of the Site underlying the cap toward Wapato Creek. A similar transect is delineated across the former dip tank remedial excavation in the Sawmill, as shown in Figure 13. These four transects each include two sampling stations in adjacent Wapato Creek, one on the east bank of the creek (Location A), and one within the channel (Location B). Collocated porewater, sediment, and surface water data from the Wapato Creek Transects (WCT-1 through WCT-4) will be evaluated in conjunction with soil and groundwater data collected in upland monitoring wells and temporary borings that fall along the same transects (Figure 13). Figure 14 shows the schematic positioning of the collocated porewater, sediment, and surface water samples relative to the tidal fluctuation zone in Wapato Creek. These sampling activities, as well as a short-term study of tidal influence at the Site, are discussed below and in Appendix A. Laboratory analyses to be conducted on the Wapato Creek sediment samples (Event 1 only) are listed in Table 6 and analyses to be conducted on porewater and surface water samples are listed in Table 7.

6.1.3.1 Porewater Sampling

Passive porewater samplers will be placed in two locations in the creek bed near the end of each transect to collect porewater from the bioactive zone (i.e., approximately 10 cm bml) and from a depth of approximately 40 to 50 cm bml (see Figures 13 and 14). Four porewater samples per transect will be collected during each sampling event and submitted to the laboratory for analysis of the Standard Analytical Suite and expanded Geochemical Suite (Table 7). Samples from Transect 4, adjacent to the former Sawmill dip tank, will also be analyzed for PCP.

6.1.3.2 Sediment Sampling

Wapato Creek sediment samples will be collected during Event 1. Sediment samples will be collected in the immediate proximity and from the same depths as the porewater samples (see Figures 13 and 14). The sediment samples will be analyzed for the Standard Analytical Suite plus sulfide and grain size (Table 6). Sediment samples from Transect 4 (WCT-4), adjacent to the former Sawmill will be analyzed for PCP. Four sediment samples from a single transect will also be selected for geochemical sequential extraction, batch adsorption tests, and arsenic speciation testing based on preliminary analytical results.

6.1.3.3 Surface Water Sampling

Surface water samples from Wapato Creek will be collected near Location B in each transect, as shown schematically in Figure 14. Two additional surface water samples will be collected for reference, including a sample in Wapato Creek upstream of the Site, and a sample in the Blair Waterway, just beyond the outlet of Wapato Creek. The surface water samples in Wapato Creek will be collected approximately 10 cm above the mudline during low-tide conditions, when groundwater discharge would be expected to be most prevalent. Sample locations for Events 2 through 4 will be based on Event 1 results. Surface water samples will be analyzed for same constituents as groundwater and porewater, including the Standard Analytical Suite plus the expanded Geochemical Suite (Table 7). Field measurements will be taken for temperature, pH, specific conductance, ORP, and DO.

6.1.3.4 Short-Term Tidal Study

The tidal study is designed to assess and document tidal fluctuations in Site groundwater and Wapato Creek. Data collected from this study will be used to assess:

- Variations in groundwater flow directions and gradient resulting from the tidal fluctuations in Wapato Creek
- Whether tidal fluctuations in surface water levels influence the discharge of groundwater to Wapato Creek
- Surface water hydrology and tidal flow dynamics

- Variations in conductivity in Wapato Creek resulting from tidal fluctuations
- The effect of tidal fluctuations on groundwater quality (e.g., conductivity)
- The interface between fresh water and brackish water within the shallow water-bearing zone (i.e., mixing analyses of major anions and cations)
- Tidal fluctuation amplitudes and phase lags of tidal groundwater harmonic motions
- Mean hydraulic conductivity and hydraulic gradient of shallow water-bearing zone using tidal data

The tidal monitoring program will consist of the following elements:

- **Synchronized Water Level Monitoring.** Synchronized monitoring of water levels in the Wapato Creek and selected groundwater monitoring wells (Figure 13, Table 7). Continuous water levels will be obtained using pressure transducers installed in a stilling well in Wapato Creek, and in selected monitoring wells. Transducers will be programed to measure water level on 5-minute intervals for a period of at least 73 hours. Manual water levels will obtained in all monitoring wells during Events 1 through 4. Water level monitoring procedures are described in the SAP (see Appendix A).
- **Review of Published Tide Table Data.** Review of published tide tables for Commencement Bay. Published data will be used to assess lag times and changes in predicted amplitude at the Site versus the published station. The results of this review and evaluation may be used for predicting groundwater response to peak tides or flood conditions.
- **Collection of General Water Quality Data.** Groundwater monitoring wells and surface water in the Wapato Creek and the Blair Waterway will be sampled and analyzed for general water quality parameters including: major cations (calcium, magnesium, potassium, sodium), major anions (carbonate, bicarbonate, sulfate, chloride, bromide, fluoride, and ortho-phosphate), pH, temperature, ORP, specific conductivity, and TOC. Groundwater samples will be collected on approximately a quarterly basis (see Section 7). Water quality sampling procedures are described in the SAP (see Appendix A).
- **Fresh Water and Saline Water Mixing Analysis**. The effect of tidal fluctuations on groundwater quality will be evaluated using general water quality data (e.g., specific conductivity, major cations and anions). Major cation (calcium, magnesium, potassium, sodium) and anions (carbonate, bicarbonate, sulfate, chloride) will be used to generate trilinear or Stiff diagrams to assess the differences in major-ion chemistry and potential mixing of fresh groundwater and saline surface water.

6.2 Events 2 through 4

Events 2 through 4 will include a repeat of the groundwater monitoring and sampling, porewater sampling, and surface water sampling (including from reference locations) conducted for Event 1 (May 2016). The sampling locations will be the same as those described above for Event 1. However, the number of surface water sampling locations will likely be reduced; locations selected for Events 2 through 4 will be based on the Event 1 results. For purposes of obtaining data representative of year-round conditions, Events 2, 3, and 4 are planned to occur approximately 3 (August 2016), 6 (November 2016), and 9 (February 2017) months after Event 1, respectively. Analyses planned for each sample location will be the same as for Event 1, as listed in Table 7.

7 Schedule and Reporting

Table 8 provides a schedule for the Scope of Work elements presented in the Order and is considered a “contingent” schedule at this time because it was built using assumed durations for Ecology review and approval time frames.

Meeting the Order schedule is an important objective for this project. RI data will be collected during four sampling events, anticipated to occur in May 2016, August 2016, November 2016, and February 2017. Data collected as part of the RI will be used to prepare an RI Report and FS technical memorandum and report. The schedule is initiated with the signing of the Order with an effective date of April 12, 2016. The Data Gaps Memorandum and this RIWP and the supporting documents are the first major deliverables required under the Order. Ecology review and approval of these documents are expected by the end of April 2016 so that fieldwork can begin as scheduled in May 2016. Submittal dates for all subsequent documents are dependent on receipt of Ecology comments on the draft reports. In general, revised documents are due to Ecology within 60 or 90 days of receipt of Ecology’s comments, as indicated in Exhibit C of the Order.

In general, it is anticipated that field work will be conducted through the spring of 2017 and that the draft RI Report and FS Technical Memorandum will be provided to Ecology by June 2017. A revised RI Report and Draft FS report will be provided to Ecology in October 2017 following discussion of the draft deliverables with Ecology. Completion of the obligation under the Order occurs when the final RI/FS Report and EIM Data Submittal are provided to EPA; this is currently anticipated to occur in January 2018.

If further investigation, beyond that identified in this RIWP, is needed to characterize the nature and extent of hazardous substances at the Site sufficiently to develop and evaluate potential cleanup alternative, the Port and Portac will develop and submit a Work Plan Addendum describing the scope of work, schedule, and submittal requirements for additional field investigations to Ecology for review and approval.

8 References

References are provided in Table 9.

Tables

Table 1. Site History/Chronology

Years	Area	Event Category	Description	Supporting Aerial Photograph Observations[1]
1890-1985	Parcel 15	Site Use	Parcel 15 is located with the air deposition area of the historical Asarco Smelter in Ruston. Arsenic, lead, and other heavy metals have been detected at elevated concentrations within soils in the air deposition plume.	Historical documents; City of Tacoma GovMe website.
pre-1950	Parcel 15	Site Use	Agricultural - Wapato Creek runs northwest across property.	1936, 1940, 1944, 1950 Aerial Photographs
1959-1965	Parcel 15	Site Use	Placement of fill on Parcel 15 (dredge sediment, likely from Blair Waterway). Re-routing of Wapato Creek.	1973. Site appears vacant with limited vegetation
1969	Parcel 15	Site Use	Site surface disturbed. Wapato Creek has been rerouted. Limited vegetation in southwestern portion of property.	1969 Aerial Photograph
1974 (actual date is uncertain)	Former Log Yard	Site Use	ASARCO slag fill used at some point during the construction and/or use of the Log Yard.	N/A
1974-1978	Parcel 15	Site Use	West Coast Orient Lumber Mills, Inc. operates Sawmill.	N/A
1978-1983	Parcel 15	Site Use	West Coast Lumber Operations Co. (WCLOC) operates mill.	N/A
1983-1988	Parcel 15	Site Use	WCLOC changes name to Portac, Inc. (1983) Mill operated by Portac Inc.	1985. Log Yard and Sawmill in full operation. Very dark soil (interpreted to be due to presence of bark) present on Log Yard. Heavy vegetation along both banks of Wapato Creek adjacent to Log Yard (north of access road). Very limited vegetation on southern banks of Creek adjacent to Sawmill - banks appear to have been cleared - creek channel very linear.
1986-1987	Former Log Yard	Investigation	Log Yard soil and groundwater assessment.	N/A
1988-1989	Former Log Yard	Cleanup	Log Yard cap is constructed; central drainage ditch cleanup completed..	N/A
1989-1992	Former Log Yard	Monitoring	Log Yard post-construction monitoring program is active.	1990. Log Yard and Sawmill in full operation. Creek vegetation similar to 1985. Dark soil/bark limited to northeast corner of site (on top of capped surface) . Western bank of Creek being used for parking.
2002 -2006	Parcel 15	Site Use	Sawmill and Log Yard in use.	2002. Sawmill appears in full operation; Log storage less than previous years. Surface of Log Yard (i.e., cap) appears reddish-brown likely due to the presence of bark. Dark circular pattern (road?) in northeastern corner. 2006. Sawmill appears in full operation; Log storage is less than previous years. Surface of Log Yard appears reddish-brown.
2008-2009	Former Log Yard	Site Use, Cleanup	Portac Sawmill closes. Sawmill demolition and soil removals. Cap repairs and maintenance conducted.	2009. Former Log Yard vacant. Cap is apparent with several large dark rectangular patches which are assumed to be areas of cap repair or modification. Former Saw Mill has been demolished and area is being used for automobile storage. Cap repairs include asphalt overlay (184,000 sq.ft) and sealing of cracks (38,500 linear feet).
2008	Former Log Yard	Site Use	Log Yard ramp demolition.	N/A
2008-2013	Former Log Yard	Investigation, Cleanup	VCP activities on Sawmill.	N/A
2010	Former Log Yard	Site Use	Portac lease with Port of Tacoma ends.	N/A
2011-2014	Former Log Yard	Investigation, Cleanup	Supplemental testing on Sawmill.	2011. Former Log Yard vacant. Cap is apparent and has numerous north-south trending lines (e.g., patches). Northwestern half of cap appears reddish brown and appears logs or lumber may be stored onsite. Former Saw Mill is gone and area is vacant. Former building foundations (e.g., slab on grade?) visible.
2012-2013	Former Sawmill	Site Use	Cap repairs occur based on recommendations in 2012 Cap Inspection Report.	2012. Former Log Yard mostly vacant - some unknown storage. Cap is apparent and has numerous north-south and east-west trending lines (e.g., patches). Surface of cap now gray. Former Saw Mill area being used for automobile storage and former building foundations visible.
2014 - 2015	Former Sawmill	Inspection	Cap inspection observations result in repair recommendations.	2015. Former Log Yard being used for automobile storage. Former Saw Mill mostly vacant. Heavy equipment parked on northwestern portion of former Saw Mill.

Notes:

N/A = Not applicable. Event not represented by an aerial photo observation.

[1] See Attachment A of the Data Gaps Memorandum for photograph log.

Table 2. Previous Investigations And Sampling Events

Area Sampled	Activity Description/ Objective	Years Sampled	Media Sampled						Analytes Tested	Source Document
			Groundwater	**Soil**	**Catch Basin Sediment**	**Stormwater/ Runoff**	**Wapato Creek Sediment**	**Wapato Creek Surface Water**		
Former Log Yard, Wapato Creek	Surface water sampling for log sort yard remediation project (1988 consent order).	1983-1990				**X** (drainage discharges)		**X**	Metals	HC 1990a
Former Log Yard, Wapato Creek	3rd and final round of surface water sampling for log sort yard remediation project (1988 consent order).	1983-1990				**X** (drainage discharges)		**X**	Metals	HC 1990c
Former Log Yard	Groundwater assessment to address whether groundwater is contributing to metals in nearby waterways	1986-1987	**X**	**X**					Metals, EP toxicity	HC 1987a
Central Drainage Ditch	Soil cleanup in central drainage ditch between Log Yard and Sawmill. Soils were excavated and disposed of offsite. Area was subsequently filled and capped.	1988		**X**		**X** (drainage ditch)			PCP, TOX, PNAs, TPH	RZA 1988a,c
Wapato Creek	Ten sediment samples collected in Wapato Creek (8 adjacent to the site and 2 upstream).	1988					**X**		PCP, TOX, PCBs, pesticides	RZA 1988b
Former Log Yard	Spring 1990 groundwater monitoring event for log sort yard remediation project (1988 consent order).	1987-1990	**X**						Metals	HC 1990b
Former Log Yard	Spring 1991 groundwater monitoring event for log sort yard remediation project (1988 consent order).	1987-1991	**X**						Metals	HC 1991d
Former Log Yard	Spring 1992, Final groundwater monitoring event for log sort yard remediation project (1988 consent order).	1987-1992	**X**						Metals	HC 1992
Former Log Yard	Characterize surface material on the sort yard.	1988		**X** (test pits, slag, wood waste, soil)					Metals	HC 1988a
Former Sawmill	Closure assessment focused on hog fuel ramp, former wood treatment area, former dip tank and drip pad.	2008	**X**	**X**					Groundwater: Metals, TCLP metals. Soil: TPH, PCP, nitrogen, BTEX	CDM 2008a
Former Log Yard	Stormwater monitoring under WA Industrial Stormwater General Permit - Discharge Monitoring Reports for 2003 - 2009	2003-2009				**X**			pH, turbidity, oil and grease, hardness, BOD, copper, lead, zinc,	Portac, 2015
Former Sawmill	Second phase of closure assessment activities	2008	**X**	**X**					Groundwater: PCP, TPH. Soil: PCP, TPH, TCLP metals.	CDM 2008b
Former Sawmill	Sediment and stormwater sampling of catch basins	2009			**X**	**X**			PCP	EMS 2009
Parcel 15	Assess catch basin solids	2009			**X**				Metals, TPH, SVOCs	HC 2009b
Wapato Creek	Evaluate potential impacts to creek sediment quality from site stormwater runoff and historical activities	2009					X (surface and subsurface)		TPH, metals, PCP	HC 2009c
Wapato Creek	Confirm PAH concentrations in creek sediment	2009					**X**		PAHs	WES 2009a
Former Sawmill	Log ramp demolition	2008		X (demolition, stockpiles)					Arsenic, Lead	WES 2009b
Former Sawmill	Additional information regarding Sawmill site: storm drain cleaning, TEE, Wapato Creek sample	2009			**X**	X (stormwater)	**X**		Storm drain sediment: PCP, TPH, BTEX. Catch basin sediment: PCP. Stormwater: PCP. Wapato Creek sediment: PAHs.	WES 2009c

Table 2. Previous Investigations And Sampling Events

Area Sampled	Activity Description/ Objective	Years Sampled	Media Sampled						Analytes Tested	Source Document
			Groundwater	Soil	Catch Basin Sediment	Stormwater/ Runoff	Wapato Creek Sediment	Wapato Creek Surface Water		
Former Log yard	Termination of Baseline General Permit to Discharge Stormwater for Industrial Activity	2009								Portac, 2009
Former Sawmill	Lumber mill demolition cleanup and testing	2008-2009	X	X (soil and waste characterization)					Groundwater: TPH, SVOCs, VOCs, metals. Soil: TPH, SVOCs, metals, dioxins, PCBs, TCLP metals.	WES 2009e
Former Sawmill	4th quarter, 2009 groundwater monitoring report	2008-2009	X						SVOCs, PAHs, TPH, metals	WES 2010a
Former Sawmill	1st quarter, 2010 groundwater monitoring report	2008-2010	X						SVOCs, PAHs, TPH, metals	WES 2010b
Former Sawmill	2nd quarter, 2010 groundwater monitoring report	2008-2010	X						SVOCs, PAHs, TPH, metals	WES 2010c
Former Sawmill	3rd quarter, 2010 groundwater monitoring report	2008-2010	X						SVOCs, PAHs, TPH, metals	WES 2010d
Former Sawmill	1st quarter, 2013 groundwater monitoring report	2008-2013	X						SVOCs, PAHs, TPH, metals	WES 2013
Former Sawmill	Collection of data to support modified MTCA screening levels	2011		X					TOC	WES 2011
Former Log Yard	Subsurface soil investigation in Log Yard area	2014		X (slag, wood waste)					Arsenic, TCLP metals	AQEA 2014
Former Log Yard	Groundwater sampling and summary of investigation for north lead rail improvement project	2013-2014	X	X					Metals	Landau 2014

Abbreviations:

BTEX = benzene, toluene, ethylbenzene, and xylenes

PAHs = polycyclic aromatic hydrocarbons

PCBs = polychlorinated biphenyls

PCP = PCP

SVOCs = semi-volatile organic compounds

TCLP metals = toxicity characteristic leaching procedure for metals

TEE = terrestrial ecological evaluation

TPH = total petroleum hydrocarbons (diesel-, motor oil- and/or gasoline-range hydrocarbon analysis)

VOCs = volatile organic compounds

Table 3. Potential Sources of Contamination and Associated Remedial Actions

Source Location	Source Activity	Site-Associated Contaminant	Remedial Activity
Regional soils	Natural and urban background conditions and presence of arsenic and/or lead in aerial deposition from the ASARCO smelter plume	Metals	NA
Former Log Yard parcel	Placement of fill containing ASARCO slag and leaching from slag over time	Metals	Log yard capped pursuant to 1988 Order to prevent surface water infiltration through the slag and associated leaching of metals (HC 1988b, HC 1988d).
Log ramp in Former Sawmill area	Use of ASARCO slag as construction material and leaching from slag over time	Metals	During removal of the log ramp in 2008, the slag containing fill was excavated beyond the planned final grade at the ramp area. The area was then backfilled, regraded, and paved in November 2008 (WES, 2009b).
Edger spray booth area of mill building	Sawmill operations/ wood treatment and processing	PCP	Impacted soil was excavated (WES, 2009e).
Mill spray area of mill building	Sawmill operations/ wood treatment and processing	PCP	Impacted soil was excavated (WES, 2009e).
Plant spray booth area of planer building	Sawmill operations/ wood treatment and processing	PCP	Impacted soil was excavated (WES, 2009e).
Former drainage ditch between former Log Yard and Sawmill	Secondary source due to accumulation of stormwater runoff and eroded soil that was impacted by PCP	PCP	Impacted soil was excavated, the ditch was backfilled, and the cap was extended to cover the former drainage ditch.
Fuel Tank Area near former Sawmill	Above ground fuel tank, leaks, spills	TPH	Impacted soil was excavated (WES, 2009e).
Mill hydraulics area in mill building	General operations, spills	TPH	Impacted soil was excavated (WES, 2009e).
Dip tank area near main storage building	General operations, spills	TPH	Impacted soil was excavated (WES, 2009e).

Notes:

PCP = pentachlorophenol

TPH = total petroleum hydrocarbons

Table 4. Existing Monitoring Well Completion Details

Well Identification	Location	Historical Well Construction Data [1]												November 2015 Well Assessment Data						
		Source Document for Well Log	Well Type	Date Drilled	Water Level ATD (ft bgs)	Casing Diameter (inches)	Casing Material	Total Depth of Boring (ft bgs)	Screen Length (ft)	Top of Screen (ft bgs)	Bottom of Screen/ Casing (ft bgs)	Screen Slot Size (inch)	Filter Pack	Latitude[5] (WGS84)	Longitude[5] (WGS84)	Depth to Water (ft BTOC)	Total Depth (ft BTOC)	Stick Up (ft bgs)	Well Casing Methane (percent LEL)	Surface Completion (notes)
B-1R	Log Yard	HC, 1987	Monitoring Well	3/24/1987	6	2	Sch 40 PVC	14	10	5	10	0.02	Silica Sand Backfill	47.25338	-122.37136	12.02	17.07	--	70.5	4" locking steel monument
B-2R	Log Yard	HC, 1987	Status Unknown Monitoring Well	3/24/1987	6.5	2	Sch 40 PVC	14	5	8	13	0.02	Silica Sand Backfill	47.25361	-122.36734	well not located - status unknown				Not located with GPS and metal detector
B-3R	Log Yard	HC, 1987	Monitoring Well	3/24/1987	7	2	Sch 40 PVC	14	5	8	13	0.02	Silica Sand Backfill	47.25189	-122.36703	13.92 [6]	15.91	--	80.1	4" locking steel monument
B-4	Sawmill	HC, 1987	Abandoned Monitoring Well	3/24/1987	6	2	Sch 40 PVC	19	5	8	13	0.02	Silica Sand Backfill	47.24968	-122.36907	no data - well abandoned				
B-5R	Sawmill	HC, 1987	Monitoring Well	3/24/1987	8.5	2	Sch 40 PVC	19	5	12	17	0.02	Silica Sand Backfill	47.25157	-122.37222	12.01	16.10	-0.30	0	4" locking steel monument
B-6R	Log Yard	HC, 1987	Monitoring Well	3/24/1987	7.5	2	Sch 40 PVC	14	5	8	13	0.02	Silica Sand Backfill	47.25188	-122.37038	12.16	15.98	--	76	4" locking steel monument
HC-1[2]	Log Yard	Unknown	Perched Monitoring Well	Unknown	Unknown	2	Sch 40 PVC[3]	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	47.25193	-122.36704	5.5	5.50	--	62	Steel monument (broken lid, bent casing)
HC-2[2]	Log Yard	Unknown	Perched Monitoring Well	Unknown	Unknown	2	Sch 40 PVC[3]	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	47.25337	-122.37140	7.56	8.57	--	15.8	4" locking steel monument
MW-1	Sawmill	CDM, 2008	Monitoring Well	4/30/2008	10	2	Sch 40 PVC	15	10	5	15	0.01	10-20 Silica Sand	47.25030	-122.37225	9.97	15.34	--	13.1	Steel surface monument
MW-2R	Sawmill	WES, 2009	Monitoring Well	4/22/2009	10	2	Sch 40 PVC	16.5	10	5	15	Unknown	10-20 Silica Sand	47.25007	-122.37206	8.8	14.74	-0.37	0.1	Steel surface monument
MW-3	Sawmill	CDM, Nov. 2008	Monitoring Well	9/8/2008	10	2	Sch 40 PVC	15	10	5	15	0.01	10-20 Silica Sand	47.25014	-122.37179	9.75	14.98	--	20.4	Steel surface monument
MW-4	Sawmill	CDM, Nov. 2008	Monitoring Well	9/8/2008	8.5	2	Sch 40 PVC	15	10	5	15	0.01	10-20 Silica Sand	47.25004	-122.37230	10.27	15.95	-0.54	0	Steel surface monument
MW-5[4]	Sawmill	WES, 2009	Damaged Monitoring Well	10/11/2008	11	2	Sch 40 PVC	17.5	10	5	15	Unknown	10-20 Silica Sand	47.24928	-122.37022	no data - damaged well to be replaced				Steel surface monument
MW-6R	Sawmill	WES, 2009	Monitoring Well	4/22/2009	10	2	Sch 40 PVC	16.5	9	5	14	Unknown	10-20 Silica Sand	47.25082	-122.37026	11.07	14.08	--	1.8	Steel surface monument (casing bent)
NLR-PORTAC-16	Log Yard	Landau, 2013	Piezometer	1/16/2014	11	0.75	Sch 40 PVC	20	2.5	12	14.5	Pre-Packed	Pre-Packed	47.25051	-122.36816	11.47	14.16	--	62	4" locking steel monument (B-16 painted label)
NLR-PORTAC-17	Log Yard	Landau, 2013	Piezometer	1/16/2014	13.5	0.75	Sch 40 PVC	20	2.5	15.3	17.8	Pre-Packed	Pre-Packed	47.25177	-122.36669	10.46	17.46	-0.32	1.7	Flush-mounted monument (B-17 painted label)
NLR-PORTAC-18	Log Yard	Landau, 2013	Piezometer	1/16/2014	10	0.75	Sch 40 PVC	20	2.5	15	17.5	Pre-Packed	Pre-Packed	47.25308	-122.36520	9.37	17.18	--	83	4" locking steel monument (B-18 label lost)

Notes:

ATD = At time of drilling
bgs = below ground surface
ft = feet
MW = monitoring well
PVC = polychlorinated vinyl
Sch = schedule
WGS84 = World Geodetic System 1984
BTOC = below top of well casing
LEL = lower explosive limit

1 Well construction information reflects information from original well logs and construction schematics. The 1988 Portac Paving Plan indicates that existing wells (those drilled in 1987) were likely extended during capping. The amount of extension for each well is unknown but the 2015 well assessment data suggests that the casing in monitoring wells B-6R and B-3R, and B-1R was extended by approximately 3 feet. The paving plan figures also suggest that B-2R was abandoned during construction of the cap.

2 Well logs have not been located for HC-1 and HC-2 by the production of this document.

3 Casing diameter and material of HC-1 and HC-2 confirmed during November, 2015 well assessment

4 MW-5 will be abandoned due to damaged casing and will be replaced by MW-5R as part of the remedial investigation.

5 Well location field data recorded from Trimble GeoExplorer 2008; wells to be professionally surveyed in 2016.

6 This measurement is suspected to be erroneous because it is deeper than anticipated. Additional measurements will be collected during the RI.

Table 5. Summary of Existing Information and Data Gaps

RI/FS Information Needs by Topic (What We Need to Know)	Existing Information (What We Already Know)	Data Gaps (What We Don't Know)	Recommended Data Collection (RI Work to Fill Data Gaps)
Environmental Site Setting			
Survey data for the site and vicinity, including topography, bathymetry, utilities, and surface features.	• Extensive survey data are available for the site and vicinity.	• Limited supplemental surveys may be required to fill gaps in existing survey data and to document the locations and elevations of newly-placed groundwater monitoring wells or other investigation features.	• Conduct targeted surveys where required to confirm topography, depths of existing drainage features and locations/elevations of monitoring wells or other RI sampling locations.
Document current and likely future land uses at the site and vicinity.	• The site is zoned for industrial uses and is located within the Port industrial area.	• Specific future development plans are not specifically known at this time, but the site is expected to remain in Port ownership and continue to be used for industrial and Port-related uses.	• The RI to contain a description of current and anticipated land uses to the extent they are known.
Document current and likely future groundwater use at the site and vicinity.	• Groundwater is not currently used onsite. • Municipal water is available from the City of Tacoma. • Water-bearing zone is shallow (8-12 ft. bgs) and likely impacted by marine waters in Commencement Bay. • Groundwater discharges towards Wapato Creek and Commencement Bay (e.g., Blair Waterway) - there is an extremely low probability that groundwater will be used for drinking water in the future. • The highest beneficial groundwater use is likely discharge to marine water.	• Sufficient information is available to support the development of the RI.	• The RI to document current and likely future groundwater use.
Current human and fish/wildlife uses of Wapato Creek	• Groundwater discharges towards Wapato Creek and Commencement Bay (e.g., Blair Waterway) - there is an extremely low probability that groundwater will be used for drinking water in the future.	• Sufficient information is available to support the development of the RI.	• The RI to contain a description of current human and fish/wildlife uses of Wapato Creek.
Geology and Hydrogeology			
Soil stratigraphy including the presence of water-bearing zones and lower-permeability confining layers.	• Regional and site geology and hydrogeology are documented in previous reports. • Silty soils have been documented beneath the sandy fill materials at the site and in the vicinity.	• The depth and type of fill placed in the former Wapato Creek channel and the former drainage ditch and are not documented. It is unknown if this fill may be acting as either a potential preferential groundwater flow pathway or groundwater barrier. Data may be useful to support interpretation of groundwater flow directions, gradients, and potential contaminant transport if pathway is complete.	• Targeted shallow soil borings within former creek channel and ditch alignment may be useful to document depth and type of fill (e.g., grainsize, moisture content, density).
Groundwater flow directions, gradients, and migration pathways	• Groundwater flow directions, gradients, and migration pathways were documented during hydrogeologic studies for the Log Yard area (late 1980s) and during the VCP studies in the Sawmill area (2009-2013).	• Current site groundwater flow directions and gradients and migration pathways are generally understood. Additional data may be useful to refine groundwater flow near Wapato Creek and along the northern property boundary.	• The RI will include updated information regarding groundwater flow directions, gradients and migration pathways within the site and adjacent to Wapato Creek.
Nature and extent of tidal influences	• Tidal influences were documented in and along the shoreline of Wapato Creek during hydrogeologic studies for the Log Yard area (late 1980s) and during the VCP studies in the Sawmill area (2009-2013).	• Tidal influences need to be considered during collection of groundwater elevation and groundwater quality data and mapping of groundwater flow directions and gradients near Wapato Creek.	• Supplemental measurements (e.g., water elevations, conductivity) of tidal fluctuation variability are needed in groundwater wells located near Wapato Creek and within Wapato Creek.
Hydrogeologic properties of water-bearing zones	• Hydrogeologic properties of the water bearing zones were documented as part of hydrogeologic studies for the Log Yard area (late 1980s) and during the VCP studies in the Sawmill area (2009-2013).	• Supplemental hydrogeologic testing (e.g., slug tests, grain size measurements) may be warranted to refine estimates of hydraulic conductivity.	• Supplemental hydrogeologic testing (e.g., slug tests, grain size measurements) may be warranted to refine estimates of hydraulic conductivity.

Table 5. Summary of Existing Information and Data Gaps

RI/FS Information Needs by Topic (What We Need to Know)	Existing Information (What We Already Know)	Data Gaps (What We Don't Know)	Recommended Data Collection (RI Work to Fill Data Gaps)
Nature & Extent of Contamination			
Documentation of historical uses and potential contaminant sources	• The history of the site is well documented, including initial filling of the site, operation of the Sawmill and Log Yard, and the uses of slag, PCP and other petroleum and chemical products associated with Portac-Inc. operations.	• Existing historical information is sufficient to identify candidate source areas and evaluate the findings of environmental testing.	• No additional information required for RI.
Identification of potential off-site sources or regional influences	• Parcel 15 is located within the regional air-deposition footprint of the historical ASARCO smelter. The ASARCO plume is a large-scale site defined by elevated arsenic levels in soil. • ASARCO fallout patterns are well defined in residential and hillside areas of northeast Tacoma and surrounding areas. The patterns of contamination are more varied in developed urban and industrial areas.	• The contribution of the ASARCO plume site and other regional contaminant sources to groundwater and pore-water arsenic concentrations are less defined.	• The potential contribution of regional arsenic sources to observed groundwater and pore-water arsenic concentrations should be considered during development of the RI and interpretation of empirical testing data.
Document nature and extent of slag-associated contaminants in soils and groundwater within the former Log Yard	• The extent of slag-containing soils was documented during investigations conducted prior to capping of the Log Yard in the late 1980s, and more recently during soil testing in 2013 (Landau) and 2014 (Anchor QEA). • Groundwater quality testing was performed within the Log Yard during the late 1980s and early 1990s. • Limited groundwater testing was performed within the eastern portion of the capped area during 2013 (Landau).	• The current nature and extent of arsenic contamination in groundwater beneath the Log Yard cap is not known. Available data suggest that the arsenic concentrations may be heterogeneous. • The current groundwater concentrations of arsenic along the migration pathway between upland slag-containing fill and Wapato creek are not known. • Documenting soil properties between the cap and Wapato Creek may be useful to help understand geochemical processes occurring in the Nearshore Transition Zone and how these may affect arsenic mobility.	• Use temporary soil borings and groundwater monitoring wells to conduct a one-time "groundwater snapshot" and document the concentrations of arsenic in groundwater beneath the Log Yard Cap. • Additional groundwater and pore-water data, collected in a phased manner, may be used to characterize contaminant levels in groundwater discharges to Wapato Creek. • Conduct wet season and dry season sampling at locations along the groundwater migration pathway between the upland zone and Wapato Creek.
Verify the current concentrations of Sawmill-associated contaminants in groundwater within the Sawmill area.	• Extensive groundwater testing including quarterly monitoring was performed within the Sawmill area as part of investigations conducted under the VCP.	• No groundwater data have been collected since early 2013. It is not known whether residual PCP detected at that time has attenuated, or whether it remains above applicable screening levels.	• Resample groundwater wells within the Sawmill area to document current groundwater quality.
Assess the nature and extent of Sawmill-associated contaminants in Sawmill-area soils.	• Extensive soil testing was performed throughout potentially contaminated areas of the Sawmill as part of investigations conducted under the VCP.	• Supplemental testing data are required to verify the absence of residual PCP-associated contamination near the former PCP dip tanks.	• Use temporary soil borings to document the quality of soils near the former dip tank. Include testing for PCP, dioxin/furans and metals.
Evaluate sediment quality within Wapato creek for potential site-associated contamination	• Surface and subsurface sediments were tested by Hart Crowser in 2009 for potential sediment contamination. No exceedances of SMS criteria for the protection of benthic community were detected. • Surface sediments were tested in 10 locations in 1988 for Site-related contaminants by RZA. PCP was detected at low concentrations, PCBs, and pesticides were not detected.	• No additional data are required to assess potential sediment contamination.	• Additional testing data are not required to characterize sediments. However, it may be beneficial to collect sediment arsenic concentrations along-side newly-collected pore-water data to aid in interpretation of the groundwater to surface water pathway.
Evaluate stormwater quality for potential impacts from site-associated contamination	• Contaminated soils in the former Log Yard are capped and the cap is maintained. The cap prevents exposure of stormwater to contaminated soils in the former Log Yard. Stormwater from the surface of the cap is captured and discharges to Wapato Creek. • Limited stormwater quality testing was performed for slag-associated metals following construction of the Log Yard Cap. • Former Sawmill area surface consists of asphalt, concrete, and graveled areas. Contaminated soils do not appear to be present at the surface. Stormwater is captured and discharged to Wapato Creek. Catch basins were observed to have stormwater filters installed in them.	• Recent stormwater testing data are not available. • Current stormwater system operations and maintenance activities should be documented.	• Review available stormwater system information. • If applicable, test stormwater for site-associated contaminants.

Table 5. Summary of Existing Information and Data Gaps

RI/FS Information Needs by Topic (What We Need to Know)	Existing Information (What We Already Know)	Data Gaps (What We Don't Know)	Recommended Data Collection (RI Work to Fill Data Gaps)
Evaluate whether the stormwater conveyance systems may intersect the shallow water-bearing zone and act as a preferential groundwater migration pathway to Wapato Creek.	• Most of the current storm drainage system is located above the elevation of site groundwater.	• Supplemental surveys may be required to determine which portions of the storm drainage system are located below the water table.	• Evaluate the existing storm drainage system at the Log Yard and Sawmill for potential entry points for contaminated groundwater in areas where system structures are located below the water table. • If system evaluations indicate potential groundwater transmission (e.g., dry weather flow), sampling of discharge may be warranted.
Contaminant Fate and Transport			
Verify the northern boundary of groundwater arsenic contamination associated with the site.	• Existing data from wells and borings documents that arsenic concentrations in groundwater are less than 5 ug/L in groundwater to the northeast of the site.	• No groundwater testing for arsenic has been performed to the northwest of the site.	• Using temporary borings and/or permanent wells, test the groundwater along the central and western portion of the northern site boundary. Evaluate for potential site-associated arsenic contamination.
Quantify the concentrations of arsenic (and if applicable PCP) in groundwater and pore-water of the Nearshore Transition Zone.	• To date, groundwater data collection has been limited to the upland zone. • No testing has been performed for porewater within the sediment bioactive zone or deeper soils/sediments within the Nearshore Wapato Creek Transition Zone.	• Additional data are required to document the concentrations of arsenic in groundwater and porewater within the Nearshore Transition Zone. • Similar data may be required for PCP adjacent to the Sawmill area. The need for those data can be assessed after review of current upland groundwater quality.	• Install and sample groundwater wells at selected locations along the nearshore transition zone. • Using passive samplers, document the concentrations of arsenic in porewater of the sediment bioactive zone, in the soils just beneath it. • Based on current groundwater quality, determine if porewater testing for PCP is warranted.
Document the hydrogeologic and geochemical processes that may affect the attenuation or transport of site-associated groundwater contaminants	• Existing groundwater studies have documented the presence of tidally-induced groundwater fluctuation and mixing in nearshore areas. • Some data for field screening parameters (pH, dissolved oxygen, redox, conductivity) have been collected during previous site groundwater investigations.	• Additional information is required to document the geochemical properties of soil and groundwater in the upland and transition zones. • Modeling can be used along with additional contaminant data (particularly for arsenic) for groundwater, pore-water and surface water, to assess whether contaminants are reaching or are likely to reach the sediment bioactive zone or Wapato Creek above applicable screening levels.	• Conduct testing for geochemical parameters within soil and groundwater of the upland zone and the transition zone. • Document geochemical parameters within the sediment bioactive zone, just below it, and just above it (in Wapato Creek). • Possibly conduct focused modeling to document the extent of attenuation and/or transport of site-associated contaminants within the transition zone between the uplands and Wapato Creek.
Determine if water quality within Wapato Creek is adversely impacted by discharges of site-associated groundwater contaminants.	• Surface water testing was performed for slag-associated metals following construction of the Log Yard Cap. Though limited, the data showed that water quality within Wapato Creek had recovered to background levels.	• Additional data are required to determine if site-related discharges (particularly for arsenic) are adversely affecting water quality within Wapato creek. • Data are also required to evaluate to characterize off-site water quality within Wapato Creek and the Blair Waterway to ensure that any site-related impacts can be distinguished from regional conditions.	• Conduct surface water testing for arsenic at selected locations within Wapato Creek upstream of the site, adjacent to the site, and within the Blair Waterway. • Based on current groundwater quality data, evaluate the need for surface water testing for PCP.
Assess whether decomposition of capped wood waste poses potential risks from production of methane.	• No vapor data are currently available for the site.	• Given the age of the site, empirical data can be used to assess the potential for significant methane generation.	• Sample selected wells within the Log Yard area for accumulation of combustible vapors.

Notes:

PCP: Pentachlorophenol

RI: Remedial Investigation

SMS: Washington Sediment Management Standards regulations (WAC-173-204)

VCP: Voluntary cleanup program

Table 6. Analytical Schedule for Soil and Sediment

Site	Station Type	Station ID	Sample Depth^2	Located Within Nearshore Study Area	Standard Analytical Suite					Add-Ons		Nearshore Study Area Geochemical				
					Arsenic	Iron	Total Organic Carbon (TOC)	Total Solids	Frozen Archival	Pentachlorophenol (PCP) and pH	Dioxins/Furans	Sulfide	Grain-Size	Sequential Extraction Testing	Batch Adsorption Testing	Arsenic Speciation - As(III)/As(V)
Soil Testing																
Log Yard	New Monitoring Wells	MW-7	Saturated Zone	X	X	X	X	X	X			X	X	X	X	X
		MW-9	Saturated Zone	X	X	X	X	X	X			X	X	X	X	X
		MW-10	Saturated Zone	X	X	X	X	X	X			X	X	X	X	X
		MW-12	Saturated Zone	X	X	X	X	X	X			X	X	X	X	X
		MW-13	Saturated Zone	X	X	X	X	X	X			X	X	X	X	X
		MW-8	Saturated Zone		X	X	X	X	X							
		MW-11	Saturated Zone		X	X	X	X	X							
	Temporary Borings	TB-3	Saturated Zone	X	X	X	X	X	X			X	X	X	X	X
		TB-5	Saturated Zone	X	X	X	X	X	X			X	X	X	X	X
		TB-7	Saturated Zone	X	X	X	X	X	X			X	X	X	X	X
		TB-1	Saturated Zone		X	X	X	X	X							
		TB-2	Saturated Zone		X	X	X	X	X							
		TB-4	Saturated Zone		X	X	X	X	X							
		TB-6	Saturated Zone		X	X	X	X	X							
		TB-8	Saturated Zone		X	X	X	X	X							
Sawmill	New Monitoring Well	MW-5R[1]	Saturated Zone		X	X	X	X	X	X	X					
	Temporary Borings	TB-9	Artificial Fill	X	X	X	X	X	X	X			X			
		TB-9	Channel Bottom	X	X	X	X	X	X	X			X			
		TB-9	Native Sediments	X	X	X	X	X	X	X			X			
	Test Pit	TP-1	Unsaturated Zone	X	X	X	X	X	X	X	X					
		TP-1	Saturated Zone	X	X	X	X	X	X	X						
		TP-2	Unsaturated Zone	X	X	X	X	X	X	X	X					
		TP-2	Saturated Zone	X	X	X	X	X	X	X						
Sediment Testing																
Log Yard	Wapato Creek Transect	WCT-1A	0-10 cm bml	X	X	X	X	X	X			X	X	*	*	*
			40-50 cm bml	X	X	X	X	X	X			X	X	*	*	*
		WCT-1B	0-10 cm bml	X	X	X	X	X	X			X	X	*	*	*
			40-50 cm bml	X	X	X	X	X	X			X	X	*	*	*
		WCT-2A	0-10 cm bml	X	X	X	X	X	X			X	X	*	*	*
			40-50 cm bml	X	X	X	X	X	X			X	X	*	*	*
		WCT-2B	0-10 cm bml	X	X	X	X	X	X			X	X	*	*	*
			40-50 cm bml	X	X	X	X	X	X			X	X	*	*	*
		WCT-3A	0-10 cm bml	X	X	X	X	X	X			X	X	*	*	*
			40-50 cm bml	X	X	X	X	X	X			X	X	*	*	*
		WCT-3B	0-10 cm bml	X	X	X	X	X	X			X	X	*	*	*
			40-50 cm bml	X	X	X	X	X	X			X	X	*	*	*
Sawmill	Wapato Creek Transect	WCT-4A	0-10 cm bml	X	X	X	X	X	X	X		X	X			
			40-50 cm bml	X	X	X	X	X	X	X		X	X			
		WCT-4B	0-10 cm bml	X	X	X	X	X	X	X		X	X			
			40-50 cm bml	X	X	X	X	X	X	X		X	X			

Notes:

cm bml = centimeters below mudline

* = Four sediment samples will be selected for analysis based on initial sediment results.

1 New monitoring well MW-5R is a replacement well for MW-5, which will be abandoned.

2 Selection of sampling depth intervals are discussed in the SAP. Additional soil samples from the capillary fringe and saturated zone will be collected from the temporary boringsand monitoring well borings for archival at the lab.

Table 7. Analytical Schedule for Surface Water, Porewater, and Groundwater

Site	Station Type	Station ID	Analyzed Sample Depth	Located Within Nearshore Study Area	Standard Analytical Suite							Add-Ons	Nearshore Study Area Geochemical					
					Water Field Parameters[1]	Headspace Monitoring (Methane)	Manual Water Level	Arsenic (total and dissolved)	Organic Carbon (total and dissolved)	Sulfide (dissolved)	Iron and Manganese (dissolved)	Pentachlorophenol (PCP)	Transducer Water Levels	Major Cations/Anions (dissolved)[2]	Alkalinity(dissolved)[3]	Nitrate and Nitrite (dissolved)	Iron Speciation - Fe(II)/Fe(III) (dissolved)	Arsenic Speciation - As(III)/As(V) (dissolved)[4]
Groundwater Testing																		
Log Yard	New Monitoring Well	MW-7	Screened Interval	X	X	X	X	X	X	X	X		X	X	X	X	X	>
		MW-9	Screened Interval	X	X	X	X	X	X	X	X		X	X	X	X	X	>
		MW-10	Screened Interval	X	X	X	X	X	X	X	X		X	X	X	X	X	>
		MW-12	Screened Interval	X	X	X	X	X	X	X	X		X	X	X	X	X	>
		MW-13	Screened Interval	X	X	X	X	X	X	X	X		X	X	X	X	X	>
		MW-8	Screened Interval		X	X	X	X	X	X	X							
		MW-11	Screened Interval		X	X	X	X	X	X	X		X					
	Existing Monitoring Well	B-1R	Screened Interval	X	X	X	X	X	X	X	X		X	X	X	X	X	>
		HC-2[5]	Screened Interval	X	X	X	X	X	X	X	X			X	X	X	X	>
		B-3R	Screened Interval		X	X	X	X	X	X	X							
		B-6R	Screened Interval		X	X	X	X	X	X	X		X					
		HC-1[5]	Screened Interval		X	X	X	X	X	X	X							
	Temporary Boring	TB-3	Saturated Zone	X	X	X	X	X	X	X	X		X	X	X	X	X	>
		TB-5	Saturated Zone	X	X	X	X	X	X	X	X		X	X	X	X	X	>
		TB-7	Saturated Zone	X	X	X	X	X	X	X	X		X	X	X	X	X	>
		TB-1	Saturated Zone		X	X	X	X	X	X	X							
		TB-2	Saturated Zone		X	X	X	X	X	X	X							
		TB-4	Saturated Zone		X	X	X	X	X	X	X							
		TB-6	Saturated Zone		X	X	X	X	X	X	X							
		TB-8	Saturated Zone		X	X	X	X	X	X	X							
Sawmill	New Monitoring Well	MW-5R[6]	Screened Interval		X	X	X	X	X	X	X	X						
	Existing Monitoring Well	MW-1	Screened Interval	X	X	X	X	X	X	X	X	X	X	X	X	X	X	>
		MW-2R	Screened Interval	X	X	X	X	X	X	X	X	X	X	X	X	X	X	>
		MS-3	Screened Interval	X	X	X	X	X	X	X	X	X	X	X	X	X	X	>
		MW-4	Screened Interval	X	X	X	X	X	X	X	X	X	X	X	X	X	X	>
		B-5R	Screened Interval	X	X	X	X	X	X	X	X	X	X	X	X	X	X	>
		MW-6R	Screened Interval		X	X	X	X	X	X	X	X						
	Temporary Boring	TB-9	Saturated Zone	X	X	X	X	X	X	X	X	X						
Porewater Testing																		
Log Yard	Wapato Creek Transect	WCT-1A	0-10 cm bml	X	X	X	X	X	X	X	X			X	X	X	X	>
			40-50 cm bml	X	X	X	X	X	X	X	X			X	X	X	X	>
		WCT-1B	0-10 cm bml	X	X	X	X	X	X	X	X			X	X	X	X	>
			40-50 cm bml	X	X	X	X	X	X	X	X			X	X	X	X	>
		WCT-2A	0-10 cm bml	X	X	X	X	X	X	X	X			X	X	X	X	>
			40-50 cm bml	X	X	X	X	X	X	X	X			X	X	X	X	>
		WCT-2B	0-10 cm bml	X	X	X	X	X	X	X	X			X	X	X	X	>
			40-50 cm bml	X	X	X	X	X	X	X	X			X	X	X	X	>
		WCT-3A	0-10 cm bml	X	X	X	X	X	X	X	X			X	X	X	X	>
			40-50 cm bml	X	X	X	X	X	X	X	X			X	X	X	X	>
		WCT-3B	0-10 cm bml	X	X	X	X	X	X	X	X			X	X	X	X	>
			40-50 cm bml	X	X	X	X	X	X	X	X			X	X	X	X	>

Table 7. Analytical Schedule for Surface Water, Porewater, and Groundwater

					Standard Analytical Suite							Add-Ons	Nearshore Study Area Geochemical					
Site	**Station Type**	**Station ID**	**Analyzed Sample Depth**	**Located Within Nearshore Study Area**	**Water Field Parameters[1]**	**Headspace Monitoring (Methane)**	**Manual Water Level**	**Arsenic (total and dissolved)**	**Organic Carbon (total and dissolved)**	**Sulfide (dissolved)**	**Iron and Manganese (dissolved)**	**Pentachlorophenol (PCP)**	**Transducer Water Levels**	**Major Cations/Anions (dissolved)[2]**	**Alkalinity(dissolved)[3]**	**Nitrate and Nitrite (dissolved)**	**Iron Speciation - Fe(II)/Fe(III) (dissolved)**	**Arsenic Speciation - As(III)/As(V) (dissolved)[4]**
Porewater Testing																		
Sawmill	Wapato Creek Transect	WCT-4A	0-10 cm bml	X	X	X	X	X	X	X	X	X		X	X	X	X	>
			40-50 cm bml	X	X	X	X	X	X	X	X	X		X	X	X	X	>
		WCT-4B	0-10 cm bml	X	X	X	X	X	X	X	X	X		X	X	X	X	>
			40-50 cm bml	X	X	X	X	X	X	X	X	X		X	X	X	X	>
Surface Water Testing																		
Log Yard	Wapato Creek Transect	WCT-1	10 cm aml	X	X	X	X	X	X	X	X			X	X	X	X	>
		WCT-2	10 cm aml	X	X	X	X	X	X	X	X			X	X	X	X	>
		WCT-3	10 cm aml	X	X	X	X	X	X	X	X			X	X	X	X	>
Sawmill	Wapato Creek Transect	WCT-4	10 cm aml	X	X	X	X	X	X	X	X	X		X	X	X	X	>
Blair Waterway	Blair Waterway Background	BWB-1	2 to 3 ft below water surface	X	X	X	X	X	X	X	X			X	X	X	X	>
Upstream	Wapato Creek Background	USB-1	10 cm aml	X	X	X	X	X	X	X	X			X	X	X	X	>

Notes:

cm aml = centimeters above mudline

cm bml = centimeters below mudline

1 Field parameters are temperature, pH, specific conductance (SC), oxidation reduction potential (ORP), dissolved oxygen (DO), and turbidity

2 Major Cations include calcium, magnesium, potassium, and sodium. Major anions include sulfate, chloride, bromide, fluoride, and ortho-phosphate.

3 Alkalinity includes total, carbonate as CaCO$_3$, bicarbonate as CaCO$_3$, and hydroxide as CaCO$_3$.

4 Arsenic and iron speciation testing will be performed on water samples with arsenic concentrations greater than (>) 36 µg/L.

5 Wells HC-1 and HC-2 historically contained perched groundwater but are anticipated to be dry now that the Former Log Yard is capped. The wells will be checked for the presence of perched water and if recoverable quantities of groundwater are encountered, then the well(s) will be sampled for the analytes listed above. If recoverable quantities are not encountered, then the wells will not be sampled.

6 New monitoring well MW-5R is a replacement well for MW-5, which will be abandoned.

Table 8. Schedule of Project Deliverables

Work Item	Deliverable	Anticipated Fieldwork Schedule *(if applicable)*	Schedule for Submittal to Ecology[1]	Estimated Order Required Due Date[2]	Anticipated Delivery Date
Data Gaps Memorandum	Data Gaps Memorandum	--	Within 30 days of the Effective Date of the Agreed Order (Assumed date of April 10, 2016).	May 10, 2016	April 1, 2016
Work Plan and Support Documents	Draft RI Work Plan	--	Within 60 days of receipt of Ecology's comments on the Data Gaps Memorandum.	May 31, 2016	April 1, 2016
	Draft Sampling and Analysis Plan (SAP); includes Quality Assurance Project Plan (QAPP)	--			
	Draft Health and Safety Plan (HSP)	--			
	Final RI Work Plan and Support Documents	--	Within 45 days of receipt of final Ecology comments on the Draft RI Work Plan.	June 24, 2016	April 22, 2016
Field Work Implementation and Interim Data Packages	Event 1 Preliminary Data Packages	May 2016	Fieldwork to be completed consistent with the schedule provided herein. Preliminary data to be transmitted in batches to Ecology within 60 days of receipt of validated data, at a minimum once per quarter.	August 2016	July 2016
	Event 2 Preliminary Data Packages	August 2016		November 2016	October 2016
	Event 3 Preliminary Data Packages	November 2016		February 2017	January 2017
	Event 4 Preliminary Data Packages	February 2017		May 2017	April 2017
Remedial Investigation/ Feasability Study (RI/FS) Reporting	Draft RI Report	--	Within 90 days of receipt of final validated data from Field Investigation Activities.	June 2017	June 2017
	Final RI Report	--	Within 60 days of receipt of final Ecology comments on the Draft RI Report.	October 2017	October 2017
	Draft FS Technical Memorandum	--	Within 90 days of receipt of final validated data from Field Investigation Activities (in parallel with the Draft RI Report).	June 2017	June 2017
	Draft FS	--	Within 60 days of receipt of Ecology approval of the Final FS Technical Memorandum.	October 2017	October 2017
	Final RI/FS	--	Within 60 days of receipt of Ecology's final comments on the Draft FS.	January 2018	January 2018
	EIM Data Submittal	--	Within 60 days of receipt of Ecology's final comments on the Draft FS (in parallel with Final RI/FS).	January 2018	January 2018

Note:

[1] These deliverables and the schedule presented herin are based on Exhibit C of the Agreed Order DE 11237

[2] Schedule assumes Ecology comments on draft documents will be provided within 30 days of the submittal dates. Actual schedule may vary based on timing of Ecology comments.

Table 9. References

Author Abbreviation	Year	Author	Document Title
AMEC	2009	AMEC	Technical Memorandum: Pavement Survey and Evaluation.
AQEA	2014	Anchor QEA (AQEA)	Log Yard Soil Testing Report. Former Portac Inc. Site. Tacoma, WA. Prepared for Portac and Port of Tacoma.
AQEA	2015a	Anchor QEA (AQEA)	Email from Mark Larsen (Anchor QEA) to Andrew Smith (Washington Department of Ecology). Subject: Thursday Port-Portac Meeting at Ecology (1:30 PM). Email presents the agenda for February 5, 2015 Meeting. Email included an attachment (Portac Site: Existing Information)
AQEA	2015b	Anchor QEA (AQEA)	Email from Mark Larsen (Anchor QEA) to Andrew Smith (Washington Department of Ecology). Subject: Confirming Friday's Meeting - Port of Tacoma and Portac Meeting. Email presents the agenda for February 5, 2015 Meeting. Email included attachments (Draft Exhibit B - 3-2-2015.docx; Exhibit C - Schedule - 3-2-2015.docx)
AQEA	2015c	Anchor QEA (AQEA)	Wapato Creek - Low Tide Conditions. Copy of presentation given to Washington Department of Ecology. Prepared for Portac and the Port of Tacoma.
Bessinger, B., and F. Mohsen,	2008	Bessinger, B., and F. Mohsen,	Simulation of Tidal Effects on Contaminant Fate and Transport near the Sediment-Water Interface. Presentation at Pacific Northwest Society of Environmental Toxicology and Chemistry (PNW-SETAC) Annual Meeting, Corvallis, OR, March 27-29, 2008.
Bessinger, et. al.,	2012	Bessinger, B.A., D. Vlassopoulos, S. Serrano, and P.A. O'Day	Reactive Transport Modeling of Subaqueous Sediment Caps and Implications for the Long-Term Fate of Arsenic, Mercury, and Methylmercury. Aquatic Geochemistry, v. 18, pp. 297-326.
CDM	2008a	CDM	Facility Closure Assessment Former Portac Lumber Facility
CDM	2008b	CDM	Facility Closure Assessment Second Phase Former Portac Lumber Facility
COT	2015a	City of Tacoma	Tacoma Public Works - Vertical Datums. Downloaded from the City of Tacoma's GovMe website: http://www.govme.org. Files downloaded on September 23, 2015.
COT	2015b	City of Tacoma	Historical Aerial Photographs downloaded from the City of Tacoma's GovMe website: http://www.govme.org. Files downloaded on October 2, 2015.
D&M	1974	Dames & Moore	Report of Soils Investigation Proposed Sawmill (West Coast Orient Lumber Mills Site)
Ecology	1989	Washington Department of Ecology (Ecology)	Letter, dated February 6, 1989, from Scott Morrison, Ecology to Curtis Ratcliffe, Port of Tacoma. Draft. Letter provides approve for filling the central ditch area of the Portac Site.

Table 9. References

Author Abbreviation	Year	Author	Document Title
Ecology	1994	Washington Department of Ecology (Ecology)	Natural Background Soil Metals Concentrations in Washington State
Ecology	2005	Washington Department of Ecology (Ecology)	Focus on Developing Ground Water Cleanup Standards Under the Model Toxics Control Act from Department of Ecology’s Toxic Cleanup Program. Washington Department of Ecology. Publication No. 01-09-049. Revised April 2005.
Ecology	2008	Washington Department of Ecology (Ecology)	The Industrial Stormwater General Permit - National Pollutant Discharge Elimination System and State Waste Discharge General Permit for Stormwater Discharges Associated with Industrial Activities. Permit issued by the Washington Department of Ecology (Ecology). Issuance Date: October 15, 2008. Effective Date: November 15, 2008. Expiration Date: April 30, 2009.
Ecology	2009a	Washington Department of Ecology (Ecology)	Letter from Ecology to Whitman Environmental Services, dated March 12, 2009, Re: Ecology Review of Portac Draft Log yard Ramp Removal Report.
Ecology	2009b	Washington Department of Ecology (Ecology)	Letter to Portac from Ecology, dated October 18, 2009, RE: Further Action at the Portac Sawmill Site, Tacoma, WA - Facility/Site No. 1215; VCP Project No. SW1016.
Ecology	2011a	Washington Department of Ecology (Ecology)	Background Characterization for Metals and Organic Compounds in Northeast Washington Lakes - Part 1: Bottom Sediments. Washington Department of Ecology. Publication No. 11-03-035. September 2011.
Ecology	2011b	Washington Department of Ecology (Ecology)	Guidance for Remediation of Petroleum Contaminated Sites. Washington Department of Ecology. Toxics Cleanup Program. Publication No. 10-09-057. September, 2011.
Ecology	2011c	Washington Department of Ecology (Ecology)	Puyallup-White Watershed, WRIA 10 – Focus on Water Availability. Water Resources Program. Publication Number: 11-11-015.
Ecology	2013a	Washington Department of Ecology (Ecology)	Letter from Ecology to Portac. Re: Notice of Potential Liability under the Model Toxics Control Act for the Release of Hazardous Substances at the following Hazardous Waste Site: Portac, Inc., 4215 SR 509 E. Frontage Road Tacoma. Facility/Site No. 1215.
Ecology	2013b	Washington Department of Ecology (Ecology)	Letter from Ecology to Port of Tacoma. Re: Notice of Potential Liability under the Model Toxics Control Act for the Release of Hazardous Substances at the following Hazardous Waste Site: Portac, Inc., 4215 SR 509 E. Frontage Road Tacoma. Facility/Site No. 1215.
Ecology	2015a	Washington Department of Ecology (Ecology)	Ecology EIM files down for Parcel 15. Files downloaded September 23, 2015.
Ecology	2015b	Washington Department of Ecology (Ecology)	Cleanup Site Details. Downloaded from Ecology's Toxic Cleanup Programs website.

Table 9. References

Author Abbreviation	Year	Author	Document Title
Ecology	2015c	Washington Department of Ecology (Ecology)	Ecology Establishing Regional Background for Sediment. Washington Department of Ecology. Toxics Cleanup Program. January 2015.
Ecology	2016	Washington Department of Ecology (Ecology)	In the Matter of Remedial Action by: Portac, Inc. and Port of Tacoma, Agreed Order No. DE 11237
EMS	2009	Environmental Management Services, LLC. (EMS)	Field Report: Catchbasin Sampling. Prepared for Portac.
EPA	1988	U.S. Environmental Protection Agency (EPA)	Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final. U.S. Environmental Protection Agency (EPA), Office of Emergency and Remedial Response, Washington, DC, EPA/540/G-89/004. Dated October 1988.
EPA	1993	U.S. Environmental Protection Agency (EPA)	Data Quality Objectives Process for Superfund: Interim Final Guidance. Office of Research and Development. EPA 540-R-93-071. September.
EPA	2000a	U.S. Environmental Protection Agency (EPA)	Guidance for the Data Quality Objectives Process. EPA QA/G-4. EPA/600/R- 96/055. U.S. Environmental Protection Agency (EPA), Office of Environmental Information, Washington, DC. 100 pp.
EPA	2000b	U.S. Environmental Protection Agency (EPA)	Transmittal of Policy Statement: “Role of Background in the CERCLA Cleanup Program.” OSWER 9285.6-07P. U.S. Environmental Protection Agency (EPA), Office of Emergency and Remedial Response, Washington, DC.
EPA	2002a	U.S. Environmental Protection Agency (EPA)	Guidance for Comparing Background and Chemical Concentrations in Soil at CERCLA Sites. U.S. Environmental Protection Agency (EPA), Office of Emergency and Remedial Response, Washington, DC. EPA/540-R-01-003. OSWER 9285.7-41. Dated September 2002.
EPA	2002b	U.S. Environmental Protection Agency (EPA)	Transmittal of Policy Statement: “Role of Background in the CERCLA Cleanup Program.” OSWER 9285.6-07P. U.S. Environmental Protection Agency (EPA), Office of Emergency and Remedial Response, Washington, DC.
EPA	2004	U.S. Environmental Protection Agency (EPA)	PCP. Environmental Fate. Washington DC: EPA-HQ-OPP-2004-0402-0015.
EPA	2005	U.S. Environmental Protection Agency (EPA)	Environmental Research Brief - The Impact of Ground-Water/Surface-Water Interactions on Contaminant Transport with Application to an Arsenic Contaminated Site EPA-600-S-05-002. Dated January 2005
EPA	2005	U.S. Environmental Protection Agency (EPA)	Field Study of the Fate of Arsenic, Lead, and Zinc at the Ground-Water/Surface-Water Interface. EPA 600-R-05-161. Dated December 2005.
EPA	2007	U.S. Environmental Protection Agency (EPA)	Monitored Natural Attenuation of Inorganic Contaminants in Ground Water, Vol. I: Technical Basis for Assessment. EPA/600/R-07/139.

Table 9. References

Author Abbreviation	Year	Author	Document Title
EPA	2008	U.S. Environmental Protection Agency (EPA)	Environmental Fate and Transport Assessment of Pentachlorophenol (PCP) for Reregistration Eligibility Decision Process. Washington DC: February 16, 2008. EPA-HQ-OPP-2004-0402-0066.
EPA	2011	U.S. Environmental Protection Agency (EPA)	Environmental Cleanup Best Management Practices: Effective Use of the Project Life Cycle Conceptual Site Model. U.S. Environmental Protection Agency (EPA), Office of Solid Waste and Emergency Response. EPA 542-F-11-011. Dated July 2011.
GeoEngineers	2003a	GeoEngineers	Supplemental Report - Geotechnical Engineering Services - Administration Building and Truck Scale Canopies - East Gate Yard - Pierce County Terminal Expansion Project - Phase 1. Tacoma, WA. Prepared for the Port of Tacoma.
GeoEngineers	2003b	GeoEngineers	Report - Geotechnical Engineering Services - Pavement Support Evaluation - Container Storage Yard and East Gate Yard - Pierce County Terminal Expansion Project - Phase 1. Tacoma, WA. Prepared for the Port of Tacoma.
Google	2015	Google Earth	Historical Aerial Photographs downloaded from Google Earth
GSI	2016	GSI Water Solutions, Inc. (GSI)	Data Gaps Memorandum. Parcel 15 (Portac) Investigation. Ecology Facility Site No. 1215/Cleanup Site No. 3642. Prepared for the Port of Tacoma and Portac, Inc. Prepared by GSI Water Solutions, Inc. and S.S. Papadopulow & Associates, Inc.
HC	1976	Hart Crowser, Inc. (HC)	Geology Study of the Port of Tacoma
HC	1986a	Hart Crowser, Inc. (HC)	Results of Test Pit Explorations and Chemical Testing Results - Portac Log Sort Yard. Letter to C. Ratcliffe, Port of Tacoma from Lori Herman, Hart Crower.
HC	1986b	Hart Crowser, Inc. (HC)	Portac Groundwater Quality Assessment
HC	1987a	Hart Crowser, Inc. (HC)	Portac Log Yard, Groundwater Assessment (See #117 & 125)
HC	1987b	Hart Crowser, Inc. (HC)	Letter from Julie Wukelic, Hart Crowser, dated September 25, 1987, to Leslie Sacha, Port of Tacoma. Re: Portac Log Sort Yard. This letter describes bulk sampling and laboratory testing of surficial soil from the log yard.
HC	1988a	Hart Crowser, Inc. (HC)	Portac Log Sort Yard, Phase I Material Characterization
HC	1988b	Hart Crowser, Inc. (HC)	Portac Log Sort Yard Remediation Plan, Volume I and II Appendices

Table 9. References

Author Abbreviation	Year	Author	Document Title
HC	1988c	Hart Crowser, Inc. (HC)	Portac Log Sort Yard Spill Contingency Plan
HC	1988d	Hart Crowser, Inc. (HC)	Portac Log Sort Yard Log Deck Maintenance Plan
HC	1988e	Hart Crowser, Inc. (HC)	Addendum 1 to Exhibit B - Volume 1 - Portac Log Sort Yard Remediation Plan. Portac Log Sort Yard - Port of Tacoma, WA.
HC	1990a	Hart Crowser, Inc. (HC)	Portac Log Sort Yard Water Quality Monitoring Program, Second Round of Surface Water Samples
HC	1990b	Hart Crowser, Inc. (HC)	Portac Log Sort Yard, Water Quality Monitoring Program, Spring Groundwater Sampling and Analysis Results
HC	1990c	Hart Crowser, Inc. (HC)	Portac Log Yard Remediation, Water Quality Monitoring Program, 3rd & Final Round of Surface Water Sampling
HC	1991d	Hart Crowser, Inc. (HC)	Portac Log Sort Yard, Spring 1991 Groundwater Sampling/Analysis Water Quality Monitoring Program
HC	1992	Hart Crowser, Inc. (HC)	Final Report Groundwater Quality Monitoring Program Portac Log Sort Yard Remediation
HC	2009a	Hart Crowser, Inc. (HC)	Roller Compacted Concrete Cap Condition Assessment
HC	2009b	Hart Crowser, Inc. (HC)	Technical Memorandum: Portac Catch Basin Sampling and Analysis Portac Sawmill and Log Yard Site
HC	2009c	Hart Crowser, Inc. (HC)	Wapato Creek Sediment Sampling and Analysis Results
HC	2009d	Hart Crowser, Inc. (HC)	Technical Memorandum, dated September 28, 2009. To Bill Evans, Port of Tacoma from Rick Moore, HC. RE: Review of Whitman Environmental Service (WES) July 6, 2009 Report - Lumber Mill Demolition, Environmental Cleanup and Testing -Former Portac, Inc. Site.
HC	2012	Hart Crowser, Inc. (HC)	Technical Memorandum, dated October 24, 2012. To Bill Evans, Port of Tacoma from Will Abercrombie and Roger McGinnis, HC. RE: Evaluation of 2011 Summary Groundwater Monitoring Reports by Whitman Environmental Services - Former Portac Inc Site
HC	2014	Hart Crowser, Inc. (HC)	Cap Inspection Report - Former Portac Facility - Port of Tacoma, Tacoma, Washington

Table 9. References

Author Abbreviation	Year	Author	Document Title
Landau	2007	Landau Associates Inc.	Geotechnical Report Blair Navigational Aid Realignment - Tacoma, WA. Prepared for the Port of Tacoma.
Landau	2014	Landau Associates Inc.	North Lead Rail Improvements - Portac Cap Subsurface Investigation - Port of Tacoma, Washington
Langmuir, et.al.,	2005	Langmuir, D., P. Chrostowski, B. Vigneault, and R. Chaney.	Issue paper on the environmental chemistry of metals. Available at: http://www.epa.gov/raf/publications/pdfs/ ENVCHEMFINAL81904CORR01-25-05.PDF.
Lovley, D.R. and S. Goodwin	1988	Lovley, D.R. and S. Goodwin	Hydrogen concentrations as an indicator of the predominant terminal electron-accepting reactions in aquatic sediments. Geochim. Cosmochim. Acta 52: 2993–3003.
Olympic	2009	Olympic Associates Company	Letter from Olympic to Ecology, dated August 26, 2009. RE: Post-Construction Report - Portac Tacoma Mill Closure/Repairs to Environmental Cap - 4215 SR 509 N. Frontage Road, Tacoma, WA
Port	1989	Port of Tacoma	Port of Tacoma Chief Engineer's Recommendation to the Port Commission for Final Acceptance of Contract No. 646 with M. A. Segale, Portac Yard Improvements, Work Order No. E1068. Prepared by R.L. MacLeod, Chief Engineer. July 19, 1989.
Port	2009	Port of Tacoma	Letter from the Port of Tacoma to Ecology, dated September 21, 2009, RE: Former Portac Site - Log Yard Environmental Cap.
Port	2015	Port of Tacoma	Port of Tacoma - Summary of past cap inspections and cap maintenance @ Portac Site. Prepared by the Port of Tacoma. Draft received October 5, 2015
Portac	2009	Portac	Letter from Portac to Ecology, dated July 1, 2009, RE: Portac Tacoma Mill Closure/Repairs to Cap. Letter transmits AMEC's Report on recommended cap repairs.
Portac	2009	Portac, Inc.	Notice of Termination - Baseline General Permit to Discharge Stormwater for Industrial Activity. Permit No. 0326. Form dated February 28, 2008. Submitted to Ecology by Portac, Inc.
Portac	2015	Portac, Inc.	Portac Industrial Stormwater General Permit - Discharge Monitoring Reports for 2003 - 2009 and reports documenting Portac activities in response to stormwater detections above benchmark values. Forms present stormwater sampling results at discharge point for "SW outflow log yard".
Puyallup River Watershed Council	2014	Puyallup River Watershed Council	Puyallup River Watershed Assessment (Draft). Prepared by Puyallup River Watershed Council. Watershed Assessment Committee. February 2014.
Root, et.al.,	2009	Root, R.A., D. Vlassopoulos, N.A. Rivera, M.T. Rafferty, C. Andrews, and P.A. O'Day.	Speciation and Natural Attenuation of Arsenic and Iron in a Tidally Influenced Shallow Aquifer. Geochim. Cosmochim. Acta 73: 5528-5553.

Table 9. References

Author Abbreviation	Year	Author	Document Title
RZA	1988a	Rittenhourse, Zeman & Associates (RZA)	Memorandum to C.C. Pittman. Regarding Results of Soil Sampling and Analytical Results Following Partial Soil Removal in the Central Ditch Area of the Portac Site. Prepared by Rittenhouse-Zeman & Associates Inc. (RZA) for Portac, Inc.. August 23, 1988.
RZA	1988b	Rittenhourse, Zeman & Associates (RZA)	Letter from Daniel Whitman, RZA to C. Pittman, Portac, Inc., dated September 8, 1988. Subject: Wapato Creek Sediment Sampling and Analytical Results.
RZA	1988c	Rittenhourse, Zeman & Associates (RSA)	Memorandum to C.C. Pittman. Regarding Results of Soil Sampling and Analytical Results following Soil Removal in the Central Ditch Area of the Portac Site. Prepared by Rittenhouse-Zeman & Associates Inc. for Portac, Inc.. September 23, 1988.
RZA	1988d	Rittenhourse, Zeman & Associates (RSA)	Remedial Action Observations, Sampling and Analyses. Portac Site. Port of Tacoma, Washington. Prepared by Rittenhouse-Zeman & Associates Inc. for Portac, Inc.. August 1988.
USGS	1987	US Geological Survey (USGS)	Water Quality in the Lower Puyallup River Valley and Adjacent Uplands, Pierce County, Washington. Prepared in Cooperation with the Puyallup Tribe of Indians.
Welch, et.al.,	2000	Welch, A.H., D.B. Westjohn, D.R. Helsel, and R.B. Wanty	Arsenic in the groundwater of the United States: Occurrence and geochemistry. Ground Water 38: 589-604.
WES	2009a	Whitman Environmental Services (WES)	Letter to Washington Department of Ecology. Subject: Additional Wapato Creek Sediment Sample Analyses. Portac, Inc. 4215 N. Frontage Road. Tacoma, WA.
WES	2009b	Whitman Environmental Services (WES)	Log yard Ramp Demolition - Portac, Inc. - 4215 N. Frontage Road, Tacoma, WA. (Draft)
WES	2009c	Whitman Environmental Services (WES)	Letter from WES to Ecology, dated November 17, 2009. RE: Additional Site Information, Portac, Inc. Tacoma, WA. Including documentation of storm drain sampling and cleaning; terrestrial ecological evaluation; Wapato Creek sediment analysis.
WES	2009d	Whitman Environmental Services (WES)	Letter from WES to Ecology, dated February 23, 2009. RE: Voluntary Cleanup Program Application, Lumber Mill Demolition, Environmental Cleanup and Testing Report, Portac, Inc. Tacoma, WA
WES	2009e	Whitman Environmental Services (WES)	Lumber Mill Demolition - Environmental Cleanup and Testing Report - Former Portac Inc. Site - Tacoma, WA. Prepared by WES for Portac, Inc. July 6, 2009.
WES	2010a	Whitman Environmental Services (WES)	Letter from WES to Ecology, dated May 7, 2010, First Quarter 2010 Groundwater Monitoring - Former Portac Inc. Site - Tacoma, WA
WES	2010b	Whitman Environmental Services (WES)	Letter from WES to Ecology, dated August 25, 2010, Second Quarter 2010 Groundwater Monitoring - Former Portac Inc. Site - Tacoma, WA

Table 9. References

Author Abbreviation	Year	Author	Document Title
WES	2010a	Whitman Environmental Services (WES)	Letter from WES to Ecology, dated January 21, 2010, Fourth Quarter 2009 Groundwater Monitoring - Former Portac Inc. Site - Tacoma, WA
WES	2010b	Whitman Environmental Services (WES)	Email from Daniel Whitman/WES to Thomas Middleton, Dom Reale/Ecology and others, dated January 29, 2010, Portac December 2009 Groundwater Monitoring Report. Transmittal.
WES	2010c	Whitman Environmental Services (WES)	Letter from WES to Ecology, dated November 29, 2010, Third Quarter 2010 Groundwater Monitoring - Former Portac Inc. Site - Tacoma, WA
WES	2011	Whitman Environmental Services (WES)	Letter from WES to Thomas Middleton/Ecology, dated September 28, 2011, Addendum to Summary of Groundwater Monitoring Report - Former Portac Inc. Site - Tacoma, WA. Presents recalculated Method B soil and groundwater cleanup levels for PCP.
WES	2012a	Whitman Environmental Services	Letter to Washington Department of Ecology, dated April 4,2012. Subject: Compliance Monitoring Plan for the Former Portac, Inc. Site -4215 N. Frontage Road. Tacoma, WA.
WES	2012b	Whitman Environmental Services (WES)	Letter from WES to Portac, dated September 5, 2012, Feasibility of Additional Cleanup and Disproportionate Cost Analyses - Former Portac Inc. Site - Tacoma, WA
WES	2013	Whitman Environmental Services (WES)	Letter from WES to Portac, dated March 25, 2013, First Quarter 2013 Groundwater Monitoring - Former Portac Inc. Site - Tacoma, WA
WDOT	2006	Washington Department of Transportation (WDOT)	SR 167, Puyallup to SR 509 -- Tier II Final Environmental Impact Statement

Figures

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FIGURE 1

Vicinity Map

Remedial Investigation Work Plan
Parcel 15 Investigation
Tacoma, WA

LEGEND

🟥 Site Boundary
〜 Watercourse
▨ Waterbody

N

0 900 1,800 2,700
Feet

MAP NOTES:
Date: March 14, 2016
Data Sources: PORTAC, Aerial photo taken in July of 2013 by the USDA

GSI Water Solutions, Inc.

FIGURE 2

1940 Aerial Photo Showing Former Location of Wapato Creek

Remedial Investigation Work Plan
Parcel 15 Investigation
Tacoma, WA

LEGEND

☐ Site Boundary[1]

Former Wapato Creek Channel[2]

NOTES:
Location of all site features is approximate.

SOURCE INFORMATION:
1. Site Boundary defined in Exhibit A of the Agreed Order No. DE 11237 (Ecology, 2016).
2. Former Wapato Creek Channel alignment based on figure provided in the Review Comments on the 2011 Groundwater Monitoring Reports (HC, 2012) and historical aerial photographs from 1931, 1936, and 1940.

Historical 1940 Aerial Photograph downloaded from the City of Tacoma's GovMe website: http://www.govme.org. File downloaded on October 2, 2015.

N

0 110 220 330
Feet

MAP NOTES:
Date: March 24, 2016
Data Sources: Aerial photo taken on July 18, 1940 by the US Army Corps of Engineers

GSI Water Solutions, Inc.

Document Path: P:\Portland\603-Port of Tacoma\GIS\Project_mxds\RIWP\Figure2_Site_Photo_from_1940.mxd

FIGURE 3

Historic Site Features and Reported Source Areas

Remedial Investigation Work Plan
Parcel 15 Investigation
Tacoma, WA

LEGEND

- ▭ Site Boundary[1]
- ⬚ Former Site Structure[2]

Contaminants of Potential Concern[3]

- ▨ Metals (Slag)
- ▨ Pentachlorophenol
- ▨ Petroleum

Former Drainage

- ■ Catch Basin[4]
- → Surface Drainage[4]
- → Subsurface Drainage[4]
- ⬚ Former Wapato Creek Channel[5]

All Other Features

- — Railroad

NOTES:

Location of all site features is approximate.

SOURCE INFORMATION:

1. Site Boundary defined in Exhibit A of the Agreed Order No. DE 11237 (Ecology, 2016).
2. Footprints of former site structures are based on the Site Plan (Figure 2) from the Catch Basin Sampling and Analysis Memo (HC, 2009).
3. Source area boundaries in the sawmill area are based on the "approximate soil clean-up area boundaries" shown on Figure 12 of the Lumber Mill Cleanup Report (WES, 2009). PCP source area in the central drainage ditch reflects the lower 200 feet of the ditch which is noted to be the extent of impact in Section 7.3 of the Portac Log Yard Remediation Plan (HC, 1988). The approximate extent of the slag fill matches the lower boundary of the phased Portac Log Sort Yard Paving Project which is shown in Sheet 2 of the associated drawing set (HC, 1988).
4. Former catch basin and surface and subsurface drainage features based on Figure 2 of the Portac Log Sort Yard Remediation Plan (HC, 1988).
5. Former Wapato Creek Channel alignment based on figure provided in the Review Comments on the 2011 Groundwater Monitoring Reports (HC, 2012) and 1931, 1936, 1940 historical aerial photographs.

N

0 110 220 330
Feet

MAP NOTES:
Date: March 14, 2016
Data Sources: Aerial photo taken in 1985

GSI Water Solutions, Inc.

Document Path: P:\Portland\603-Port of Tacoma\GIS\Project_mxds\RIWP\Figure3_Historical_Site_Map.mxd

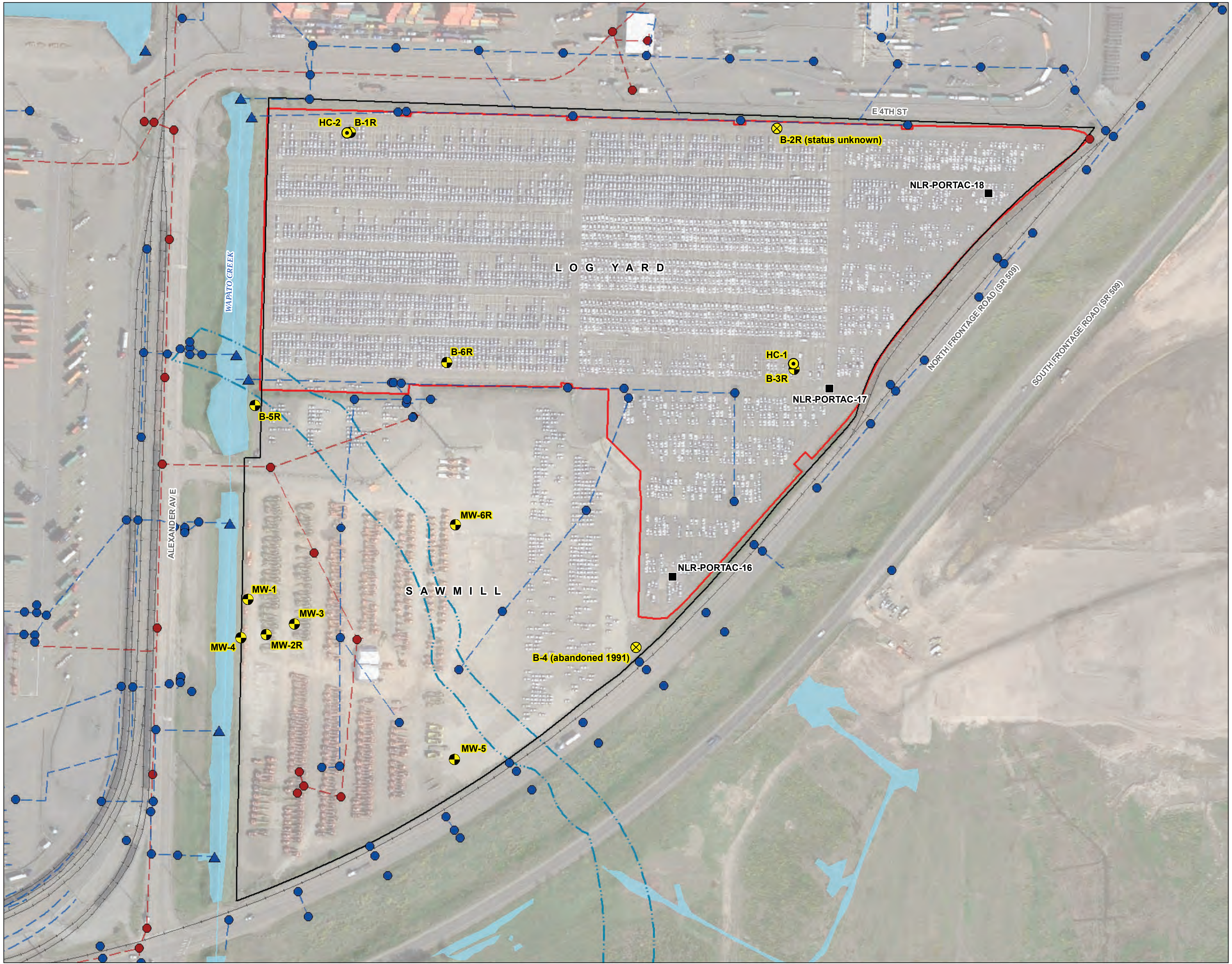

FIGURE 4

Site Map

Remedial Investigation Work Plan
Parcel 15 Investigation
Tacoma, WA

LEGEND

Monitoring Wells and Piezometers[2]

- Monitoring Well
- Perched Monitoring Well
- Abandoned or Status Unknown Monitoring Well
- ■ Piezometer

Storm Features[3]

- ▲ Outfall
- ● Vault
- Storm Line

Sanitary Features[3]

- ● Sanitary Point
- Sanitary Line

All Other Features

- ☐ Site Boundary[4]
- ☐ Cap[5]
- Railroad
- Former Wapato Creek Channel[6]
- Watercourse
- Waterbody

SOURCE INFORMATION:

1. Locations of all site features are approximate.
2. Piezometer and monitoring well locations were derived from GPS data collected by GSI on November 10, 2015.
3. Storm, sanitary, and electrical features provided by Port of Tacoma, 2016.
4. Site Boundary defined in Exhibit A of the Agreed Order No. DE 11237 (Ecology, 2016).
5. Cap extent defined on Figure 2 of the Former Portac Inc. Site (AQEA, 2014).
6. Former Wapato Creek Channel alignment based on figure provided in the Review Comments on the 2011 Groundwater Monitoring Reports (HC, 2012) and 1931, 1936, 1940 historical aerial photographs.

N

0 100 200 300
Feet

MAP NOTES:
Date: March 24, 2016
Data Sources: PORTAC, Aerial photo
taken on April 19, 2015 by the Google Earth

GSI Water Solutions, Inc.

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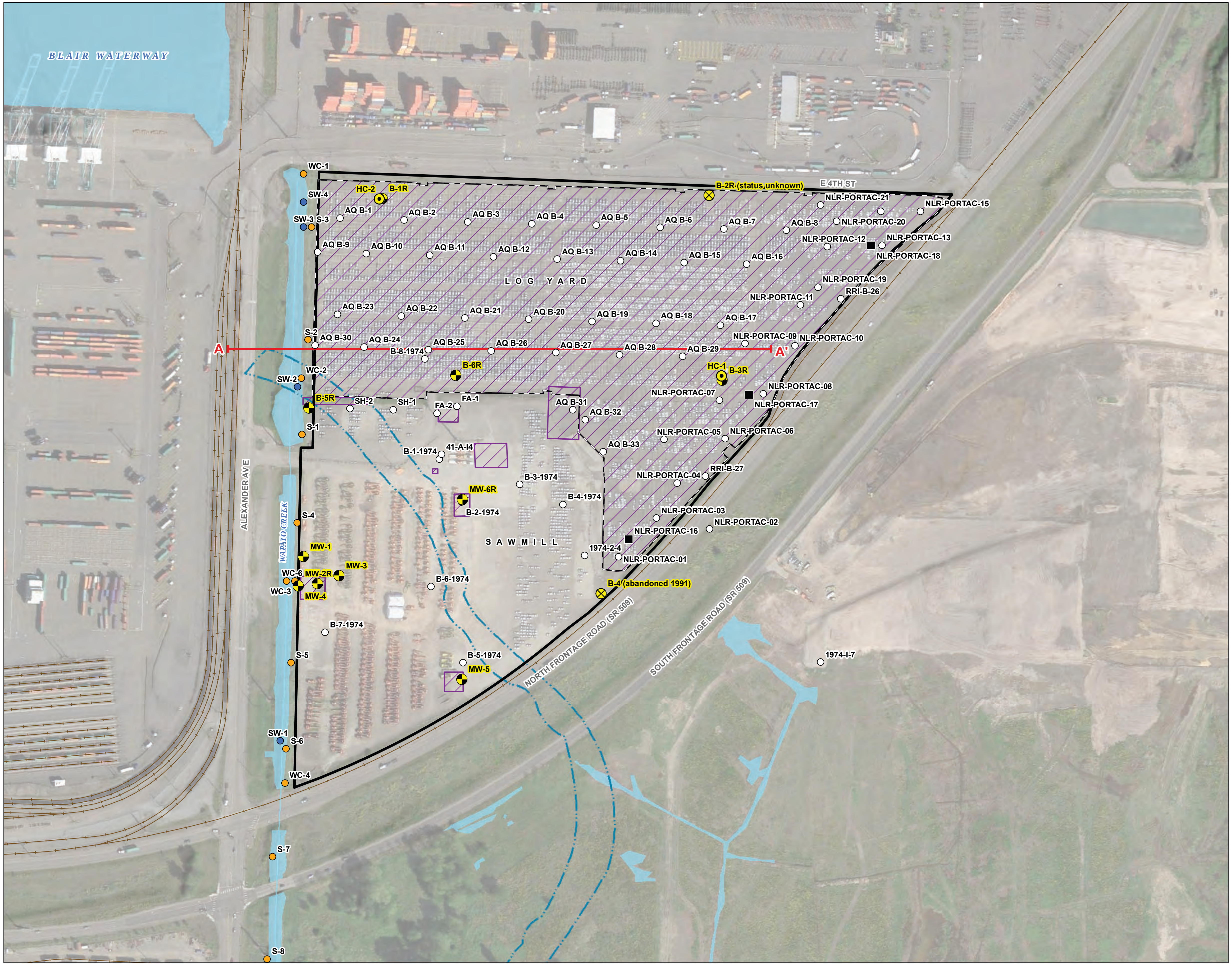


Document Path: P:\Portland\603-Port of Tacoma\GIS\Project_mxds\RIWP\Figure5_Parcel15_Previous_Samples.mxd

FIGURE 5

Parcel 15 Previous Sampling Locations

Remedial Investigation Work Plan
Parcel 15 Investigation
Tacoma, WA

LEGEND

- ● Monitoring Well[1]
- ⊙ Perched Monitoring Well[1]
- ⊗ Abandoned or Status Unknown Monitoring Well[1]
- ■ Piezometer[1]
- ○ Soil Boring[1]
- ● Sediment Sample[1]
- ● Surface Water Sample[1]
- ├─┤ Cross Section Line
- ☐ Site Boundary[2]
- ☐ Cap[3]
- ▨ Approximate Soil Clean-Up Area[4]
- ┼ Railroad
- ⌇ Former Wapato Creek Channel[5]
- ～ Watercourse
- ▰ Waterbody

NOTES:

Location of all site features is approximate.
Additional test pit and grab soil sampling locations are provided in the attachments to the Data Gaps Memorandum.

SOURCE INFORMATION:

1. Piezometer and monitoring well locations were derived from GPS data collected by GSI on November 10, 2015.
2. Site Boundary defined in Exhibit A of the Agreed Order No. DE 11237 (Ecology, 2016).
3. Cap extent defined on Figure 2 of the Former Portac Inc. Site (AQEA, 2014).
4. Approximate soil cleanup areas are based on Figure 12 of the Lumber Mill Cleanup Report (WES, 2009).
5. Former Wapato Creek Channel alignment based on figure provided in the Review Comments on the 2011 Groundwater Monitoring Reports (HC, 2012) and historical aerial photographs from 1931, 1936 and 1940.

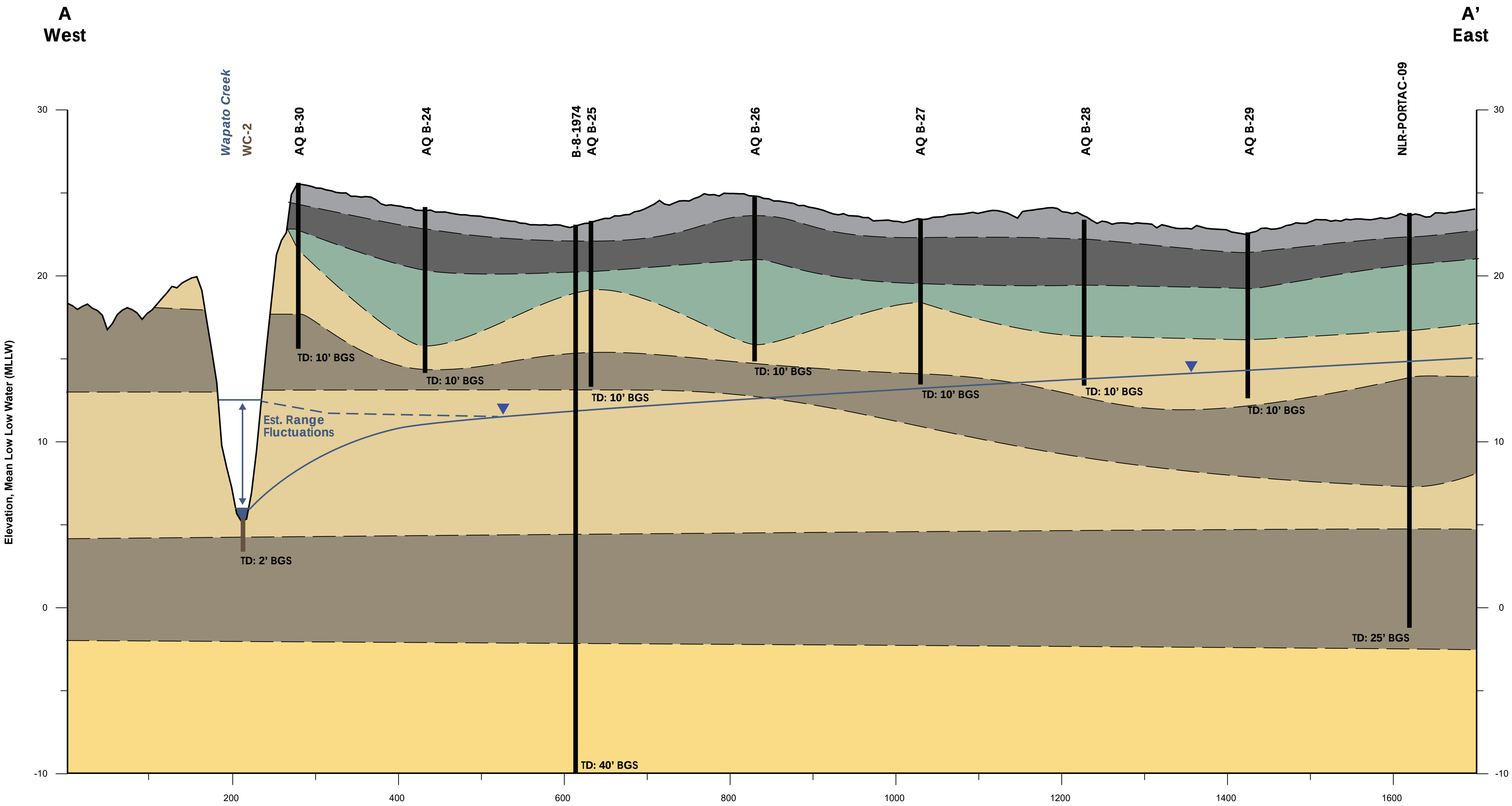
N

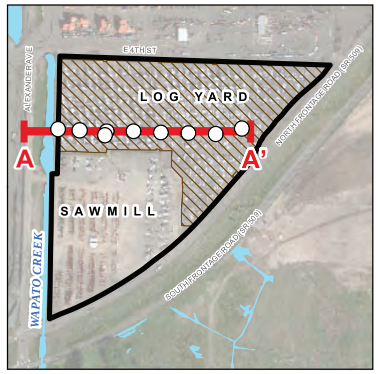
0 150 300 450
Feet

MAP NOTES:

Date: March 24, 2016
Data Sources: PORTAC, Aerial photo taken on April 19, 2015 by the Google Earth

GSI Water Solutions, Inc.





LEGEND

▮ Soil Boring

▮ Sediment Core

— Estimated Water Level (April 1988; HC, 1988b)

Geology

■	Roller Compacted Concrete	■	Silty Sand
■	Gravel Base Coarse	■	Silt
■	Fill Containing Slag	■	Sand

NOTE

Vertical Exaggeration = 20X

FIGURE 6

Geologic Cross Section A-A' through Former Logyard

Remedial Investigation Work Plan
Parcel 15 Investigation
Tacoma, WA

GSI Water Solutions, Inc.

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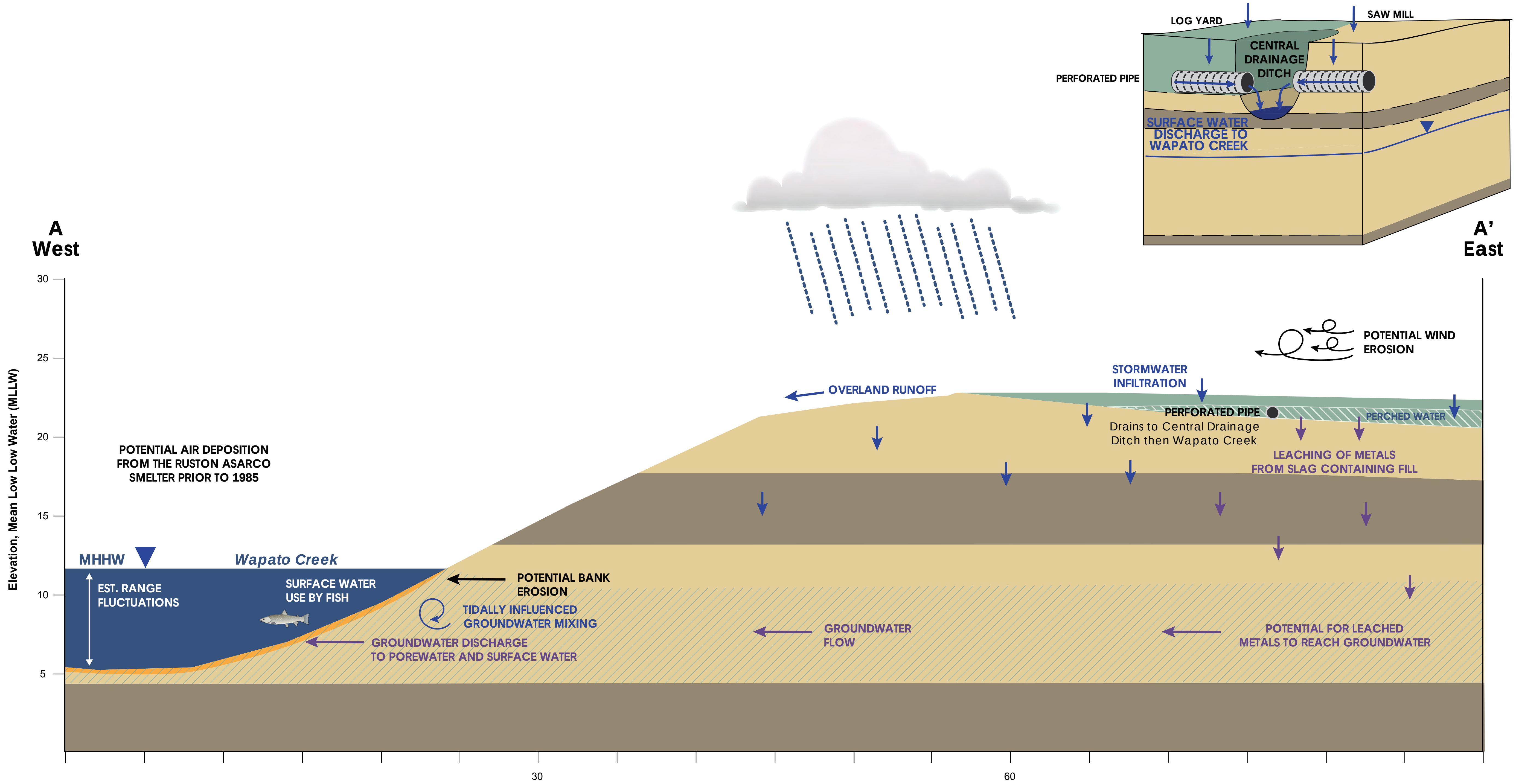
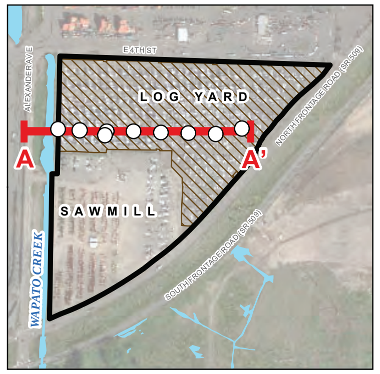




LEGEND

▨ Approximate Groundwater Fluctuations

▨ Approximate Extent of Perched Water

Geology

🟩 Fill Containing Slag

🟩 Slag

🟨 Silty Sand

🟫 Silt

NOTE

Vertical Exaggeration = 1X

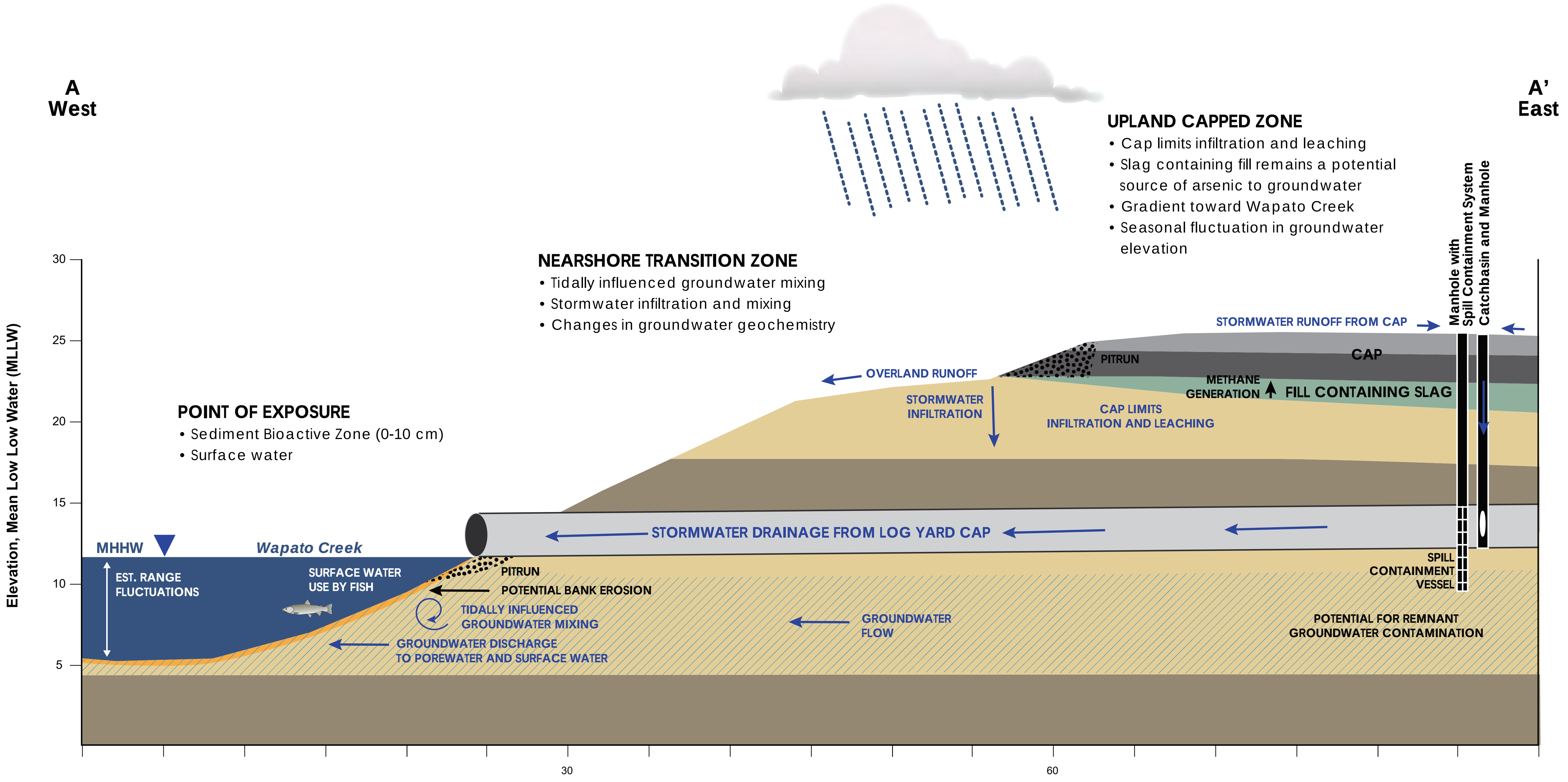
P:\Portland\603-Port of Tacoma\Figures\RIWP

FIGURE 7

Conceptual Site Model, Historical (Pre-Cap) Conditions

Remedial Investigation Work Plan
Parcel 15 Investigation
Tacoma, WA

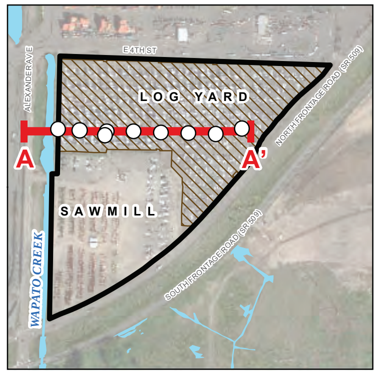
GSI Water Solutions, Inc.



POINT OF EXPOSURE
- Sediment Bioactive Zone (0-10 cm)
- Surface water

NEARSHORE TRANSITION ZONE
- Tidally influenced groundwater mixing
- Stormwater infiltration and mixing
- Changes in groundwater geochemistry

UPLAND CAPPED ZONE
- Cap limits infiltration and leaching
- Slag containing fill remains a potential source of arsenic to groundwater
- Gradient toward Wapato Creek
- Seasonal fluctuation in groundwater elevation



LEGEND

▯ Stormwater Pipe
■ Catch Basin/Manhole
▦ Spill Containment System
▨ Approximate Range in Groundwater Levels

Geology

■	Roller Compacted Concrete
■	Gravel Base, Coarse
■	Fill Containing Slag
■	Silty Sand
■	Silt

NOTE
Vertical Exaggeration = 1X

FIGURE 8

Conceptual Site Model, Current (Post-Cap) Conditions

Remedial Investigation Work Plan
Parcel 15 Investigation
Tacoma, WA

GSI Water Solutions, Inc.

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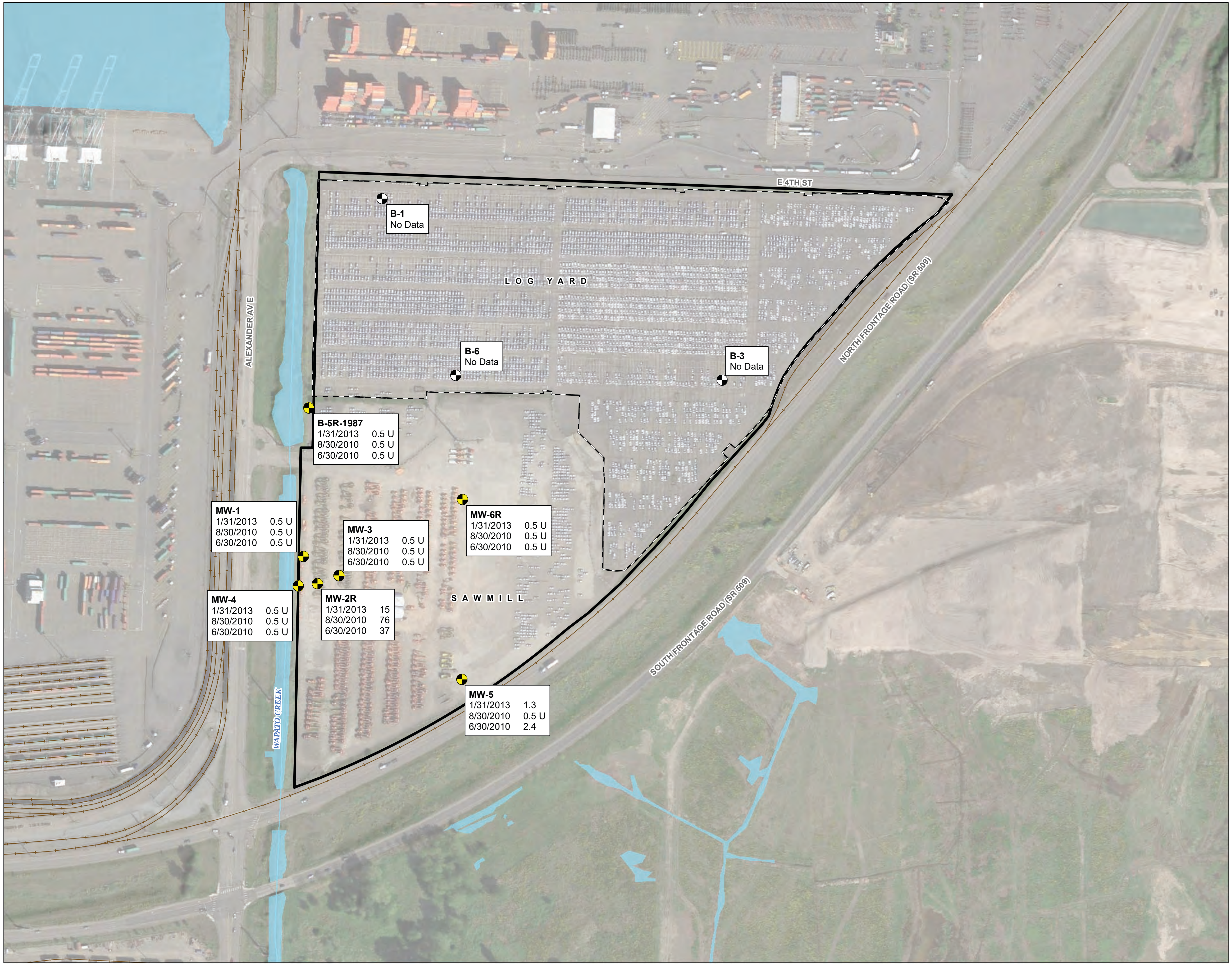

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FIGURE 9

Groundwater Concentrations - Pentachlorophenol

Remedial Investigation Work Plan
Parcel 15 Investigation
Tacoma, WA

LEGEND

- ◐ Monitoring Well[1]
- ☁ No Data[2]
- 🟨 Results from Most Recent Sampling Event[3]

All Other Features

- ☐ Site Boundary
- ⬚ Cap[6]
- ┼ Railroad
- ～ Watercourse
- 🟦 Waterbody

NOTES:

Location of all site features is approximate.
All results in ug/L.

SOURCE INFORMATION:

1. Piezometer and monitoring well locations were derived from GPS data collected by GSI on November 10, 2015.
2. Wells not sampled for pentachlorophenol.
3. Results are concentrations from the three most recent sampling events, as presented in WES, 2013.
6. Cap extent defined on Figure 2 of the Former Portac Inc. Site (AQEA, 2014).

N

0 150 300 450
Feet

MAP NOTES:
Date: March 14, 2016
Data Sources: PORTAC, Aerial photo taken on April 19, 2015 by the Google Earth

GSI Water Solutions, Inc.

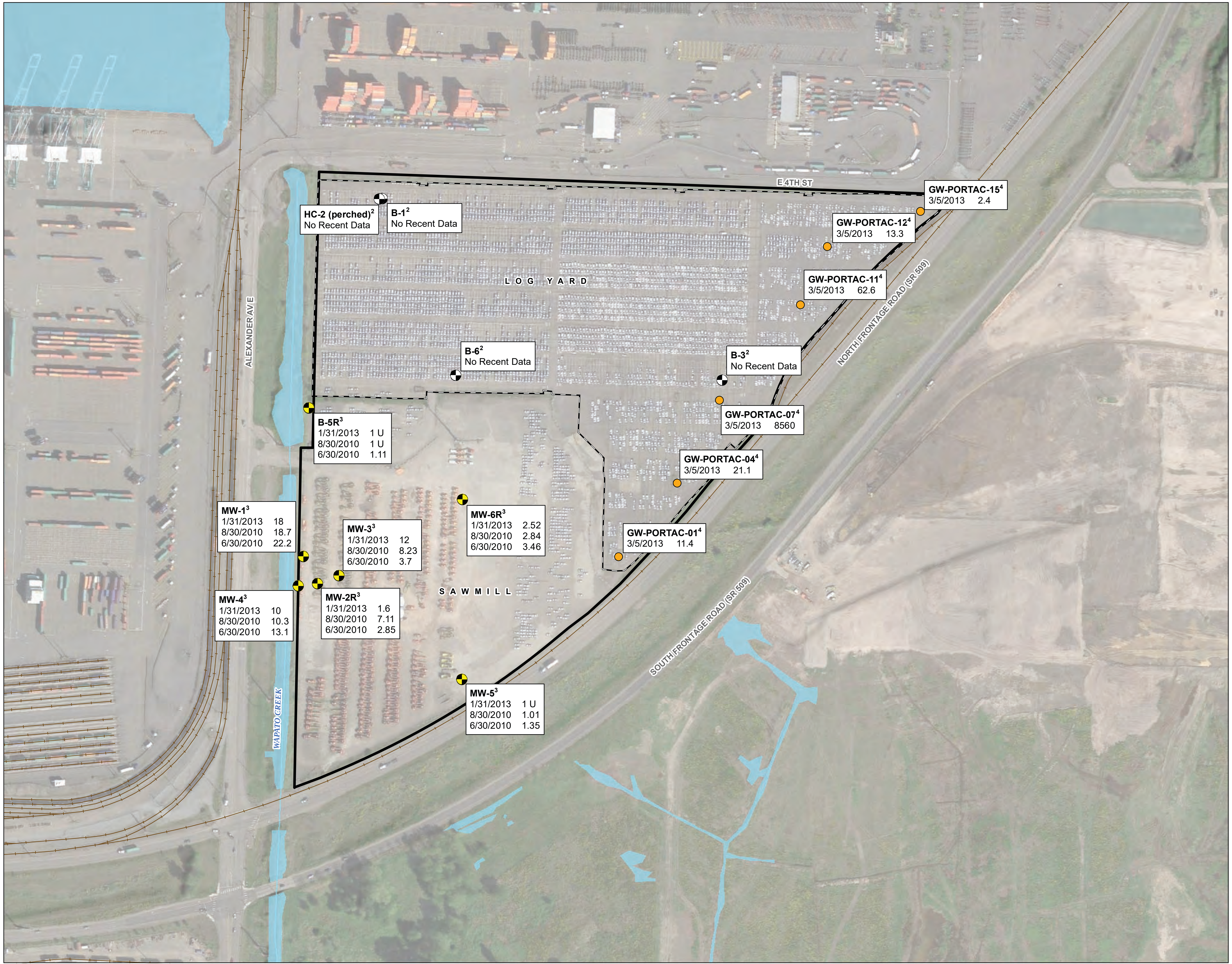


FIGURE 10

Groundwater Concentrations - Arsenic

Remedial Investigation Work Plan
Parcel 15 Investigation
Tacoma, WA

LEGEND

- Monitoring Well[1]
- Soil Boring[1]
- No Recent Data[2]
- Total Arsenic Concentration[3]
- Dissolved Arsenic Concentration[4]

All Other Features

- Site Boundary
- Cap[5]
- Railroad
- Watercourse
- Waterbody

NOTES:

Location of all site features is approximate.
All results in ug/L.

SOURCE INFORMATION:

1. Piezometer and monitoring well locations were derived from GPS data collected by GSI on November 10, 2015.
2. The most recent data from these locations was collected prior to 2000, and current conditions are considered a data gap.
3. Results are total arsenic concentrations from the three most recent sampling events, as presented in WES, 2013.
4. Results are dissolved arsenic concentrations in groundwater collected as grab samples during the Portac Cap Subsurface Investigation (Landau 2014).
5. Cap extent defined on Figure 2 of the Former Portac Inc. Site (AQEA, 2014).

N

0 150 300 450
Feet

MAP NOTES:
Date: March 14, 2016
Data Sources: PORTAC, Aerial photo taken on April 19, 2015 by the Google Earth

GSI Water Solutions, Inc.

Document Path: P:\Portland\603-Port of Tacoma\GIS\Project_mxds\RIWP\Figure10_GW_Arsenic_Concentrations.mxd

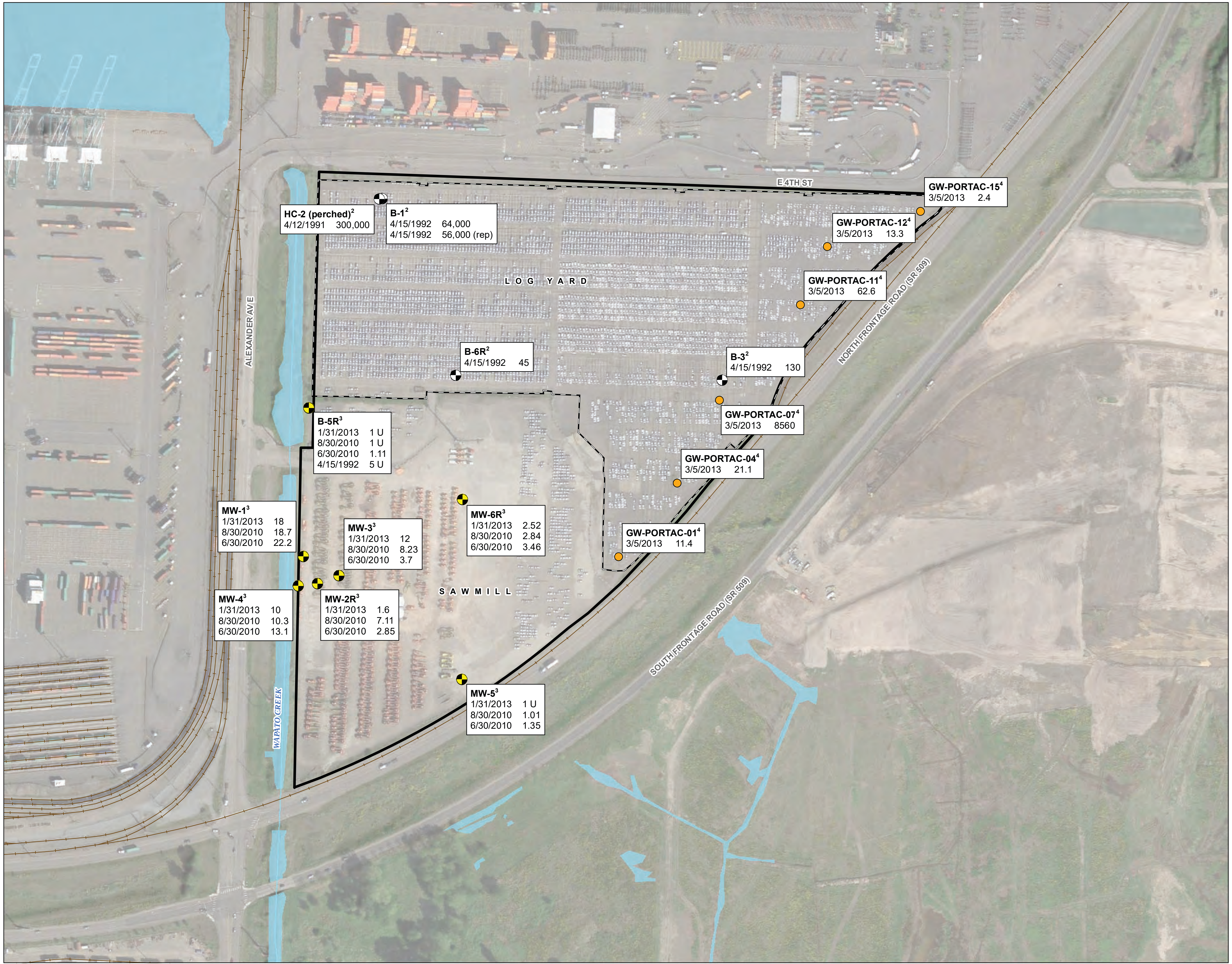


FIGURE 11

Historical and Recent
Groundwater Concentrations - Arsenic

Remedial Investigation Work Plan
Parcel 15 Investigation
Tacoma, WA

LEGEND

- ◐ Monitoring Well[1]
- ○ Soil Boring[1]
- ▢ No Recent Data[2]
- 🟨 Total Arsenic Concentration[3]
- 🟧 Dissolved Arsenic Concentration[4]

All Other Features

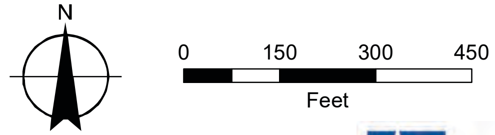
- ▢ Site Boundary
- ▢ Cap[5]
- —+— Railroad
- ～ Watercourse
- ▨ Waterbody

NOTES:

Location of all site features is approximate.
All results in ug/L.

SOURCE INFORMATION:

1. Piezometer and monitoring well locations were derived from GPS data collected by GSI on November 10, 2015.
2. The most recent data from these locations was collected prior to 2000, and current conditions are considered a data gap.
3. Results are total arsenic concentrations from the three most recent sampling events, as presented in WES, 2013.
4. Results are dissolved arsenic concentrations in groundwater collected as grab samples during the Portac Cap Subsurface Investigation (Landau 2014).
5. Cap extent defined on Figure 2 of the Former Portac Inc. Site (AQEA, 2014).



MAP NOTES:
Date:March 14, 2016
Data Sources: PORTAC, Aerial photo taken on April 19, 2015 by the Google Earth

GSI Water Solutions, Inc.

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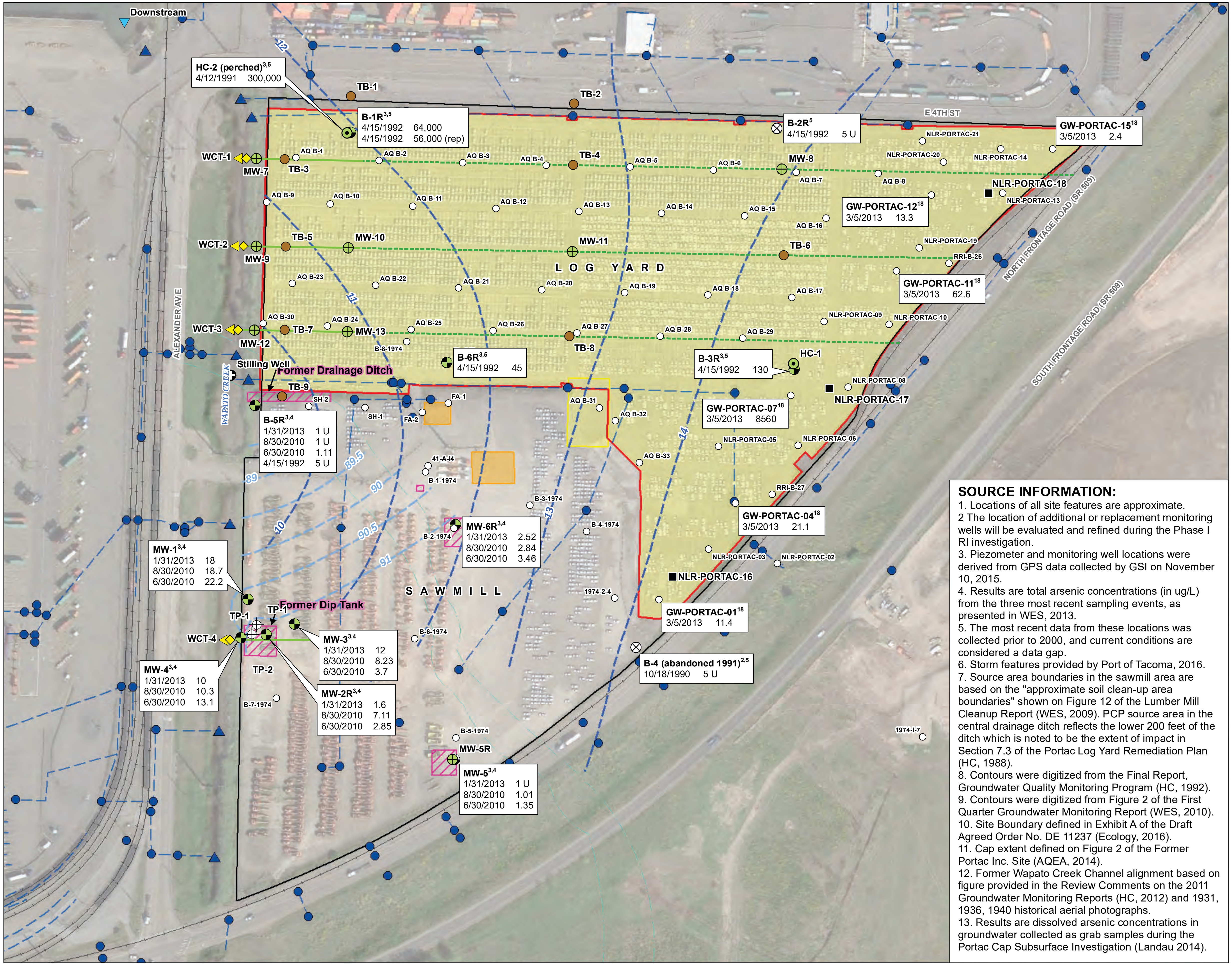

FIGURE 12

Proposed RI Sampling Locations with Existing Features

Remedial Investigation Work Plan
Parcel 15 Investigation
Tacoma, WA

LEGEND

- ⊕ New Monitoring Well
- ◐ Existing Monitoring Well[2]
- ⊙ Existing Perched Monitoring Well
- ✚ Stilling Well
- ● Temporary Soil and Groundwater Boring
- ⌖ Test Pit
- ▼ Surface Water
- ◀ Wapato Creek Porewater, Surface Water, and Sediment
- ◆ Wapato Creek Porewater and Sediment
- - - Sampling Transect
- — Nearshore Sampling Transect

Existing Sample Locations

- ■ Piezometer[3]
- ◑ Monitoring Well[3,4,5]
- ⊗ Abandoned Monitoring Well or Status Unknown
- ○ Soil Boring

Storm Features[6]

- ▲ Outfall
- ● Vault
- – – Storm Line

Historical Source Areas[7]

- 🟨 Metals (Slag)
- ▨ Pentachlorophenol
- 🟧 Petroleum

Historic Groundwater (GW) Elevation

- Inferred GW Elevation Contour - 1992[8]
- Inferred GW Elevation Contour - 1Q 2010[9]

All Other Features

- ☐ Site Boundary[10]
- 🟥 Cap[11]
- ☐ Former Wapato Creek Channel[12]
- —+— Railroad

N

0 100 200 300
Feet

SOURCE INFORMATION:

1. Locations of all site features are approximate.
2. The location of additional or replacement monitoring wells will be evaluated and refined during the Phase I RI investigation.
3. Piezometer and monitoring well locations were derived from GPS data collected by GSI on November 10, 2015.
4. Results are total arsenic concentrations (in ug/L) from the three most recent sampling events, as presented in WES, 2013.
5. The most recent data from these locations was collected prior to 2000, and current conditions are considered a data gap.
6. Storm features provided by Port of Tacoma, 2016.
7. Source area boundaries in the sawmill area are based on the "approximate soil clean-up area boundaries" shown on Figure 12 of the Lumber Mill Cleanup Report (WES, 2009). PCP source area in the central drainage ditch reflects the lower 200 feet of the ditch which is noted to be the extent of impact in Section 7.3 of the Portac Log Yard Remediation Plan (HC, 1988).
8. Contours were digitized from the Final Report, Groundwater Quality Monitoring Program (HC, 1992).
9. Contours were digitized from Figure 2 of the First Quarter Groundwater Monitoring Report (WES, 2010).
10. Site Boundary defined in Exhibit A of the Draft Agreed Order No. DE 11237 (Ecology, 2016).
11. Cap extent defined on Figure 2 of the Former Portac Inc. Site (AQEA, 2014).
12. Former Wapato Creek Channel alignment based on figure provided in the Review Comments on the 2011 Groundwater Monitoring Reports (HC, 2012) and 1931, 1936, 1940 historical aerial photographs.
13. Results are dissolved arsenic concentrations in groundwater collected as grab samples during the Portac Cap Subsurface Investigation (Landau 2014).

MAP NOTES:
Date: March 25, 2016
Data Sources: PORTAC, Aerial photo taken on April 19, 2015 by the Google Earth

GSI Water Solutions, Inc.

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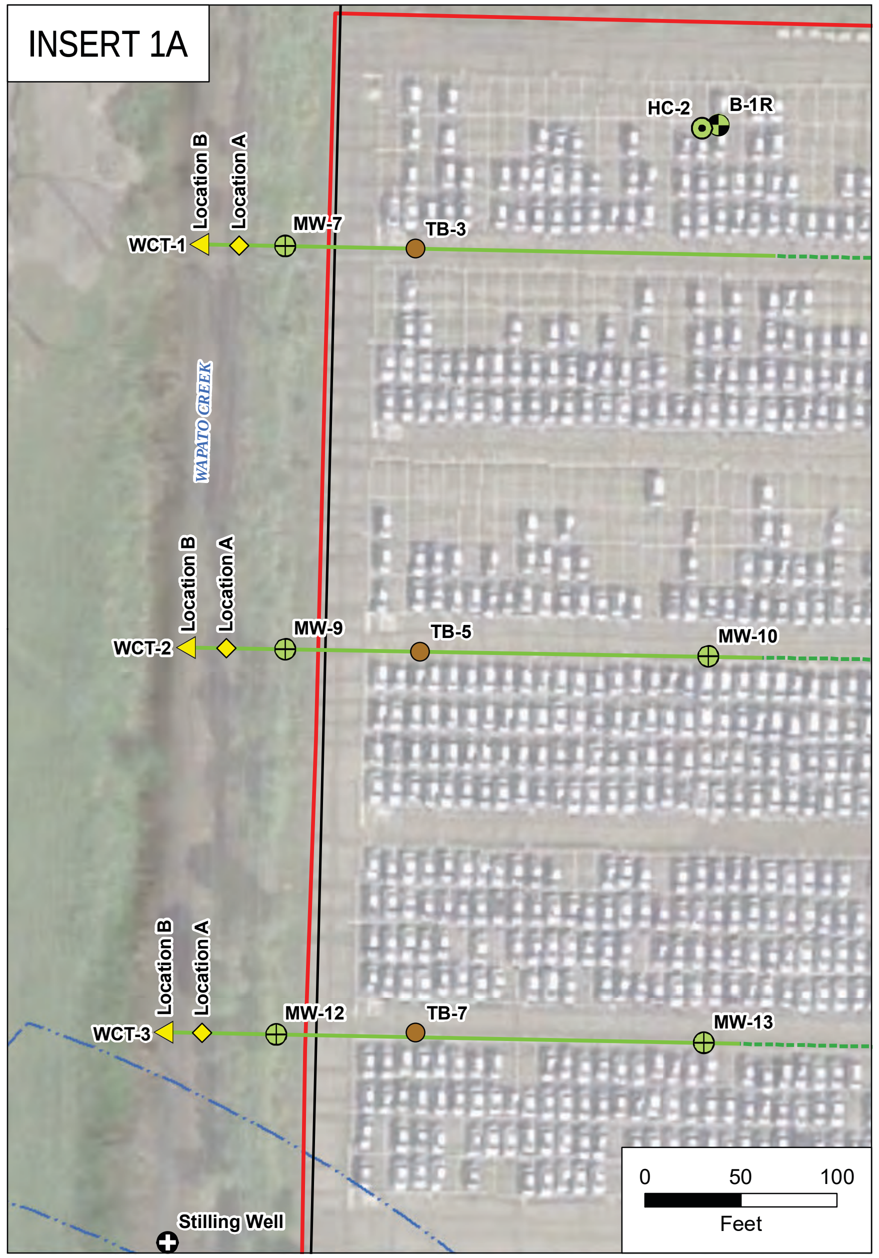

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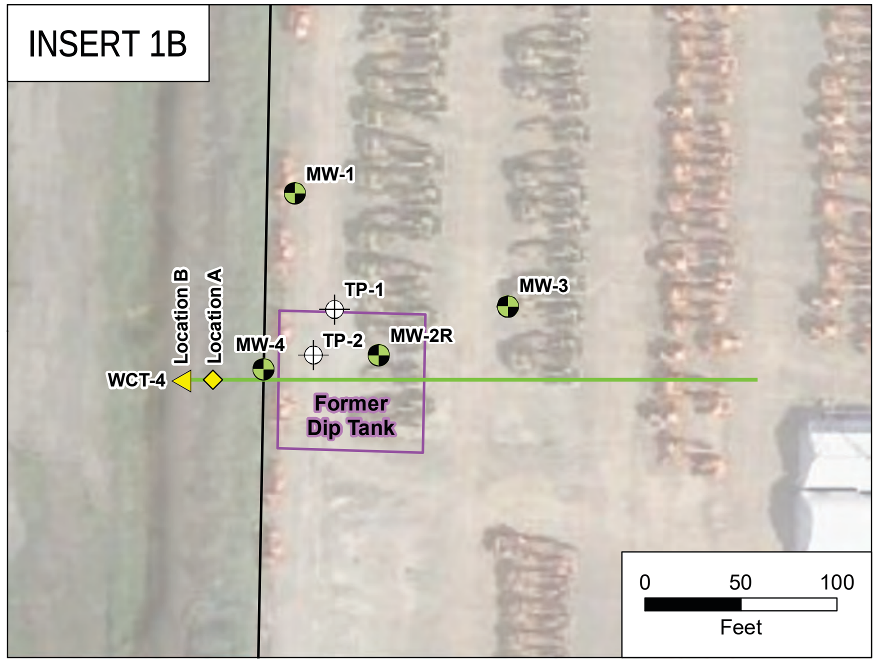


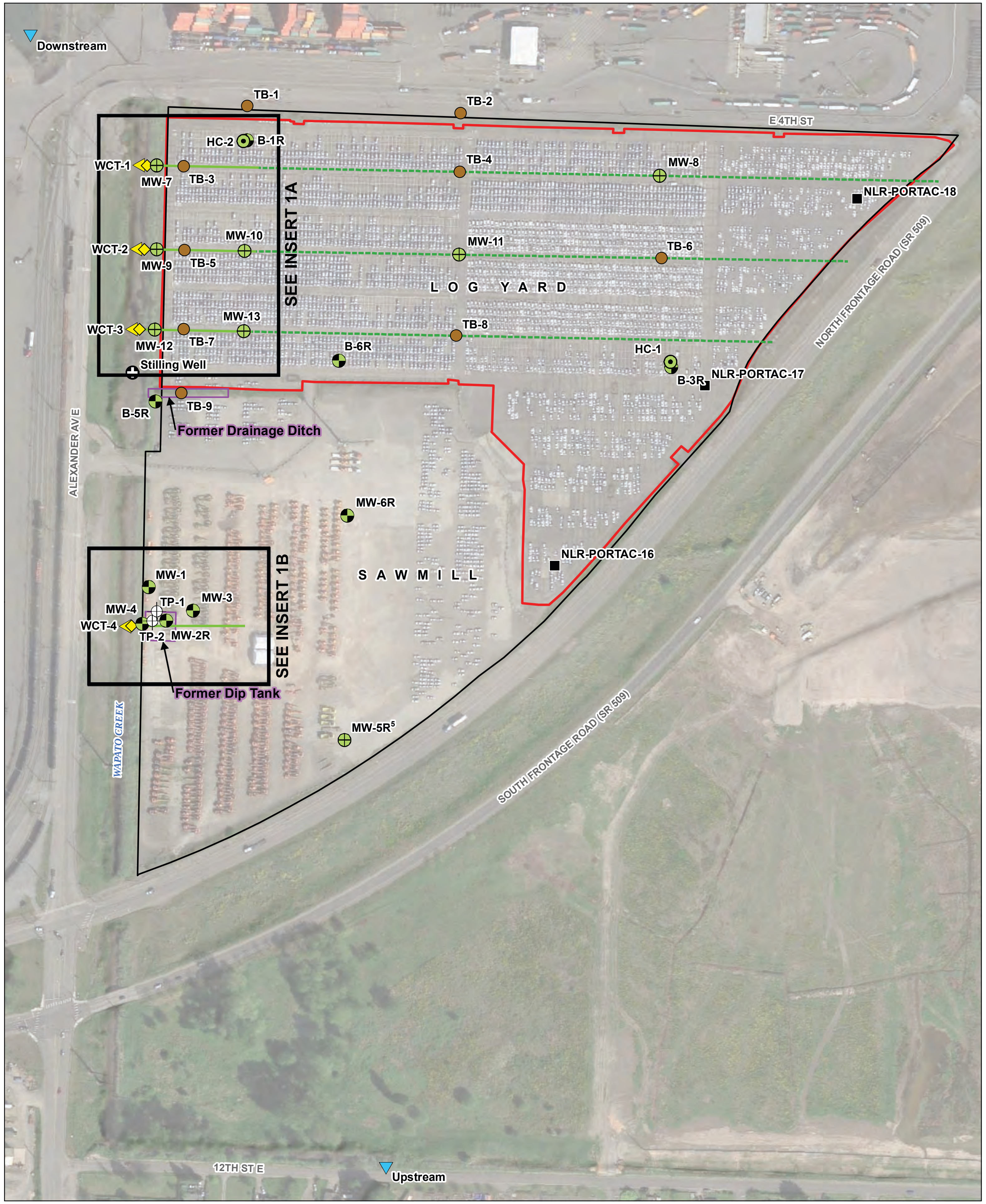


FIGURE 13

Sampling Locations

Remedial Investigation Work Plan
Parcel 15 Investigation
Tacoma, WA

LEGEND

Sampling Locations

- ⊕ New Monitoring Well
- ◐ Existing Monitoring Well[2]
- ◉ Existing Perched Monitoring Well[2]
- ✚ Stilling Well
- ● Temporary Soil and Groundwater Boring
- ⌖ Test Pit
- ▼ Surface Water
- ◀ Wapato Creek Porewater, Surface Water, and Sediment
- ◆ Wapato Creek Porewater and Sediment
- ---- Sampling Transect
- — Nearshore Study Area Transect

All Other Features

- □ Site Boundary[4]
- 🟥 Cap[5]
- □ Former Drainage Ditch and Dip Tank Boundaries[6]

SOURCE INFORMATION:

1. Locations of all site features are approximate.
2. Monitoring well locations were derived from GPS data collected by GSI on November 10, 2015.
3. Piezometer and monitoring well locations were derived from GPS data collected by GSI on November 10, 2015.
4. Site Boundary defined in Exhibit A of the Agreed Order No. DE 11237 (Ecology, 2016).
5. Cap extent defined on Figure 2 of the Former Portac Inc. Site (AQEA, 2014).
6. Former dip tank boundary based on the "approximate soil clean-up area boundaries" shown on Figure 12 of the Lumber Mill Cleanup Report (WES, 2009). Former drainage ditch boundary reflects the lower 200 feet of the ditch which is noted to be the extent of impact in Section 7.3 of the Portac Log Yard Remediation Plan (HC, 1988).
7. MW-5R will be abandoned due to damaged casing. A replacement well MW-5R will be installed as part of the RI.

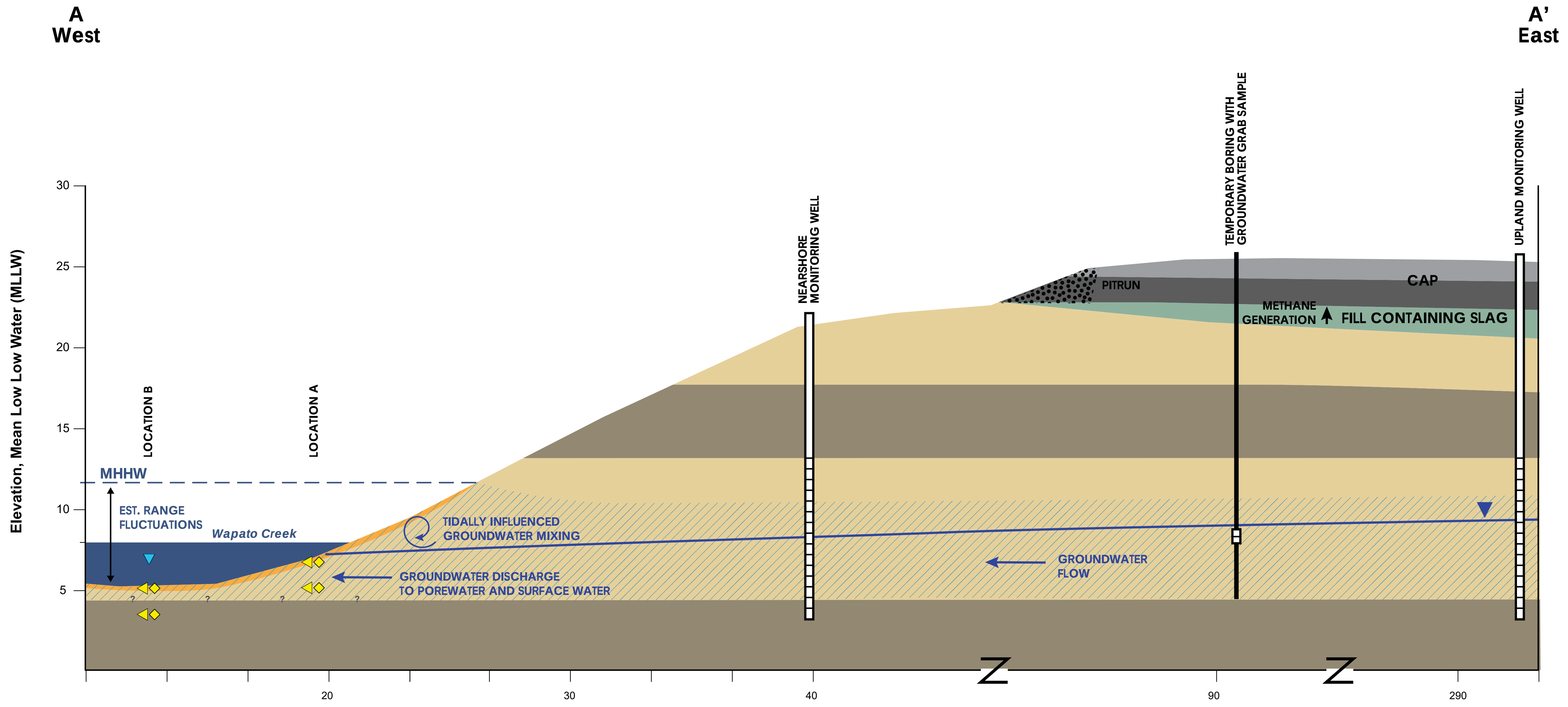
N

0 150 300 450
Feet

MAP NOTES:
Date: March 25, 2016
Data Sources: PORTAC, Aerial
photo taken on April 19, 2015 by the Google Earth

GSI Water Solutions, Inc.

Document Path: P:\Portland\603-Port of Tacoma\GIS\Project_mxds\RIWP\Figure13_Sampling_Locations.mxd



LEGEND

- ◆ Sediment Grab Sample (0-10 cm, 40-50 cm)
- ◀ Porewater Sample (0-10 cm, 40-50 cm)
- ▼ Surface Water Sample (1' above mud line)
- ▯ New Monitoring Well
- ▨ Approximate Range in Groundwater Levels
- ▼ Approximate Static Water Level (April 1988)

Geology

- ⬛ Roller Compacted Concrete
- ⬛ Gravel Base, Coarse
- ⬛ Fill Containing Slag
- ⬛ Silty Sand
- ⬛ Silt
- ⬛ Biozone

NOTE

Vertical Exaggeration = 1X

FIGURE 14

Nearshore Study Area Transect Sampling Schematic

Remedial Investigation Work Plan
Parcel 15 Investigation
Tacoma, WA

P:\Portland\603-Port of Tacoma\Figures\RIWP

Appendix A: Sampling and Analysis Plan (SAP)

Includes Field Sampling Plan (FSP) and Quality Assurance Project Plan (QAPP)

Final

Sampling and Analysis Plan

Parcel 15 (Portac) Investigation

Ecology Facility Site No. 1215 / Cleanup Site No. 3642

April 2016

Prepared for

Port of Tacoma and

Portac, Inc.

Prepared by

GSI
Water Solutions, Inc.

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Abbreviations and Acronyms

ASTM	American Society for Testing and Materials
ATD	at the time of drilling
bgs	below ground surface
bml	below mudline
CFR	*Code of Federal Regulations*
cm	centimeter
COC	chain-of-custody
DM	data manager
DQO	Decision Quality Objectives
DO	dissolved oxygen
DOT	U.S. Department of Transportation
DTW	depth to water
Ecology	Department of Ecology, Washington State
EDD	electronic data deliverable
EIM	Environmental Information Management, Washington State Department of Ecology
FD	field director
FSP	field sampling plan
GPS	global positioning system
GSI	GSI Water Solutions, Inc.
HDPE	high-density polyethylene
HSA	hollow stem auger
HSP	health and safety plan
ID	identification
IDW	investigation-derived waste
LG	licensed geologist
Log Yard	former log yard area
LCS/ LCSD	laboratory control sample/ laboratory control sample duplicate
MDL	method detection limit
MQO	Measurement Quality Objectives
MRL	method reporting limits
MS/MSD	matrix spike/matrix spike duplicate
MLLW	Mean low low water
MTCA	Model Toxics Control Act, Washington State
NSDS	nylon-screen diffusion sampler
NTU	nephelometric units
ORP	oxidation-reduction potential
PM	project manager
Port	Port of Tacoma
Portac	Portac, Inc.
PPE	personal protective equipment
PVC	polyvinyl chloride
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RCC	roller-compacted concrete
RCW	Revised Code of Washington

Abbreviations and Acronyms (continued)

RI	remedial investigation
RIWP	remedial investigation work plan
RPD	relative percent difference
SAC	sampling and analysis coordinator
SAP	sampling and analysis plan
Sawmill	former sawmill area
SC	specific conductance
SMS	Sediment Management Standards, Washington State
SOP	standard operating procedure
SRM	standard reference material
TBD	to be determined
UULC	Washington Utilities Underground Location Center
WAC	Washington Administrative Code
WCT	Wapato Creek transect

1 Introduction

This *Sampling and Analysis Plan* (SAP) was prepared by GSI Water Solutions, Inc. (GSI), on behalf of the Port of Tacoma (Port) and Portac, Inc. (Portac), to meet requirements of their Agreed Order (Order) No. DE11237 with the State of Washington Department of Ecology (Ecology). This SAP is Appendix A to the *Remedial Investigation Work Plan* (RIWP) for the Parcel 15 property (Site). The Site is located in an industrial area between Interstate 5 and Commencement Bay, in Tacoma, Washington, as shown in Figure 1 of the RIWP. Portac and its predecessors leased the Site from the Port beginning in 1974 and vacated the Site in 2009. The Site consists of two functionally distinct historical areas: the former sawmill area (Sawmill) in the southwestern part of the property, and the former log yard area (Log Yard) occupying the remainder of the Site, as shown in Figure 4 of the RIWP.

The purpose of this SAP is to ensure that field sample collection, handling, and laboratory analysis conducted during the RI will generate representative data to meet project-specific data objectives in accordance with Washington State Model Toxics Control Act (MTCA; Revised Code of Washington [RCW] 70.105D), MTCA regulations (Washington Administrative Code [WAC] Chapter 173-340), and Washington's Sediment Management Standards (SMS; WAC 173-204).

This SAP has two major components: a *Field Sampling Plan* (FSP), which defines field protocols, and a *Quality Assurance Project Plan* (QAPP), which defines analytical protocols. The FSP and QAPP are presented in Sections 2 and 3, respectively.

2 Field Sampling Plan

2.1 Project Organization and Responsibilities

This SAP will be implemented by a team of GSI scientists and supporting subcontractors who will be retained by GSI. This section summarizes the organizational structure, responsibilities, and resources employed to support the implementation of field activities. Contact information for the project personnel is provided in Table A-1. Information about laboratory services, data validation, and data management is provided in Section 3.1 of the QAPP.

2.1.1 Senior Project Manager (PM)

Rod Struck, LG, is the Senior PM. In this role he will work closely with the Remedial Investigation Manager (RI Manager), the Port, and Portac to address any field issues and approve any changes to the SAP to ensure that project objectives are achieved. The responsibilities of the PM include the following:

- Track schedule and performance of the sampling and analysis activities for conformance with the SAP.
- Coordinate with the RI Manager to address field problems, approve changes or departures from the SAP, and assist with the resolution of any emergencies that may arise.
- Communicate the project status and any required modifications to the SAP to the Port, Portac, and Ecology. Significant changes to the approach presented in this SAP (e.g., abandoning sample locations or moving them more than 30 feet) will be discussed with

Ecology before implementation and subsequently submitted in writing to Ecology per Section VIII.J of the Order.

2.1.2 Remedial Investigation Manager (RI Manager)

Erin Carroll Hughes, LG, is the RI Manager. In this role, she will oversee all phases of the investigation and will be the point of contact for the Port and Portac during field work. Erin will work closely with the Field Director (FD) and Sampling and Analysis Coordinator (SAC), discussed below, and other project staff members to ensure that the project objectives are achieved. Departures from the SAP by the field staff will not be made without prior discussion and approval from the RI Manager or the PM and/or Ecology, as needed.

The responsibilities of the RI Manager include the following:

- Oversee the planning and implementation of field sampling efforts for conformance with the SAP.
- Coordinate with the Port and current lessees to obtain Site access and insure compliance with Site security measures. Work to minimize interference with current operations at the Site by the field investigation teams and activities.
- Coordinate with the FD and PM to address any field problems, approve required modifications to the SAP, and resolve any emergencies that may arise.
- Communicate with the Port and Portac regarding the schedule, performance, and any required modifications to the planned sampling and analysis activities.
- Oversee the activities of the FD, SAC, and other field staff members during implementation of the RI to ensure that all planned field investigation activities are being followed.

The RI Manager will work closely with the PM, FD, and SAC to fulfill the listed responsibilities and may be assisted at times by other project staff members.

2.1.3 Field Director (FD)

Peter Pellegrin will serve as the FD for all sampling activities. He will report directly to the RI Manager and coordinate with other project staff members. The FD generally is responsible for the following:

- Mobilize crews and equipment for field work and direct the planning and implementation of all field sampling efforts to ensure that the appropriate procedures and methods are used in accordance with the SAP. This includes arranging for necessary sampling equipment and overseeing the operations of subcontractors (see Section 2.1.6).
- Assist the RI Manager in site access and security coordination.
- Coordinate closely with the RI Manager, SAC, and field staff members to address any field issues, changes to the SAP, or emergencies that may arise.
- Function as the Field Safety Officer and ensure that the sampling activities adhere to the Health and Safety Plan (HSP).
- Coordinate with the RI Manager to track the project schedule and performance of the sampling activities in conformance with the SAP.

- Assist with investigation-derived waste (IDW) management to ensure that it is properly labeled, stored, and removed from the Site in a timely manner.

The FD will work closely with the RI Manager and SAC to fulfill the listed responsibilities and may be assisted at times by other project staff members.

2.1.4 Sampling and Analysis Coordinator (SAC)

Renee Fowler will be the SAC and will work closely with the RI Manager and FD. The SAC generally is responsible for the following:

- Mobilize equipment and supplies for field work and direct all aspects of the sampling to ensure that the appropriate procedures and methods are used in accordance with the SAP.
- Coordinate sample packaging and custody transfers with project laboratories.
- Receive and maintain copies of field documentation and laboratory chain-of-custody (COC) forms.
- Assist the FD and RI Manager in tracking the schedule and performance of the sampling and analysis activities according to the SAP.
- Coordinate, assist, and manage sampling efforts with the FD.
- Assist with safety operations.

The SAC may be assisted at times by the FD, RI Manager, and other project staff members.

2.1.5 Field Support

GSI's field staff will work closely with the FD and SAC to facilitate completion of the field sampling efforts. It is anticipated that this project will require support from one to three additional field staff members during the active sampling investigations. The primary responsibilities of the field staff will be to:

- Assist with sample collection and processing efforts.
- Assist with equipment decontamination and the collection of quality control (QC) samples.
- Work with the SAC to ensure that field documentation is complete, accurate, and in compliance with the SAP.
- Support the FD and SAC by assisting with sample handling and transport.
- Assist with IDW management.

2.1.6 Field Subcontractors

Subcontractors anticipated to be used to support this work are listed below by work type:

- **Steadfast Services Northwest.** Will provide professional services for the drilling and installation of new monitoring wells, abandonment of one existing monitoring well, drilling and abandonment of temporary borings, development of new and existing wells, and IDW management and disposal. The drilling contractor will also contract and oversee the concrete coring services for the new monitoring wells and temporary borings.

- **Sitts & Hill Engineers, Inc.** Will provide professional services for the survey of new and existing wells, the new stilling well, and Wapato Creek sampling locations.
- **Applied Professional Services, Inc.** Will provide professional services for the identification (ID) and marking of any subsurface utilities in the vicinity of the new monitoring wells, temporary borings, test pits, and subsurface work to be performed in Wapato Creek.

2.2 Health and Safety

The FD will function as the Field Safety Officer during the field work and ensure safe practices and operating conditions are maintained during the field investigation. The field crews will comply with HAZWOPER regulations under 29 *Code of Federal Regulations* (CFR) 1910.120. The FD will provide a safety briefing at the beginning of the field work, during sampling events as needed (e.g., when conducting new or different field activities), and to any new personnel involved in the field activities. Subcontractors will provide daily health and safety tailgate sessions in accordance with their company's health and safety programs.

GSI prepared an HSP (Appendix B of RIWP) in accordance with Occupational Safety and Health Administration regulations found at 29 CFR Part 1910. The HSP covers all known field hazards associated with the tasks necessary to complete the SAP, including methane monitoring during drilling activities. All other consultants, subconsultants, and subcontractors will prepare their own HSP and will be responsible for their own health and safety programs. All field personnel will have stop-work authority during the completion of field activities.

2.3 Field Schedule and Sampling Summary

The field work described in the FSP (see Sections 2.4 through Section 2.6) includes four sampling events (Events 1 through 4). These events will occur approximately every 3 months during the next year. Event 1 is scheduled to be completed in May and June 2016. Events 2, 3, and 4 are scheduled for August 2016, November 2016, and February 2017, respectively. The majority of the planned RI field work will take place during Event 1 and includes the following tasks:

- Abandon one damaged Sawmill monitoring well (MW-5) and replace the monitoring well monument for existing Sawmill well (MW-6R).
- Install new groundwater monitoring wells (including a replacement well at the MW-5 location), and collect soil samples from the borings advanced for the installation of new monitoring wells.
- Develop new and existing groundwater monitoring wells.
- Collect soil and groundwater samples from temporary direct-push boreholes.
- Collect soil samples from two shallow test pits excavated adjacent to the former Sawmill dip tank remediation area.
- Collect sediment samples in Wapato Creek adjacent to the Site.
- Collect groundwater samples from the monitoring well network.
- Collect surface water and porewater samples from Wapato Creek.

- Perform a tidal study in nearshore monitoring wells and a stilling well installed in Wapato Creek.
- Perform limited aquifer tests (e.g., slug test, modified pump test) on selected monitoring wells.

Events 2, 3, and 4 will include groundwater monitoring and porewater and surface water sampling in Wapato Creek, as described in Sections 2.4.7, 2.6.1, and 2.6.3, respectively.

2.4 Monitoring Wells

The Site has 12 existing groundwater monitoring wells and three existing piezometers. Of these wells, seven monitoring wells are located in the Sawmill area, and five monitoring wells and the three piezometers are located in the Log Yard (Figure 13 of the RIWP). To address existing data gaps, seven new monitoring wells will be installed in the Log Yard in the locations shown in Figure 13 of the RIWP. One existing monitoring well, MW-5, was discovered to be damaged in the Sawmill area and will be abandoned and replaced with a new monitoring well (MW-5R). After the new monitoring wells have been installed there will be a total of 19 monitoring wells at the Site, with 12 monitoring wells in the Log Yard and 7 monitoring wells in the Sawmill (Figure 13 of the RIWP).

All modifications to monitoring wells, including abandonment, drilling, and installation, will be performed by an environmental driller licensed and bonded in the State of Washington. The project approach, including positioning of the new monitoring wells, is discussed in the Section 6 of the RIWP. The subsections below outline the procedures for well abandonment, soil sampling, well installation, well development, and groundwater sampling. Sample handling and documentation are described in Section 2.7, IDW management is described in Section 2.8, and equipment decontamination is described in Section 2.9.

2.4.1 Well Abandonment and Repair

Monitoring well MW-5 in the Sawmill is damaged beyond repair and will be abandoned and replaced during Event 1 with a new monitoring well (MW-5R). The monitoring well monument for MW-6R is damaged and will be repaired. Construction details for monitoring wells MW-5 and MW-6R are presented in Table 4 of the RIWP.

Before abandonment, the monitoring well monument will be removed and manual excavation will be performed to locate the well casing. If the total depth of the well casing can be measured, then the borehole can be abandoned by grouting in place. If the damage is severe and the casing is not accessible to the total depth indicated on the well log, then the borehole will be overdrilled using a hollow stem auger (HSA) drill rig to remove annular sealing material and the well screen filter pack material. The borehole will be backfilled with grout, placed from the bottom up using a tremie pipe. The total volume of grout used in the borehole will be documented. The driller will ensure the abandonment and grout seal conforms to the requirements of WAC 173-160 and other applicable regulations and guidance.

The steel monument and well casing at MW-6R are damaged. The current steel monument will be removed and replaced with a heavy-traffic rated monument during Event 1. The well casing, although bent, is still functional.

IDW generated during well abandonment activities will be contained in U.S. Department of Transportation (DOT)-approved 55-gallon drums, labeled as non-hazardous waste, stored onsite in a secure location, and managed as described in Section 2.8. An inventory of IDW will be maintained.

2.4.2 Well Drilling

Seven monitoring wells will be installed in the Log Yard and one replacement well will be installed in the Sawmill (Figure 13 of the RIWP). The coordinates for each proposed monitoring well are listed in Table A-2. Known storm water and sewer utility features are shown in Figure 4 of the RIWP. Before work begins, GSI will ensure that both private and public utility surveys have been completed, including providing the driller with the locate ticket number from the Washington Utilities Underground Location Center (UULC) (Call Before You Dig, 1-800-424-5555 [or 811]).

Before commencing drilling, water levels in nearby monitoring wells will be measured to assist in estimating the anticipated depth to water (DTW) in each boring. The monitoring well borings will be advanced using a Geoprobe rig with direct push and HSA capabilities. Continuous soil cores will be collected during drilling using a 1.5-inch to 3.0-inch inner diameter, 5-foot-long direct push sampler with acrylic liner (or an equivalent continuous core method).

Monitoring well borings will be advanced to a total depth of approximately 20 feet below ground surface (bgs) or approximately 6 to 7 feet below the observed DTW in the boring. Soil cores will be sampled and logged during drilling, as discussed in Sections 2.4.2.1 through 2.4.1.3. As described in Section 2.4.3, monitoring well screen depths will be placed approximately 4 feet above and 6 feet below the observed water level at the time of drilling (ATD).

Once the soil samples have been collected from the soil cores and the total depth of the well has been determined, the driller will complete the well using HSA (see Section 2.4.3).

Drilling equipment (e.g., augers, samplers) will be steam cleaned prior to use onsite, between each boring location, and before leaving the Site. Decontamination fluids generated during steam cleaning of the drill rig and drilling equipment be captured in a decontamination pad and pumped and contained. All non-dedicated equipment will be decontaminated per Section 2.9. An inventory of IDW will be maintained.

Soil cuttings and decontamination fluids generated during the well installations will be stored in DOT-approved 55-gallon drums, stored onsite in a secure location, labeled, and managed as described in Section 2.8. Soil and liquid IDW will be contained in separate drums.

2.4.2.1 Soil Sample Intervals

Conceptual soil sampling intervals and anticipated geologic units to be encountered during drilling are shown in Figure A-1. Detailed observations and measurements will be made during borehole logging and used in determining the appropriate soil sampling intervals and monitoring well design (e.g., total depth, screened interval). Prior to starting drilling, water levels will be measured in the nearest existing monitoring well(s) to help define the anticipated depth that water will be encountered in each boring. This information will be used to plan soil core sample drive depths and anticipated soil sample depths.

Continuous soil cores will be collected during drilling using a 1.5-inch to 3.0-inch inner-diameter, 5-foot-long direct push sampler with acrylic liner (or an equivalent continuous core method). After driving each core and before opening the acrylic liner to log the soil, GSI's field staff will identify the soil samples to be collected for analyses or archiving. Soil core samples (~1 foot in length) will be collected for potential analytical laboratory testing on approximately 3-foot centers, as shown in Figure A-1. Target soil sample depth intervals are described below and are shown in Figure A-1.

Uncapped Area Soil Intervals

Continuous soil samples in the uncapped Log Yard (i.e., creek bank) and Sawmill (replacement well MW-5R) will be advanced starting at a depth of approximately 6 to 12 inches bgs (below asphalt, surface soil, grass, etc.) to a total depth of approximately 20 feet or approximately 6 to 7 feet below the water table ATD. Soil borings are anticipated to encounter hydraulic fill and alluvium described by others as silty sand, silt, and sand units**.** Soil core samples (~1 foot in length) will be collected for potential analytical laboratory testing on approximately 3-foot centers, as shown in Figure A-1. The following bullets summarize the anticipated sampling intervals and samples to be collected. It should be noted that actual sample depths and total boring depths will be determined in the field, based on observations in boring location (DTW ATD, soil types, stratigraphy, etc.).

- *Asphalt, Surface Soil, Grass (6 to 12 inches thick)*: Removed; no sample collected.
- *Hydraulic Fill/Alluvium (described by others as silty sand, silt, and sand units)*: Soil core samples (approximately 1 foot in length) will be collected for potential analytical laboratory testing (Table A-3) on approximately 3-foot centers (Figure A-1).
    - Sample 1 – approximately 1 to 2 feet bgs. Sample will be archived.
    - Sample 2 – approximately 4 to 5 feet bgs. Sample will be archived.
    - Sample 3 – approximately 7 to 8 feet bgs. Sample will be archived.
    - Sample 4 – approximately 1 to 2 feet above the estimated water level in the borehole. Sample will be archived.
    - Sample 5 – approximately 1 to 2 feet below the water level observed ATD in the borehole. Sample will be submitted for analytical testing (see Table A-3).
    - Sample 6 – approximately 4 to 5 feet below the water level observed ATD in the borehole. Sample will be archived.

Capped Area Soil Intervals

The Log Yard was capped in the late 1980s to eliminate infiltration into the fill containing slag. The fill containing slag is now overlain by gravel base course and the roller-compacted concrete (RCC) cap and asphalt overlay and the thicknesses of these units varies across the Log Yard. The average thickness of each unit in the capped area is described below. Soil core samples (~1 foot in length) will be collected for potential analytical laboratory testing on approximately 2- to 3-foot centers, as shown in Figure A-1. The following bullets summarize the anticipated sampling intervals and samples to be collected. It should be noted that actual sample depths and total boring depths will be determined in the field, based on observations in boring location (DTW ATD, soil types, stratigraphy, etc.).

- *RCC cap and Asphalt Overlay (approximately 15 inches thick combined)*: Concrete coring; no sample collected.
- *Gravel Base Course (approximately 26 inches thick):* Vacuum extraction; no sample collected. The soil sampler should start being advanced at the bottom of the gravel layer.
- *Fill Containing Slag (approximately 38 inches thick)*: Soil logging only; no sample collected.
- *Hydraulic Fill/Alluvium (previously described by others as silty sand, silt, and sand units)*: Continuous soil cores will be advanced to a total depth of approximately 20 feet or

approximately 6 to 7 feet below the water table ATD. Soil core samples (approximately 1 foot in length) will be collected for archival or analytical testing (Table A-3).

- Sample 1 – approximately 2 to 3 feet below the bottom of the fill containing slag unit. Sample will be archived.
- Sample 2 – approximately 1 to 2 feet above the estimated DTW in the borehole. Sample will be archived.
- Sample 3 – approximately 1 to 2 feet below the water level observed in the borehole ATD. Sample will be submitted for analytical testing (Table A-3).
- Sample 4 – approximately 4 to 5 feet below the water level observed in the borehole ATD. Sample will be archived.

2.4.2.2 Anoxic Soil Sample Procedure

Once the sample intervals have been identified, as described in Section 2.4.2.1, GSI's field staff will collect the soil sample using the following anoxic procedure to minimize the potential of oxidizing the sample to the extent practicable:

1. Cut the soil sample length (e.g., 12 inches) from the acrylic core. Cap both ends of the sample core.
2. Place the sample core in a Mylar bag. Add oxygen-absorbing packets to the Mylar bag and manually express as much air as possible from the bag.
3. Purge the bag with nitrogen or argon gas.
4. Seal bag with a portable heat sealer and label the bag (see Section 2.7.4 for labeling details).
5. Place the Mylar bagged core in a re-sealable plastic bag. Manually remove air from the bag and seal.
6. Place the sample in a cooler with ice or dry ice and transport sample to analytical laboratory in accordance with Sections 2.7.3 and 3.4.

Note that the capped sections of the cores that are submitted to the laboratory will not be directly logged, but any changes in lithology noted along the cut edges of the core tubes or through the clear plastic core tube liners, will be noted on the soil boring log (Section 2.4.2.3).

2.4.2.3 Soil Logging

Soil cores will be examined and classified in the field based on American Society for Testing and Materials (ASTM) D2488 – Standard Practice for Description and Identification of Soils (Visual/Manual Procedure) (ASTM, 2000). The soil descriptions on the boring logs will include, but is not limited to, soil classification (e.g., gravel, sand, silt, clay) and physical characteristics (e.g., density, color, moisture, plasticity, coarseness). The presence of odor, sheen, and synthetic material also will be noted. Additionally, observations made by the driller will be recorded including refusal, heaving sand, and rig behavior (e.g., drill casing sinking, rig bouncing on gravels or cobbles). Soil logging will be performed by a field hydrogeologist, engineer, or environmental scientist working under the supervision of a Geologist licensed in the State of Washington.

2.4.3 Well Installations

Seven new monitoring wells will be installed at the approximate locations shown in Figure 13 of the RIWP. Proposed monitoring well locations are presented in Table A-2. The proposed wells are intended to monitor the top of the unconfined water-bearing zone. The conceptual monitoring well design is shown in Figure A-2.

Each groundwater monitoring well will be installed in accordance with Chapter 173-160 of WAC, *Minimum Standards for Construction and Maintenance of Water Wells*, and Chapter 173-162 WAC, *Regulation and Licensing of Well Contractors and Operators* and applicable guidance by a Washington licensed and bonded driller. Drilling and well installation activities will be documented by a field hydrogeologist, engineer, or environmental scientist working under the supervision of a Geologist licensed in the State of Washington.

Borings for monitoring well completion will be advanced using an HSA drill rig after completion of the direct push soil boring advanced to collect soils cores for logging and soil sample collection (as described in Section 2.4.2). The total depth of each well and the target screened will be determined in the field, based on the drilling log and discussions with the supervising geologist. The well screen will be positioned across the water table with the screen depth based on field observations of stratigraphy and moisture during the drilling. In general, the well screen will be targeted to extend approximately 4 feet above the observed water table.

Prior to advancing the HSA to install the monitoring well, a wooden plug will be placed in the lead auger. The HSA will then be advanced to total depth and the plug knocked out. A 2-inch-diameter groundwater monitoring well will be installed in each boring during the process of removing the HSA auger casing. The monitoring wells will be constructed of 2-inch-diameter Schedule 40, flush-threaded polyvinyl chloride (PVC) pipe with 10 feet of 0.010-inch milled slot screen. The top of the screen will be placed approximately 4 feet above the groundwater surface to account for seasonal and tidal groundwater fluctuations. A blank riser pipe attached to the top of the screen will extend to approximately ground surface. Well screen, casing, and caps will be pre-cleaned by the manufacturer and shipped in plastic. A 10-20 graded Colorado silica sand pack (or equivalent) will be installed within the annular space from the bottom of the screen to approximately 2 feet above the top of the screen. During well construction, the sand pack will be poured slowly through the HSA as the auger are extracted to minimize any possibility of bridging. The well screen will be surged gently with a bailer during installation of the sand pack to reduce the potential for bridging and ensure a uniform distribution of the sand around the screen. The annular space above the sand pack will be sealed with bentonite chips to 2 feet bgs, followed by a high early strength concrete seal, which will extend to the ground surface. The monitoring wells will be completed with a heavy-traffic-rated flush-mount monument set in concrete.

Upon completion, all wells will be surveyed by a Washington licensed surveyor to the mean low low water (MLLW) datum. Each horizontal well location will be surveyed to the nearest 1 foot and the top of the well casing and ground surface elevations will be surveyed to the nearest 0.01 foot vertically.

2.4.4 Well Development

The objective of the well development is to remove fine-grained material from the filter pack and borehole wall thereby improving the hydraulic connection between the well and the aquifer. Monitoring wells will be developed using a combination of surging, bailing, or other methods approved by the supervising geologist.

During Event 1, both existing and new monitoring wells, will be developed. Typical well development steps are:

1. Upon removing the cap on the well casing, measure the percent methane present in the head space at the top of the well casing using a portable methane meter (i.e., GEM 2000). Measure and record the static water level in the well to the nearest 0.01 foot.
2. Surge, bail, brush (as needed on existing wells), and pump the well. Record temperature, pH, dissolved oxygen (DO), oxidation-reduction potential (ORP), specific conductance (SC), and turbidity of the purged groundwater on a well development field form at regular intervals. Water level measurements and flow rates will also be recorded at periodic intervals.
3. Continue development until groundwater turbidity is approximately 10 nephelometric units (NTU) or less and groundwater parameters have stabilized. If turbidity and parameter stabilization goals cannot be achieved, continue development until a minimum of three well casing volumes have been removed or the well goes dry.
4. Purged groundwater will be stored in DOT-approved 55-gallon drums, stored onsite in a secure location, and managed as described in Section 2.8. Drums labels will clearly identify whether the drum contains water or soil and identify the approximate level of the material in the drum.
5. Well development equipment will be decontaminated between wells following the procedures described in Section 2.9.

Existing wells HC-1 and HC-2 are shallow and not anticipated to have sufficient water production to allow sampling. These wells are expected to pump dry during well development. If the well is purged dry and the water level does not recover to sufficiently fill the required sample bottles within 24 hours, then the well will be deemed “not enough water to sample” and no sample will be collected.

2.4.5 Groundwater Elevation Monitoring

Groundwater levels will be monitored to evaluate the seasonal and tidal fluctuations at the Site and to obtain a better understanding of groundwater flow directions and gradients at the Site. This information will be useful in refining the conceptual site model and assessing groundwater/surface water interconnections.

Groundwater levels will be measured manually during each sampling event. A round of water levels will be measured as quickly as possible on the same day, starting at a nearshore well, such as MW-7, and making a loop around the Site, and ending with a re-measurement of the nearshore starting well.

At each well, the cap will be removed and the percent methane will be measured in the head space at the top of the well casing. The wells will be allowed to equilibrate with atmospheric pressure, and the water level will be measured from the surveyed measurement mark on the north side of the top of casing using an electronic water level meter to the nearest 0.01 foot.

Electronic water level meter will be decontaminated between each well per Section 2.9.

2.4.6 Groundwater Sampling Procedures

Groundwater samples will be collected at 19 monitoring wells: 12 monitoring wells in the Log Yard and 7 monitoring wells in the Sawmill (Figure A-1). Groundwater samples initially will be collected following well installation and development (Event 1). Future groundwater samples will be collected at monitoring wells on a quarterly basis for 1 year (Events 2 through 4). The collection of groundwater samples from Site monitoring wells generally will consist of three steps:

1. Measurement of the percent methane in well head space and static water level (Section 2.4.6)
2. Well purging and monitoring for field parameter stabilization
3. Analytical sample collection

In general, groundwater sampling will proceed across the Site from the southeast to northwest based on a desire to move from lower to higher concentration regimes. The sampling order in subsequent sampling events may be revised on the basis of the analytical results obtained in Event 1.

Equipment used for groundwater sampling will consist of a peristatic pump, well-dedicated high-density polyethylene (HDPE) purge tubing, and a flow-through cell with field water quality parameter sensors (i.e., YSI 556 Multiparameter Instrument). During sampling activities, the field staff will attempt to minimize introduction of air to the monitoring well water column (i.e., slowly lowering sampling equipment into well), water purged from the well, and collected groundwater samples. The goal of the sampling activities is to prevent field induced changes in the groundwater chemistry (i.e., oxidation). Groundwater purging and parameter measurement techniques to be used are:

1. Calibrate field meters daily according to factory instructions and record results in instrument calibration logs.
2. Open well cap and measure the percent methane in the head space using a methane meter (per Section 2.4.6). Measure water depth to the nearest 0.01 foot using an electronic water level meter (per Section 2.4.6). Record the percent methane and DTW measurements and the time of measurement on the groundwater sampling form.
3. Insert purge tubing in the well. Connect purge tubing to the pump and begin purging water into a bucket until the initial high turbidity slug of water passes.
4. Connect tubing to the flow-through cell and begin purging, typically at a rate of approximately 250 milliliters per minute, but no more than 1 liter per minute. Record the purge rate and changes to the purge rate.
5. Field parameters will be measured using a flow-through cell equipped with quality parameter sensors (i.e., YSI 556YSI meter). Monitor and record pH, temperature, conductivity, ORP, DO, and turbidity and record readings at regular intervals (e.g., 2-liter purge interval or 3 minutes).
6. Measure and record DTW during sampling activities and after sampling is complete.
7. Purging will be considered complete only after one of the following purge conditions is met:
    - Low-flow sampling: parameters have stabilized (Table A-4) and water level drawdown is controlled in accordance with EPA low-flow purging and sampling procedures (EPA, 1996, 2010a).
    - Other sampling methods, if low-flow sampling cannot be achieved:

  - A minimum of three well volumes have been removed and successive field parameter measurements agree with the stability criteria presented in Table A-4. Water level drawdown cannot be controlled.
  - At least five well volumes have been removed, although field parameter stabilization criteria cannot be attained.
  - The well has been pumped dry and allowed to recover sufficiently such that adequate sample volumes can be collected within 24 hours of the initial well purging.

8. Record the final groundwater parameters before beginning sample collection. Parameter stabilization should be based on three consecutive measurements taken 3 to 5 minutes apart.

9. Disconnect purge tubing from flow-through cell. Fill laboratory prepared bottles directly from purge tubing, as outlined in the groundwater analytical summary (Table A-5). All bottles will be filled according to laboratory and sample method instructions (Table A-12). Samples will be placed in an iced cooler after collection.

10. Purge water will be stored in DOT-approved 55-gallon drums, labeled, stored onsite in a secure location, and managed as described in Section 2.8.

Purge tubing used during groundwater sampling will be dedicated to a single monitoring well and placed in a sealed zip-lock bag and labeled with the well ID for reuse during subsequent sampling events. All non-dedicated equipment will be decontaminated per Section 2.9.

2.5 Temporary Borings and Test Pits

Temporary borings and test pits will be used to characterize Site geology and to collect additional information on soil and groundwater contaminants at the Site. Samples from the proposed temporary borings will provide additional data on arsenic concentrations in groundwater and saturated soil in the Log Yard under the cap. Samples from the proposed test pits will provide additional data to characterize soil near the former dip tank in the Sawmill area and identify the edge of previous cleanup excavation work. The project approach, including positioning of the temporary borings and test pits, is discussed in the Sections 5 and 6 of the RIWP. Sample handling and documentation are described in Section 2.7, IDW management is described in Section 2.8, and equipment decontamination is described in Section 2.9.

Known storm water and sewer utility features at the Site are provided in Figure 4 of the RIWP. Before work begins, private utility locates will be completed and GSI will provide the drilling contractor with the locate ticket number from the Washington Utilities Underground Location Center (UULC) Utility Notification Center (Call Before You Dig, 1-800-424-5555 [or 811]).

2.5.1 Temporary Borings

Of the nine temporary borings, six of the boreholes are in the Log Yard, two boreholes are located north of the site boundary, and one borehole is located in a former drainage ditch (Figure A-1 and Table A-6). Before drilling, water levels will be measured in nearby monitoring wells to help predict the depth that water will be encountered in each boring. The borings will extend to approximately 5 to 6 feet below the DTW measured in the borehole to a total anticipated depth of approximately 13 to 20 feet bgs.

Continuous soil cores will be advanced using a Geoprobe drilling rig equipped with a 1.5-inch to 3-inch inner diameter, 5-foot-long direct push sampler with acrylic liner (or an equivalent continuous core method). Soil cores will be sampled and logged during drilling, as discussed in Sections 2.4.2.1 through 2.4.1.3 and shown in Figure A-1. The targeted sampling depths are different for shallow soil boring TB-9, which is located within the former channel of Wapato Creek and the central drainage ditch (Figure 13 of the RIWP). Soil from TB-9 will be logged to document depth and type of fill and the depth of former drainage channel and/or Wapato Creek beds. Soil samples from TB-9 will be collected from the fill, the base of the former channel, and the native sediments for laboratory analyses (Table A-3).

Upon reaching total depth of the borehole (approximately 5 to 6 feet below the groundwater level), the driller will install a temporary monitoring well using a dedicating screen. HDPE purge tubing will be placed in the temporary monitoring well, which will be connecting to a peristaltic pump and a flow-through cell with field water quality parameter sensors (i.e., YSI 556). The temporary monitoring well will be developed to reduce turbidity and ensure that a representative groundwater sample is collected. Groundwater samples from the temporary wells are still likely to have some turbidity. The duration of the development will be determined by GSI's field staff examining the development trends and the site specific soil conditions. Field parameter measurements of the development water and water level measurements will be collected at regular intervals during development to assess borehole development progress.

Purge rates will be kept low during development to minimize turbidity (at an approximate rate of 250 ml/min, but no more than 1 liter per minute). The field staff will consult with the FD to determine if a sample needs to be collected prior to field parameter stabilization or complete clearing of the well if water production is limited. A groundwater sample will be collected per Section 2.4.7 into laboratory prepared bottles, as outlined in the temporary boring analytical summary (Tables A-5 and A-12). All samples will be placed in iced coolers after collection.

Drilling equipment (e.g., drill rod, samplers) will be steam cleaned prior to use onsite, between each boring location, and before leaving the Site. Decontamination fluids generated during steam cleaning of the drill rig and drilling equipment be captured in a decontamination pad and pumped and contained. All non-dedicated equipment will be decontaminated per Section 2.9. An inventory of IDW will be maintained.

Soil cuttings and purged groundwater will be stored in DOT-approved 55-gallon drums, stored onsite in a secure location, and managed as described in Section 2.8. All non-dedicated equipment will be decontaminated per Section 2.9.

2.5.2 Test Pits

Two test pits will be excavated and sampled in the Sawmill, adjacent to the former dip tank (Figure 13 of the RIWP and Table A-6), to approximately 5 to 10 feet bgs. Backhoe excavation of the test pits will proceed as follows:

1. Remove gravel and vegetation, if present, to provide access to the surface soil and to identify the edge of the former dip tank cleanup area (i.e., excavation).
2. Position the test pits, to the extent practicable, to expose soil outside the area of previous excavation (approximately 3 to 5 feet from the previous excavation wall).
3. Excavate soil from test pit in lifts of approximately 6 to 8 inches deep.
4. Log the soil as outlined in Section 2.4.2.3.

5. Collect two soil samples from each test pit:
    a. The first soil sample will be collected to representative surface soil below the gravel layer (approximately 0.5 to 1.5 feet bgs). This sample will be collected manually using stainless-steel spoons.
    b. The second soil sample will collected from the backhoe bucket from a depth representing approximately 1 to 2 feet below the observed water level in the pit, or a maximum depth of 9 to 10 feet bgs.
    c. Each sample will be homogenized using stainless-steel spoons and bowls and placed into laboratory prepared containers. Each sample will be analyzed for the constituents listed in Table A-3. All samples will be placed in an iced cooler after collection.
6. Excavated soil will be placed back into the test pits and compacted to restore surface conditions.

All non-dedicated sampling equipment will be decontaminated per Section 2.9.

2.6 Nearshore Study Area

To better understand the relationship between groundwater and Wapato Creek, four sampling transects have been established as shown in Figure 13 of the RIWP. As discussed in the RIWP, these transects will provide data to assess the groundwater migration pathway from the upland site (Log Yard, Sawmill) to Wapato Creek (i.e., groundwater, porewater, surface water). The nearshore study area is located along the western boundary of the Site, beginning in Wapato Creek (i.e., porewater and surface water) and extending approximately 300 feet to the east into the Log Yard and Sawmill (i.e., groundwater). Samples collected during Event 1 will provide comprehensive groundwater, porewater, surface water, sediment, and soil chemistry data across the Site and within Wapato Creek. These data will be used to supplement existing Site information and evaluate arsenic fate and transport mechanisms.

Additionally, a bank reconnaissance and short-term tidal study (Section 2.6.5) will be completed to refine the conceptual site model. The project approach for the nearshore study area, including the positioning of transects, is discussed in the Sections 5 and 6 of the RIWP. Sample handling and documentation are described in Section 2.7, IDW management is described in Section 2.8, and equipment decontamination is described in Section 2.9.

2.6.1 Porewater Sampling

Each transect consists of two porewater locations, collocated with sediment samples, and each porewater location consists of two sample depths (zero to 10 centimeters [cm] below mudline [bml] and 40 to 50 cm bml) (Figure 14 of the RIWP and Table A-7). Thus, four porewater samples will be collected along each transect.

Porewater samples will be collected using a nylon-screen diffusion sampler (NSDS). The NSDS consists of a polyethylene jar with a threaded rim, a 120-micron nylon screen mesh (or finer), and a threaded jar ring; the mesh is placed over the mouth of the jar and secured by the ring. The NSDS will be filled with deoxygeneated deionized water, buried in the sediment, allowed to equilibrate for approximately 2 weeks. During sampling activities, the field staff will attempt to minimize introduction of air to the porewater samples. The goal of the sampling activities is to prevent field induced changes in the porewater chemistry (i.e., oxidation). Porewater samplers will be deployed and collected from upstream (i.e., Sawmill) to downstream. The installation of the NSDS in each transect is as follows:

1. Prepare appropriate number of NSDSs prior to sampling: Use laboratory provided or decontaminated sample jars and open top caps (e.g., jar rings), and assemble NSDS with deoxygenated, deionized water for each sample location (designated as Location A and Location B) and both sample depths (zero to 10 cm bml and 40 to 50 cm bml) at each location. Multiple NSDS jars may be needed to provide the required volume per porewater analytical sample listed in Table A-5. Each NSDS jar will be labeled with the sample ID (see Section 2.7.4 for more details).
2. Locate porewater samples: Location A samples. Location A samples will be placed at the edge of Wapato Creek at an elevation approximately 8 to 9 feet MLLW (between approximate high tide and low tide). Locations may be moved based on field conditions (e.g., boulders, gravel, and creek bed topography).
3. Deploy the deep NSDS (40 to 50 cm bml) first. To reach the proper depth, remove one shovel of sediment (i.e., to 30 cm bml). Then use the shovel to displace the sediment and place the NSDS jar within the deep depth range (40 to 50 cm bml). Place the jar sideways with the mesh facing east towards the Site. After sampler deployment, remove the shovel to allow for sediment to cover the NSDS jar. If multiple NSDS jars are necessary for the 40 to 50 cm bml depth, place NSDS jars next to one another and perpendicular to the creek with the opening facing the Site. Replace surface sediment to fill the hole up to mudline. Place a flag or stake to mark the location of the samples. Avoid stepping on or near the deployed samplers.
4. Next, deploy the shallow NSDS (zero to 10 cm bml) within a couple feet slightly upstream from the deep NSDS (40 to 50 cm bml). Insert a shovel to displace the sediment and place NSDS so the jar is within the lower portion of the shallow depth range (zero to 10 cm bml). Similar to the deep sample, the jar should be placed sideways so the mesh is facing the Site. After deployment, remove the shovel to allow for sediment to cover the NSDS jar. If multiple NSDS jars are necessary for the zero to 10 cm bml depth, place NSDS jars next to one another and perpendicular to the creek with the opening facing east towards the Site. Make sure each NSDS jar is covered with sediment after deployment. Place a flag or stake to mark the location of the samples.
5. Locate the porewater: Location B samples. Location B samples will be placed at the approximate break in slope (see Figure 14 of the RIWP) or approximately midpoint between Location A and the deepest location in Wapato Creek, based on field conditions.
6. Redo step 3 to deploy the NSDS jar(s) at the deeper depth (40 to 50 cm bml).
7. Redo step 4 to deploy the NSDS jar(s) at the shallower depth (zero to10 cm bml).
8. Leave samplers to equilibrate in place for approximately 2 weeks.
9. Retrieve the NSDS jars from shallow depth (zero to 10 cm bml) at Location A. Extract sample from NSDS jars using a peristaltic pump or disposable syringe and hypodermic needle (or equivalent). Porewater sample will be transferred directly into laboratory-prepared containers. Each sample will be analyzed for the constituents listed in Table A-5 for porewater samples. All bottles will be filled according to laboratory and sample method

instructions. Samples will be placed on ice in a cooler after collection. Field parameters will be collected by removing the nylon mesh from a NSDS and inserting a water quality parameter sensor (i.e., YSI 556 Multiparameter Instrument).

10. Retrieve the NSDS jars from the deeper depth (40 to 50 cm bml) at Location A. Extract sample from NSDS jars using a peristaltic pump or disposable syringe and hypodermic needle (or comparable). Porewater sample will be placed into laboratory-prepared containers. Each sample will be analyzed for the constituents listed in Table A-5 for porewater samples. All bottles will be filled according to laboratory and sample method instructions (Table A-12). Samples will be placed on ice in a cooler after collection. Field parameters will be collected by removing the nylon mesh from a NSDS and inserting a water quality parameter sensor (i.e., YSI 556 Multiparameter Instrument).

All non-dedicated sampling equipment will be decontaminated (see Section 2.9). When porewater samples are replicated in subsequent sampling events, the field staff will slightly move the sample locations so the NSDS jars are not deployed in disturbed sediment.

2.6.2 Sediment Sampling

As stated in Section 2.6.1, sediment samples are collocated with porewater samples. Each sediment location consists of two sample depths (zero to 10 cm bml and 40 to 50 cm bml) (Figure 14 of the RIWP and Table A-7). Therefore, four sediment samples will be collected per transect.

The sediment sample will be collected prior to the installation of the collocated porewater samples. The sediment sample will be collected immediately downstream of the collocated NSDS jars. The field staff will take care to not disturb the sediments where the NSDS jars will be deployed while collecting the sediment sample. Sediment samples will be collected from upstream to downstream, to the extent practicable.

Sediment samples will be collected using a sampling device, such as a core-shaped push tubes (e.g., stainless-steel tube, PVC tube). Sampling device will either have an acrylic liner or will be extruded into a stainless-steel tray. The zero to 10 and 40 to 50 cm bml intervals from the sampling device will be preserved in following the anoxic procedure described in Section 2.4.2.2. Each sample will be analyzed for the constituents listed in Table A-3 for sediment. Excess sediment from sampling device will be placed back into the hole.

All non-dedicated sampling equipment will be decontaminated per Section 2.9.

2.6.3 Surface Water Sampling

A total of 6 surface water samples will be collected during Event 1 (Figure 13 of the RIWP and Table A-8). Sampling locations for Events 2 through 4 will be based on Event 1 results. One surface water sample will be collected near Location B on each of the four transects. Additionally, upstream and downstream surface water samples will be collected. Surface water samples in Wapato Creek will be collected during low tide conditions (i.e., within approximately 1 hour of the low tide) and approximately 10 cm above mudline. The downstream sample will be collected in Blair Waterway from a depth of approximately 2 to 3 feet below the water surface. Surface water samples will be collected immediately before the NSDS jars are retrieved. Surface water samples will be collected from downstream to upstream. Techniques to be used to collect surface water are:

1. Calibrate field meters daily according to factory instructions, with calibration results recorded on calibration forms.

2. Set up peristaltic pump and HDPE sample tubing. Affix the sample tubing approximately 10 cm above a stake marking the NSDS jar or separate rod.
3. Connect other end of sample tubing to a flow-through cell. Monitor pH, temperature, SC, ORP, and DO. Record field parameters until stabilization (Table A-4).
4. Disconnect sample tubing from flow-through cell. Fill laboratory prepared bottles directly from tubing, as outlined in the surface water analytical summary (Table A-5 and Table A-12). All bottles will be filled according to laboratory and sample method instructions. Samples will be placed on ice in a cooler after collection.

Sample tubing will be discarded after each use. All non-dedicated equipment will be decontaminated per Section 2.9.

2.6.4 Bank Reconnaissance

The field staff will explore and document the bank adjacent to the Site along Wapato Creek. It is important to conduct this reconnaissance during low tide for the full extent of the bank to be exposed. The following is a list that the field staff will identify, if present:

- Dry weather flow from outfalls
- Groundwater seeps
- Sediment with any odor, discoloration or sheen
- Rills, channels, etc. (evidence of preferential flow or erosion)
- Animal tracks, burrows, nesting areas, etc.
- Benthic communities (clam tubes, etc.)

When any of the above is identified, the field staff will describe it in the field logbook, record global positioning system (GPS) coordinates and/or a description of the feature location, and take photographs.

2.6.5 Short-Term Tidal Study

Continuous groundwater levels, surface water levels (Wapato Creek), temperature, and conductivity data will be collected from nearshore monitoring wells and a monitoring station installed in Wapato Creek to better understand the tidal fluctuations and relationship of Wapato Creek and groundwater at the Site. Transducers will be programed to collect data every 5 minutes for a period of at least 73 hours. This information also will be useful in refining the conceptual site model and assessing groundwater-surface water interactions.

2.6.5.1 Wapato Creek Stage Monitoring

Continuous surface water levels, temperature, and conductivity data will be collected in Wapato Creek. A stilling well will be installed in Wapato Creek, south of WCT-3 and north of the Site access road from Alexander Avenue (Figure A-1). A non-vented pressure transducer (e.g., CT2X) will be installed in the stilling well to monitor the creek’s water level, temperature, and conductivity.

The stilling well and staff gauge will be surveyed by a licensed surveyor using an established datum (i.e., MLLW) to the nearest 1 foot horizontal and the nearest 0.01 foot vertical.

2.6.5.2 Continuous Groundwater Level and Conductivity Monitoring

Continuous groundwater level data will be monitored using transducers programed to collect data every 5 minutes for a period of at least 73 hours. The transducers will be installed in monitoring wells MW-7, MW-9, MW-10, MW-11, MW-12, MW-13, B-1R, and B-6R on the Log Yard and MW-1, MW-2R, MW-3, MW-4, and B-5R on the Sawmill (Table A-5). While all transducers will measure water levels, a subset of the monitoring wells closest to Wapato creek and along a single transect will be equipped with non-vented pressure transducers that also measure conductivity and temperature. An additional pressure transducer will be installed onsite to measure barometric pressure, which will be used to correct water level data for potential barometric changes.

Manual water level measurements will be collected (per Section 2.4.5.1) during deployment and retrieval to verify pressure transducers are operational, and conduct any necessary maintenance (i.e., conductivity pressure transducer calibration).

2.7 Sample Handling, Documentation, and Transport

Samples will be traceable from the time of collection through laboratory and data analysis. To ensure samples collected during the RI are traceable, the procedures described in this section will be followed.

2.7.1 Field Logbook and Forms

The field activities and observations will be noted in a field logbook or applicable field forms. The following site activity records will be documented in the field logbook:

- Time of arrival and departure from the Site
- Project personnel onsite
- Downtime or equipment breakage
- Sample information, including station ID, date/time of collection, type of sample, and description (only applicable when field form is not used)
- Names of visitors, their association, and purpose of visit
- Any changes that occur at the Site (e.g., personnel, responsibilities, deviations from the SAP) and the reasons for such changes

Field logbook entries will be written clearly with enough detail so that participants can reconstruct events later, if necessary. Field logbooks will be bound, with consecutively numbered pages, and removal of any pages is prohibited. Unbiased, accurate language will be used and entries will be made while activities are in progress or as soon afterward as possible. Field logbook corrections will be made by drawing a single line through the original entry allowing the original entry to be legible. Corrections will be initialed and the corrected entry will be written alongside the original. When field activities are complete, the field logbook will be retained in the project file at GSI's Portland, Oregon, office.

Field data forms (e.g., soil boring log, groundwater sampling form) will be completed for activities that are not described in the field logbook and kept in the project file at GSI's Portland, Oregon, office. Depending on the activity, the type of field data form and the information recorded on it may vary. Sample field forms are provided in Attachment 1.

The FD is responsible for ensuring that the field logbook and all field data forms are completed and accurate.

2.7.2 Equipment and Supplies

Equipment and supplies will include sampling equipment, utensils, decontamination supplies, sample containers, coolers, field logbooks and forms, personal protective equipment (PPE), and personal gear. A comprehensive checklist of sampling equipment will be developed before implementation. Protective wear (e.g., hard hats, gloves), as required for the health and safety of field personnel, will be as specified in the HSP (Appendix B of the RIWP).

2.7.3 Sample Containers, Preservation, and Holding Times

Groundwater and surface water samples will be placed directly in the appropriate sample containers (Table A-12). Porewater will be transferred from the passive collection field sampling jars (i.e. NSDS) to the appropriate laboratory provided containers (see Section 2.6.1). Sample containers and preservatives, as well as coolers and packing material, will be supplied by the contract laboratory. Commercially available pre-cleaned jars will be used and the laboratory will maintain a record of certification from the suppliers. Sample containers will be labeled clearly at the time of sampling. Labels will include the project name, sample ID, sampler's initials, analysis to be performed, date, and time. The nomenclature used for designating field samples is described in Section 2.7.4.

Soil, sediment, and porewater samples will require additional handling and processing prior to being placed into the appropriate sample containers. Soil and sediment samples that will be analyzed for arsenic speciation, batch adsorption and sequential extraction testing, will be collected and managed in the field following the anoxic procedures described in Section 2.4.2.2. Those soil and sediment samples will be collected in food-grade Mylar^{TM} bags and processed at Brooks Applied Laboratory prior to analyses (see Section 3.4). Soil and sediment samples collected for archival, will be sent to Test America for freezing.

2.7.4 Sample Identification and Labeling

During sample collection, a unique code will be assigned to each sample as part of the data record. Station IDs are listed in the Tables A-3 and A-5 for soil/sediment and water media, respectively. The ID code will indicate the sample type, sampling location, and level of duplication. The first component of the sample ID will contain an abbreviation for the sample type followed by the station ID or monitoring well number, with leading zeros used for stations for ease of data management and correct sorting. The following abbreviations for sample types are listed below. Additional codes may be adopted, if necessary, to reflect sampling needs.

- MWS = monitoring well boring soil sample
- TBS = temporary boring soil sample
- TPS = test pit soil sample
- WCTSD = Wapato Creek transect sediment sample
- MW, B, or HC = groundwater sample from monitoring well, exact abbreviation based on monitoring well (i.e., MW for monitoring well MW-1, B for monitoring well B-3R, HC for monitoring well HC-1)

- TBGW = temporary boring groundwater sample
- WCTPW = Wapato Creek transect porewater sample
- WCTSW = Wapato Creek transect surface water sample

The second component will be used to code the sample depth for soil and sediment sampling intervals. This code will include the start and end depth in feet with an underscore ("_") between them (e.g., '0_2' = a sample collected from zero to 2 feet).

For field duplicate samples, sequential numbers starting at 500 will be assigned and integrated with the station ID number of the original sample. For equipment rinsate blanks, sequential numbers starting at 900 will be assigned and integrated with the station ID number. The sample type code (e.g., TBS, WCTSD, or MW) will correspond to the sample type for which the field duplicate sample or equipment rinsate blank was collected. For quarterly groundwater, porewater, and surface water samples, an identifier designating each sampling event will be added (i.e., E1, E2, E3, or E4).

Examples of sample IDs are offered below:

- Monitoring Well Boring Soil Samples
    - MW009-13_14: soil sample from 13 to 14 feet bgs at monitoring well MW-9.
    - MW509-13_14: duplicate soil sample from 13 to 14 feet bgs at monitoring well MW-9.
    - MW909-13_14: equipment rinsate blank sample during collection of surface soil sample at monitoring well MW-9, at 13 to 14 feet bgs.
- Groundwater Samples
    - TB003-E2: groundwater sample collected during the second event from temporary boring TB-3.
    - B001R-E2: groundwater sample collected during the second event from monitoring well B-1R.
    - MW509-E2: duplicate groundwater sample collected during the second event from monitoring well MW-9.

2.7.5 Chain-of-Custody Procedures

Samples are in custody if they are in the custodian's view, stored in a secure place with restricted access, or placed in a container secured with custody seals. A COC record will be signed by each person who has custody of the samples and will accompany the samples at all times. Copies of the COC will be included in contract laboratory reports and attached to the RI Report.

The FD will be responsible for all sample tracking and COC procedures for samples collected in the field, and will be responsible for any final sample inventory and maintaining sample custody documentation. When transferring sample custody, the COC will be signed, dated, and the time of transfer will be noted on the form.

The original COC form will be transported with the samples to the selected contract laboratories. Upon receipt, the laboratory sample custodian will inventory the samples by comparing sample labels to those on the COC document. The custodian will enter the sample number into a laboratory tracking system by project code and sample designation. The custodian will assign a unique laboratory number to each sample and will be responsible for distributing the samples to the appropriate analyst or for storing samples in an appropriate secure area.

The contract laboratories will maintain COC procedures internally and when samples are shipped to subcontracted laboratories or during shipment between laboratories.

2.7.6 Sample Packaging and Shipping

The contract laboratory will supply sample coolers and packing materials for each sampling event. Upon completion of the final sample inventory, samples will be packed in a cooler. Glass jars will be packed to prevent breakage and separated in the shipping container by bubble wrap or other shock-absorbent material. Ice in sealed plastic bags will be placed in the cooler to maintain a temperature of approximately 4 degrees Celsius (ºC). Alternatively, dry ice may be used to expedite cooling if recommended by the laboratory.

When the cooler is full, the COC form will be placed into a re-sealable bag and taped onto the inside lid of the cooler. A temperature blank will be added to each cooler. Coolers will be transported to the contract laboratory by lab courier or overnight shipping service. These packaging and shipping procedures are in accordance with DOT regulations as specified in 49 CFR 173.6 and 49 CFR 173.24.

2.8 Investigation Derived Waste Management

2.8.1 Soil

Soil samples from new monitoring wells and temporary borings will be collected, processed, and placed in labeled DOT-approved 55-gallon drums that specify the collection site (e.g., boring number). Drums will be stored on the Site pending receipt of analytical soil results. IDW will be presumptively labeled as non-hazardous waste based on historical sampling results and waste determinations. A final hazardous waste determination will be performed using the results of the Event 1 soil samples to evaluate the proper disposal method of drums. Representative samples will be collected, as needed, for approved disposal at a permitted landfill. After sample results are available, GSI will coordinate proper disposal. An inventory of stored IDW will be maintained.

2.8.2 Groundwater/Decontamination Fluids

Groundwater and decontamination fluids produced during well development and sampling activities will be contained in DOT-approved 55-gallon drums stored onsite. Drums will be stored on the Site pending receipt of analytical groundwater results. IDW will be presumptively labeled as non-hazardous waste based on historical sampling results and waste determinations. A final hazardous waste determination will be performed using the available groundwater data to evaluate the proper disposal method of drums. Representative samples will be collected, as needed, for disposal at an approved facility. GSI will coordinate proper disposal. An inventory of stored IDW will be maintained.

2.8.3 Sediment

The sediment sampling procedures selected for this study eliminate the collection of sample volume in excess of the amount that will be submitted to the contract laboratory for analysis and/or archival. Any excess sediment that is removed during sampling activities will be placed in a DOT-approved 55-gallon drum that and labeled to specify that the drum contains sediment from WCT-1 through WCT-4. Drums will be stored on the Site pending receipt of analytical results. IDW will be presumptively labeled as non-hazardous waste based on historical sampling results and waste determinations. A final hazardous waste determination will be performed using the results of the Event 1 soil samples to evaluate the proper disposal method of drums. Representative samples will be collected, as needed, for approved disposal at a permitted landfill. After sample results are available, GSI will coordinate proper disposal. An inventory of stored IDW will be maintained.

2.8.4 Other Waste (PPE, decontamination solutions)

All disposable materials used in sample collection and processing, such as paper towels, aluminum foil, and gloves, will be placed in heavyweight garbage bags or other appropriate containers. Disposable supplies will be placed in a normal refuse container for disposal at a solid waste landfill.

2.9 Equipment Decontamination Procedures

Drilling equipment (e.g., augers, samplers) will be steam cleaned prior to use onsite, between each boring location, and before leaving the Site. Decontamination fluids generated during steam cleaning of the drill rig and drilling equipment be captured in a decontamination pad and pumped and contained.

Equipment that comes in direct contact with samples, such as NSDS jars, push tubes, scoops, spoons, and mixing bowls, will be decontaminated in the following manner at the beginning of the sampling event, between use at each station, and at the end of the sampling event:

- Wash with brush and Liquinox or other phosphate-free detergent.
- Double rinse with tap water.
- Rinse with deionized water.
- When dry, cover decontaminated equipment with aluminum foil for temporary storage and/or transport.

To minimize sample contamination, gloves will be replaced after handling each sample, as appropriate. Decontamination solutions containing Liquinox will be placed in DOT-approved 55-gallon drums stored onsite and disposed of per Section 2.8.

3 Quality Assurance Project Plan

This QAPP describes the plan and procedures in place to ensure the data collected during the remedial investigation are of the quality and type needed. This QAPP was developed in general accordance with the Ecology QAPP Guidance (Ecology, 2004).

3.1 Project Organization and Responsibilities

This section describes the project team responsible for laboratory analysis, data validation, and data management. Table A-1 provides contact information for project personnel.

3.1.1 Laboratory Services

Test America. Test America is located in Tacoma, Washington, is the primary contract laboratory and will perform analyses for the following analytes:

- Pentachlorophenol (PCP)
- Sulfide
- Major ions (calcium, magnesium, potassium, sodium, bromide, chloride, fluoride, ortho-phosphate, sulfate)
- Alkalinity (including total, carbonate, bicarbonate, and hydroxide alkalinity)
- Nitrate and Nitrite as N
- Organic carbon (total and dissolved)
- Metals (arsenic, iron, manganese)
- Dioxins/furans
- Grain-size
- pH (soil, sediment)

Christabel Escarez will serve as the Laboratory PM for Test America to oversee laboratory performance in accordance with this QAPP. Test America is accredited by the Washington State Department of Ecology.

Brooks Applied Labs. Brooks Applied Labs (Brooks) is located in Bothell, Washington, and will perform specialized analyses for the following data needs:

- Arsenic (total and dissolved arsenic in saline water)
- Arsenic (soil and sediment)
- Arsenic speciation (Arsenic III, Arsenic V, dimethylarsinic acid [DMA] and monomethylarsonic acid [MMA])
- Iron and Manganese (dissolved iron in saline water)
- Iron (soil and sediment)
- Iron speciation (iron II and iron III in dissolved in water samples only)
- Batch adsorption testing
- Sequential extraction testing

Elizabeth Madonick will serve as the Laboratory PM for Brooks to oversee laboratory performance in accordance with this QAPP. Brooks is accredited by the Washington State Department of Ecology.

Both laboratories and their respective PMs are responsible for the following:

- Assisting with selection of analytical methods that meet project needs
- Providing sampling containers and supplies
- Analyzing samples using methods selected for the project
- Carrying out appropriate QC procedures
- Documenting performance characteristics for methods use
- Providing information on how QC limits are set and how they are used for lab QC
- Reviewing data and verifying results
- Reporting results for samples and QC procedures
- Responding to questions regarding laboratory results during data validation process

A turn-around time of approximately 3 weeks is anticipated for all analyses from both laboratories.

3.1.2 Data Validation and Chemistry QA Manager

Cindy Ryals will serve as Chemical Quality Assurance (QA) Manager responsible for laboratory coordination and oversight in cooperation with the Senior PM, and will conduct the quality review of analytical data. The Chemistry QA Manager is generally responsible for the following:

- Make sure data package obtained from the laboratory is complete and provides the information needed to performed a QA and validation
- Perform quality review of data, and add qualifiers to the electronic data deliverable (EDDs) from the laboratory, as required during data review and validation
- Prepare a data validation summary, which will be included in the RI Report.

3.1.3 Senior Geochemist

Brad Bessinger (SSPA) will serve as the Senior Geochemist for the project, and will coordinate data use, data interpretation, and data needs for fate and transport modeling of Site-associated contaminants at the Site. The Senior Geochemist is generally responsible for the following:

- Ensure sampling and laboratory analyses meet data needs to perform fate and transport/geochemical modeling for the Site
- Advise on appropriate analytical methods to meet geochemical data quality objectives
- Assist in the development of specific procedures to be used for the batch adsorption and sequential extraction tests
- Perform geochemical modeling for the Site
- Confirm or revise existing conceptual site model for fate and transport of chemicals at the Site
- Oversee QA needs for modeling efforts and ensure a QA review is performed for the model

3.1.4 Data Manager

Cindy Ryals will serve as the Data Manger (DM) who will maintain the project database, and in cooperation with the PM will coordinate communications with the FD, SAC, Chemical QA Manager, and primary contract laboratories, as needed.

The Data Manager is generally responsible for the following:

- Tracking receipt of laboratory reports and EDDs
- Developing project database structure and integrity
- Managing receipt of data and data validation process
- Uploading data into project specific database
- Uploading data into the Washington Department of Ecology Environmental Information Management (EIM) database, as required by the Agency
- Performing or oversee data queries and reporting of data

3.2 Data Objectives

The overall quality objective for this investigation is to collect representative data of known, acceptable, and defensible quality that can be used to answer questions for the Site related to: the fate and transport of chemicals (indicator hazardous substances); the nature and extent of contamination; and potential risks to human health and the environment.

Specific quality objectives include Decision Quality Objectives (DQOs) and Measurement Quality Objectives (MQOs). The decision that the data need to support is determining whether Site concentrations meet the preliminary screening levels under MTCA for soil, sediment, groundwater, surface water, and porewater. Therefore, a sampling program of adequate spatial density and frequency has been developed to meet this DQO, as described in the SAP, and summarized in Tables A-6 through A-8.

As stated in the QAPP guidance (Ecology, 2004*), MQOs specify how good the data must be in order to meet the objectives of the project, and are based primarily on precision, sensitivity, and bias.* Each of these factors is defined and discussed briefly below.

- **Precision**. Precision is *a measure of the variability in the results of replicate measurements due to random error* (Ecology, 2004). Random error can occur as a result of both field and laboratory procedures, and is measured by a series of replicates (i.e., duplicates) collected and analyzed in both the field and laboratory, as discussed in Section 3.4. Field duplicates that will be collected to measure precision in sampling procedures are presented in Tables A-3 and A-4 and discussed in Section 3.4.2. Laboratory replicates used in analytical methods include standard QC spikes and replicates, and are discussed in Section 3.4.3.

  Field precision will be assessed by collecting at least one duplicate sample for every twenty field samples (i.e., 5 percent) of each matrix (i.e., water or solids). Field precision is determined by the relative percent difference (RPD) between a sample and it's duplicate. However, results from the analysis of a duplicate sample also test laboratory precision. Therefore, the RPD between the sample and the field replicate provides an indication of both the field and laboratory precision. The tolerance limit for percent differences between field duplicates will be ±50 percent for soil and ±35 percent for groundwater. If the RPDs exceed these limits, a replicate sample may be run to verify laboratory precision. If any RPD exceedance is linked to field sampling, the FD will recheck field sampling procedures and identify the problem. Resampling and analysis may be required.

  Laboratory precision can be measured through the evaluation of laboratory control samples/laboratory control sample duplicates (LCSs/ LCSDs). The laboratory will perform the analysis of one set of LCS/LCSD samples for every 20 samples. Laboratory precision will be evaluated by the RPD for each analyte between LCS/LCSD samples.

$$\text{RPD} = \frac{\text{ABS(R1-R2)}}{\text{(R1+R2)/2}} \times 100$$

Where:
ABS = absolute value
R1 = Sample result
R2 = Duplicate sample result.

The tolerance limit for percent differences between LCSD will be based on the laboratory accepted limits, which are established on a per-analyte basis and are evaluated annually. In general, $\underline{+}$20 percent for soil and groundwater samples is acceptable. If the precision values are outside of their accepted limits, the laboratory will recheck the calculations and/or identify the problem. Reanalysis may be required.

- **Sensitivity**. Sensitivity is the ability of a chemical *analysis to discern the difference between very small amounts of substance* (Ecology, 2004). Sensitivity requirements of the data are set by the target method reporting limits (MRLs) and method detection limits (MDLs) of the analytical methods (see Tables A-9 and A-10), and will be verified by the reported MRLs/MDLs in the laboratory data report. All MRLs will be lower than the respective screening criteria for the parameters of interest.

- **Bias/Accuracy**. Bias is *the difference between the population mean and the true value of the parameter being measured* (Ecology, 2004). Bias can be a result of sample design (intentional or unintentional), sample handling, laboratory instrument calibration, or contamination. Bias from sample handling will be minimized by following the recommended sample container preservation and holding times required for each analysis, which are shown in Table A-11 and A-12). Bias from laboratory methods will be minimized through instrument calibration and analysis of blanks, with results reported in the laboratory data report and subject to a data validation review.

  Accuracy may be expressed as a percentage of the true or reference value for reference material or as spike recovery from matrix spike/matrix spike duplicate (MS/MSD) samples. The RPD between the MS and MSD is used to evaluate laboratory precision. The following equations are used to express accuracy:

  - For reference materials: Percent of true value = (measured value/true value) x 100
  - For spiked samples:

    Percent recovery = ([SQ – NQ]/S) x 100

    Where:
    SQ = quantity of spike or surrogate found in sample
    NQ = quantity found in native (unspiked) sample
    S = quantity of spike or surrogate added to native sample

The performance of the method will be monitored using surrogate compounds or elements. Surrogate standards are added to all samples, method blanks, MS, and calibration standards. The laboratory establishes acceptable tolerance limits annually and will apply those limits when conducting their internal data review and qualification. Typically, recoveries between 70- 130 percent are acceptable.

- **Comparability**. Comparability is a qualitative parameter expressing the confidence with which one data set can be compared against another. Comparability will be assessed by using Ecology-accredited laboratories, which are running standard analytical methods for all analyses. Additionally, split samples (i.e., duplicates) of selected groundwater, surface water, and porewater samples will be submitted to both laboratories for analyses of dissolved arsenic, iron, and manganese to evaluate the comparability of methods used.

MQOs will be based on the standard accuracies prescribed for each analytical method used in the laboratory. The achievement of MQOs based on laboratory precision and bias of analytical methods will be determined through validation of laboratory QC data, as described in Section 3.6. For field-measured parameters, MQOs will be met by regular calibration of field instruments, which will be documented. MQOs for sensitivity include setting target MRLs at or below preliminary screening levels as much as practical, and meeting the MDLs required for geochemical fate and transport modeling, as discussed below.

3.3 Analytical Methods and Reporting Limits

The analytical methods and target detection and reporting limits to meet the MQOs are provided in Table A-9 for solid media, and as Table A-10 for aqueous media.

Chemical analysis of sediment, soil, groundwater, surface water, and porewater will be performed by Test America and Brooks in accordance with the methods listed in the tables. Samples will be analyzed in accordance with established methods with the exception of the batch adsorption and sequential extraction testing that will be performed in accordance with the procedures described in Attachment 2.

Groundwater, porewater, and surface water samples may create analytical interferences for trace metals analyses due to the potential high level of dissolved solids in the samples (e.g., brackish, saline). To achieve optimal detection limits and minimize accuracy bias for metals, the laboratories will select the appropriate analytical method with consultation with the Senior Geochemist and/or Chemistry QA Manager (e.g., reductive precipitation). To assist the laboratory in identifying brackish or saline water samples, the field measured SC for each water sample with conductance greater than 1,000 µS/cm will be noted on the COC form.

Both laboratories will submit electronic data packages for validation, including analytical results and QC results as discussed in Section 3.4 through 3.6.

3.4 Quality Control Procedures

QC procedures are in place for both field sampling procedures and laboratory analytical methods, as described below.

3.4.1 Field Quality Control

The following steps and activities will ensure QC to achieve data quality objectives during field activities, and will be overseen by the FD:

- Close adherence to the SAP, and documentation of any deviations from the SAP

- Maintain a detailed field notebook and field logs
- Collection of field duplicate samples at a rate of at least 5 percent (1 in 20) of total samples for all media sampled (groundwater from monitoring wells and temporary borings, porewater, surface water, soil, sediment), as indicated in Tables A-3 and A-4 for solids and aqueous samples, respectively.
- Collection of field blanks
- Collection of equipment rinsate blanks for soil and sediment
- Maintenance of a field temperature blank for each cooler
- Use of appropriate, lab-supplied sample containers and preservatives (see Tables A-11 and A-12)
- Adherence to appropriate holding times (see Tables A-11 and A-12)
- Daily calibration of field instruments, and documentation of standards used
- Completion and appropriate use of COC documentation
- Limited photographs of site and site sampling event
- Adherence to standard operating procedures in sample collection methods

3.4.2 Field QA/QC Samples

QC requirements will be instituted during field sampling, sample handling, sample transfer, and data management to ensure that the DQOs are met; detailed information on laboratory QA/QC procedures and reporting are provided below. If any field QC problems are encountered, they will be brought to the attention of the PM, RI Manager, SAC, or Chemistry QA Manager. Corrective actions, if appropriate, will be implemented to meet the project DQOs.

Field QC procedures for soil and groundwater samples are used to assess within-station variability (e.g., replicates), evaluate the effectiveness of sample homogenization and within-sample variability (e.g., duplicates), evaluate potential sources of sample cross-contamination (e.g., rinsate and trip blanks), or confirm proper shipping/storage conditions (e.g., temperature blanks). Duplicate samples will be collected at a 5 percent frequency during each soil, sediment, porewater, surface water and groundwater sampling event.

Field QA/QC samples will be used to evaluate the effectiveness of field decontamination and processing procedures. The following types of field QA/QC samples will be collected:

- **Duplicate samples**: Duplicate samples will be collected for each media (soil, sediment, groundwater, surface water, porewater and sediment). At least 5 percent (1/20) field duplicates will be collected and analyzed.
- **Trip blank samples**: Trip blanks will not be collected because volatile organic compounds are not a Site-associated contaminant.
- **Porewater method blank**: A method blank consisting of the water used to fill the passive porewater samples will be collected and analyzed during each event.
- **Rinsate and equipment blanks**: will not be collected because samples will be collected using either disposable or dedicated sample tubing, which prevents cross-contamination.

Field QA/QC samples will be blind-labeled and preserved as if they are typical samples. Field QA/QC samples will be clearly identified on the sample collection logs. Analytical results from the blanks facilitate crosschecking of the data. Detection of analytes in blanks may indicate possible contamination introduced by field or laboratory procedures. All field QA/QC samples will be documented in the field logbook and verified by the QA/QC manager or designee.

Field samples and QA/QC samples will be packaged, managed, and transferred to the primary contract laboratory according to the appropriate procedures and with sufficient time and coordination to meet analytical holding times

3.4.3 Laboratory QA/QC Procedures

Laboratory QA/QC will be maintained through the use of standard EPA methods and other accepted methods and standard analytical procedures for the target analytes. Analytical methods and QC measurements and criteria are based on the current SW-846 requirements, and EPA guidance. The Chemistry QA Manager will coordinate with the primary contract laboratory during performance of the chemical analyses and through delivery and validation of the laboratory results.

Laboratory QA/QC will be maintained through the use of standard EPA methods and other accepted methods and standard analytical procedures for the target analytes. Analytical methods and QC measurements and criteria are based on the current SW-846 requirements, and EPA guidance. The Chemistry QA Manager will coordinate with the primary contract laboratory during performance of the chemical analyses and through delivery and validation of the laboratory results (data validation is discussed in Section 3.6).

As noted for the field QC protocols, the field samples will be packaged, managed, and transferred to the primary contract laboratory according to the appropriate procedures and with sufficient time and coordination to meet analytical holding times, as generally summarized in Tables A-11 and A-12. Following the successful delivery of samples, the laboratory will follow the method-specific and other analytical and laboratory QC procedures and protocols that will be requested by the laboratory before selection.

- **Internal QC Samples:** Various QC samples are used to evaluate the precision, accuracy, representativeness, completeness, and comparability of the analytical results. Analytical methods specify routine procedures that are required to evaluate if data are within proper QC limits.
- **Method Reporting Limit (MRL) Check:** MRL checks, as applicable, are made to ensure that primary contract laboratory instrumentation can achieve the required MRLs. If the initial calibration curve contains a standard at the MRL, the laboratory may forgo analyzing a daily MRL check standard. If not, the laboratory will run an MRL check standard per analytical sequence. This sample will be after the instrument blank check sample and before analyzing samples from this group. The instrument must be able to achieve the requested MRLs without interference. If the instrument cannot achieve these levels, the samples must be analyzed on a different instrument that is able to achieve the required MRLs for this project.
- **Method Blanks:** Introduction of chemicals during sampling and analytical activities will be assessed by the analysis of blanks. Method blanks, as applicable, are used to check for laboratory contamination and instrument bias. Laboratory method blanks will be analyzed at a minimum frequency of 5 percent for all chemical parameter groups.
- **Laboratory Duplicates:** Sample analytical variability and laboratory precision and accuracy will be determined by the analysis of primary contract laboratory-generated sample splits at a frequency of 5 percent or at least once per batch. The duplicate results will be used for determination of RPD. Variability in organic compound analysis will be evaluated by analysis of MS and MSD samples. Duplicate samples for inorganic analysis will be analyzed at a

frequency of approximately 5 percent. Conventional parameters also will be analyzed in duplicate at a frequency of 5 percent. Precision and accuracy information will be generated for dioxins and furans using the ongoing precision and recovery samples run per the method.

- **Surrogate Spikes:** Surrogate compound analysis for organic analyses also will follow the guidance in the primary contract laboratory's standard operating procedures (SOPs) and will evaluate the laboratory's ability to recover the analytes of interest. If data fall outside the established limits for the surrogates, a corrective action must be implemented, and the Chemistry QA Manager will be notified. The corrective action can range from re-analysis to re-extraction/re-analysis of the sample. If after these actions the surrogates are still outside of established limits, it will be considered matrix effects and narrated in the final data validation report. Qualification of data will occur when organic compound surrogate recoveries fall outside acceptance limits and will be noted in the laboratory case narrative.
- **Laboratory Control Samples:** LCS, as applicable, are used to monitor the primary contract laboratory's day-to-day performance of routine analytical methods independent of matrix effects. In this sampling effort an LCS/LCSD pair will be analyzed at a minimum frequency of 5 percentFor inorganic samples, a standard reference material (SRM) also will be run. If the laboratory runs a blank spike and blank spike duplicate for organics, then it also will run an appropriate SRM.
- **Matrix Spike and Matrix Spike Duplicates:** MS and MSD samples, as applicable, provide information to assess precision and accuracy. The primary contract laboratory will follow EPA guidance for MS/MSD sample analysis. Percent recoveries, including RPD, will be assessed for organic compounds from the MS/MSD and for inorganic compounds from the MS. MS/MSD recovery will be measured at a minimum frequency of 5 percent

The laboratories will comply with all standard operating procedures, analytical methods, and their own QA plans except as noted by the modified analytical methods described in Attachment 2.

Results of QC samples from each group will be reviewed by the analyst immediately after a sample group has been analyzed. QC sample results will then be evaluated to determine if control limits have been exceeded. If control limits are grossly exceeded in the sample group, the QA manager will be contacted immediately and corrective action (e.g., method modifications followed by reprocessing the affected samples) will be initiated prior to processing a subsequent group of samples.

3.4.4 Laboratory Sample Processing/Storage

Field soil and sediment samples that will be analyzed for arsenic speciation, batch adsorption and sequential extraction testing will be collected, handled and processed following the anoxic procedure described in Section 2.4.2.2 and transported to Brooks on ice.

Brooks will process soil and sediment samples in an anoxic nitrogen fill glove box. Using the following process:

1. Remove sample from the sealed anoxic Mylar bag (nitrogen or argon filled bag)
2. Remove sample from core tube (if applicable)
3. Place the entire sample in laboratory cleaned stainless steel bowl and homogenize with stainless steel spoon (or equivalent)

4. Place homogenized sample into appropriate sample jars for analyses and to create laboratory QA/QC samples.
5. Send subsample(s) in appropriate laboratory provided containers to Test America for testing of additional parameters (e.g., grainsize). Maintaining anoxic conditions is not needed for sample transfers. Samples will be maintained and shipped under COC procedures and will maintain GSI field sample ID numbers.

The laboratories will maintain a thorough sample inventory (written and/or computerized). Samples will be tracked by GSI sample number, laboratory sample number, site name, date of sample analysis, parameters, contaminants found, sample matrices, and remaining sample volume.

Selected soil and sediment samples will be archived by the contract analytical laboratories. The laboratories will provide secured archival storage of samples with controlled access. Samples will be frozen and maintained under COC procedures. Samples may be archived for up to a 1 year period.

3.5 Laboratory Data Reporting Requirements

Analytical data records will be retained by the laboratory and stored electronically in the GSI project file and project database. Because data are a direct electronic output from the Laboratory Information Management System, hard-copy data packages will not be requested or stored for this project. The analytical laboratory will be required, where applicable, to provide the following:

A. **General Project Information:**
   1. Site Name
   2. Laboratory Coordinator's name
   3. GSI Project Manager and Project Number

B. **Case Narrative**

   In the form of a cover letter, this summary will discuss problems, if any, encountered during any aspect of analysis. This summary should discuss, but is not limited to, QC, sample shipment, sample storage, and analytical difficulties. Any problems encountered (actual or perceived) and their resolutions will be documented in as much detail as appropriate.

C. **COC Records**

   Legible copies of COC forms will be provided as part of the data package. Forms will include the time of receipt and condition of each sample received by the laboratory. Additional internal tracking of sample custody by the laboratory will also be documented on a sample receipt form. The form must include all sample shipping container temperatures measured at the time of sample receipt.

D. **Sample Results**
   1. Field sample ID and corresponding laboratory sample number
   2. Date and time sample received
   3. Sample matrix (e.g., groundwater, soil, sediment, porewater)
   4. Analytical Method – MDLs and MRLs (including sample – specific factors such as dilution, total solids, etc.)
   5. Sample preparation

6. Extraction date and time
7. Instrument used for analysis
8. Date and time of analyses
9. Analytical results with reporting units
10. Data qualifiers and definitions

E. QA/QC Results

The results of laboratory QA/QC procedures will be summarized in the data package. QA/QC sample analysis will be documented with the same information required for sample results (see above). No recovery or blank corrections will be made by the laboratory. The required summaries are listed below, though additional information may be requested:

1. Laboratory QA Manager sign-off sheet
2. MS and MSD data
3. Method blank analyses
4. Surrogate spike recoveries
5. Replicate results
6. Internal standard recoveries
7. LCS results

3.6 Data Validation and Usability

Data validation or data review will be performed using U.S. Environmental Protection Agency National Functional Guidelines data validation procedures (EPA, 2002, 2008, 2010b), project-specific DQOs, analytical method criteria, and the laboratories' internal performance standards based on their standard operating procedures.

Data will be reviewed by the laboratory, as data are generated. The Laboratory PM or designee will be responsible for ensuring that the data generated meet minimum QA/QC requirements, and that instruments are operating under acceptable conditions during generation of data. DQOs will also be assessed by comparing the results of QC measurements with pre-established criteria, as a measure of data acceptability. The Laboratory PM will ensure that appropriate QC procedures have been followed at the laboratory, and that data are correct and complete.

Analytes detected at concentrations between the MRL and the MDL will be reported with a J qualifier to indicate that the value is an estimate (i.e., the analyte concentration is below the calibration range). J-qualified data are considered valid when completeness is calculated. Undetected data will be reported at the MRL. The MRL will be adjusted by the laboratory as necessary to reflect sample dilution or matrix interference.

Data validation will be performed by GSI. The Chemistry QA Manager will coordinate with the primary contract laboratory during sample analysis and delivery of analytical results. The Chemistry QA Manager will perform data validation of the reported results to document the performance of the laboratory analyses and to determine the usability of the data toward meeting project objectives. The Chemistry QA Manager will review data packages for completeness immediately upon receipt from the laboratory to ensure that data and QA/QC information requested are present and will conduct data validation on the data packages received from the laboratory. The data validation (Level 2 plus) generally will address the following components:

- QC analysis frequency
- Analysis holding times
- MDLs
- MRLs
- COC documentation and sample receipt condition
- Field duplicate results
- Porewater method blank results
- Surrogate recoveries
- LCS/LCSD recoveries
- MS/MSD recoveries
- MS/MSD RPDs

The Chemistry QA Manager will review the field notebooks, laboratory reports, and the data validation report to determine if the data quality objectives have been met. Instances where the data quality objectives were not met will be documented. The usability of the data will depend on the magnitude of the data quality objective exceedance. Data that has been rejected will be flagged as “R” and will not be included in the database. The QA Officer will determine if rejected data trigger additional sample collection.

Data validation review and findings will be documented and summarized in the RI report.

3.7 Corrective Actions

Upon receipt of data, the Chemistry QA Manager will evaluate field and laboratory precision by the RPDs between the field duplicate and sample data. Non-conforming items and activities are those which do not meet the project requirements or approved work procedures.

Corrective actions that will be taken as a result of non-conformance during field activities will be situation-dependent. If possible, the FD will identify any action that can be taken in the field to correct any non-conformance observed during field activities. Corrective action may consist of a modification of methods or a re-collection of samples. If implementation of corrective action in the field is not possible, the non-conformance and its potential impact on data quality will be discussed in the data quality section of the RI/FS Report.

The laboratory will be contacted regarding any deviations from the QAPP, will be asked to provide written justification for such deviations, and in some instances, will be asked to reanalyze the sample(s) in question. All corrective actions must be documented. The person identifying the nonconformance will be responsible for its documentation.

Documentation will be made available to project, laboratory, and/or QA management. Appropriate personnel will be notified by the management of any significant nonconformance detected by the project, laboratory, or QA staff. Implementation of corrective actions will be the responsibility of the FD or the Chemistry QA Manager.

3.8 Data and Records Management

3.8.1 Field Documentation

A field notebook will be used to record activities during the sampling event, noting any discrepancies from the FSP. The FD will maintain the notebook. The following information will be recorded on a daily basis in either the notebook or record-keeping forms to be included with the notebook:

- Date, general description of site conditions and weather
- Documentation of sampling personnel on site, including subcontractors
- Documentation of site safety considerations and health and safety briefings
- Time, location, medium, and sample ID of each sample collected
- Documentation of instrument calibration
- Documentation of field parameters collected
- Deviations from SAP or other problems in the field
- Visitors to the Site relating to the sampling event
- Communications made with outside parties relating to the sampling event
- Time of day that work began and stopped

3.8.2 Analytical Data Management

Analytical data will be received as an EDD from the laboratory and maintained by the Data Manager as part of project-specific database. Data will also be uploaded to the Ecology EIM database, which is accessible online.

All hard copies of field forms or log book pages scanned as PDFs and stored electronically in the project files. Well installation logs and boring logs will be transcribed from hand-written field notes into formal electronic logs. Field forms, field-prepared boring logs, and graphic logs will be included in the RI/FS report appendices.

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Tables

Table A-1. Project Contact List

Name	Project Role	Company	Email	Direct Phone	Cell Phone
Common Consultants					
Rod Struck	Senior Project Manager (PM)	GSI	Rstruck@gsiws.com	503-200-8510	503-536-5810
Erin Carroll Hughes	Remedial Investigation Manager (RI Manager)	GSI	EcHughes@gsiws.com	503-200-8528	503-927-4553
Peter Pellegrin	Field Director (FD)	GSI	PPellegrin@gsiws.com	971-200-8514	503-729-9098
Renee Fowler	Sampling and Analysis Coordinator (SAC)	GSI	RFowler@gsiws.com	503-200-8512	503-318-4521
Steven Kuhlmeier	Field Support	GSI	SKuhlmeier@gsiws.com	971-200-8529	208-631-4887
Jacob Gorski	Field Support	GSI	Jgorski@gsiws.com	971-200-8516	925-389-2281
Cindy Ryals	Chemical QA Manager and Data Manager (DM)	GSI	Cryals@gsiws.com	971-200-8531	503-799-7326
Brad Bessinger	Senior Geochemist	SSPA	bbessinger@sspa.com	360-566-7119	360-566-7119
Sub-Consultants					
Darryl Metzger	Drilling Project Manager	Steadfast Services Northwest	dmetzger@steadfast-services.com	971-645-9242	
Christabel Escarez	Analytical Project Manager	Test America	Christabel.Escarez@testamericainc.com	253-248-4975	
Elizabeth Madonik	Analytical Project Manager	Brooks Applied Labs	elizabeth@brooksapplied.com	206-632-6206, ext. 141	
Ben Foster	Private Utility Locator	Applied Professional Services, Inc.	benf@apslocates.com	425-864-4443	
Mike McEvilly	Surveyor	Sitts & Hill Engineers, Inc.	MikeMcEvilly@sitts-hill-engineers.com	253-474-9449	
--	Lab Courier Service	Thunderdog Delivery	info@thunderdogdelivery.com	866-610-9183	
Client Contacts					
Rob Healy	Project Manager	Port of Tacoma	rhealy@portoftacoma.com	253-428-8643	503-970-6855
Mark Larsen	Project Manager	Anchor QEA (Portac Consultant)	mlarsen@anchorqea.com	206-903-3359	206-310-2263
Nik Bacher	Managing Geologist	Anchor QEA (Portac Consultant)	nbacher@anchorqea.com	206-287-9130	206-351-0951
Patrick Ryan	Attorney	Perkins Coie LLP (Portac Rep)	PRyan@perkinscoie.com	206-359-8662	
Ecology Contacts					
Andrew Smith	Site Manager	Ecology	ansm461@ECY.WA.GOV	360-407-6316	
Jason Landskron	Cleanup PM/Geochemist	Ecology	jala461@ECY.WA.GOV	360-407-6388	

Table A-2. Proposed Monitoring Well Locations

Well Identification	Location	Latitude (WGS84)	Longitude (WGS84)	Sample Method	Sample Type	Number of Samples	Sample Interval [1]
MW-5R	Sawmill	47.24928	-122.37024	Direct Push or Split Spoon	Discrete	1 for Analysis; 4 to 6 for Archival	Sample will be collected from approximately 1 to 2 feet below the water table and submitted for analysis; additional samples from the unsaturated zone, the capillary fringe, and saturated zone will be collected for archival at approximate three foot intervals.
MW-7	Log Yard	47.25319	-122.37227	Direct Push or Split Spoon	Discrete	1 for Analysis; 4 to 6 for Archival	Sample will be collected from approximately 1 to 2 feet below the water table and submitted for analysis; additional samples from the unsaturated zone, the capillary fringe, and saturated zone will be collected for archival at approximate three foot intervals.
MW-8	Log Yard	47.25320	-122.36719	Direct Push or Split Spoon	Discrete	1 for Analysis; 4 to 6 for Archival	Sample will be collected from approximately 1 to 2 feet below the water table and submitted for analysis; additional samples from the unsaturated zone, the capillary fringe, and saturated zone will be collected for archival at approximate three foot intervals.
MW-9	Log Yard	47.25261	-122.37225	Direct Push or Split Spoon	Discrete	1 for Analysis; 4 to 6 for Archival	Sample will be collected from approximately 1 to 2 feet below the water table and submitted for analysis; additional samples from the unsaturated zone, the capillary fringe, and saturated zone will be collected for archival at approximate three foot intervals.
MW-10	Log Yard	47.25262	-122.37136	Direct Push or Split Spoon	Discrete	1 for Analysis; 4 to 6 for Archival	Sample will be collected from approximately 1 to 2 feet below the water table and submitted for analysis; additional samples from the unsaturated zone, the capillary fringe, and saturated zone will be collected for archival at approximate three foot intervals.
MW-11	Log Yard	47.25263	-122.36920	Direct Push or Split Spoon	Discrete	1 for Analysis; 4 to 6 for Archival	Sample will be collected from approximately 1 to 2 feet below the water table and submitted for analysis; additional samples from the unsaturated zone, the capillary fringe, and saturated zone will be collected for archival at approximate three foot intervals.
MW-12	Log Yard	47.25206	-122.37224	Direct Push or Split Spoon	Discrete	1 for Analysis; 4 to 6 for Archival	Sample will be collected from approximately 1 to 2 feet below the water table and submitted for analysis; additional samples from the unsaturated zone, the capillary fringe, and saturated zone will be collected for archival at approximate three foot intervals.
MW-13	Log Yard	47.25207	-122.37135	Direct Push or Split Spoon	Discrete	1 for Analysis; 4 to 6 for Archival	Sample will be collected from approximately 1 to 2 feet below the water table and submitted for analysis; additional samples from the unsaturated zone, the capillary fringe, and saturated zone will be collected for archival at approximate three foot intervals.

Table A-2. Proposed Monitoring Well Locations

Notes:
bgs = below ground surface
ft = feet
MW = monitoring well drilling
PVC = polychlorinated vinyl
Sch = schedule
WGS84 = World Geodetic System 1984
1 Selection of sampling depth intervals are discussed in the SAP.

Table A-3. Analytical Schedule for Soil and Sediment

Site	Station Type	Station ID	Sample ID[1,2,3]	Sample Depth	Number of Samples	Within Nearshore Study Area?	Standard Analytical Suite					Add-Ons		Nearshore Study Area Geochemical					Archived Only[4]
							Arsenic	Iron	Total Organic Carbon (TOC)	Total Solids	Frozen Archival	Pentachlorophenol (PCP) and pH	Dioxins/Furans	Sulfide	Grain-Size	Sequential Extractions	Batch Adsorption	Arsenic Speciation - As(III)/As(V)	
Soil Testing																			
Log Yard	New Monitoring Wells	MW-7	MWS007-x_x	See Figure 4[5]	6	yes	1	1	1	1	1			1	1	1	1	1	5
		MW-8	MWS008-x_x	See Figure 4[5]	4		1	1	1	1	1								3
		MW-9	MWS009-x_x	See Figure 4[5]	6	yes	1	1	1	1	1			1	1	1	1	1	5
		MW-10	MWS010-x_x	See Figure 4[5]	4	yes	1	1	1	1	1			1	1	1	1	1	3
		MW-11	MWS011-x_x	See Figure 4[5]	4		1	1	1	1	1								3
		MW-12	MWS012-x_x	See Figure 4[5]	6	yes	1	1	1	1	1			1	1	1	1	1	5
		MW-13	MWS013-x_x	See Figure 4[5]	4	yes	1	1	1	1	1			1	1	1	1	1	3
	Temporary Borings	TB-1	TBS001-x_x	See Figure 4[5]	4		1	1	1	1	1								3
		TB-2	TBS002-x_x	See Figure 4[5]	4		1	1	1	1	1								3
		TB-3	TBS003-x_x	See Figure 4[5]	4	yes	1	1	1	1	1			1	1	1	1	1	3
		TB-4	TBS004-x_x	See Figure 4[5]	4		1	1	1	1	1								3
		TB-5	TBS005-x_x	See Figure 4[5]	4	yes	1	1	1	1	1			1	1	1	1	1	3
		TB-6	TBS006-x_x	See Figure 4[5]	4		1	1	1	1	1								3
		TB-7	TBS007-x_x	See Figure 4[5]	4	yes	1	1	1	1	1			1	1	1	1	1	3
		TB-8	TBS008-x_x	See Figure 4[5]	4		1	1	1	1	1								3
Sawmill	New Monitoring Well	MW-5R[6]	MW005R-x_x	See Figure 4[5]	6		1	1	1	1	1	1	1						5
	Temporary Borings	TB-9	TBS009-x_x	Artificial Fill	2	yes	1	1	1	1	1	1			1				1
			TBS009-x_x	Channel Bottom	2	yes	1	1	1	1	1	1			1				1
			TBS009-x_x	Native Sediments	2	yes	1	1	1	1	1	1			1				1
	Test Pit	TP-1	TPS001-x_x	Surface Soil[7]	1	yes	1	1	1	1	1	1	1						0
		TP-1	TPS001-x_x	Saturated Zone[8]	1	yes	1	1	1	1	1	1							0
		TP-2	TPS002-x_x	Surface Soil[7]	1	yes	1	1	1	1	1	1	1						0
		TP-2	TPS002-x_x	Saturated Zone[8]	1	yes	1	1	1	1	1	1							0
QA/QC	Field Duplicate	--	ccc5zz-x_x	--	2	--	2	2	2	2	2	1	1	1	1	1	1	1	--

Table A-3. Analytical Schedule for Soil and Sediment

Site	Station Type	Station ID	Sample ID[1,2,3]	Sample Depth	Number of Samples	Within Nearshore Study Area?	Standard Analytical Suite					Add-Ons		Nearshore Study Area Geochemical					Archived Only[4]
							Arsenic	Iron	Total Organic Carbon (TOC)	Total Solids	Frozen Archival	Pentachlorophenol (PCP) and pH	Dioxins/Furans	Sulfide	Grain-Size	Sequential Extractions	Batch Adsorption	Arsenic Speciation - As(III)/As(V)	
Sediment Testing																			
Log Yard	Wapato Creek Transect	WCT-1A	WCTSD001A-x_x	0-10 cm, 40-50 cm	2	yes	2	2	2	2	2			2	2	*	*	*	0
		WCT-1B	WCTSD001B-x_x	0-10 cm, 40-50 cm	2	yes	2	2	2	2	2			2	2	*	*	*	0
		WCT-2A	WCTSD002A-x_x	0-10 cm, 40-50 cm	2	yes	2	2	2	2	2			2	2	*	*	*	0
		WCT-2B	WCTSD002B-x_x	0-10 cm, 40-50 cm	2	yes	2	2	2	2	2			2	2	*	*	*	0
		WCT-3A	WCTSD003A-x_x	0-10 cm, 40-50 cm	2	yes	2	2	2	2	2			2	2	*	*	*	0
		WCT-3B	WCTSD003B-x_x	0-10 cm, 40-50 cm	2	yes	2	2	2	2	2			2	2	*	*	*	0
Sawmill	Wapato Creek Transect	WCT-4A	WCTSD004A-x_x	0-10 cm, 40-50 cm	2	yes	2	2	2	2	2	2		2	2				0
		WCT-4B	WCTSD004B-x_x	0-10 cm, 40-50 cm	2	yes	2	2	2	2	2	2		2	2				0
QA/QC	Field Duplicate	--	ccc5zz-x_x	--	1	--	1	1	1	1	1	0		1	1	1	1	1	--

Notes:

cm = centimeters

* = Four sediment samples will be selected for analysis based on initial sediment results.

1 x_x = sample interval (i.e., sample interval of 0-1 ft bgs would be 0_1).

2 ccc = sample type abbrievation associated with field duplicate or equipment rinsate blank.

3 zz = station ID number associated with field duplicate or equipment rinsate blank.

4 Count includes samples that are only archived. Analyzed samples that will also be archived are not included in this count

5 Soil will be sampled as outlined in Figure 4 and the SAP. Sample collected 1-2 feet below groundwater table will be analyzed as well as archived. Samples from other intervals will be archived.

6 New monitoring well MW-5R is a replacement well for MW-5, which will be abandoned.

7 Soil sample will be collected approximately 1.5 to 2.5 feet bgs, as outlined in the SAP.

8 Soil sample will be collected 0.5 to 1.5 feet below groundwater table, as outlined in the SAP.

Table A-4. Groundwater Field Parameter Stabilization Goals

Parameter	Units	Stabilization Goals[1]
pH	standard units	± 0.1
Temperature	°C	± 0.2
Specific Conductivity	µmhos/cm	± 5% (SC ≤ 100) ± 3% (SC > 100)
Dissolved Oxygen	mg/L	± 0.3
ORP/Eh	mV	± 10 [2]
Turbidity	NTU	10 % for three consecutive values greater than 5 NTUs; if three consecutive values are less than 5 NTU, consider the values as stabilized. [2]

Notes

1 Stability criteria obtained from USGS National Field Manual for the Collection of Water Quality Data: Chapter A4, Collection of Water Samples (USGS, 2006).

2 Stability criteria from the US Environmental Protection Agency (EPA) Region 1. Standard Operating Procedure for Low-Stress (low-flow) Purging and Sampling from Monitoring Wells (EPA, 2010). Available from http://www.epa.gov/region1/lab/qa/pdfs/EQASOP-GW001.pdf

ORP/Eh = oxidation reduction potential

Table A-5. Analytical Schedule for Surface Water, Porewater, and Groundwater

							Standard Analytical Suite							Add-Ons	Nearshore Study Area Geochemical					
Site	Station Type	Station ID	Sample ID[1,2,3,4]	Sample Depth	Number of Samples per Event	Within Nearshore Study Area?	Water Field Parameters[5]	Headspace Monitoring (Methane)	Manual Water Level	Arsenic (total and dissolved)	Organic Carbon (total and dissolved)	Sulfide (dissolved)	Iron and Manganese (dissolved)	Pentachlorophenol (PCP)	Transducer Water Levels	Major Cations/Anions (dissolved)[6]	Alkalinity (dissolved)[7]	Nitrate and Nitrite(dissolved)	Iron Speciation - Fe(II)/Fe(III) (dissolved)	Arsenic Speciation - As(III)/As(V) (dissolved)[8]
Groundwater Testing																				
Log Yard	New Monitoring Well	MW-7	MW007-En	Screened Interval	1	yes	1	1	1	1	1	1	1		1	1	1	1	1	>
		MW-8	MW008-En	Screened Interval	1		1	1	1	1	1	1	1							
		MW-9	MW009-En	Screened Interval	1	yes	1	1	1	1	1	1	1		1	1	1	1	1	>
		MW-10	MW010-En	Screened Interval	1	yes	1	1	1	1	1	1	1		1	1	1	1	1	>
		MW-11	MW011-En	Screened Interval	1		1	1	1	1	1	1	1		1					
		MW-12	MW012-En	Screened Interval	1	yes	1	1	1	1	1	1	1		1	1	1	1	1	>
		MW-13	MW013-En	Screened Interval	1	yes	1	1	1	1	1	1	1		1	1	1	1	1	>
	Existing Monitoring Well	B-1R	B001R-En	Screened Interval	1	yes	1	1	1	1	1	1	1		1	1	1	1	1	>
		B-3R	B003R-En	Screened Interval	1		1	1	1	1	1	1	1							
		B-6R	B006R-En	Screened Interval	1		1	1	1	1	1	1	1		1					
		HC-1[9]	HC001-En	Screened Interval	1		1	1	1	1	1	1	1							
		HC-2[9]	HC002-En	Screened Interval	1	yes	1	1	1	1	1	1	1			1	1	1	1	>
	Temporary Boring (Event 1 Only)	TB-1	TBGW001-En	Saturated Zone	1		1	1	1	1	1	1	1							
		TB-2	TBGW002-En	Saturated Zone	1		1	1	1	1	1	1	1							
		TB-3	TBGW003-En	Saturated Zone	1	yes	1	1	1	1	1	1	1			1	1	1	1	>
		TB-4	TBGW004-En	Saturated Zone	1		1	1	1	1	1	1	1							
		TB-5	TBGW005-En	Saturated Zone	1	yes	1	1	1	1	1	1	1			1	1	1	1	>
		TB-6	TBGW006-En	Saturated Zone	1		1	1	1	1	1	1	1							
		TB-7	TBGW007-En	Saturated Zone	1	yes	1	1	1	1	1	1	1			1	1	1	1	>
		TB-8	TBGW008-En	Saturated Zone	1		1	1	1	1	1	1	1							

Table A-5. Analytical Schedule for Surface Water, Porewater, and Groundwater

Site	Station Type	Station ID	Sample ID[1,2,3,4]	Sample Depth	Number of Samples per Event	Within Nearshore Study Area?	Standard Analytical Suite							Add-Ons	Nearshore Study Area Geochemical					
							Water Field Parameters[5]	Headspace Monitoring (Methane)	Manual Water Level	Arsenic (total and dissolved)	Organic Carbon (total and dissolved)	Sulfide (dissolved)	Iron and Manganese (dissolved)	Pentachlorophenol (PCP)	Transducer Water Levels	Major Cations/Anions (dissolved)[6]	Alkalinity (dissolved)[7]	Nitrate and Nitrite(dissolved)	Iron Speciation - Fe(II)/Fe(III) (dissolved)	Arsenic Speciation - As(III)/As(V) (dissolved)[8]
Groundwater Testing																				
Sawmill	New Monitoring Well	MW-5R[10]	MW005R-En	Screened Interval	1		1	1	1	1	1	1	1	1						
	Existing Monitoring Well	MW-1	MW001-En	Screened Interval	1	yes	1	1	1	1	1	1	1	1	1	1	1	1	1	>
		MW-2R	MW002R-En	Screened Interval	1	yes	1	1	1	1	1	1	1	1	1	1	1	1	1	>
		MW-3	MW003-En	Screened Interval	1	yes	1	1	1	1	1	1	1	1	1	1	1	1	1	>
		MW-4	MW004-En	Screened Interval	1	yes	1	1	1	1	1	1	1	1	1	1	1	1	1	>
		MW-6R	MW006R-En	Screened Interval	1		1	1	1	1	1	1	1	1						
		B-5R	B005R-En	Screened Interval	1	yes	1	1	1	1	1	1	1	1	1	1	1	1	1	>
	Temporary Boring	TB-9	TBGW009-En	Saturated Zone	1	yes	1	1	1	1	1	1	1	1						
QA/QC	Field Duplicate, Monitoring Wells	--	ccc5zz-En	--	1	--				1	1	1	1	1		1	1	1	1	1
	Field Duplicate, Temporary Boring (Event 1 Only)	--	ccc5zz-En	--	1	--				1	1	1	1							
Porewater Testing																				
Log Yard	Wapato Creek Transect	WCT-1A	WCTPW001A-x_x-En	0-10 & 40-50 cm bml	2	yes	2	2	2	2	2	2	2			2	2	2	2	>
		WCT-1B	WCTPW001B-x_x-En	0-10 & 40-50 cm bml	2	yes	2	2	2	2	2	2	2			2	2	2	2	>
		WCT-2A	WCTPW002A-x_x-En	0-10 & 40-50 cm bml	2	yes	2	2	2	2	2	2	2			2	2	2	2	>
		WCT-2B	WCTPW002B-x_x-En	0-10 & 40-50 cm bml	2	yes	2	2	2	2	2	2	2			2	2	2	2	>
		WCT-3A	WCTPW003A-x_x-En	0-10 & 40-50 cm bml	2	yes	2	2	2	2	2	2	2			2	2	2	2	>
		WCT-3B	WCTPW003B-x_x-En	0-10 & 40-50 cm bml	2	yes	2	2	2	2	2	2	2			2	2	2	2	>
Sawmill	Wapato Creek Transect	WCT-4A	WCTPW004A-x_x-En	0-10 & 40-50 cm bml	2	yes	2	2	2	2	2	2	2	2		2	2	2	2	>
		WCT-4B	WCTPW004B-x_x-En	0-10 & 40-50 cm bml	2	yes	2	2	2	2	2	2	2	2		2	2	2	2	>
QA/QC	Field Duplicate	--	WCTPW5zz-x_x-En	--	1	--				1	1	1	1	1		1	1	1	1	1
	Method Blank	--	WCTPW5MB-En	--	1	--				1	1	1	1	1		1	1	1	1	1

Table A-5. Analytical Schedule for Surface Water, Porewater, and Groundwater

Site	Station Type	Station ID	Sample ID[1,2,3,4]	Sample Depth	Number of Samples per Event	Within Nearshore Study Area?	Standard Analytical Suite							Add-Ons	Nearshore Study Area Geochemical					
							Water Field Parameters[5]	Headspace Monitoring (Methane)	Manual Water Level	Arsenic (total and dissolved)	Organic Carbon (total and dissolved)	Sulfide (dissolved)	Iron and Manganese (dissolved)	Pentachlorophenol (PCP)	Transducer Water Levels	Major Cations/Anions (dissolved)[6]	Alkalinity (dissolved)[7]	Nitrate and Nitrite(dissolved)	Iron Speciation - Fe(II)/Fe(III) (dissolved)	Arsenic Speciation - As(III)/As(V) (dissolved)[8]
Surface Water Testing																				
Log Yard	Wapato Creek Transect	WCT-1B	WCTSW001B-Qn-yyyy	10 cm aml	1	yes	1	1	1	1	1	1	1			1	1	1	1	>
		WCT-2B	WCTSW002B-Qn-yyyy	10 cm aml	1	yes	1	1	1	1	1	1	1			1	1	1	1	>
		WCT-3B	WCTSW003B-Qn-yyyy	10 cm aml	1	yes	1	1	1	1	1	1	1			1	1	1	1	>
Sawmill	Wapato Creek Transect	WCT-4B	WCTSW004B-Qn-yyyy	10 cm aml	1	yes	1	1	1	1	1	1	1	1		1	1	1	1	>
Blair Waterway	Blair Waterway Background	BWB-1	BWSW001-Qn-yyyy	2 to 3 feet below water surface	1	yes	1	1	1	1	1	1	1			1	1	1	1	>
Upstream	Wapato Creek Background	USB-1	USSW001-Qn-yyyy	10 cm aml	1	yes	1	1	1	1	1	1	1			1	1	1	1	>
QA/QC	Field Duplicate	--	ccc5zz-Qn-yyyy	--	1	--				1	1	1	1	1		1	1	1	1	1

Notes:

\> = See footnote 6 below

cm aml = centimeters above mudline

cm bml = centimeters below mudline

1 x_x = sample interval (i.e., sample interval of 0-10 cm bml would be 0_10).

2 En = sampling event number (E1 through E4)

3 ccc = sample type abbreviation associated with field duplicate or equipment rinsate blank.

4 zz = station ID number associated with field duplicate or equipment rinsate blank.

5 Field parameters are temperature, pH, specific conductance (SC), oxidation reduction potential (ORP), dissolved oxygen (DO), and turbidity

6 Major Cations include calcium, magnesium, potassium, and sodium. Major anions include sulfate, chloride, bromide, fluoride, and ortho-phosphate.

7 Alkalinity includes total, carbonate as $CaCO_3$, bicarbonate as $CaCO_3$, and hydroxide as $CaCO_3$.

8 Arsenic speciation testing will be performed on water samples with arsenic concentrations greater than (>) 36 µg/L.

9 Wells HC-1 and HC-2 historically contained perched groundwater but are anticipated to be dry with the presence of the cap. The wells will be checked for the presence of perched water and if recoverable quantities of groundwater are encountered, then the well(s) will be sampled for the analytes listed above. If recoverable quantities of groundwater are not encountered, then the wells will not be sampled.

10 New monitoring well MW-5R is a replacement well for MW-5, which will be abandoned.

Table A-6. Temporary Boring and Test Pit Locations

Station ID	Location	Latitude (WGS84)	Longitude (WGS84)	Sample Method	Sample Type	Number of Samples	Sample Interval [1]
Temporary Borings							
TB-1	Log Yard	47.25361	-122.37137	Direct Push	Discrete	1 for Analysis; 4 to 6 for Archival	Sample will be collected from approximately 1 to 2 feet below the water table and submitted for analysis; additional samples from the unsaturated zone, the capillary fringe, and saturated zone will be collected for archival at approximate three foot intervals.
TB-2	Log Yard	47.25360	-122.36921	Direct Push	Discrete	1 for Analysis; 4 to 6 for Archival	Sample will be collected from approximately 1 to 2 feet below the water table and submitted for analysis; additional samples from the unsaturated zone, the capillary fringe, and saturated zone will be collected for archival at approximate three foot intervals.
TB-3	Log Yard	47.25319	-122.37199	Direct Push	Discrete	1 for Analysis; 4 to 6 for Archival	Sample will be collected from approximately 1 to 2 feet below the water table and submitted for analysis; additional samples from the unsaturated zone, the capillary fringe, and saturated zone will be collected for archival at approximate three foot intervals.
TB-4	Log Yard	47.25320	-122.36921	Direct Push	Discrete	1 for Analysis; 4 to 6 for Archival	Sample will be collected from approximately 1 to 2 feet below the water table and submitted for analysis; additional samples from the unsaturated zone, the capillary fringe, and saturated zone will be collected for archival at approximate three foot intervals.
TB-5	Log Yard	47.25262	-122.37196	Direct Push	Discrete	1 for Analysis; 4 to 6 for Archival	Sample will be collected from approximately 1 to 2 feet below the water table and submitted for analysis; additional samples from the unsaturated zone, the capillary fringe, and saturated zone will be collected for archival at approximate three foot intervals.
TB-6	Log Yard	47.25264	-122.36716	Direct Push	Discrete	1 for Analysis; 4 to 6 for Archival	Sample will be collected from approximately 1 to 2 feet below the water table and submitted for analysis; additional samples from the unsaturated zone, the capillary fringe, and saturated zone will be collected for archival at approximate three foot intervals.
TB-7	Log Yard	47.25207	-122.37195	Direct Push	Discrete	1 for Analysis; 4 to 6 for Archival	Sample will be collected from approximately 1 to 2 feet below the water table and submitted for analysis; additional samples from the unsaturated zone, the capillary fringe, and saturated zone will be collected for archival at approximate three foot intervals.
TB-8	Log Yard	47.25207	-122.36920	Direct Push	Discrete	1 for Analysis; 4 to 6 for Archival	Sample will be collected from approximately 1 to 2 feet below the water table and submitted for analysis; additional samples from the unsaturated zone, the capillary fringe, and saturated zone will be collected for archival at approximate three foot intervals.
TB-9	Sawmill	47.25163	-122.37196	Direct Push	Discrete	3 for Analysis; 3 for Archival	Sample will be collected from the artificial fill, channel bottom, and native sediment. Three additional samples will be collected for archival.

Table A-6. Temporary Boring and Test Pit Locations

Station ID	Location	Latitude (WGS84)	Longitude (WGS84)	Sample Method	Sample Type	Number of Samples	Sample Interval [1]
Test Pits							
TP-1	Sawmill	47.25013	-122.37215	Backhoe	Discrete	2 for Analysis	0.5-1.5 ft bgs, Saturated Zone
TP-2	Sawmill	47.25007	-122.37220	Backhoe	Discrete	2 for Analysis	0.5-1.5 ft bgs, Saturated Zone

Notes:

ft bgs = feet below ground surface

TB = temporary boring

TP = test pit

WGS84 = World Geodetic System 1984

1 Selection of sampling depth intervals are discussed in the SAP. Additional soil samples from the capillary fringe and saturated zone will be collected for archival at the lab.

Table A-7. Surface Water Sample Locations

Station ID	Location	Latitude (WGS84)	Longitude (WGS84)	Sample Type	Sample Depth
BWB-1	Blair Waterway	47.25406111	-122.3735685	Grab	2 - 3 feet below water surface
USB-1	Upstream	47.24634661	-122.3697141	Grab	10 cm aml
WCT-1	Log Yard	47.25318999	-122.3724441	Grab	10 cm aml
WCT-2	Log Yard	47.25261383	-122.3724532	Grab	10 cm aml
WCT-3	Log Yard	47.25206411	-122.3724806	Grab	10 cm aml
WCT-4	Sawmill	47.2500244	-122.372473	Grab	10 cm aml

Notes:

aml = above mud line
BWB = Blair Waterway Background
USB = Upstream Background
WCT = Wapato Creek transect
WGS84 = World Geodetic System 1984

Table A-8. Sediment and Porewater Sample Locations

Station ID	Location	Latitude	Longitude	Sample Media	Sample Type	Number of Samples	Sample Depth (bml)
WCT-1A	Log Yard	47.25319019	-122.3723612	Porewater	Discrete	2	0-10 cm, 40-50 cm
WCT-1B	Log Yard	47.25318999	-122.3724441	Porewater	Discrete	2	0-10 cm, 40-50 cm
WCT-2A	Log Yard	47.25261422	-122.3723678	Porewater	Discrete	2	0-10 cm, 40-50 cm
WCT-2B	Log Yard	47.25261383	-122.3724532	Porewater	Discrete	2	0-10 cm, 40-50 cm
WCT-3A	Log Yard	47.25206431	-122.3724003	Porewater	Discrete	2	0-10 cm, 40-50 cm
WCT-3B	Log Yard	47.25206411	-122.3724806	Porewater	Discrete	2	0-10 cm, 40-50 cm
WCT-4A	Sawmill	47.25002716	-122.3724073	Porewater	Discrete	2	0-10 cm, 40-50 cm
WCT-4B	Sawmill	47.2500244	-122.372473	Porewater	Discrete	2	0-10 cm, 40-50 cm
WCT-1A	Log Yard	47.25319019	-122.3723612	Sediment	Discrete	2	0-10 cm, 40-50 cm
WCT-1B	Log Yard	47.25318999	-122.3724441	Sediment	Discrete	2	0-10 cm, 40-50 cm
WCT-2A	Log Yard	47.25261422	-122.3723678	Sediment	Discrete	2	0-10 cm, 40-50 cm
WCT-2B	Log Yard	47.25261383	-122.3724532	Sediment	Discrete	2	0-10 cm, 40-50 cm
WCT-3A	Log Yard	47.25206431	-122.3724003	Sediment	Discrete	2	0-10 cm, 40-50 cm
WCT-3B	Log Yard	47.25206411	-122.3724806	Sediment	Discrete	2	0-10 cm, 40-50 cm
WCT-4A	Sawmill	47.25002716	-122.3724073	Sediment	Discrete	2	0-10 cm, 40-50 cm
WCT-4B	Sawmill	47.2500244	-122.372473	Sediment	Discrete	2	0-10 cm, 40-50 cm

Notes:

bml = below mud line

cm = centimeters

WCT = Wapato Creek transect

WGS84 = World Geodetic System 1984

Table A-9. Soil and Sediment: Analytes, Analytical Methods, Detection Limits, Method Reporting Limits, and Preliminary Screening Level Values

						Preliminary Screening Level Values[a]						
Analyte	Laboratory	Analytical Method	Reporting Limit	Method Detection Limit	Units	MTCA A Industrial (WAC 173-340)	MTCA C for Soil (WAC 173-340) Non cancer	MTCA C for Soil (WAC 173-340) Cancer	Natural Soil Background (ECY 94-115)	Washington Marine Sediment Quality Standards[b] (WAC 173-204-562) Sediment Cleanup Objective	Washington Marine Sediment Quality Standards[b] (WAC 173-204-562) Cleanup Screening Level	Natural Sediment Background (SCUM II)
Pentachlorophenol	TA	8270D SIM	0.0200	0.0050	mg/kg		17,500	328		0.360	0.690	
Grain-Size[c]	TA	D422	N/A	N/A	N/A							
pH[c]	TA	9045D	N/A	N/A	N/A							
TOC[c]	TA	9060	2000	44.4	mg/kg							
Sulfide[c]	TA	9034	5.00	2.40	mg/kg							
Dioxins/Furans	TA	1613B			pg/g		4,080	1,683	5.2[f]			4[e]
2,3,7,8-TCDD			1.00		pg/g							
2,3,7,8-TCDF			1.00		pg/g							
1,2,3,7,8-PeCDD			5.00		pg/g							
1,2,3,7,8-PeCDF			5.00		pg/g							
2,3,4,7,8-PeCDF			5.00		pg/g							
1,2,3,4,7,8-HxCDD			5.00		pg/g							
1,2,3,6,7,8-HxCDD			5.00		pg/g							
1,2,3,7,8,9-HxCDD			5.00		pg/g							
1,2,3,4,7,8-HxCDF			5.00		pg/g							
1,2,3,6,7,8-HxCDF			5.00		pg/g							
1,2,3,7,8,9-HxCDF			5.00		pg/g							
2,3,4,6,7,8-HxCDF			5.00		pg/g							
1,2,3,4,6,7,8-HpCDD			5.00		pg/g							
1,2,3,4,6,7,8-HpCDF			5.00		pg/g							
1,2,3,4,7,8,9-HpCDF			5.00		pg/g							
OCDD			10.0		pg/g							
OCDF			10.0		pg/g							
Total Solids	Brooks	BAL-0501	NA	NA	mg/kg							
Arsenic	Brooks	6020 Mod. (ICP-QQQ-MS)	0.11	0.035	mg/kg	20	1,050	87.5	7.30[d]	57	93	11[e]
Arsenic III [g]	Brooks	BAL-4100/BAL-4111/BAL-4112 (IC-ICP-CRC-MS)	0.05	0.005	mg/kg							
Arsenic V [g]	Brooks	BAL-4100/BAL-4111/BAL-4112 (IC-ICP-CRC-MS)	0.05	0.005	mg/kg							
DMAs [g]	Brooks	BAL-4100/BAL-4111/BAL-4112 (IC-ICP-CRC-MS)	0.05	0.005	mg/kg							
MMAs [g]	Brooks	BAL-4100/BAL-4111/BAL-4112 (IC-ICP-CRC-MS)	0.05	0.005	mg/kg							
Iron[c]	Brooks	6020 Mod. (ICP-QQQ-MS)	3.2	1.0	mg/kg		2,450,000		36,128[d]			
Sequential Extractions[c]	Brooks	See Attachment 2	See Table 10	See Table 10	ug/L							
Batch Adsorption[c]	Brooks	See Attachment 2	See Table 10	See Table 10	ug/L							
					Applied to Soil:	x	x	x	x			
					Applied to Sediment:					x	x	x

Notes

a Blank cells indicate a screening level value is not published for the given analyte. Sediment standards will be applied to sediment samples; MTCA values will be applied to upland soil samples. Screening levels for soil leaching to groundwater are not considered because both Site groundwater and surface water are anticipated to be brackish due to tidal influences and the Site proximity to Commencement Bay, rendering them non-potable water sources.

b The Washington Sediment Management Standards (2013) define freshwater sediment as surface sediments in which the sediment pore water contains less than or equal to 0.5 parts per thousand (ppt) salinity, and marine sediment pore water contains 25 ppt salinity or greater. Site sediment is expected to be classified as marine.

c Analysis is being performed to develop the geochemical conceptual site model and understand fate and transport of chemicals at the site. Not considered an indicator hazardous substance for the Site.

d 90th percentile concentration for the Puget Sound. Natural Background Soil Metals Concentrations in Washington State. Toxics Cleanup Program. Washington Department of Ecology. Pub #94-115. October 1994.

e 90/90 Upper Tolerance Limit, intended to be used as a guide for sediment natural background values for Puget Sound, from Table 10-1 of the Sediment Cleanup Users Manual II, Department of Ecology, March 2015. Values listed as dry weight. Dioxin/furan value listed as 2,3,7,8-TCDD toxic equivalent.

f Natural Background for Dioxins/Furans in WA Soils. Technical Memorandum #8. Washington Department of Ecology. Publication No. 10-09-053. August 9, 2010. Value listed is 2,3,7,8-TCDD toxic equivalent.

g Estimated laboratory detection limits and reported limits. If samples need to be analyzed at a dilution or reduced mass, MDLs will be increased proportionally.

Abbreviations

Brooks = Brooks Applied Labs
CRC = Collision Reaction Cell
DMA = dimethylarsinic acid
ECY indicates Washington State Department of Ecology Publication Number
IC = ion chromatography
ICP = inductively coupled plasma
MMA = monomethylarsonic acid
MTCA = Model Toxics Control Act
N/A = Not applicable
QQQ = Triple Quadrupole
SCUM = Ecology Sediment Cleanup Users Manual
SIM = selective ion monitoring
SOP = Standard Operating Procedure
TA = Test America Laboratory

Table A-10. Surface Water, Porewater, and Groundwater: Analytes, Analytical Methods, Detection Limits, Method Reporting Limits, and Preliminary Screening Level Values

Analyte	Laboratory	Analytical Method	Reporting Limit	Method Detection Limit	Units	Preliminary Screening Level Values[a]					
						Water Quality Standards For Surface Waters of the State of Washington (WAC 173-201A)		NTR 40 CFR 131	MTCA B for Surface Water (WAC 173-340)		
						Marine Water Acute	Marine Water Chronic	Marine Water Fish Consumption	Non cancer	Cancer	Marine Water Background
Pentachlorophenol	TA	8270D SIM	0.020	0.0136	ug/L	13.0	7.9	8.2	1180	1.47	
Sulfide (dissolved)[b]	TA	4500 S2 D	0.050	0.007	mg/L						
Major Cations[b]	TA	6010C									
Calcium	TA		1.10	0.0230	mg/L						
Magnesium	TA		1.10	0.133	mg/L						
Potassium	TA		3.30	0.146	mg/L						
Sodium	TA		2.0	0.550	mg/L						
Major Anions[b]	TA	300.0									
Bromide	TA		0.50	0.060	mg/L						
Chloride	TA		0.50	0.040	mg/L						
Fluoride	TA		0.20	0.030	mg/L						
Sulfate	TA		1.20	0.260	mg/L						
Nitrite as N[b]	TA	300.0	0.40	0.080	mg/L						
Nitrate as N[b]	TA	300.0	0.20	0.020	mg/L						
Major Ions[b] (ortho-phosphate)	TA	365.1	0.10	0.030	mg/L						
Organic Carbon (total and dissolved)[b]	TA	SM5310B	0.5	0.05	mg/L						
Alkalinity (dissolved)	TA	SM2320B	5.0	5.00	mg/L						
Arsenic (total)	TA	6020A	5.0	1.35	ug/L			0.14	17.7	0.0982	5[d]
Arsenic (dissolved)	TA	6020A	5.0	1.35	ug/L	69	36				
Iron[b] (dissolved)	TA	6020A	200.0	29.0	ug/L						
Manganese (dissolved)[b]	TA	6020A	10.0	1.77	ug/L						
Arsenic (total)	Brooks	1638 Mod. (ICP-QQQ-MS)	0.048	0.016	ug/L			0.14	17.7	0.0982	5[d]
Arsenic (dissolved)	Brooks	1638 Mod. (ICP-QQQ-MS)	0.048	0.016	ug/L	69[f]	36[f]				
Arsenic III (dissolved)[e]	Brooks	SOP #BAL-1400 (IC-ICP-CRC-MS)	0.020	0.002	ug/L						
Arsenic V (dissolved)[e]	Brooks	SOP #BAL-1400 (IC-ICP-CRC-MS)	0.020	0.002	ug/L						
DMAs[b,e]	Brooks	SOP #BAL-1400 (IC-ICP-CRC-MS)	0.020	0.002	ug/L						
MMAs[b,e]	Brooks	SOP #BAL-1400 (IC-ICP-CRC-MS)	0.020	0.002	ug/L						
Iron[b] (dissolved)	Brooks	1638 Mod. (ICP-QQQ-MS)	0.40	0.12	ug/L						
Iron II [b] (dissolved)	Brooks	SM3500B	20.0	7.5	ug/L						
Iron III [b] (dissolved)	Brooks	SM3500B	20.0	7.5	ug/L						
Manganese (dissolved)[b]	Brooks	1638 Mod. (ICP-QQQ-MS)	0.063	0.021	ug/L						
					Applied to Groundwater:	x	x	x			x
					Applied to Surface Water/Porewater:	x	x	x	x	x	x

Notes

a Blank cells indicate a screening level value is not published for the given analyte. Screening levels for drinking water scenarios are not considered because both Site groundwater and surface water are anticipated to be brackish due to tidal influences and the Site proximity to Commencement Bay, rendering them unlikely non-potable water sources. Should the data collected indicate otherwise, drinking water screening levels will be used.

b Analyte is being tested to develop geochemical conceptual site model and understand fate and transport of chemicals at the site. Not considered an indicator hazardous substance for the Site.

c Updated Water Quality Standards for Surface Waters Of the State of Washington, WAC 173-201A, are currently undergoing review, including the development of human health criteria. In the case of arsenic, the proposed value is 10 ug/L, which would be higher than the current 5 ug/L value generally accepted by Ecology under MTCA Method A.

d MTCA Method A value for groundwater used as surrogate for the natural background concentration of arsenic in marine water. Under MTCA rules, cleanup levels are not established below natural background levels. Therefore, the background concentration will be the lowest screening level value applied to the data.

e Estimated laboratory detection limits and reported limits. If samples need to be analyzed at a dilution or reduced mass, MDLs will be increased proportionally.

f Value is based on National Recommended Water Quality Criteria for Aquatic Life, which is expressed in terms of the dissolved metal in the water column. It is appropriate to compare this value to dissolved arsenic concentrations from the Site since the dissolved fraction is generally considered more mobile and bioavailable.

Abbreviations

Brooks = Brooks Applied Labs	MTCA = Model Toxics Control Act
CRC = Collision Reaction Cell	NTR = National Toxics Rule
CFR = Code of Federal Regulations	QQQ = Triple Quadrupole
DMA = dimethylarsinic acid	SIM = selective ion monitoring
IC = ion chromatography	SOP = Standard Operating Procedure
ICP= inductively coupled plasma	TA = Test America Laboratory
MMA = monomethylarsonic acid	WAC = Washington Administrative Coce
MS =mass spectrometry	

Table A-11. Soil and Sediment: Sample Container, Preservation Requirements, and Holding Times

Analyte	Lab	Method	Sample Container	Volume	Preservation	Holding Time
TOC	TA	9060	G	4 oz	Cool	28 days
pH	TA	9045D				immediate
Pentachlorophenol	TA	8270D SIM				14 days
Grain-Size	TA	D422	G	16 oz	N/A	N/A
Sulfide	TA	9034	G	4 oz	Cool	28 days
Dioxins/Furans	TA	1613B	G	4 oz	Cool	none
Total Solids	Brooks	BAL-0501	N/A	N/A	N/A	N/A
Arsenic and Iron	Brooks	6020 Mod. (ICP-QQQ-MS)	G	20g (4 oz)	Cool	7 days to freeze; 1 year to analyze
Arsenic Speciation - As(III)/As(V) DMAs MMAs	Brooks	BAL-4100/BAL-4111/ BAL-4112 (IC-ICP-CRC-MS)	G	20g (4 oz)	Anoxic Preservation[1], Dry Ice/ Freeze	7 days to freeze; 1 year to analyze
Sequential Extractions	Brooks	See Attachment 2	G	20g (4 oz)	Anoxic Preservation[1], Dry Ice/ Freeze	7 days to freeze; 1 year to analyze
Batch Adsorption	Brooks	See Attachment 2	G	20g (4 oz)	Anoxic Preservation[1], Dry Ice/ Freeze	7 days to freeze; 1 year to analyze

Notes

1. Samples will be handled following the procedure described in Section 2.4.2.2 of the Sampling and Analyses Plan. Samples will be placed on ice or dry ice in the field immediately following collection. Following anoxic sample homogenization at the laboratory, sames will be frozen and archived -15 °C.

Abbreviations

Brooks = Brooks Applied Labs
CRC = Collision Reaction Cell
Cool = Cool sample to ≤4° C
DMA = dimethylarsinic acid
DRC = dynamic reaction cell
G = glass
IC = ion chromatography
ICP= inductively coupled plasma
MMA = monomethylarsonic acid
MS =mass spectrometry
N/A = not applicable
QQQ = Triple Quadrupole
SIM = selective ion monitoring
SOP = Standard Operating Procedure
TA = Test America
TOC = total organic carbon

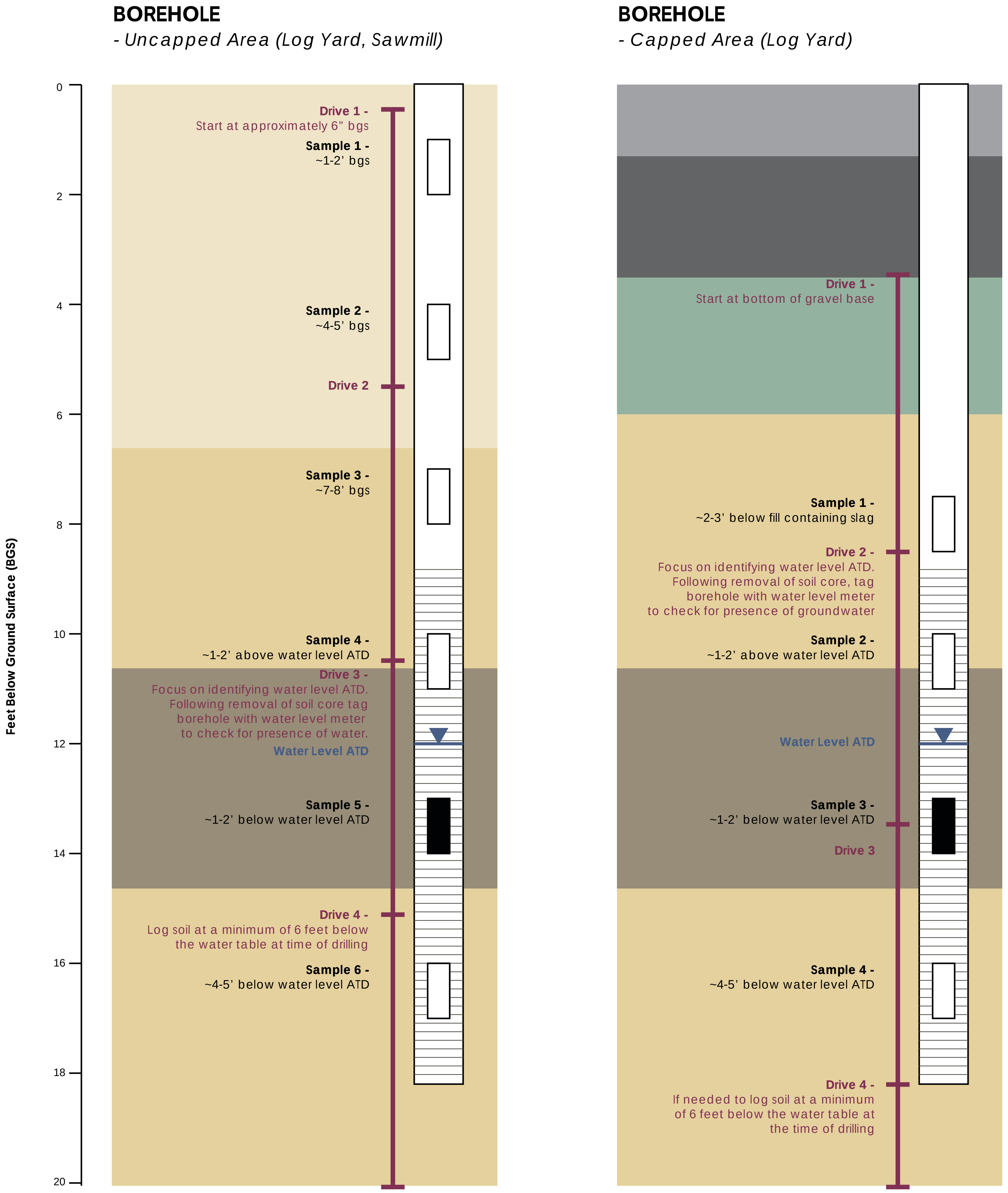
Table A-12. Surface Water, Porewater, and Groundwater: Sample Containers, Preservation Requirements, and Holding Times

Analyte	Lab	Method	Sample Container	Volume	Field Filter	Preservation [1]	Holding Time
Arsenic (total)	TA	6020A	HDPE	250 mL	No	HNO_3	180 days
Organic Carbon (total)	TA	SM5310B	G- amber	250mL		Cool, H_2SO_4	28 days
Pentachlorophenol	TA	8270D SIM	G - amber (2x250 mL)	500 mL		Cool	7 days
Arsenic, Iron, Manganese (dissolved)	TA	6020A	HDPE	250 mL	Yes	HNO_3	180 days
Major Cations (calcium, magnesium, potassium, sodium; dissolved)	TA	6010C					
Major Anions (bromide, chloride, fluoride, sulfate; dissolved)	TA	300.0	HDPE	500 mL		Cool	28 days
Nitrate as N and Nitirite as N (dissolved)	TA	300.0					48 hours
Alkalinity (dissolved)	TA	SM2320B					14 days
Major Anions (ortho-phosphate; dissolved)	TA	365.1	HDPE	250 mL		Cool	48 hours
Sulfide (dissolved)	TA	4500 S2 D	HDPE	250 mL		Cool, ZnOAc+NaOH	7 days
Organic Carbon (dissolved)	TA	SM5310B	G- amber	250mL		Cool, H_2SO_4	28 days
Arsenic (total)	Brooks	1638 Mod. (ICP-QQQ-MS)	HDPE	125 mL	No	Cool, HNO_3 in lab	180 days
Arsenic, Iron, Manganese (dissolved)	Brooks	1638 Mod. (ICP-QQQ-MS)	HDPE	125 mL	Yes	Cool, HNO_3 in lab	180 days
Arsenic Speciation - As(III)/As(V)	Brooks	SOP #BAL-1400 (IC-ICP-CRC-MS)	V (2x9 mL)	18 mL		Pre-preserved with EDTA; minimal headspace; keep dark, cool	28 days
DMAs							
MMAs							
Iron Speciation - Fe(II)/Fe(III)	Brooks	BAL-4500	G (2X40 mL)	80 mL		Cool, dark, HCL in field	48 hours

Abbreviations

Brooks = Brooks Applied Labs
Cool = Cool sample to ≤4° C
CRC = Collision Reaction Cell
DMA = dimethylarsinic acid
G = glass
HCL = 4% degassed 6m hydrochloric acid.
HDPE = High density polyethylene
HNO3 = add Nitric Acid to a pH<2 within 14 days of collection.
IC = ion chromatography
ICP= inductively coupled plasma
MMA = monomethylarsonic acid
MS =mass spectrometry
QQQ = Triple Quadrupole
SIM = selective ion monitoring
SOP = standard operating procedure
TA = Test America
V = Vacutainer
Yes = samples will be filtered in the field using 0.45 micron filter.

Figures



LEGEND

■ Sample for Analytical Testing (~1’ Core)
▯ Sample for Archival (~1’ Core)
☰ Approximate Location of Well Screen

Geology

■ Roller Compacted Concrete
■ Gravel Base, Coarse
■ Fill
■ Fill Containing Slag
■ Silty Sand
■ Silt

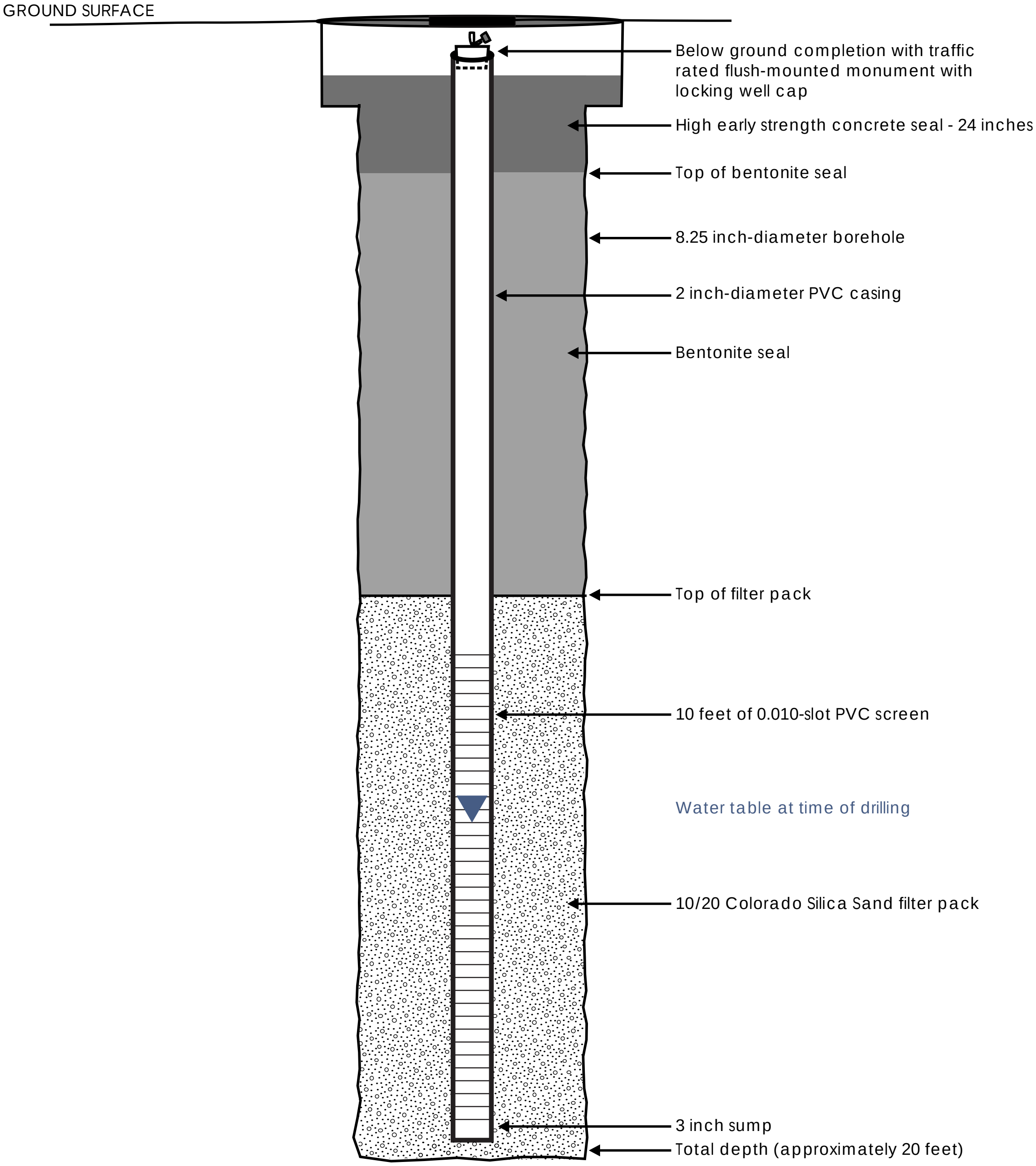
NOTES:

ATD = At time of drilling
Actual sample locations will be based on consideration of soil type, stratigraphy, sample recovery, depth of water at time of drilling (ATD), observations, etc.
Well screen placement will be determined by field conditions.
Screen depths will be placed approximately 4 feet above and 6 feet below water level ATD.

FIGURE A-1
Conceptual Soil Sampling Intervals
Sampling and Analysis Plan
Parcel 15 Investigation
Tacoma, WA

GSI Water Solutions, Inc.

P:\Portland\603-Port of Tacoma\Figures\SAP



NOTE:
Well drilling and construction will be performed in accordance with state regulations (Chapter 173-160 WAC) and other applicable regulations and guidance.

FIGURE A-2

New Monitoring Well Schematic

Sampling and Analysis Plan
Parcel 15 Investigation
Tacoma, WA

GSI Water Solutions, Inc.

Attachment 1 – Field Forms and Checklists

GSI Water Solutions, Inc.

Boring ID

Project Number

Sheet of

SOIL BORING LOG

Project: Location:

Drilling Contractor: Drilling Method:

Start Date: End Date: Field Personnel:

Sampling Method: Water Levels:

Start Card No: L WA ID: Total Depth:

Depth Below Surface (ft)	Sample		Description	Comments
	Sample Interval/ Recovery	Lab Sample Interval	Soil Name, USCS Group Symbol, Color, Moisture, Relative Density/Consistency, Soil Structure, Mineralogy	Air Monitoring/PID Readings, Sheen/Odor, Issues Encountered, Water Levels

GSI Water Solutions, Inc.

Boring ID

Project Number

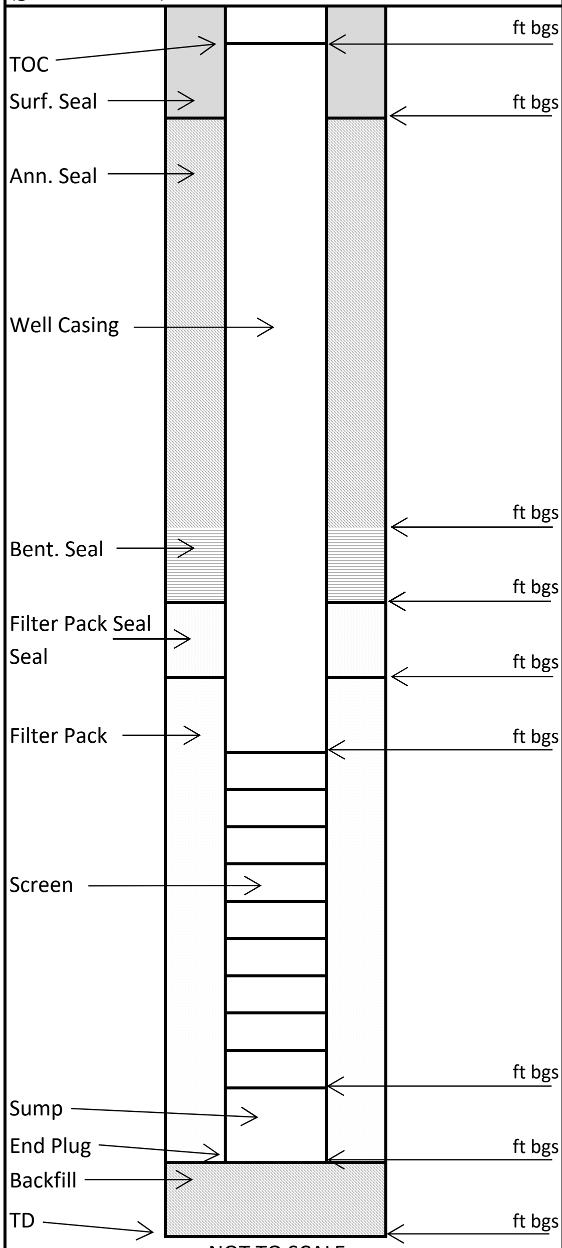
WELL CONSTRUCTION

Project:
Location:
Drilling Contractor:
Drilling Method:
Start Date:
End Date:
Field Personnel:
TOC Elev (& datum):
GS Elev (& datum):
Static Water Levels:
WA ID:
Start Card: L

Well Construction Drawing

(below ground completion)

(ground surface)



NOT TO SCALE

bgs = below ground surface

Well Construction Materials

Borehole TD (ft bgs): Well TD (ft bgs):
Borehole Diameter: inches to ft bgs
Borehole Diameter: inches to ft bgs

Monument Type: Lockable cap: yes / no
Monument Diam. (in): Industrial Traffice Rated: yes / no
Well Casing Type: Casing Diam. (in):
Well Casing Interval: ft bgs to ft bgs
Screen Type: Screen Length (ft):
Screen Slot Size: Screen Diameter (in):
Screen Interval : ft bgs to ft bgs
Sump Type: Sump Length:
End Cap Type: End Cap Length:
Centralizer Type:
Centralizer Locations (ft bgs):

Backfill Material:
Backfill Interval: ft bgs to ft bgs
Filter Pack Material: Calc. Quantity:
Filter Pack Interval: ft bgs to ft bgs
Filter Pack Seal Material: Calc. Quantity:
Filter Pack Seal Interval: ft bgs to ft bgs
Bentonite Seal Material: Calc. Quantity:
Bentonite Seal Interval: ft bgs to ft bgs
Annular Seal Material: Calc. Quantity:
Annular Seal Interval: ft bgs to ft bgs
Surface Seal Material:
Surface Seal Interval: ft bgs to ft bgs

Material Type: Quantity (bags):

Holeplug: 2"d = 1.6 lb/ft, 4"d = 6.3 lb/ft, 6"d = 14.1 lb/ft; **Grout**: 20% solids = 3.6 ft^3/bag, 25% = 2.8 ft^3/bag
Sand: 2"d = 6.6 lb/ft, 4"d = 17.5 lb/ft, 6"d = 23.7 lb/ft

Notes (i.e., grout emplacement [tremied, poured, tamped], water source):

GSI Water Solutions, Inc.

Project Number

GRAB SAMPLE LOG

Project: Location:

Sampling Method: Field Personnel:

Location		General		Sample			Description	Comments		
Station	Rep	Date	Time	Water Depth (ft)	Recovery Depth (cm)	Sample Analysis Depth (cm)	Soil Name, USCS Group Symbol, Color, Moisture	Debris	Odor	Sheen

GSI Water Solutions, Inc.

Project Number

WATER LEVEL DATA

Project: Parcel 15 Investigation Field Personel:

Weather:

Well ID	**Location**	**Date**	**Time**	**Methane** (%)	**Depth to Water** (ft btoc)	**Comments**
B-1R	Log Yard					
B-3R	Log Yard					
B-5R	Sawmill					
B-6R	Log Yard					
HC-1	Log Yard					
HC-2	Log Yard					
MW-1	Sawmill					
MW-2R	Sawmill					
MW-3	Sawmill					
MW-4	Sawmill					
MW-5R	Sawmill					
MW-6R	Sawmill					
MW-7	Log Yard					
MW-8	Log Yard					
MW-9	Log Yard					
MW-10	Log Yard					
MW-11	Log Yard					
MW-12	Log Yard					
MW-13	Log Yard					

General Comments:

WELL DEVELOPMENT FIELD LOG
Port of Tacoma/Portac
Parcel 15 Investigation

Well I.D.:

Client: Port of Tacoma/Portac	Well Dia:(in.): 0.75-inch - 2-inch - 4-inch - _________other
Project #: 603.	Sand Pack Dia (in.):
Developed By:	Bore Hole Dia (in.):
	Total Gallons Removed:

Static Well Casing Volume [(TD-DTW) x gal/ft.]:_________ T.D._________DTW_________gallons/ft._________

Start: Date / /	Time:	DTW (BTOC):	Total Depth (BTOC):
Stop: Date / /	Time:	DTW (BTOC):	Total Depth (BTOC):

Development Methods / Comments:

Time	Volume Removed (gallons)	Temp (^{O}C)	Cond. (µS/cm)	D.O. (mg/L)	pH (mV)	ORP (mV)	D.T.W. (0.01 ft.)	Surging (Y/N)	Clarity - Color - Remarks - (ntu)

WELL DEVELOPMENT FIELD LOG

Port of Tacoma/Portac

Parcel 15 Investigation

Well I.D.: **Developer:** **Date:**

Additional Development Methods / Comments/Observations:	
Continued Development Records	

Time	Volume Removed (gallons)	Temp (^{O}C)	Cond. (µS/cm)	D.O. (mg/L)	pH (mV)	ORP (mV)	D.T.W. (0.01 ft.)	Surging (Y/N)	Clarity - Color - Remarks - (ntu)

Groundwater Sampling FIELD LOG

Port of Tacoma/Portac

Parcel 15 Investigation

(Circle)

Site	**Station Type**	**Headspace Methane**	**Date:**
Logyard	New MW		
Sawmill	Existing MW	___________________%	
QAQC	Temp.Boring		**Station I.D.:**

Total Depth: (ft)	Time (-) DTW: (ft)	=	(X) 0.16 gal\ft	= Well Casing Volume:

Field Conditions:

Decontamination: Alconox + tap wash; Tap rinse; DI rinse

PURGE INFORMATION

☒ Purge Method : GeoPump II peristaltic

☐ Purge Method :

☐ Refer to calibration log this date.

Pump Suction Depth(ft BTOC): Purge water disposal: Drummed

Type of Flow Through Cell: ☐ 10 oz cup ☒ YSI 556 Flow Cell

Comments/Exceptions to SAP:

Time	Purge Volume (gallons)	Temp. (°C)	SC (uS/cm)	DO (mg/L)	pH (mV)	ORP (mV)	Purge Rate (mL/min)	DTW (ft BTOC)	Pump Speed/*Clarity/ Color/Remarks (NTU)
Stabilization Criteria		± 0.2	±3% (SC>100) ±5% (SC≤100)	± 0.3	± 0.1	± 10	--	--	± 10% (NTU>5) 3 readings < 5 (NTU<5)
:	Pump On: *Water Reaches the Purge Bucket*							Initial	
:									
:									
:									
:									
:									
:									
:									
:									
:	Start Sampling								
:	End Sampling								

* **VC**=Very cloudy **Cl**=Cloudy **SC**=Slightly Cloudy **VSC**=Very Slightly Cloudy **AC**=Almost Clear **C**=Clear **CC**=Crystal Clear

Laboratory Analytical Program
Port of Tacoma/Portac
Groundwater Sampling Information

Date: / /		**Time:** :	
Sampling Method:	☐	From: A	dedicated purge tube disconnected from flow through cell
	☐	From: B	d dedicated polyethylene bailer (other:)

Sample I.D. ____________________ (MW-B-HC-TB-XXX-E1) (TB003-E1 = GW sample from TB-3, Event 1) (MW009-E1 = GW sample MW-9, Event 1)	Duplicate	(Circle) Number of sample containers	Volume of each container	Container Type	Presv.	Method (A or B)	Analytical Method
(to be completed after finalization with the analytical laboratories)		1	500 ml	poly	4^0C		Nitrate E 300.0 Nitrite E 300.0 Bicarbonate E 310.1 Sulfate EPA 300.0 Chloride EPA 300.0
Examples Only --->		1	250 ml	poly	HNO_3		Dissolved Metals 200.7 **Field Filtered**
		1	250 ml	Amber glass	H_2SO_4		Diss. Organic Carbon **Field Filtered** SM 5310B
		1	40 ml	Vial	zincAc NaOH		NCASI RSC-2.01 Sulfide
		1	1 Liter	poly	zincAc NaOH		Sulfide SM 5310B
QAQC Samples (Sample ID and Time) (5XX is a duplicate sample)		4		match of parent sample			

QA/QC: One duplicate per sample type(GW-PW-SW)

Labs: Brooks Applied Lab; 18804 North Creek Pkwy; Bothell, WA 98011 - 206-632-6206
Test America; 5755 8th Street E.; Tacoma, WA 98424 - 253-922-2310

Surface Water Sampling FIELD LOG

Port of Tacoma/Portac

Parcel 15 Investigation

Date:

Wapato Creek Transect Surface Water Sampling (WCTSW)

Station I.D.:

Low Tide (hhmm):	Sample Time (hhmm):	Height Above Mudline (cm):	Blair Waterway Depth (ft or NA):

Field Conditions:

Decontamination: Alconox + tap wash; Tap rinse; DI rinse

PURGE INFORMATION

X	Purge Method : GeoPump II peristaltic
	Purge Method :
	Refer to calibration log this date.

Distance to the NSDS stake(cm):

Coordinates (if needed):

Type of Flow Through Cell: ☐ 10 oz cup ☒ YSI 556 Flow Cell

Comments/Exceptions to SAP:

Time	Purge Volume (gallons)	Temp. (ºC)	SC (uS/cm)	DO (mg/L)	pH (mV)	ORP (mV)	Purge Rate (mL/min)	DTW (ft BTOC)	Pump Speed/*Clarity/ Color/Remarks (NTU)
Stabilization Criteria		± 0.2	±3% (SC>100) ±5% (SC≤100)	± 0.3	± 0.1	± 10	--	--	± 10% (NTU>5) 3 readings < 5 (NTU<5)
:	Pump On: *Water Reaches the Purge Bucket*							Initial	
:									
:									
:									
:									
:									
:									
:									
:									
:	Start Sampling								
:	End Sampling								

* **VC**=Very cloudy **Cl**=Cloudy **SC**=Slightly Cloudy **VSC**=Very Slightly Cloudy **AC**=Almost Clear **C**=Clear **CC**=Crystal Clear

Laboratory Analytical Program

Port of Tacoma/Portac

Surface Water Sampling Information

Date: / /		**Time:** :	
Sampling Method:	☐	From: A	dedicated purge tube disconnected from flow through cell
	☐	From: B	d dedicated polyethylene bailer (other:)

Sample I.D. ______________________ (BWSW-001-E1) (USBSW-001-E1) (WCTSW-001,2,3,4-E1)	Duplicate	(Circle) Number of sample containers	Volume of each container	Container Type	Presv.	Method (A or B)	Analytical Method
(to be completed after finalization with the analytical laboratories)		1	500 ml	poly	4^0C		Nitrate E 300.0 Nitrite E 300.0 Bicarbonate E 310.1 Sulfate EPA 300.0 Chloride EPA 300.0
Examples Only --->		1	250 ml	poly	HNO_3		Dissolved Metals 200.7 **Field Filtered**
		1	250 ml	Amber glass	H_2SO_4		Diss. Organic Carbon **Field Filtered** SM 5310B
		1	40 ml	Vial	zincAc NaOH		NCASI RSC-2.01 Sulfide
		1	1 Liter	poly	zincAc NaOH		Sulfide SM 5310B
QAQC Samples ______________________ (Sample ID and Time) (5XX is a duplicate sample)		4		match of parent sample			

Comments/Sketches:

QA/QC: One duplicate per sample type(GW-PW-SW)

Labs: Brooks Applied Lab; 18804 North Creek Pkwy; Bothell, WA 98011 - 206-632-6206
Test America; 5755 8th Street E.; Tacoma, WA 98424 - 253-922-2310

GSI Water Solutions, Inc.
55 SW Yamhill St, Suite 300
Portland, Oregon 97204
503.239.8700

Chain of Custody Record

Client Contact

Project Name: Parcel 15 - POT

Project # or PO #: 603.002.010

Project Manager: Erin Hughes/Cindy Ryals

Phone #:971-200-8528 and 971-200-8531

Report to email: echughes@gsiws.com, cryals@gsiws.com

Analysis Turnaround Time: ☐ 21 days (STD)
☐ 14 days * ☐ 7 days * ☐ 5 days *
☐ 3 day * ☐ 2 days * ☐ 1 day *

For Lab Use Only:

SDG:___
Custody Seals intact? ☐ Yes ☐ No
Hand delivered? ☐ Yes ☐ No
Cooler Temp :____°C
Therm ID No.:____Therm Exp.____

Lab PM

Brooks- Elizabeth Madonick- 206-632-6206, ext.141

Test America - Christobel Escarez- 253.248.4975

						Laboratory														
						Brooks Applied Labs								Test America						
						Analysis Requested														
Sample Identification	**Sample Date**	**Sample Time**	**Sample Type** (C=Comp, G=Grab)	**Matrix**	**Total # of Cont.**	Anoxic Homogenization*	Arsenic	Iron	Total Solids	Arsenic Speciation - As (III)/As(V)	Sequential Extraction	Batch Adsorption	Archive (frozen)**	Total Organic Carbon	Pentachlorophenol and pH	Dixon/Furans	Sulfide	Grain Size	Archive Only (Frozen)***	Sample Specific Notes:

Possible Hazard Identification:
Are samples hazardous? ☐ Yes ☐ No
If yes, select hazard(s): ☐ Listed ☐ Ignitable ☐ Corrosive ☐ Reactive ☐ Toxic
If YES or NO is not checked above, samples will be assumed hazardous and hazardous disposal fees will be applied.

Sample Disposal **(A fee may be added if samples are retained longer than 30 day per client request, samples are returned to client, or classified as hazardous.)**
☐ Return to Client ☐ Disposal by Lab ☐ Archive for

Received by: Date/Time:
Received by: Date/Time:
Received in Laboratory by: Date/Time:

Relinquished by: Date/Time:
Relinquished by: Date/Time:
Shipped Via: ☐ UPS ☐ Fed-Ex ☐ USPS ☑ Other
Tracking #:

Special Instructions/QC Requirements
*** Brooks analytical to homogenize sediment anoxically in a glove box and provide aliquotes for analysis at Brooks and Test America.**
**** Brooks to archive approximately 8 oz of extra homogenized soil/sediment frozen for potential future analysis.**
***** Sample cores have been packaged anoxically and will be held under frozen archival at Test America for potential future analysis.**
Please contact Cindy Ryals at 971-200-8531 with any questions.

GSI Water Solutions, Inc.
55 SW Yamhill St, Suite 300
Portland, Oregon 97204
503.239.8700

Chain of Custody Record

Client Contact

Project Name: Parcel 15 - POT
Project # or PO #: 603.002.010
Project Manager: Erin Hughes/Cindy Ryals
Phone #:971-200-8528 and 971-200-8531
Report to email: echughes@gsiws.com, cryals@gsiws.com

Analysis Turnaround Time: ☐ 21 days (STD)
☐ 14 days * ☐ 7 days * ☐ 5 days *
☐ 3 day * ☐ 2 days * ☐ 1 day *

For Lab Use Only:
SDG:___
Custody Seals intact? ☐ Yes ☐ No
Hand delivered? ☐ Yes ☐ No
Cooler Temp :____°C
Therm ID No.:____Therm Exp.____

Lab PM
Brooks- Elizabeth Madonick- 206-632-6206, ext.141
Test America - Christobel Escarez- 253.248.4975

Laboratory

Analysis Requested

Sample Identification	**Sample Date**	**Sample Time**	**Sample Type** (C=Comp, G=Grab)	**Matrix**	**Total # of Cont.**	Test America								Brooks				Sample Specific Notes:
						Total Organic Carbon	Dissolved Organic Carbon	Sulfide (dissolved)	Major Cations (dissolved)*	Major Anions, Alkalinity, Nitrate/Nitrate (dissolved)**	Arsenic (total)	Arsenic, Iron, and Manganese (dissolved)	Pentachlorophenol and pH	Arsenic (total)	Arsenic, Iron, and Manganese (dissolved)***	Iron Speciation - Fe(II)/Fe(III) (dissolved)	Arsenic Speciation - As (III)/As(V) (dissolved) ***	

Possible Hazard Identification:
Are samples hazardous? ☐ Yes ☐ No
If yes, select hazard(s): ☐ Listed ☐ Ignitable ☐ Corrosive ☐ Reactive ☐ Toxic
If YES or NO is not checked above, samples will be assumed hazardous and hazardous disposal fees will be applied.

Sample Disposal **(A fee may be added if samples are retained longer than 30 day per client request, samples are returned to client, or classified as hazardous.)**
☐ Return to Client ☐ Disposal by Lab ☐ Archive for

Received by: Date/Time:
Received by: Date/Time:
Received in Laboratory by: Date/Time:

Relinquished by: Date/Time:
Relinquished by: Date/Time:
Shipped Via: ☐ UPS ☐ Fed-Ex ☐ USPS ☑ Other Tracking #:

Special Instructions/QC Requirements
*Major Cations include calcium, magnesium, potassium, and sodium.
**Major anions include sulfate, chloride, bromide, fluoride, and ortho-phosphate. Alkalinity includes total, carbonate as CaCO3, bicarbonate as CaCO3, and hydroxide as CaCO3.
*** Arsenic analysis to be rushed. Arsenic speciation to be performed on samples with arsenic concentrations greater than (>) 36 ug/L.
Brooks to follow special anoxic sample handling procedures as outlined in Attachment 2 of the Project SAP.
Please contact Cindy Ryals at 971-200-8531 with any questions.

Attachment 2: Arsenic Specialized Testing – Standard Operating Procedures

Batch Adsorption Test Description

Description of the batch adsorption testing procedure is described in EPA's *Batch Type Procedures for Estimating Soil Adsorption of Chemicals* (EPA 530/SW-87/006-F, April 1992). Chapter 17 of this document (Laboratory Procedures for Generating Adsorption Data) is included in this Attachment. Applicable steps are summarized in the table below.

The following soil:solution ratios ($g_{adsorbent}$:$mL_{solution}$) will be used (assuming a fixed groundwater volume of 40 mL):

Soil: Solution
1:4
1:10
1:50
1:100

Note that ratios are based on oven-dry equivalent weights of adsorbent, which must be calculated from air-dry weights using the method in Chapter 17, Section 7 of EPA (1992) (see attached document).

Three soil samples will initially (i.e., Step 1) be tested at a soil-to-solution ratio of 1:50 at three equilibration times (48 hours, 96 hours, and 168 hours) in order to determine the amount of time required for equilibrium to be achieved in the samples.

Based a review of the results of the three equilibration times, an appropriate equilibration time will be selected by the Parcel 15 consulting team in consultation with Brooks and the remaining samples will be tested using the selected equilibration time. This means there will be a total of:

14 samples x 4 ratios (and selected equilibration time)
+ 3 sample x 2 additional times
62 tests total

This will require 62 x 0.04 L = 2.48 L of unimpacted groundwater[1].

Each test will be run in the presence of an inert gas in a glove box. Groundwater in each test may be spiked with sodium arsenite (1 mg/L) if an appropriate site groundwater cannot be identified that has arsenic concentrations exceeding 1 mg/L.

At the completion of each test, dissolved arsenic (EPA Method 1638, Mod.) and pH will be measured. Samples from the three tests (Step 1) will be analyzed on a 5-day turn-around-time from the time of completion of the batch tests.

---

[1] 2.48 L of groundwater is the minimum amount required. Additional volume should be collected.

Table 1. Batch Adsorption Test Procedure (EPA 1992, Chapter 17)

Chapter 17 Subsections	Subsection Title	Procedure
7.1 – 7.5	Preparation of Adsorbents	7.1 Air dry samples until in equilibrium with moisture content of under anoxic conditions (in a glove box with nitrogen). 7.2 Weigh air-dried samples and pass through 2-mm screen sieve. Crush large aggregates (without grinding). If pebbles are present, remove and weigh these. 7.3 Homogenize sample. Use unbiased splitting procedure to remove representative subsample. 7.4 Determine moisture content of air-dried sample. 7.5 Determine the mass of the sample, corrected for moisture content (see equation in Section 7.5.1).
8.5	Soil:Solution Procedure	8.5.1 Calculate mass of adsorbent sample for the various soil: solution ratios based on an oven-dried equivalent weight. The volume of adsorbent plus solution should occupy 80-90% of the container. 8.5.2 Weigh the samples of adsorbent (<u>anaerobic special handling procedures are required</u>). 8.5.3 Place the weighed samples into clean, labeled containers. 8.5.4 Pipette the solution containing the solutes from the stock (1 mg/L arsenic-fortified groundwater) solution. The volume of solution should be identical in all containers. 8.5.5 Pipette the stock solution into a container holding no adsorbent. This is the laboratory “blank.” One blank will be used for this study. 8.5.6 Close the bottles, ensuring watertight seal, and place on rotary tumbler for mixing. 8.5.7 Collect and preserve, an aliquot of stock solution before contact with reaction containers, adsorbent, and other surfaces. Aliquot of the stock solution will be analyzed with BAT extracts. This is the initial concentration that will be used for calculating total adsorption. 8.5.8 Agitate samples at 29 rpm for specified test duration (48, 96, or 168 hours) at room temperature. 8.5.9 After test, open containers and record temperature and pH. 8.5.10 Separate the solid and liquid phase using either centrifugation or filtration (Section 5.2). Collect and preserve aliquots of each supernate of sufficient volume to determine arsenic concentration. 8.5.11 Determine the arsenic concentration of the aqueous phase.

Sequential Extraction Test Description

Selected soil samples will be subjected to sequential extraction analysis to quantify the different forms of arsenic present. The extraction procedure is designed to release arsenic fractions from a sample according to its availability by subjecting the sample to a series of chemical treatments targeted at specific chemical forms.

A simplified procedure consisting of five extraction steps will be performed yielding the following fractions: (1) soluble, (2) exchangeable (strongly adsorbed), (3) sulfide and/or organic bound, (4) iron oxide, and (5) insoluble. Concentrations of arsenic, iron, manganese, sulfate, sulfide, and pH will be determined for each of the fractions collected. Details of the sequential extraction procedure, which is adapted from methods published by Dhoum and Evans (1998), Keon et al. (2001), and Wenzel et al. (2001), are provided in Table 1.

Sequential extraction procedures will be performed on subsamples taken from homogenized, sieved core samples. All sample handling and fraction collection prior to and including the first four extraction steps (except for agitation, centrifugation, and heating, during which sample tubes are tightly sealed) shall be done under a positive-pressure N_2 atmosphere to avoid oxidation artifacts.

References

Dhoum, R.T., Evans, G.J. (1998) Evaluation of uranium and arsenic retention by soil from a low level radioactive waste management site using sequential extraction. *Applied Geochemistry* 13: 415-420.

Keon, N. E., Swartz, C. H., Brabander, D. J., Harvey, C., Hemond, H. F. 2001. Validation of an arsenic sequential extraction method for evaluating mobility in sediments. *Environmental Science & Technology* 35: 2778-2784.

Wenzel, W.W., Kirchbaumer, N., Prohaska, T., Stingeder, G., Lombi, E., Adriano, D. 2001. Arsenic fractionation in soils using an improved sequential extraction procedure. *Anal Chim Acta* 436:309-323.

Table 1. Sequential Extraction Procedure

Target Fraction	Extraction Fluid	Procedure
Soluble	1 M $MgCl_2$, pH 8	1. Add 50 mL fluid to 1 g sample in centrifuge tube. 2. Agitate in tumble-shaker for 8 hours at room temperature. 3. Centrifuge for 25 minutes at 11,000g 4. Decant fluid. 5. Repeat steps 1 to 4 with new extraction fluid. 6. Repeat steps 1, 3 and 4 with DI water. 7. Combine all decanted fluid, acidify with HNO_3 to pH <2, and analyze for COCs*. This is the soluble fraction
Exchangeable (Strongly Adsorbed)	1 M NaH_2PO_4, pH 5	1. Add 50 mL fluid to same 1 g sample in centrifuge tube. 2. Agitate in tumble-shaker for 16 hours at room temperature. 3. Centrifuge for 25 minutes at 11,000g 4. Decant fluid. 5. Repeat steps 1 to 4 with new extraction fluid for 24 hours. 6. Repeat steps 1, 3 and 4 with DI water. 7. Combine all decanted fluid, acidify with HNO_3 to pH <2, and analyze for COCs*. This is the exchangeable fraction
Amorphous oxides/As-sulfide/Organic Bound	0.1 M NaOH	1. Add 50 mL fluid to same 1 g sample in centrifuge tube. 2. Agitate in tumble-shaker for 16 hours at room temperature. 3. Centrifuge for 25 minutes at 11,000g 4. Decant fluid. 5. Repeat steps 1 to 4 with new extraction fluid for 24 hours. 6. Repeat steps 1, 3 and 4 with DI water. 7. Combine all decanted fluid and analyze for COCs*. This is the sulfide/organic fraction.
Iron Oxide	0.2 M ammonium oxalate/oxalic acid with 0.1 M ascorbic acid, pH 3	1. Add 50 mL fluid to same 1 g sample in centrifuge tube. 2. Set in hot block (96 deg. C) for 30 minutes. 3. Centrifuge for 25 minutes at 11,000g. 4. Decant fluid and filter. 5. Repeat steps 1, 3 and 4 with the following extraction fluid (Wenzel wash step): 0.2 M ammonium oxalate/oxalic acid, pH 3. For this step, agitate for 10 minutes in the dark (wrapped in aluminum foil) 6. Repeat steps 1, 3 and 4 with DI water. 7. Combine all decanted fluid and analyze for COCs*. This is the iron oxide fraction.
Residual/Fe-sulfides	16 N HNO_3 + 30% H_2O_2	1. Prepare same 1 g sample according to EPA 3050B. 2. Analyze for COCs*. This is the insoluble fraction.

*COCs = Arsenic, iron, manganese, sulfate, sulfide, and pH. (As, Fe, Mn, and pH will be analyzed by BAL; Sulfate and sulfide will be measured by TA)

Appendix B: Health and Safety Plan (HSP)

Site-Specific Health and Safety Plan

Port of Tacoma/Portac: Parcel 15
Tacoma, Washington

This Site-Specific Health and Safety Plan (HSP) has been developed in accordance with Occupational Safety and Health Act (OSHA) 29 CFR 1910 and 1926, and the GSI Water Solutions, Inc. (GSI), Health and Safety Policy. It covers known field hazards associated with the tasks necessary to complete the *Remedial Investigation (RI) Work Plan* (draft prepared by GSI in March 2016). All other consultants, subconsultants, and subcontractors will prepare their own HSP and will be responsible for their own health and safety. Any modifications to this HSP will be attached to this document.

1. Project Information

Date: May 2016

GSI Project Number: 603.002

Site/Project Name: POT/Portac: RI WP Field Implementation

Site Address/Location: 658 Alexander Avenue, Tacoma, Washington
(Note address is for the entrance gate)

2. Contact Information

GSI Project Manager: Rod Struck
Phone: 971-200-8510
Cell Phone: 503-536-5810

GSI Technical Project Lead: Erin Carroll Hughes
Phone: 971-200-8528
Cell Phone: 503-927-4553

GSI Health and Safety Coordinator: Rod Struck
Office Phone: 971-200-8510
Cell Phone: 503-536-5810

Port of Tacoma Client Contact: Rob Healy
Phone: 253- 428-8643
Cell Phone: 503-970-6855

Port of Tacoma Client Health and Safety Representative: Stuart Currie
Phone: 253-428-8615
Cell Phone: 425-749-6918

Portac Client Contact: Mark Larsen
Phone: 206-903-3376
Cell Phone: 206-310-2264

Portac Client Health and Safety Representative: Nik Bacher
Phone: 206-903-9130

Cell Phone: 206-351-0951

Will a Site Representative be present on-site? *yes*

3. Field Team

Table 1. GSI Field Staff

Name	Role	Responsibility
Rod Struck	Project Manager (PM)	The GSI PM has overall responsibility for the delivery of the project and management of all members of the team, including external advisors and subcontractors. The PM and TPL are the points-of-contact for the Client and regulatory agencies. The GSI PM is responsible for field operations and ensures the implementation of the HSP requirements and procedures in the field.
Erin Carroll Hughes	Technical Project Lead (TPL)	The GSI TPL has responsibility and authority to direct all work operations. The TPL will work closely with the PM, and is a point-of-contact for the client and regulatory agencies. The TPL will coordinate safety and health functions with the Site Safety and Health Officer (SSHO), has the authority to oversee and monitor the performance of the SSHO, and bears ultimate responsibility for the proper implementation of this HSP.
Peter Pellegrin	Site Safety and Health Officer (SSHO)	The GSI SSHO has full responsibility and authority to develop and implement this HSP and to verify compliance. The SSHO is on site or readily accessible to the site during all work operations and has the authority to halt site work if unsafe conditions are observed or suspected.
Peter Pellegrin Renee Fowler Erin Carroll Hughes Stephen Kohlmeier Jake Gorski Jesse Manley	Field Activities	GSI’s staff will be responsible for complying with this HSP, using the proper personal protective equipment (PPE), reporting unsafe acts and conditions, and following the work and safety and health instructions of the PM, SSHO, field director, and site-specific HS plans and protocols.
Subcontractors	Field Activities	Subcontractors will be responsible for their own HSPs.

All personnel requiring access to controlled work areas must have completed the appropriate training.

Substitutions will be made with similarly qualified personnel.

Table 2. Project Subcontractors/Team Members

(Include contact information for others who will be working onsite.)

Company	Contact Information	Task
Port of Tacoma	Stuart Currie (253) 428-8615	Field Activities
Anchor	Nik Bacher (206) 351-0951	Field Activities
Utility Locator	TBD	
Surveyor	TBD	
Drilling Company	TBD	

4. Emergency Preparedness and Telephone Numbers

The site safety and health officer or technical project lead, as noted in Table 1, will assess emergency conditions and issue stop-work or evacuation instructions based on the situation and best professional judgment. Emergency procedures will be discussed during daily safety briefings. Emergency evacuation may occur as the result of a medical emergency (life-threatening) or site condition (e.g., gas line rupture, spills). In the event of emergency, personnel will be instructed to leave the site immediately and *the site safety and health officer (or onsite field lead if the safety and health officer is unavailable) will contact the appropriate emergency response providers* listed below. Directions to the nearest medical facility from each sampling location are provided below. An accident report will be completed (see Section 14 and Attachment 1).

GSI field personnel will be trained in first aid [including cardiopulmonary resuscitation (CPR)] procedures and have access to a first aid kit.

IN CASE OF LIFE-THREATENING INJURIES, CALL 911

USE AMBULANCE TO GO TO CLOSEST HOSPITAL

Emergency Contacts	Name	Phone Number
Port of Tacoma Security		**(253) 383-9472** Port recommends, prior to calling 911, for any incidents (spills, accidents, injuries) requiring emergency services, to first call Port of Tacoma. They will indicate if calling 911 is necessary, or if they will contact other emergency services for you (911 isn't always the fastest way to get a response to the tideflats).
Local Police	—	**911 emergency** (253) 594-7800 non-emergency
Local Ambulance	—	**911 emergency**
Local Fire Department	—	**911 emergency** (253) 591-5177 non-emergency

Emergency Contacts	Name	Phone Number
Local Hospital	St. Joseph Medical Center	(253) 426-4101
Local Hospital Address	1717 S J St, Tacoma, WA 98405	See above
GSI Health and Safety Coordinator	Rod Struck	Office: 971-200-8510 Cell: 503-536-5810
Poison Control Center	Washington Poison Center (open 24 hours)	1-800-222-1222
Spill Response (spill to state waters oil or hazardous substances) (Note: spills to land must be reported to local Ecology office within 90 days)	WA Dept. of Emergency Management Ecology SW Regional Office Port of Tacoma Security Office	**911 emergency –if threat to human health** 1-800-258-5990 (WDOM) (360) 407-6300 (Ecology SW) (253) 383-9472 (Port Security)
National Response Center (NRC)	—	1-800-424-8802
State OSHA	—	425-450-5480 (Washington)

In the event of an occupational accident or incident, please indicate to the medical facility that this is a Workers' Compensation case; that your employer is GSI; and that the insurance administrator for Workers' Compensation claims is (**highlight one**):

- **For projects in Washington**: Washington Department of Labor and Industries

5. Directions to the Nearest Medical Facility

(attach map to this page)

9 min (3.9 miles)

via WA-509 S

8 min without traffic

Pierce County Terminal

4015 State Route 509, North Frontage Rd, Tacoma, WA 98421

↑ Head south on Alexander Ave E toward WA-509 S

⚠ Restricted usage road

125 ft

↱ Turn right at the 1st cross street onto WA-509 S

2.9 mi

↑ Continue straight onto S 21st St

0.3 mi

↱ Turn right onto Jefferson Ave

121 ft

↖ Slight left onto Market St

0.1 mi

↰ Turn left at the 1st cross street onto S 19th St

0.4 mi

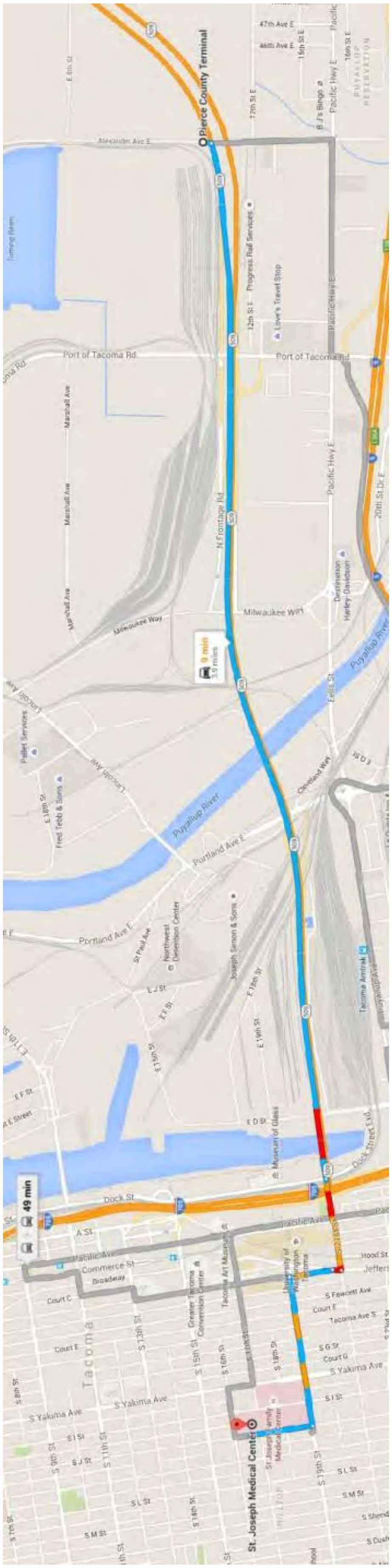
↱ Turn right onto S J St

ⓘ Destination will be on the right

0.2 mi

St. Joseph Medical Center

1717 South J Street, Tacoma, WA 98405



6. Site Characterization and Job Hazard Analyses

Access: Site accessed from Alexander Avenue

Approximate Size: 52 acres

Topography: Generally flat with creek on west side

Site Status: Active industrial site

Site Operations: *Kia is current tenant and stores new cars onsite. Generally, low traffic onsite unless unloading/loading cars.Site is roughly triangular in shape, with car storage on north section of Site. Former tenant was Portac, which used the Site as a sawmill and log sorting facility (HC HSP, 1988).*

Table 3. Site Activities Planned

Activity[1]	Location(s)	Date(s)
Well Abandonment and Repair	Sawmill	May 2016
Well Drilling, Soil Sampling, and Well Installation, and well development	Throughout, see facility figure	May 2016
Groundwater Sampling	Throughout, see facility figure	May 2016 August 2016 November 2016 February 2017
Temporary Borings: Soil and Groundwater Sampling	Throughout, see facility figure	May 2016
Test Pits: Soil Sampling	Sawmill	May 2016
Porewater, Surface Water and Sediment Sampling	Wapato Creek	May 2016 August 2016 November 2016 February 2017

Notes:

[1] Describe activities to be conducted under this HSP. For each activity, identify potential hazards (physical and chemical) using the job hazard assessment in Table 5 and subsequent sections. If planned scope of services changes from the descriptions above, a revised HSP must be developed and approved before field work is conducted.

Facility Layout and Key Features

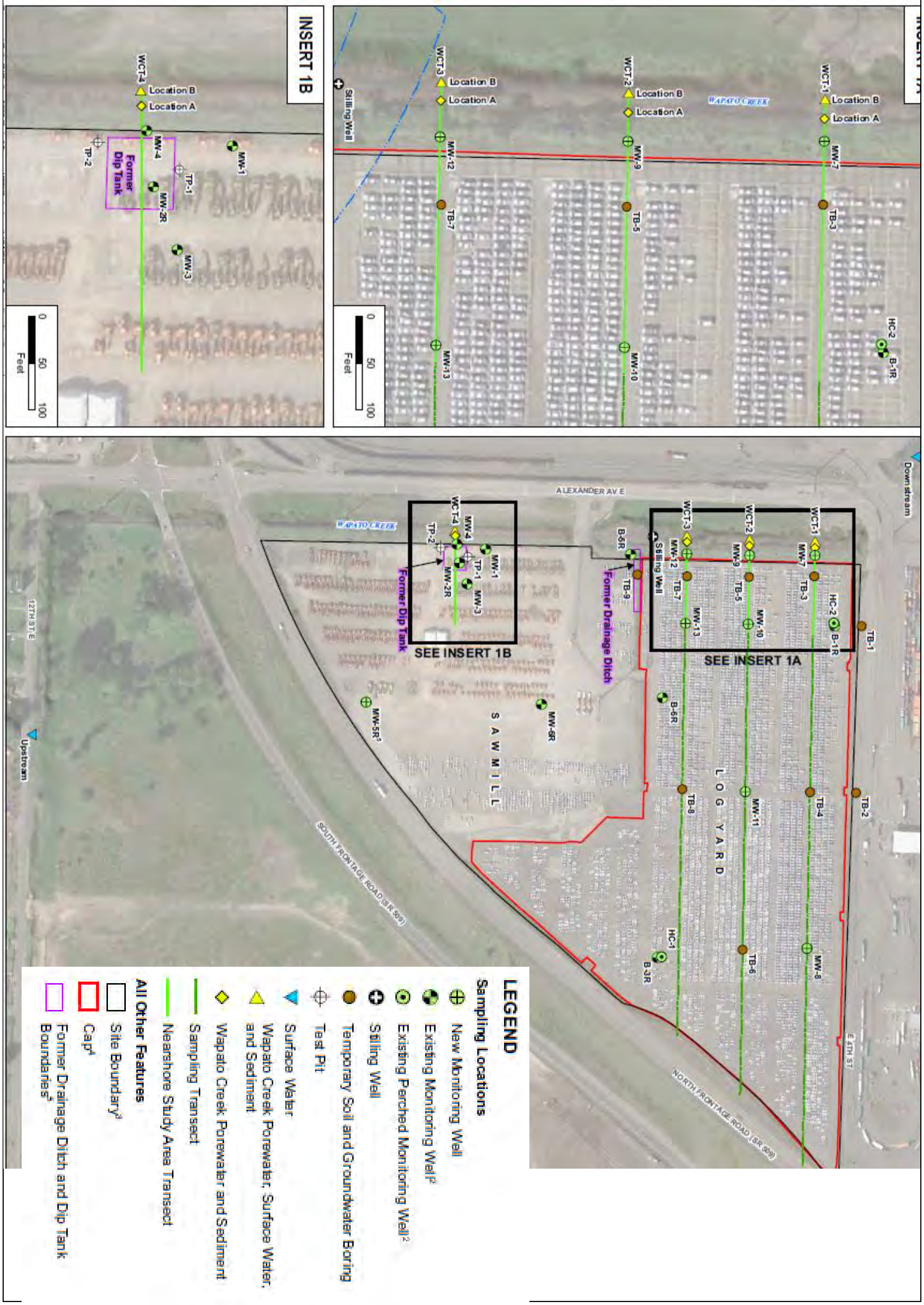


Table 4. Locations of Nearest Facilities	
Telephone	GSI field staff should keep fully charged cellular phones onsite.
Water Source	GSI should carry water or identify the location of the nearest drinking water source.
Restroom	Portable toilet will be located onsite during Event 1 field work.
First Aid Kit	GSI field staff should check out a GSI field backpack, which contains a first aid kit, and carry it in the vehicle.

Table 5. Job Hazard Assessment

Potential Hazards *(Provide additional details if these potential hazards may be encountered during the activities defined in Table 3)*	**Identified Hazard** *(If yes, place an "**X**." If no, leave blank or delete the row.)*	**Description of Hazard and How to Avoid Hazard**
Vehicle Travel	**X**	Adhere to traffic regulations and speed limits, onsite and offsite. Move the vehicle to be close to the location of the sampling location. Inspect the area for access, soft ground, and obstacles that may damage the vehicle. If possible, drive in and drive out of the location, rather than reversing. If you need to reverse, use a spotter to guide you. Use chocks where needed.
Heat Stress	**X**	Where possible, shift work hours to cooler times of the day. Allow frequent and adequate rest periods, adequate fluid intake, and monitor employees for signs of thermal stress. Wear clothing suitable for the current weather conditions. To avoid heat stress, cool potable water will be readily available, and site personnel will be encouraged to drink plenty of fluids and take periodic work breaks in hot weather.
Cold Stress/Hypothermia	**X**	Drink plenty of fluids (not caffeine), wear clothing appropriate for the weather conditions, wear multiple layers.
Slips/Trips/Falls	**X**	Maintain good housekeeping standards and avoid leaving items on the ground where they could present a trip hazard. Set up adequate staging areas for all equipment needed. Inspect work area and level ground surface where possible.
Unstable/Uneven Terrain/ Steep Grades/Elevated Surfaces	**X**	If there is a potential for falls because of unstable, steep surface, the buddy system and additional safety precautions should be developed and discussed with the GSI Health and Safety Coordinator. Before field work,

Table 5. Job Hazard Assessment		
Potential Hazards *(Provide additional details if these potential hazards may be encountered during the activities defined in Table 3)*	**Identified Hazard** *(If yes, place an "**X**." If no, leave blank or delete the row.)*	**Description of Hazard and How to Avoid Hazard**
		perform reconnaissance and develop a plan for safe ingress and egress. Wear sturdy work boots.
Machinery (welding, cutting, grinding, etc.)/Mechanical Equipment/Heavy Equipment (drill rig, backhoe, etc.)	**X**	Stand clear of machinery when in operation and be familiar with emergency stop devices, if applicable. No loose clothing to be worn and all long hair to be tied back. If safety vests are worn, they must be fastened at the front. Stay clear of hoisting operations (drill rod attachment and detachment). Be aware of all pinch points and provide guarding where possible. Be aware that heavy equipment activity may change daily or hourly, with differing potential hazards that need to be identified and addressed.
Lifting Hazards	**X**	Assess the load to be lifted, loaded, pushed, or pulled. Solicit help if the load cannot be safely moved by one person or if handling too awkward. Lift with knees and hold load close to body. Make sure footing is firm, path is clear, and avoid twisting. Use same techniques when setting load down.
Hazardous Insects/Plants/Animals	**X**	Bees, snakes, spiders, and ticks. Avoid contact – seek medical attention if necessary. Wear insect repellant, as appropriate.
Electrical Hazards	**X**	Electrical equipment should be inspected to ensure it is in safe working order before use. Equipment should be grounded and operated under dry conditions.
Vehicular Traffic	**X**	Work will be conducted in close proximity to traffic. Traffic control will be provided by the driller contractor. Personnel will be traffic-aware and will stay out of the street and curb to the extent practicable.
Overhead Hazards	**X**	• Look 'up' to determine location of hazard(s). If overhead hazards exist, change locations of the work to be performed where possible, otherwise, secure the overhead hazard(s) (e.g., de-energize live electrical lines). • Stand clear of drill rig and facility operations. Do not walk under a raised load or a load supported by a winch. Stand uphill from drilling activities (if possible) as falling drill strings may roll. Be aware of overhead activities during over-water work.
Subsurface Utilities Call the Northwest Utility Notification Center "**One Call**" system at **811** or 1-800-424-5555 at least 2 full business days before conducting subsurface work. http://www.callbeforeyoudig.org/washington/	**X**	Check for location of underground services before beginning ground-penetrating work. OSHA regulations require the estimated location of utility installations (sewer, telephone, fuel, electric, water lines) or any other underground installations that reasonably may be expected to be encountered during excavation work, will be determined before opening an excavation. Use a service locator and the following cues to assist in identifying possible underground services: (1) signs of patching of pavements, (2) service boxes, pits, and

Table 5. Job Hazard Assessment		
Potential Hazards *(Provide additional details if these potential hazards may be encountered during the activities defined in Table 3)*	**Identified Hazard** *(If yes, place an "**X**." If no, leave blank or delete the row.)*	**Description of Hazard and How to Avoid Hazard**
		manholes as they may indicate the presence or alignment of services, and (3) note services coming into or out of the ground, like power lines and down spouts. When possible, shut off utilities that are in the area while drilling is taking place. Consider pot-holing using vac-truck/air-knife to a depth of 4 to 5 feet below surface for physical confirmation of absence/presence of utilities.
Over Water/Near Water	**X**	The following precautions should be taken when conducting activities near Wapato Creek and Blair Waterway: • Access creek during low tide and remain on the creek bank. • Recommend use of sturdy boots and walking stick for support walking on creek bank, due to silty, slippery surface. Use buddy system. • GSI employees will wear U.S. Coast Guard (USCG for U.S. operations)-approved personal flotation devices (PFDs) (i.e., life jacket or buoyant work vest), if more than 3-foot depth of water in creek (i.e., high tide) or when working near Blair Waterway. Employees should inspect life jackets or work vests daily before use for defects. Do not use defective jackets or vests. • Employees will use extreme care when walking along the creek bank or near Blair Waterway, especially when carrying equipment or transferring samples.
Splashing	**X**	Care should be taken to prevent splashing during sample collection activities to prevent liquids from splashing onto skin, clothing, and face. Sampling equipment should be handled carefully (e.g., placed, opened, moved) to prevent splashing. If splashing occurs, area should be rinsed with clean water and dried. Employee should have safety glasses available during sampling activities and wear them during activities with splash potential.
Excessive Noise	**X**	Have hearing plugs or sound-insulating headphones available. Wear hearing protection if you need to shout to be heard.
Gasoline/Diesel	**X**	• Do not add fuel to running motors or hot motors. • If gasoline, or other flammable material is being used, it must be transported in a U.S. Department of Transportation (DOT)-approved labeled container. Fuel should be transported, used, and stored a well-ventilated area away from heat or spark sources.
Fire	**X**	Sound an emergency alarm (continuous blast on a canned siren, vehicle horn, or direct oral communication) to notify nearby workers. Decide whether to call the Fire Department for outside assistance or to extinguish the

Table 5. Job Hazard Assessment

Potential Hazards *(Provide additional details if these potential hazards may be encountered during the activities defined in Table 3)*	**Identified Hazard** *(If yes, place an "**X**." If no, leave blank or delete the row.)*	**Description of Hazard and How to Avoid Hazard**
		fire with an accessible ABC fire extinguisher. Trained emergency crews will be summoned to control any large-scale or potentially unmanageable incident.
Sharp Objects (e.g., nails, metal shards, glass, sharps)	**X**	Field staff should look for and scan the work area for the presence of sharp objects to avoid contact (stepping on, sitting on, etc.) and potential injury. Particular care should be taken in areas where debris is present. If sharps (e.g., nails) are present, steel-shanked boots should be considered. If sharps are present, leather gloves should also be considered to avoid injury.
Inclement Weather (ice, snow, lightning)	**X**	Work will cease if precipitation is severe enough to impair safe movement/travel, lightening is in the immediate area, or excessive winds, flooding, or other conditions are determined by the field manager or PM.
UV Exposure	**X**	Wear appropriate clothing, hats, and sunscreen to prevent sunburn.
Oxygen Deficient	**This HSP cannot be used.**	
Trenches/Vaults/Enclosed Spaces/Confined Space	**It is against GSI policy for employees to enter confined spaces. No GSI personnel shall enter a confined space or trench for any reason without prior approval and completion of site-specific confined space entry training.**	
Inorganic Chemicals	**See Section 7 below.**	
Organic Chemicals	**See Section 7 below.**	
Unknown Chemicals	**This HSP cannot be used.** *Work will be stopped if visual or olfactory observations indicate unanticipated conditions.*	
Blood-Borne Pathogens	First aid responders have the potential to be exposed to blood-borne pathogens. The potential for exposure to blood-borne pathogens outside of emergency response is not anticipated. While rendering first aid where exposure to blood may occur, GSI employees will wear, at a minimum, latex or blue nitrile gloves. Gloves are in the field first aid backpack and often are part of field sampling materials. Other suggested protection in the event of a serious blood-producing injury is safety glasses.	
Other *(Describe)*	Test pit excavation. Excavation safety guidelines (provided in Attachment 2) will be followed. GSI personnel will not enter test pit at any time.	

Table 5. Job Hazard Assessment

Potential Hazards *(Provide additional details if these potential hazards may be encountered during the activities defined in Table 3)*	**Identified Hazard** *(If yes, place an "***X***." If no, leave blank or delete the row.)*	**Description of Hazard and How to Avoid Hazard**
Dry Ice	**Please read additional information in Section 6.** Store Dry Ice in an insulated container. The thicker the insulation, the slower it will sublimate. Do not store Dry Ice in a completely airtight container. The sublimation of Dry Ice to Carbon Dioxide gas will cause any airtight container to expand or possibly explode. Keep proper air ventilation wherever Dry Ice is stored. Do not store Dry Ice in unventilated rooms, cellars, autos or boat holds. The sublimated Carbon Dioxide gas will sink to low areas and replace oxygenated air. Plan to pick up the Dry Ice as close to the time it is needed as possible. It sublimates at 10%, or 5 to 10 pounds every 24 hours, whichever is greater. Carry it in a well-insulated container such as an ice chest. If it is transported inside a car or van for more than 15 minutes make sure there is fresh air. Treat Dry Ice burns the same as a regular heat burns. See a doctor if the skin blisters or comes off. Otherwise if only red it will heal in time as any other burn. Apply antibiotic ointment to prevent infection and bandage only if the burned skin area needs to be protected.	

Table 6. Safety Equipment *(Check all that apply)*

First Aid Kit	**Required for all GSI field work**
Fire Extinguisher	Recommended on all jobs
Whistle/air horn	Recommended on all jobs
Spill Equipment (sorbent pads, booms, etc.)	
Eye Wash Station	
Wheel chocks	
Other *(If applicable, provide list.)*	

7. Potential Chemical Hazards

Chemicals of Concern

Based on historical data, the chemicals of potential concern (COPC) anticipated at the Site include the following: pentachlorophenol and arsenic. Pentachlorophenol and arsenic are remnants of the previous wood treating facility onsite. Concentrations of COCs in the groundwater are presented in Attachment 3 to assess potential exposure. These chemicals are relatively nonvolatile. Personnel will be wearing nitrile gloves and working in an open-air environment. Nonetheless, these compounds are potentially hazardous and exposure by all routes should be minimized. The following COPCs under investigation may be present at in the Project Area:

Chemicals identified onsite or anticipated to be present onsite.

- Pentachlorophenol (detected at low part per billion range concentrations in groundwater on former sawmill site)
- Arsenic (associated with slag used as road ballast; detected in soil and groundwater on former log yard). Fill containing slag is present beneath the Log Yard cap.
- Methane gas (present in monitoring well head space). Methane is associated with the degradation of wood waste in the fill containing slag beneath the Log Yard cap.

See Table 7 for more detailed chemical information.

Chemicals used on this project for decontamination and sample preservation purposes include:

- Liquinox detergent
- Argon or Nitrogen Gas

Other chemicals that will be used onsite include:

- Dry Ice (optional)

Chemical State:	X	**Liquid**	X	**Solid**	X	**Gas**		**Other**		**Unknown**
Chemical Characteristics:		**Corrosive**		**Flammable**	X	**Toxic**		**Volatile**		**Other**

X = Potential contaminant of concern present in site media (soil, sediment, groundwater, vapor, etc.)

D = Chemical characteristics of decontamination fluids

O = Other chemicals used onsite

The following hazardous materials identified above (i.e., decontamination materials or other chemicals brought onsite) are subject to the Hazard Communication Standard (29 CFR 1910.1200) and required Safety Data Sheets (SDS) are presented in Attachment 4:

- Liquinox
- Argon Gas
- Nitrogen Gas
- Dry Ice (carbon dioxide, solid)

The hazardous materials container(s) must be properly labeled with the identity of the hazardous chemical(s) and the appropriate hazardous warning information.

SDS are also presented, for informational purposes, in Attachment 4 for the primary contaminants of concern at the Site. It should be noted that these SDS are for chemicals in their pure form (i.e., laboratory or industrial use). The known release mechanisms of these chemicals and environmental concentrations result in significantly lower concentrations than anticipated by these forms. are expected to

- Arsenic
- Pentachlorophenol
- Methane Gas

The PM or TPL will ask the Client for copies of SDSs for any hazardous materials in use at the Project Area. The SSHO or TPL will orient GSI employees and subcontractors to the potential hazards posed by chemicals used and present onsite.

Potential Chemical Exposure Pathways

The primary routes of exposure for site chemicals include:

- **Inhalation of vapors** (i.e., methane during Log Yard drilling and groundwater sampling activities) and dusts (i.e., metals, semivolatile organic compounds, during invasive drilling and test pit activities)
- **Skin contact** with contaminated materials during soil, sediment, groundwater, and porewater sampling activities.
- **Ingestion of airborne dusts (see above) or materials** from hand-to-mouth contact caused by inadequate personal hygiene, and splashing during soil, sediment, porewater or groundwater sampling.

Field staff and onsite subcontractors will identify steps to minimize these exposure pathways and discuss as appropriate during daily tail gate meeting. Dust suppression techniques are not anticipated for this project. The SSHO will periodically access the potential for dust generation by observing field activities in the work and perimeter areas. If dust, generation is notes, the SSHO and subcontractor will take immediate steps to control suts. In addition, all required PPE as specified in in the following sections will be worn, and personal hygiene will be carefully monitored.

Table 7. Site Chemical Hazards

Chemical of Concern	PEL -TWA1 mg/m^3 [1]	TLV - TWA2 mg/m^3	STEL mg/m^3	Ceiling Limit mg/m^3	Exposure Routes [2]	IP (EV) [3]	Symptoms
Decontamination/Sample Preservation Chemicals (Note: Exposure to be minimal during field managed and controlled decontamination and sample preservation procedures)							
Liquinox	-	-	-	-	Inh, abs, Ing	Unknown	Irritation for all exposure routes
Argon Gas	Asphyxiant; limiting factor is available oxygen which shall be at least 18%	-	-	-	Inh	Unknown	Asphyxiation
Nitrogen Gas	Asphyxiant	-	-	-	Inh	Unknown	Asphyxiation
Dry Ice (Carbon dioxide, solid)*							Dry Ice temperature is extremely cold at -109.3°F or -78.5°C. Always handle Dry Ice with care and wear protective cloth or leather gloves whenever touching it. An oven mitt or towel will work. If touched briefly it is harmless, but prolonged contact with the skin will freeze cells and cause injury similar to a burn. (See additional information below and in Table 5)
Other Chemicals (Note: Exposure to these chemicals is expected to be low based on existing data (Attachment 4) and staff shouldn't come in direct contact with surface soil. Care should be taken to avoid dusty conditions and to stand up wind of samples and sample locations).							
Arsenic (inorganic)	0.01	0.01	-	-	Inh, Abs, Con, Ing	Unknown	Ulceration of nasal septum, dermatitis, respiratory irritation
Pentachlorophenol (PCP)	0.5	0.5	-	-	Inh, Abs, Ing, Con	NA	Eyes, nose, throat irritation; sneezing, coughing; weakness, anorexia, weight loss; sweating; headache; dizziness; nausea, vomiting; dyspnea, chest pain; high fever; dermatitis
Methane Gas	-	Asphyxiant	-	-	Inh	Unknown	Drowsiness, unconsciousness

Notes:

* Normal air is 78% Nitrogen, 21% Oxygen and only 0.035% Carbon Dioxide. If the concentration of carbon dioxide in the air rises above 0.5%, carbon dioxide can become dangerous. Smaller concentrations can cause quicker breathing and headaches but is otherwise not harmful. If Dry Ice has been in a closed auto, van, room, or walk-in, for more than 10 minutes, open doors and allow adequate ventilation before entering. Leave area containing Dry Ice if you start to pant and breath quickly develop a headache or your fingernails or lips start to turn blue. This is the sign that you have breathed in too much CO2 and not enough oxygen. Dry Ice CO2 is heavier than air and will accumulate in low spaces. Do not enter closed storage areas that have or have had stored Dry Ice before airing out completely.

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[1] PEL = Permissible Exposure Limit; Accessed online at http://www.osha.gov/dts/chemicalsampling/toc/toc_chemsamp.html

[3] IP = Ionization Potential; Accessed online at http://www.cdc.gov/niosh/npg/npgd0337.html

8. Personnel Protection

The prescribed methods and procedures used to protect personnel (Project Area workers and adjacent community) from overexposure to hazardous materials and hazardous conditions posed by Project Area operations are grouped into three primary categories: Administrative Controls, Engineering Controls, and PPE.

Administrative Controls

Medical Surveillance

GSI employees anticipated to spend >29 days at HAZWOPER sites or be required to wear a respirator are enrolled in GSI's medical surveillance program. Use of air purifying respirators is not anticipated for this work and will not be used unless field personnel are enrolled in GSI's medical surveillance program.

Periodic Comprehensive Exam

All personnel requiring access to controlled work areas will have completed a baseline medical examination and a periodic (usually annual) update medical examination before assignment, in accordance with the OSHA 29 CFR 1910.120(f). The exam must be performed by an Occupational Health Physician, who will provide written clearance for hazardous waste Project Area work and for respirator usage. Protocols for the baseline, periodic, and exit exams must be at least as stringent as those defined in the GSI Medical Surveillance Program.

Medical Clearance Record Keeping

Medical clearance documents are on file at the GSI office located in Portland, Oregon. To ensure confidentiality, results of the medical exams or treatment records are maintained at the Medical Care Provider's clinical offices.

Training

Table 8. Training Requirements for This Project

Type of Current Certificate*	Yes	No	Trained GSI Employee(s)
HAZWOPER 40-Hour	X		**Required for all GSI field personnel working on HAZWOPER projects.**
HAZWOPER Annual 8-Hour Refresher	X		**Required for all GSI field personnel working on HAZWOPER projects.**
HAZWOPER Supervisor Training	X		Supervisors will have completed the above and an additional 8 hours of OSHA Management and Supervisory Training.
First Aid/CPR/AED	X		**Required for all GSI field personnel.**
CSTOP		X	
Respirator Certification/Fit Test	GSI Employee-Specific		Respirators are not anticipated for this project. Additional detail is provided in GSI's Health and Safety Policy, Appendix E, Respirator Protection Program.
Medical Surveillance	GSI Employee-Specific		GSI employees anticipated to spend >29 days at HAZWOPER sites are enrolled in a medical surveillance program. Use of air-purifying respirators is

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[3] IP = Ionization Potential; Accessed online at http://www.cdc.gov/niosh/npg/npgd0337.html

Table 8. Training Requirements for This Project		
		not anticipated and will not be used unless field personnel are enrolled in GSI's medical surveillance program.
Buddy System	Depends on the task, yes for near water work	The buddy system will be discussed and assignments made during daily safety meetings.
Other		

* *All GSI employees' certificates are on file in GSI's Portland, Oregon, office. Field projects will not be allowed to take place in the absence of adequate documentation.*

Project Area Security

Access will be limited to all controlled areas via the prescribed administrative (certifications) and engineering (barricades) controls. All Project Area staff and visitors will note arrival and departure times on a field log by SSHO. All equipment, tools, and property shall be secured at the end of each day.

Work Limitations: Daylight hours

Site Entry Procedures: Site is located off of Alexander Ave, just north of SR509 HWY. GSI personnel will be accompanied by Port employee. Port employee will check GSI personnel in with Site Security. Port employee with work with Longshoreman representative to move cars for well access as needed.

Visitor Access: All project area visitors (except OSHA inspectors) must receive prior approval from the field manager, PM, and Client, and may do so only for the purposes of observing project area conditions or operations.

Work Zones

Work zones typically are categorized into the following three zones. However, it is acceptable to combine EZ and CRZ for simple or small sites.

Support Zone (SZ)

The SZ will be upwind or crosswind and away from the contaminated area. Vehicles, emergency equipment, the telephone and break area, and any nonessential personnel will be maintained in this area.

Contamination Reduction Zone (CRZ)

Decontamination lines shall be established for personnel and sampling equipment in the Contamination Reduction Zone (CRZ). The CRZ should be marked through which personnel and equipment pass from the EZ to the SZ. An additional buffer, or transition zone (TZ), will be established upwind or crosswind of the contaminated zones and will serve as support for sample quality assurance/quality control (QA/QC) and packing. Coolers in this zone will be protected from contamination and decontaminated before leaving the Project Area.

Exclusion Zone (EZ)

The EZ is defined around intrusive activities or located in the immediate hazard area. The EZ is often identified by cones, hazard tape, or other means to notify unauthorized individuals of the presence of potential hazards. Access should be restricted to field sampling crews and necessary equipment operators.

Noise Reduction

Site activities in proximity to welding, construction, and heavy equipment often expose workers to excessive noise. It is anticipated that situations may arise when noise levels may exceed the OSHA Action Level of 85 decibels (A-weighted scale) (dBA) in an 8-hour time-weighted average (TWA). An example of this possibility is working in close proximity to the subcontractor during drilling or trenching activities at the Project Area. If excessive noise levels occur, ear plugs with appropriate the Noise Reduction Ratings (NRR) will be issued to all personnel and a system of hand signals understood by all will be implemented.

Engineering Controls

Barriers and Signs

Barricades, traffic cones, and/or marking or caution tape will be erected, as appropriate, at a safe distance from wells, excavations, pits, hazardous areas, and moving equipment to prevent unauthorized access to work areas from vehicular and pedestrian traffic. Barriers will be appropriate for the level of work activities and anticipated traffic.

Personal Protective Equipment

Levels of Protection

Initial levels of protection for the Project Area may vary depending on the task. All personnel entering controlled work zones initially will be required to wear the U.S. Environmental Protection Agency (EPA)/OSHA Level of Protection as specified in this plan.

Protection may be upgraded or downgraded depending on monitoring data (compared with action levels) and Project Area conditions, as determined by the SSHO. The following outlines the **minimum** guidelines for each level of protection that is assigned or potentially assigned.

Level D PPE:

- Work shirt and full-length pants or coveralls
- American National Standards Institute (ANSI) standard safety-toe work boots
- ANSI standard hard hat (when working around heavy equipment or overhead “bump” hazards)
- High visibility safety vest will be worn at all times on Site.
- ANSI standard safety glasses
- ANSI standard hearing protectors (when working in high noise areas, e.g., steam cleaners and heavy equipment)

Modified Level D PPE:

- Level D equipment
- Tyvek® coverall or equivalent (upgrade to polyethylene [PE] or Saranex-coated Tyvek® as needed)
- Outer chemical-resistant gloves and inner nitrile gloves
- Boot covers or chemical-resistant boots

Table 9. Personal Protective[1] Equipment to be Used

Activity	Well Abandonment /Repair	Well Drilling, Soil Sampling, Well Installation	Well Development, Groundwater Sampling	Temporary Borings	Test Pits	Porewater, Surface Water, Sediment Sampling
Steel-toe boots (leather, neoprene safety)	X	X	X	X	X	X
Gloves (nitrile or equivalent.)	X	X	X	X	X	X
Eye/Face Protection (safety glasses, goggles, face shield)	X	X	X	X	X	X
Hardhat	X	X		X	X	
Splash Protection (apron)			Optional			
Hearing Protection	X	X		X		
Clothing (cold weather gear, rain gear)	X	X	X	X	X	X
Respiratory Protection						
Additional Gear *(If applicable, provide list.)*	*Safety Vest (required)*	*Safety Vest (required)* *rubber boots (recommended)*	*Safety Vest (required)*	*Safety Vest (required)*	*Safety Vest (required)*	*Safety Vest (required); Lifejacket may be required for surface water sampling (Blair Waterway)* *Rubber boots (recommended)*
Other *(Examples: drinking water, hand sanitizer, sunblock)*	*Sunblock, drinking water, hand sanitizer*	*Sunblock, drinking water, hand sanitizer*	*Sunblock, drinking water, hand sanitizer*	*Sunblock, drinking water, hand sanitizer*	*Sunblock, drinking water, hand sanitizer*	*Sunblock, drinking water, hand sanitizer*

[1] Gloves and PPE appropriate for the expected contaminants that may be encountered will be worn during sampling activities. When selecting PPE, consider potential exposure routes associated with the contaminant (e.g., inhalation, ingestion, skin contact).

PPE Donning/Doffing Procedure

The following procedures are given as a guide. Failure to adhere to these procedures may result in the PPE being ineffective against contaminants. These procedures may be altered by the SSHO if improvements can be made and these changes are warranted in the field. Also, some articles of PPE may not be necessary for all Project Area tasks.

PPE Donning Procedure (for Mod. Level D and greater):

- Inspect all protective gear before donning.
- Don Tyvek® coverall or equivalent, inner gloves and outer gloves, secure with tape, as required, leave pull tab. If coverall is loose, secure with tape to avoid capture in moving or rotating equipment.

PPE Doffing Procedure:

- Wash/rinse (if necessary) excess mud or other debris from outer boots, gloves, and clothing.
- Remove tape using pull tab and remove outer clothing in the order of boots, outer gloves, and coverall suits. Place disposable and reusable PPE in designated (separate) containers.
- Remove inner gloves.
- Wash face, neck, and hands.
- Enter the Support Zone (SZ).

PPE Failure/Chemical Exposure

In the event of PPE failure, worker and/or buddy will cease work, perform personal decontamination procedures, and exit to the SZ/Clean Zone (CZ). Refer to the SDSs and Section 3 (Emergency Actions) if emergency medical response is needed. If chemicals contact the eyes, irrigate for 15 minutes and consult a physician.

PPE Inspection, Storage, and Maintenance

Reusable PPE will be decontaminated, inspected, and maintained, as necessary, after each use. Personal equipment (e.g., respirators, leather safety-toe boots) will be properly stored by the employee/subcontractor.

The SSHO will periodically inventory the disposable and reusable PPE at the Project Area and will replenish stocks in a timely manner.

9. Exposure Monitoring

Type and Frequency of Monitoring

Table 10 outlines the recommended frequency of air surveillance monitoring for all other work activities in an EZ.

Table 10. Air Surveillance Monitoring Frequency

Type	Minimum Recommended Monitoring Frequency
Air monitoring during drilling activities (boreholes) and during monitoring well development and sampling.	See Table 11 below.

Table 11. Air Monitoring Equipment[1] and Protocols

Equipment	Contaminant	Work Activity	**Monitoring Protocols** Specify equipment type (e.g., PID lamp, Draeger Tube range). Describe sampling protocols, locations, frequency, etc.
Photo-ionization Detector (PID) (11.7 eV lamp)	Volatile Organic Compounds (VOCs)	Soil sampling in new monitoring wells, temporary borings, and test pits	VOCs are not contaminants of interest on this site. Therefore, use of a PID is not required
Multi gas meter	Methane/LEL	Drilling (monitoring well boreholes) Temporary borings (boreholes and temporary wells) Monitoring wells (water levels, development, sampling)	The meter will be calibrated and used in accordance with its user manual. **Drilling**: Measurements will be collected in the borehole and immediately adjacent to the borehole at regular intervals during drilling. **Wells**: Measurements will be collected in the monitoring well and immediately adjacent to the well upon opening at regular intervals during sampling activities.

[1] *The SSHO will maintain instrument manuals that specify calibration, general use, and troubleshooting procedures. All monitoring equipment will be field calibrated on a daily basis according to the manufacturer's instructions and will be recorded on the field notebook.*

Table 12. Air Monitoring Action Levels and Actions

Action levels should be established for upgrading/downgrading PPE, work stoppages, and evacuation. The decision to upgrade/downgrade the level of PPE must be based on instrument readings measured in the breathing zone of Project Area personnel. Record readings in the field notebook.

Equipment	**Action Level**	**Action To Be Taken**
Multi gas meter *Attempt to measure in well or borehole at a depth of 36 inches below top of casing.*	Explosive level <20% LEL	Non-explosive environment and work may proceed. (no apparent threat[4])
	Explosive level >20% LEL (1% by volume)	Potentially explosive environment. Avoid activities that could create spark. Ventilate the space to increase oxygen level or reduce explosive level. At the land surface, methane is anticipated to diffuse rapidly into the ambient air to concentrations below the 5% LEL.
	Explosive level > 60% LEL[5] (3% by volume)	Potentially explosive environment. Drilling activities should stop and no activities that could create spark should be performed. Allow space to ventilate to increase oxygen level and reduce explosive level to acceptable concentrations

Note: The principal danger associated with methane is fire and explosion. Methane is lighter than air and will rise and accumulate in enclosed spaces (e.g., well casings, stormwater vaults). Methane may occur as gas or as dissolved gas in groundwater. Natural gas may come out of solution in low baro-metric pressure. Concentrations of methane in well headspace may pulse with respect to barometric pressure over time. Naturally occurring gas is rarely if ever 100 percent methane (commercial natural gas is approximately 85% methane.

The explosive range for methane in air is 5% to 15% methane by volume (v/v) [50,000 to 150,000 ppm]. A 5 percent of total methane in air is 100 percent of LEL. While monitoring with an LEL instrument, 10 percent LEL is 0.5% concentration of combustible gas in air and 25% LEL is 1.25% total concentration of combustible gas in air.

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[4] Moody and Associates, 2016. Stray Gas Safety Overview. Downloaded from www.moody-s.com\news\stray-gas-safety-overview on March 28, 2016.

[5] Guidelines for the Safe Investigation by Drilling of Landfills and contaminated land. Site Investigation Steering Group. Thomas Telford, London.

DECONTAMINATION PROCEDURES

Procedures for the decontamination of sampling tools and other related equipment are specified in the sampling plan. Note that separate areas should be established for personnel, sampling, and heavy equipment decontamination.

Personnel Decontamination

Equipment	Decontamination Solution	Procedures	
		Intermediate	Final
Long-handled, soft-bristled brushes Galvanized wash tubs or equivalent Pump-activated sprayer Garbage cans with plastic liners and drums with liners Plastic Sheeting Paper towels Duct tape	Liquinox Tap water for rinsing	Dispose of or wash outer boot and glove with Liquinox solution. Rinse outer boot and glove. Remove outer glove and store for later use. Enter TZ for sample management. Return to EZ wearing new or cleaned outer gloves.	Segregate equipment drop (for instruments and equipment requiring special decontamination; see the Field Sampling Plan). Dispose of or wash outer boot and glove with Liquinox solution. Rinse outer boot and glove. Remove and dispose of outer boots. Remove and dispose of outer gloves (if not cleaned to “like new” condition). Remove and dispose of coverall. Remove and dispose of inner gloves in designated receptacle. Field wash for personal hygiene. Exit to SZ.
Note: *Intermediate decontamination is for periodic exits from the EZ during sample transport and management, or for short breaks. Final decontamination is performed before lunch, when taking cool down breaks, and when exiting the Project Area.*			

Field staff will wash hands and face after removing PPE.

Equipment Decontamination

All equipment that will potentially contact samples will be decontaminated before and following, sampling events according to procedures specified in the Field Sampling Plan. Heavy equipment in direct contact with soil and/or groundwater, such as the drill rig augers and backhoe buckets, will be steam cleaned at the CRZ and inspected by the PM or TPL before leaving the Site. Temporary decontamination stations (bucket wash) will be located near work areas and will be positioned upwind or crosswind of operations.

Emergency Decontamination

In the event of an accident or incident where work must cease and staff must exit the EZ, emergency decontamination should be performed to the greatest extent feasible. In an emergency, the primary concern is to prevent the loss of life or severe injury. If immediate medical attention is required to save a life, decontamination should be delayed until the victim is stabilized. If the decontamination can be performed without interfering with essential life-saving techniques or first aid, or if a worker has been contaminated with an extremely toxic or corrosive material that could cause severe illness or loss of life, decontamination must be performed immediately. If an emergency resulting from a heat-related illness develops, protective equipment should be removed carefully from the victim as soon as possible.

Any time emergency decontamination methods must be used, an Incident Report (see Attachment 1) must be completed by the SSHO and submitted to GSI's Safety Committee.

10. *Disposal* Procedures

Waste PPE, including used nitrile gloves, and disposable sample equipment (e.g., sample tubing, field filters) will be contained in garbage bags and disposed with common waste at the site. All soil cuttings, excess sediment, purged groundwater and decontamination fluids will be contained in a labeled DOT approved 55-gallon drum.

11. Communications

Daily Tailgate Safety Meetings

Tailgate safety meetings will be conducted by the SSHO or TPL each morning before work begins or before:

- A change of work tasks or conditions
- When new employees join the crew
- If site conditions change unexpectedly or when a specific task or location poses a safety hazard.
- To review proper use of PPE

Topics of discussion will include work tasks and designated PPE, emergency procedures, evacuation routes, instruction in use of safety equipment (as required), prior safety problems, etc. These meetings must be documented in the field notebook or Tailgate Safety Meeting Checklist.

Buddy System

The "buddy system" will be used during field activities involving potential exposure to hazardous or toxic materials and during any work within the EZ. Each person will observe his/her buddy for symptoms of chemical or heat overexposure and will provide first aid or emergency assistance when warranted. A mobile phone will be maintained at the Project Area for emergency use.

The following emergency hand and horn signals will be used as necessary where verbal communication is limited:

Thumbs up	=	OK; understand
Thumbs down	=	No; negative
Grasping buddy's wrist	=	Leave Project Area now
Hands on top of head	=	Need assistance
Horn - one long blast	=	Evacuate Project Area
Horn - two short blasts	=	All clear, return to Project Area

12. Safe Work Practices

Accident Prevention

The SSHO and all site employees will inspect the work site and/or Project Area daily to identify and correct any unsafe conditions. GSI field personnel and subcontractors should inspect work area thoroughly before leaving the Site. Adherence to the Safe Work Practices and procedures outlined in this HSP will assist with accident prevention.

Personal Conduct

- Unauthorized personnel are not allowed on the project site.
- A high standard of personal hygiene will be observed. Smoking, eating, drinking, chewing gum or tobacco, taking medication, and applying cosmetics will not be permitted within work zones.
- Personnel under the obvious influence of alcohol or controlled substances are not allowed in the Project Area; those taking medications must notify the GSI Health and Safety Coordinator.
- All project area personnel will familiarize themselves with these practices and the emergency procedures during daily tailgate and pre-work safety meetings.
- GSI employees who are passengers or drivers of vehicles will wear their seat belts any time the vehicle is in motion.
- No cellular phone use while driving is permitted.

Equipment and Activities

- All unsafe conditions will be corrected immediately. All unsafe conditions not in the scope of the project will be reported to the field manager or PM and the condition corrected.
- Loose-fitting clothing and loose long hair are prohibited near moving machinery.
- Do not fuel engines while the vehicle is running.
- Install adequate project area roads, signs, lights, and devices.
- Where portable electric tools and appliances can be used (where there is no potential for flammable or explosive conditions), they will be equipped only with 3-wire grounded power and extension cords to prevent electrical shock. Use a ground fault circuit interrupter (GFCI) to prevent electrical shock.
- Store tools in clean, secure areas so they will not be damaged, lost, or stolen.
- Before exiting a vehicle, shift into park, set the parking brake, and shut off the engine. Never leave a running vehicle UNATTENDED.

Sanitation

Potable drinking water will be supplied in tightly closed containers and will be clearly marked for its intended use. If vehicles are available for use by field crews, restrooms and a field washing area with potable water will be available within a reasonable distance from the Project Area. If such facilities are not located within a reasonable distance, portable facilities will be installed for use by field employees.

Illumination

It is anticipated that all Project Area work will be conducted during daylight hours. If circumstances arise in which fieldwork is to be conducted before or after daylight, or sunlight is obstructed, illumination within all general Project Area locations will be maintained at or above 5 foot-candles for general Project Area locations.

13. Spill and/or Discharge of Hazardous Materials

Training

Responses to incidental releases or spills of hazardous substances that can be absorbed, neutralized, or otherwise controlled at the time of release by employees in the immediate release area are not considered to be emergency responses under 29 CFR 1910.120(I) and do not require additional specialized training.

Spill Control and Response

There is a potential for incidental spillage/leakage of hazardous materials. Some hazardous material handled at the Site include: NONE. Store these materials properly and maintain the appropriate spill response equipment in the area where the materials are used/stored. In case of incidental spills or leaks, follow these steps:

1. Notify the SSHO and/or TPL as soon as possible.
2. Select appropriate PPE and response equipment.
3. Contain the spill to the extent possible.
4. Neutralize or solidify the liquid per the SDS.
5. Transfer the material to an appropriate compatible container.
6. Document with an Incident Report (see Attachment 1).
7. PM or TPL will notify the Client.

Discharge Control and Response

In the event of an uncontrollable discharge of hazardous material from an existing Client structure (e.g., impoundment, tank, etc.) the SSHO or TPL will immediately contact the Client to coordinate implementation of the Client’s Emergency Response Plan. If safe to do so, shut off affected lines and activate the alarm system at locations predetermined by the Client. Other than to take diligent measures to prevent further discharge, GSI personnel shall not assist in emergency response activities, but will evacuate to a prearranged Safe Refuge Area(s) and implement the Project Area security and control measures.

Spill Response Reporting

Although spills in reportable quantities are not anticipated, field personnel will be instructed on requirements and procedures for reporting to Washington Department of Emergency Response, Ecology, the National Response Center (NRC), and Port of Tacoma Security. Spills will be reported immediately after the safety of onsite personnel has been secured. Potentially reportable spills include any amount of oil/diesel/gas spilled in water, or more than 42 gallons of oil spilled on land. Reporting will include the following information:

1. Your name and company.
2. Your telephone number.
3. Type of incident and the materials involved.
4. Location/time of incident. Background/how the incident occurred.
5. On-scene contact and how to reach them.
6. Severity of incident - threat to people, property, or the environment.
7. Actions taken - containment, evacuation.
8. Responsible party and telephone number.

Evacuation Procedures

Expeditious evacuation routes to the Safe Refuge Area(s) will be established daily for all work area locations, with respect to the wind direction. Evacuation notification will be a **continuous blast on a canned siren, vehicle horn, or direct verbal communication**. Emergency drills should be performed periodically. Any additions to evacuation procedures require an update to this HSP.

In the unlikely event that an evacuation is necessary, all personnel will immediately proceed to the predetermined Safe Refuge Area, decontaminating to the extent possible for personal safety, based on the emergency. The SSHO or TPL should then begin the Project Area security and control measures.

14. Accident Reporting and Record Keeping

At the onset of an employee work-related injury or illness the GSI employees should notify the supervisor on duty. The employee is required to report all work-related injuries; plus all non-work related injuries that may affect his/her ability to safely perform their job.

After the initial accident report, the SSHO or other designated GSI employee will immediately contact the immediately contact the PM, Supervisor, Unit Manager, or GSI Safety Committee to conduct an investigation jointly with the FM. The SSHO or PM will complete the Accident or Incident Report (Attachment 1). These completed reports must be transmitted to the Safety Committee within 24 hours of an occurrence; a fax or pdf file is acceptable. The Safety Committee will submit the appropriate reports to the GSI Human Resources Department (for Workers' Compensation), and OSHA (as applicable). All near miss incidents will be reported.

The foreman or field supervisor of subcontracting crews will investigate and complete an injury/illness report (similar in content to the GSI report) in accordance with their internal company policy. This report must be transmitted to GSI within 24 hours.

In case of environmental incidents, property damage, power disruption, or mandated work "shutdowns," an Incident Report (Attachment 1) will be prepared by the SSHO or TPL. Any damage, loss, or theft of GSI property (items/tools/equipment) will be reported to the PM or TPL.

15. Signatures

Table 13. Signatures for Health and Safety Plan

This signature indicates that the PM is aware of the potential hazards at this site, has reviewed this HSP, and will communicate these hazards and appropriate controls to GSI employees before they travel to the project site.

	Name (Printed)	Signature	Date
Prepared by	Renee Fowler		
Reviewed by	Rod Struck		
Project Manager	Rod Struck		

Table 14. GSI Employee Health And Safety Plan Acceptance

I have had access to the HSP and opportunity to ask questions about this HSP. I have received site-specific information and orientation regarding the identified hazards anticipated at the project site. My signature certifies that I understand the procedures, equipment, and restrictions of this HSP and agree to abide by them.

Signature	Name (Printed)	Date

16. Limitations

This HSP was prepared exclusively for the Port of Tacoma/Portac project by GSI. The quality of information contained herein is consistent with the level of effort involved in GSI services and based on: (i) information available at the time of preparation, (ii) data supplied by outside sources, and (iii) the assumptions, conditions, and qualifications set forth in this HSP. This HSP is intended to be used by GSI personnel providing well assessment only, to the terms and conditions of its contract with GSI. Any other use of, or reliance on, this HSP by any third party is at that party's sole risk. The information contained herein are relevant to the Facilities prior the development of this HSP and should not be relied upon to represent conditions at later dates. In the event that changes in the nature, usage, or layout of the property or nearby properties are made, the information contained in this HSP may not be valid. If additional information becomes available, it should be provided to GSI so the HSP can be modified as necessary.

If a coworker is injured, these are the steps to take:

1. **Provide or get medical help immediately.** Use your first aid training. If the injury is beyond first aid treatment and emergency services are needed, call 911 or use the contact information in the project's Health and Safety Plan (HSP) and call for help.

2. **Note the date and time of the accident.** Write this information on the HSP.

3. **Do not move equipment.** If there has been a fatality or three or more people are injured, do not move any equipment at the job site, except to remove victims or to prevent further injury.

4. **Go to the hospital with the injured employee, if possible.** Remain with the injured employee until you contact a member of the Safety Committee.

5. **Contact a member of GSI's Safety Committee.** Members of the Safety Committee are the main point of contact during an accident or incident. They will reach the employee's emergency contacts and inform GSI managers.

GSI Safety Committee Members

- **Rod Struck**
  Work: 971-200-8510
  Cell: 503-536-5810
- **Andrew Davidson**
  Work: 971-200-8535
  Cell: 773-817-4229
- **Walt Burt**
  Work: 971-200-8508
  Cell: 503-781-6895
- **Jill Carroll**
  Work: 971-200-8524
  Cell: 503-329-4343

ATTACHMENT 1

Health and Safety Plan Forms

EMPLOYEE EXPOSURE / INJURY INCIDENT / SPILL / NEAR MISS REPORT

(Use additional page if necessary)

Date: ______________________________ Time: ____

Name: ____________________________ Employer: _______________________________________

Type of Occurrence: employee exposure , / injury incident , / spill , / near miss ,

Site Name and Location: ____

Site Weather (clear, rain, snow, etc.): ____

Nature of Illness/Injury: ____

Symptoms: ____

Action Taken: Rest ____________ First Aid ______________ Medical ______________________

Transported By: ____

Witnessed By: ____

Hospital's Name: ____________________________ Treatment: ___________________________

Describe in detail how this Accident/Incident/Spill/Near Miss occurred. (If a spill, list the name of the compounds, quantities and method of clean-up/containment.)

____

____

____

____

____

____

____

____

What was the person doing at the time of the accident/incident? _______________________

____

Personal Protective Equipment Worn: ____

____

What immediate action was taken to prevent recurrence? ______________________________

____

____

Employee's Signature: ____ Date: _________________

Supervisor's Signature: _______________________________________ Date: _________________

Site Safety Representative's Signature: ________________________ Date: _________________

SAFETY MEETING RECORD

Project:

Date:

Time:

Person Conducting Meeting:

Topics Addressed:

Signatures of Persons Attending Meeting:

________________________________ ________________________________

________________________________ ________________________________

________________________________ ________________________________

________________________________ ________________________________

________________________________ ________________________________

________________________________ ________________________________

________________________________ ________________________________

________________________________ ________________________________

________________________________ ________________________________

________________________________ ________________________________

MODIFICATION TO HEALTH AND SAFETY PLAN

Project:

Modification:

____
____
____
____

Reasons for Modification:

____
____
____
____
____
____

Site Personnel Briefed

Name: ________________________________ Date: ______________________________
Name: ________________________________ Date: ______________________________
Name: ________________________________ Date: ______________________________
Name: ________________________________ Date: ______________________________
Name: ________________________________ Date: ______________________________
Name: ________________________________ Date: ______________________________
Name: ________________________________ Date: ______________________________
Name: ________________________________ Date: ______________________________
Name: ________________________________ Date: ______________________________

Approvals

Site Supervisor: ____
Site Safety and Health Officer: ____

Other: ____

ATTACHMENT 2

Excavation Safety Guidelines

OSHA® FactSheet

Trenching and Excavation Safety

Two workers are killed every month in trench collapses. The employer must provide a workplace free of recognized hazards that may cause serious injury or death. The employer must comply with the trenching and excavation requirements of 29 CFR 1926.651 and 1926.652 or comparable OSHA-approved state plan requirements.

An excavation is any man-made cut, cavity, trench, or depression in an earth surface formed by earth removal.

Trench (Trench excavation) means a narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet (4.6 meters).

Dangers of Trenching and Excavation

Cave-ins pose the greatest risk and are much more likely than other excavation-related accidents to result in worker fatalities. Other potential hazards include falls, falling loads, hazardous atmospheres, and incidents involving mobile equipment. One cubic yard of soil can weigh as much as a car. An unprotected trench is an early grave. Do not enter an unprotected trench.

Trench Safety Measures

Trenches 5 feet (1.5 meters) deep or greater require a protective system unless the excavation is made entirely in stable rock. If less than 5 feet deep, a competent person may determine that a protective system is not required.

Trenches 20 feet (6.1 meters) deep or greater require that the protective system be designed by a registered professional engineer or be based on tabulated data prepared and/or approved by a registered professional engineer in accordance with 1926.652(b) and (c).

Competent Person

OSHA standards require that employers inspect trenches daily and as conditions change by a competent person before worker entry to ensure elimination of excavation hazards. A competent person is an individual who is capable of identifying existing and predictable hazards or working conditions that are hazardous, unsanitary, or dangerous to workers, soil types and protective systems required, and who is authorized to take prompt corrective measures to eliminate these hazards and conditions.

Access and Egress

OSHA standards require safe access and egress to all excavations, including ladders, steps, ramps, or other safe means of exit for employees working in trench excavations 4 feet (1.22 meters) or deeper. These devices must be located within 25 feet (7.6 meters) of all workers.

General Trenching and Excavation Rules

- Keep heavy equipment away from trench edges.
- Identify other sources that might affect trench stability.
- Keep excavated soil (spoils) and other materials at least 2 feet (0.6 meters) from trench edges.
- Know where underground utilities are located before digging.
- Test for atmospheric hazards such as low oxygen, hazardous fumes and toxic gases when > 4 feet deep.
- Inspect trenches at the start of each shift.
- Inspect trenches following a rainstorm or other water intrusion.
- Do not work under suspended or raised loads and materials.
- Inspect trenches after any occurrence that could have changed conditions in the trench.
- Ensure that personnel wear high visibility or other suitable clothing when exposed to vehicular traffic.

Protective Systems

There are different types of protective systems.

Benching means a method of protecting workers from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels. *Benching cannot be done in Type C soil.*

Sloping involves cutting back the trench wall at an angle inclined away from the excavation.

Shoring requires installing aluminum hydraulic or other types of supports to prevent soil movement and cave-ins.

Shielding protects workers by using trench boxes or other types of supports to prevent soil cave-ins. Designing a protective system can be complex because you must consider many factors: soil classification, depth of cut, water content of soil, changes caused by weather or climate, surcharge loads (e.g., spoil, other materials to be used in the trench) and other operations in the vicinity.

Additional Information

Visit OSHA's Safety and Health Topics web page on trenching and excavation at

www.osha.gov/SLTC/trenchingexcavation/index.html
www.osha.gov/dcsp/statestandard.html

For assistance, contact us. We can help. It's confidential.

OSHA®
**Occupational
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U.S. Department of Labor
www.osha.gov (800) 321-OSHA (6742)

DOC FS-3476 9/2011

EXCAVATIONS

SAFE PRACTICES FOR SMALL BUSINESS OWNERS AND CONTRACTORS

Oregon OSHA

HOW TO DIG YOUR OWN GRAVE

No protective system

Spoils too close

Excavator bucket over worker

No hard hat

No means for entering or exiting

EXCAVATIONS

www.orosha.org

About this document

Excavations – Safe practices for small business owners and contractors is an Oregon OSHA Standards and Technical Resources publication.

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- ***Layout and design:*** Patricia Young, Oregon OSHA
- ***Editing and proofing:*** Mark Peterson, DCBS Communications

We want you to understand what you read

This guide comes with a plain-language guarantee! Let us know if you're not satisfied. Contact Ellis Brasch at **ellis.k.brasch@state.or.us** or call 503-947-7399.

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DEPARTMENT OF
CONSUMER
& BUSINESS
SERVICES

Oregon
OSHA

CONTENTS

INTRODUCTION

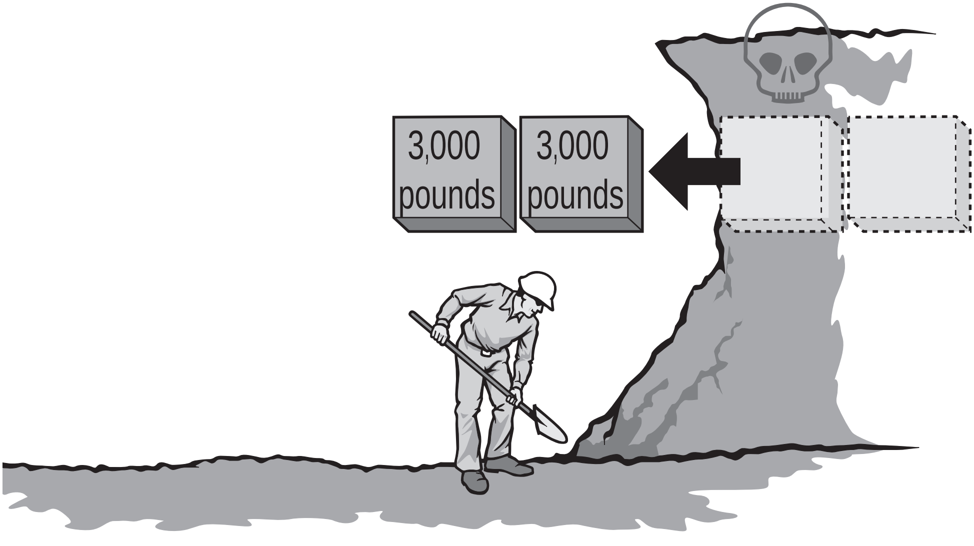
A cave-in can trap you within seconds and kill you within minutes.

Two cubic yards of soil weigh about 6,000 pounds. If you're buried, you'll suffocate in less than three minutes. Even if you survive, the weight of the soil is likely to cause serious internal injuries.

But cave-ins aren't the only dangers in excavation work. Lack of oxygen, toxic fumes, explosive gases, and buried power lines are also hazards. Unfortunately, many contractors who do excavation work still think that it's too expensive or takes too much time to provide appropriate safeguards.

How much does soil weigh?

Two cubic yards of soil weigh about 6,000 pounds!



EXCAVATIONS AND TRENCHES

Dig a hole in the ground and you've made an **excavation**. Excavations can be any size: wide, narrow, deep, or shallow.

A **trench** is a narrow excavation, not more than 15 feet wide at the bottom. If you install *forms* or other structures in an excavation that reduce its width to less than 15 feet, measured at the bottom, the excavation is also considered a trench.

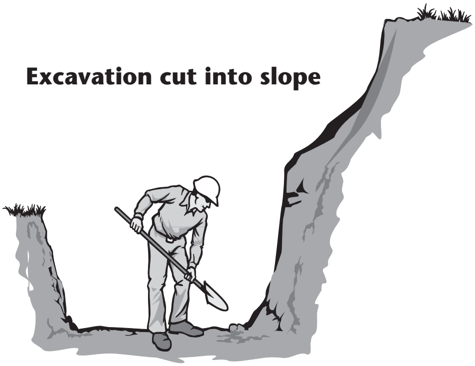
- If you work in an excavation that's five feet deep (or deeper) you must be protected from a cave-in.
- If a *competent person* determines that there's a potential for an excavation to cave-in, you must be protected regardless of its depth.

What is an excavation?

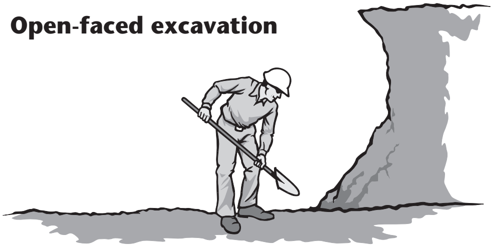
An excavation is a man-made cut, cavity, or depression in the earth's surface.

Excavation

Excavation cut into slope



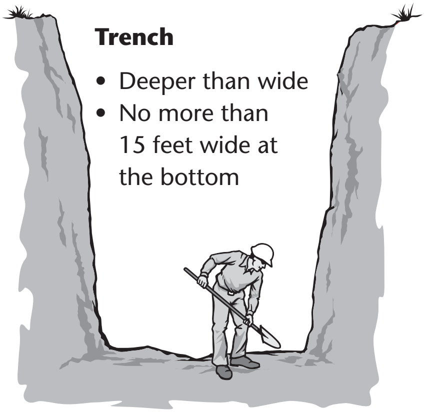
Open-faced excavation



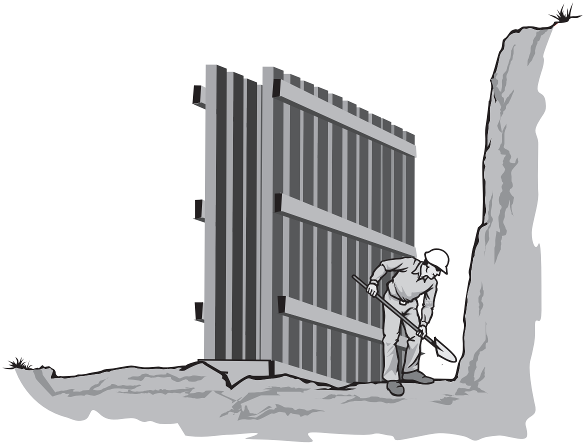
What is a trench?

A trench is deeper than it is wide – and not more than 15 feet wide at the bottom.

- **Typical trench**



- **Trench created by formwork**



PLAN BEFORE YOU DIG

Planning reduces the chance that something will go wrong when you start a job. Consider the following before you start excavating:

- Debris near the excavation site that could create a hazard
- How employees will get in and out of the excavation
- How to protect people from falling into the excavation
- How to respond to emergencies
- Location of overhead power lines and underground utility lines *(**Call 811** from anywhere in Oregon for help in locating underground utility lines)*
- Possibility of atmospheric hazards in the excavation
- Possibility of water in the excavation
- Stability of soil at the excavation site
- Stability of structures adjacent to the excavation site
- Vehicles and other mobile equipment that will operate near the excavation
- Weather conditions

THE ROLE OF THE COMPETENT PERSON

A designated competent person who has training in soil analysis, protective systems, and Oregon OSHA's *Division 3, Subdivision P, Excavation* requirements must be on site to classify the soil, select a protective system, oversee installation, and inspect the system after installation.

If there are no existing hazards the competent person can leave the excavation site for a short time, but must be present when a protective system is moved. Soil conditions could change or new hazards may arise that require the competent person's judgment.

The competent person must be knowledgeable about the type of soil excavated and the protective system used and must inspect them daily for signs of instability, damage, or other hazards; the competent person must approve any changes. Inspections are also necessary after heavy rain or activities such as blasting that may increase the risk of cave-in.

The competent person must have authority to immediately correct the hazards and to order employees to leave the excavation until the hazards have been corrected. An employee who is trained and can identify excavation hazards but doesn't have the authority to correct them is not a competent person.

HOW CAVE-INS OCCUR

Undisturbed soil stays in place because opposing horizontal and vertical forces are evenly balanced. When you create an excavation, you remove the soil that provides horizontal support. Soil will eventually move downward into the excavation. The longer the face (a side of the excavation) remains unsupported, the more likely it is to cave in.

How do cave-ins occur?

When you create an excavation, you remove the soil that provides horizontal support.

Soil and stability

Some soils are more stable than others. The type of soil is one of the factors that determine the chance that an excavation will cave in. There are three basic soil types that you may encounter in Oregon:

- **Type A** – very stable. Clay is an example.
- **Type B** – less stable than type A soil. Crushed rock, silt, and soils that contain an equal mixture of sand and silt are examples.
- **Type C** – less stable than type B soil. Gravel and sand are examples.

Soil has other qualities that affect its stability. These include *granularity, saturation, cohesiveness,* and *unconfined compressive strength*.

- Granularity refers to the size of the soil grains; the larger the grains, the less stable the soil.
- Saturation means how much water soil will absorb.
- Cohesiveness means how well soil holds together; clay is a cohesive soil.
- Unconfined compressive strength is determined by a test that shows how much pressure it takes to collapse a soil sample. For example, type A soil must have an unconfined compressive strength of at least 1.5 tons per square foot.

HOW SOIL IS TESTED

A competent person must conduct **visual** and **manual** soil tests before anyone enters an excavation. Visual and manual tests are a critical part of determining the type of protective system that will be used.

Visual tests

Visual testing involves looking at the soil and the area around the excavation site for signs of instability. The competent person might do visual tests such as the following:

- Observe the soil as it is excavated. Soil that remains in large clumps when excavated may be cohesive. Soil that breaks up easily is granular.
- Examine the particle sizes of excavated soil to determine how they hold together.
- Look for cracks or fissures in the faces of the excavation.
- Look for layers of different soil types and the angle of the layers in the face of the excavation that may indicate instability.
- Look for water seeping from the sides of the excavation.
- Look for signs of previously disturbed soil from other construction or excavation work.
- Consider vibration from construction activity or highway traffic that may affect the stability of the excavation.

Manual tests

Manual testing involves evaluating a sample of soil from the excavation to determine qualities such as cohesiveness, granularity, and unconfined compressive strength. Soil can be tested either on site or off site but should be tested as soon as possible to preserve its natural moisture.

Examples of manual tests:

Plasticity test. Shape a sample of moist soil into a ball and try to roll it into threads about 1/8-inch in diameter. Cohesive soil will roll into 1/8-inch threads without crumbling.

Dry strength test. Hold a dry soil sample in your hand. If the soil is dry and crumbles on its own or with moderate pressure into individual grains or fine powder, it's granular. If the soil breaks into clumps that are hard to break into smaller clumps, it may be clay combined with gravel, sand, or silt.

Thumb penetration test. This test roughly estimates the unconfined compressive strength of a sample. Press your thumb into the soil sample. If the sample resists hard pressure it may be type A soil. If it's easy to penetrate, the sample may be type C.

Pocket penetrometers offer more accurate estimates of unconfined compressive strength. These instruments estimate the unconfined compressive strength of saturated cohesive soils. When pushed into the sample, an indicator sleeve displays an estimate in tons per square foot or kilograms per square centimeter.

PROTECTIVE SYSTEMS

The basic methods for protection from cave-ins are **sloping**, **benching**, **shoring**, and **shielding**. The method you should use depends on factors such as soil type and water content, excavation depth and width, the nature of the work, and nearby activities that could increase the risk of a cave-in. The competent person has the responsibility for considering these factors and for determining the appropriate protective system.

➡ A *registered professional engineer* must design protective systems for all excavations that are more than 20 feet deep.

Sloping and benching

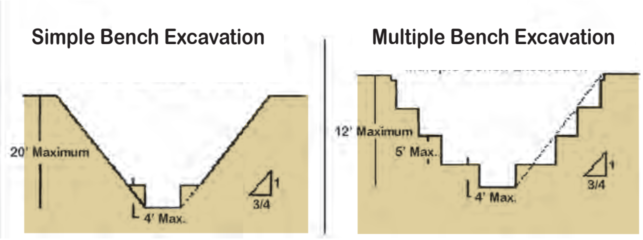
Sloping and benching provide protection by removing material from the face of an excavation at an angle to its floor; in general, the flatter the angle, the greater the protection. Benches are cuts in the slope that give it a stair-step appearance. There are two types of benches: simple and multiple.

Rain, vibration, and pressure from heavy equipment can make soil unstable and increase the risk of a cave-in. Sloped or benched excavations that show signs of cracks, bulges, or clumps of soil that fall away from the faces are dangerous and must be inspected by a competent person. You must immediately get out of the excavation and stay away until the competent person determines it is safe to enter.

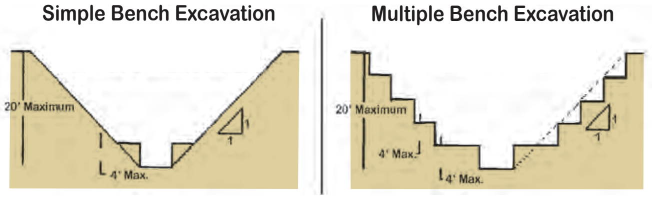
➡ A registered professional engineer must determine the angle of slopes in excavations that are deeper than 20 feet.

What do benched slopes look like in type A, type B, and type C soil?

- Type A soil: simple and multiple benches



- Type B soil: simple and multiple benches



- Type C soil: simple and multiple benches

  Benching in type C soil requires a registered professional engineer.

Shoring and shielding

Shoring and shielding systems can prevent cave-ins in excavations with or without sloped or benched faces. The safest way to install and remove them is from outside the excavation.

Shores are vertical or horizontal supports that prevent the faces of an excavation from collapsing. Vertical shores are called uprights. They're easy to install, relatively inexpensive, and often used in stable soil or in shallow excavations that have parallel faces. Vertical shores must be sized for the excavation's dimensions and soil type.

Horizontal shores are called *walers*. Walers are often used when unstable soil makes sloping or benching impractical and when sheeting is necessary to prevent soil from sliding into the excavation.

Shields provide employees a safe work area by protecting them from collapsing soil. Shields don't prevent cave-ins but "shield" workers if a face does collapse. They are usually placed in the excavation by heavy equipment.

Shoring and shielding systems are available from manufacturers in a variety of dimensions, usually aluminum or steel, or they can be custom-built from *tabulated data* approved by a registered professional engineer. Manufacturers will also provide tabulated data with their systems that includes engineering specifications, depth ratings, special instructions, and system limitations. Only by carefully studying and understanding the manufacturer's tabulated data can the competent person choose the correct protective system.

What do shores and shields look like?

Horizontal shore

Photo credit: Speed Shore Corp.

Vertical shore

Photo credit: Speed Shore Corp.

Trench shield

Photo credit: Speed Shore Corp.

GETTING IN AND OUT OF AN EXCAVATION

An excavation that has a depth of four feet or more must have a means for entering and exiting — such as a stairway, ladder, or ramp — within 25 feet of employees; their safety may depend on how quickly they can climb out.

Structural ramps that are used to enter and exit the excavation must have nonslip surfaces and be designed by a competent person. A competent person must also evaluate ramps made from soil that are used to enter and exit an excavation.

MATERIALS AND MOBILE EQUIPMENT

Excavated soil, called *spoils*, piled too close to the edge of an excavation can cause a cave-in. So can heavy equipment. Keep spoils and heavy equipment at least two feet from the edge; when possible, use vertical shores or shields that extend above the top of the excavation to restrain spoils. Spoils and heavy equipment that exert an excessive load on ground adjacent to the excavation could cause a cave-in.

When are spoils hazardous?

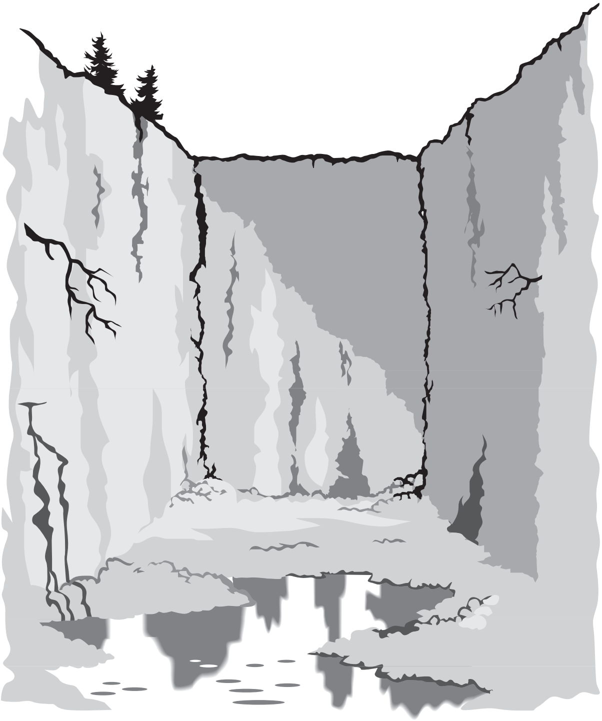
Spoils and heavy equipment that exert an excessive load on ground adjacent to an excavation could cause a cave-in.

HAZARDOUS ATMOSPHERES

Hazardous atmospheres can occur in excavations near landfills, sites contaminated by leaking gas lines or storage tanks, in sewers, and in other confined spaces. If these conditions are possible, a competent person must test for oxygen deficiency (oxygen levels less than 19.5 percent) and hazardous atmospheres before you can enter.

WATER ACCUMULATION

Water makes soil unstable. You can't enter an excavation when water has built up unless you are protected from the unstable soil. Protection includes specialized support systems and water-removal equipment. A competent person must inspect the excavation and monitor methods used to control water accumulation.



WORKING WITH HYDRAULIC EXCAVATORS AND BACKHOE LOADERS

You can dig an excavation with a hand shovel or an excavator. Use a hand shovel improperly and you risk blisters. Use an excavator improperly and you risk a life. Too many workers are hurt because they don't follow safe practices when they use hydraulic excavators and backhoe loaders. Most accidents happen for three reasons:

- Entering the excavator's swing area
- Using quick-coupling devices improperly
- Using unsafe rigging methods to drag a trench shield

Entering the excavator's swing area

Be aware of the excavator's swing area and blind spots. Always maintain at least three feet of unimpaired clearance between the excavator's rotating superstructure and adjacent objects. Keep others outside the area by marking it with rope, tape, or a similar barrier, if necessary.

- Post warning signs that say **DANGER – STAY CLEAR** on all sides of the excavator.
- Don't allow anyone to stand under a suspended load or the boom, arm, or bucket.
- Keep the bucket as close to the ground as possible when workers are attaching loads.
- Lower the boom to a safe position with the bucket on the ground and turn off the excavator before getting off.

Where do I post the warning signs?

Post warning signs that say **DANGER – STAY CLEAR** on all sides of the excavator [from *Division 3, Subdivision O*, 437-003-0090(1)]

Photo credit: Robert I. Carr, Ph.D., P.E.

Don't allow anyone to stand under the boom, arm, or bucket!

Using quick-coupling devices improperly

Aftermarket “quick-coupling” devices make it easy to change buckets or replace other attachments. However, a number of workers have been killed when the coupling devices have not been locked properly and the buckets have detached. Manufacturers of quick couplers recognized the hazard and newer devices have locks that prevent buckets from detaching unintentionally, but not all users may be aware of the problem. Retrofit locking pins are available for older equipment.

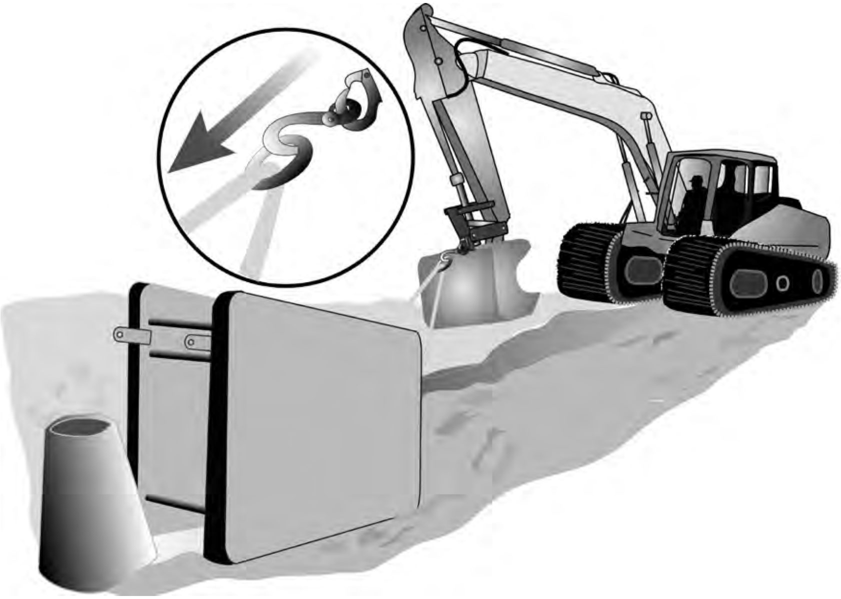
- Follow the manufacturer’s instructions for using positive locks on quick-disconnect equipment.
- Securely latch attachments such as quick-disconnect buckets before beginning work.
- Make frequent visual inspections of quick-disconnect systems — especially after changing attachments.

Using unsafe rigging methods to drag a trench shield

Using an excavator to drag a shield through a trench can put tremendous forces on rigging components. For example, the force required to drag a 10,000-pound trench shield through a narrow trench will increase dramatically with resistance from the trench walls or from plowing of the front of the shield. Know the sling’s rated capacities and never exceed them. The whiplash effect of a broken or improperly rigged sling can kill anyone in its path.

- Follow the instructions in the operator’s manual when using an excavator to lift or move an object.
- “Lift and drag” to move a trench shield horizontally in a trench; avoid “plowing” with the front of the shield. Plowing significantly increases the tension on the slings.
- Some manufacturers of trench shields warn workers to stay out of the “box” while it is being moved. Always check the manufacturers’ requirements.

- Never use damaged chains or frayed cables, slings, straps, or ropes.
- Use an appropriate lifting shackle for attaching cables or slings.
- Never stand in line with, or next to, a sling that is under tension.



WORKING NEAR OVERHEAD POWER LINES

Before you do any work within 10 feet of a high-voltage power line, notify the utility that controls the line at least two business days before you begin. If you don't know who controls the line, any utility can help you.

You need to tell the utility the location, what work you need to do, and when you need to do it.

To ensure that you do the work safely, the utility may help you with tasks such as the following:

- Coordinate work schedules
- Identify and provide temporary visual barriers that help prevent encroachment with the lines
- De-energize and ground the lines
- Temporarily raise or move the lines

What happens if you don't notify the utility?

Oregon's Overhead Line Safety Act and Oregon OSHA rules require that you stay at least 10 feet away from these utilities. You could be responsible for all damages and costs that result from an electrical contact. There's also a potential penalty of up to $70,000 for violations of these rules, in addition to the cost of injuries and repairs to the system.

STABILITY AND ADJACENT STRUCTURES

Make sure that structures, roadways, and sidewalks adjacent to the excavation are adequately supported.

- Use an appropriate support system – such as shoring or bracing – if the excavation could affect the stability of nearby buildings, sidewalks, and roads.
- Don’t excavate below the base or footing of any foundation that might endanger employees unless you do one of the following:
  - Use a support system that protects employees and keeps the structure stable.
  - Ensure that the excavation is in stable rock.
  - Have a registered professional engineer determine that the structure will not be affected by the excavation work.
  - Have a registered professional engineer determine that the excavation work will not endanger employees.

EXCAVATION REQUIREMENTS

Oregon OSHA's *Division 3, Subdivision P, Excavation* requirements apply to all open excavations.

- 1926.650 — Scope, application, and definitions
- 1926.651 — Specific excavation requirements
- 437-003-0096 — Underground installations
- 1926.652 — Requirements for protective systems
- Appendix A — Soil classification
- Appendix B — Sloping and benching
- Appendix C — Timber shoring for trenches
- Appendix D — Aluminum hydraulic shoring for trenches
- Appendix E — Alternatives to timber shoring
- Appendix F — Selection of protective systems

SAFE PRACTICES CHECKLIST

	All your answers should be "Yes!"	**Yes**	**No**
1.	A designated competent person at the excavation site understands visual and manual test methods, use of protective systems, the hazards of excavation work, and the requirements of Oregon OSHA's excavation standards.	☐	☐
2.	A designated competent person inspects the excavation, adjacent areas, and protective systems daily before work begins, as necessary throughout the shift, and after rain or other conditions that could increase the risk of a hazard.	☐	☐
3.	A designated competent person has authority to immediately correct hazards and to order employees to leave the excavation until the hazards have been corrected.	☐	☐
4.	Sewer, telephone, fuel, electric, or water lines near the site have been located and clearly marked. Contact the Oregon Utility Notification Center for help in locating underground utility lines – call 811 from anywhere in Oregon.	☐	☐
5.	Hard hats are required whenever there are overhead hazards.	☐	☐
6.	Debris and other unnecessary material have been cleared from the site.	☐	☐

		Yes	No
7.	Employees who are exposed to vehicle traffic are provided with and wear high-visibility garments.	☐	☐
8.	Excavations at remote sites have appropriate warning barriers.	☐	☐
9.	Employees are protected from loose rock or soil that could fall into the excavation.	☐	☐
10.	Employees are prohibited from working or standing under suspended loads.	☐	☐
11.	Employees are required to stand away from vehicles that are being loaded or unloaded.	☐	☐
12.	Employees are prohibited from working on the faces of sloped or benched excavations when other employees are below them.	☐	☐
13.	Mobile equipment operators have an effective way of knowing when they are too close to the edge of an excavation. Examples include barricades, hand or mechanical signals, stop logs, or grading away from the excavation.	☐	☐
14.	Spoils, equipment, and tools are at least two feet from the edge of the excavation.	☐	☐
15.	Walkways that cross over excavations more that six feet deep have standard guard rails and toe boards.	☐	☐

		Yes	No
16.	Underground installations are protected, supported, or removed when the excavation is open.	☐	☐
17.	Excavations that have a depth of four feet or more have ladders or other means of safe access within 25 feet of employees.	☐	☐
18.	Ladders are secured and extend three feet above edge of the excavation.	☐	☐
19.	A designated competent person designs the structural ramps that employees use to enter and exit the excavation.	☐	☐
20.	Structural ramps have nonslip surfaces.	☐	☐
21.	Employees are prohibited from entering an excavation that shows signs of water accumulation unless they are protected from the risk of a cave-in.	☐	☐
22.	A competent person monitors the methods used to control water from accumulating in an excavation.	☐	☐
23.	Surface water or runoff is diverted away from the excavation.	☐	☐
24.	The atmosphere in an excavation is tested when the possibility of a hazardous atmosphere exists.	☐	☐
25.	Employees are protected from hazardous atmospheres or atmospheres containing less than 19.5 percent oxygen.	☐	☐

		Yes	No
26.	Emergency rescue equipment is available when hazardous atmospheres could exist in an excavation.	☐	☐
27.	Employees who work in excavations are trained to use appropriate personal protective equipment.	☐	☐
28.	A designated competent person has classified soil at the excavation site with at least one manual test and one visual test.	☐	☐
29.	Materials and equipment used for protective systems at the excavation site are chosen based upon soil analysis, excavation depth, and expected loads.	☐	☐
30.	Materials and equipment used for protective systems are inspected regularly and in good condition.	☐	☐
31.	Damaged equipment is removed from service immediately.	☐	☐
32.	Protective systems are installed without exposing employees to the risk of cave-ins.	☐	☐
33.	Structures, roadways, and sidewalks adjacent to the excavation are adequately supported.	☐	☐
34.	Excavations are backfilled when protective systems are removed.	☐	☐

		Yes	No
35.	Appropriate sloping, shoring, or shielding protects employees who work in excavations five or more feet deep.	☐	☐
36.	A designated competent person determines the type of shield used at a site by considering factors such as the nature of the work, excavation dimensions, soil characteristics, and equipment used to lower or position the shield.	☐	☐
37.	Employees in excavations more than 20 feet deep are protected by a system designed by a registered professional engineer.	☐	☐
38.	Shields are installed so that they do not move laterally.	☐	☐
39.	Employees are not allowed in shields that are moved vertically.	☐	☐

IMPORTANT TERMS

Adjacent	The area within a horizontal distance from the edge of a vertical-sided excavation equal to the depth of the excavation.
Aluminum hydraulic shoring	A pre-engineered system of aluminum hydraulic cylinders (cross braces) and vertical rails (uprights) or horizontal rails (walers). Designed to support the faces of an excavation.
Benching	A method of sloping the sides of an excavation by forming a series of steps.
Cave-in	The separation of a mass of soil or rock from the face of an excavation into an excavation.
Competent person	A person capable of identifying existing and predictable hazards in the surroundings or working conditions and who has authorization to take prompt corrective measures to eliminate the hazards.
Cross brace	Horizontal member of a shoring system installed perpendicular to the sides of an excavation, the end of which bears against uprights or wales.
Excavation	A man-made cut, cavity, or depression in the earth's surface.
Face	The side of an excavation.
Hazardous atmosphere	An atmosphere that could cause an injury or illness. Examples: explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen deficient, or toxic.
Previously disturbed soil	Soil that has been disturbed from excavation work or other digging. Soil cannot be classified type A if it has been previously disturbed. Use visual tests to identify previously disturbed soil.
Protective system	A system designed to protect workers in excavations. Sloping and benching, shores, and shields are examples of protective systems.
Ramp	An inclined walking or working surface constructed from earth or from structural materials such as steel or wood.

Registered professional engineer	A professional engineer registered in the state where the work is performed. A professional engineer registered in any state can approve designs for manufactured protective systems or tabulated data used in interstate commerce.
Sheeting	Component of a shoring system that prevents soil from sliding into an excavation.
Shield	A structure able to withstand forces caused by a cave-in. Shields can be manufactured or custom-built in accordance with 1926.652(c)(2)-(c)(4). Shields are also called trench boxes and trench shields.
Shore	A structure that supports the sides of an excavation and prevents cave-ins.
Sloping	A method of inclining the face of an excavation to minimize the risk of a cave-in. The maximum allowable slope varies with soil type, environment, and work done at the excavation site.
Soil	Weathered rock, gravel, sand, or combinations of clay, silt, and loam.
Stable rock	Natural solid mineral material that can be excavated with vertical sides and will remain intact while exposed.
Structural ramp	A ramp made of steel or wood, usually for vehicle access. Ramps made from soil or rocks are not considered structural ramps.
Support system	A system that supports an adjacent structure, underground installation, or the face of an excavation.
Surcharge	A load exerted on ground adjacent to an excavation.
Tabulated data	Tables and charts, approved by a registered professional engineer, used to design and construct a protective system. At least one copy of the data and the name of the engineer who approved it must be kept at the site while the system is constructed.
Trench	An excavation that is longer than wide. In general, the depth is greater than the width but the width measured at the bottom of the trench is not greater than 15 feet.
Upright	The vertical member of a shoring system.

NOTES

NOTES

Oregon OSHA Services

Oregon OSHA offers a wide variety of safety and health services to employers and employees:

Consultative Services

- Offers no-cost on-site safety and health assistance to help Oregon employers recognize and correct workplace safety and health problems.
- Provides consultations in the areas of safety, industrial hygiene, ergonomics, occupational safety and health programs, assistance to new businesses, the Safety and Health Achievement Recognition Program (SHARP), and the Voluntary Protection Program (VPP).

Enforcement

- Offers pre-job conferences for mobile employers in industries such as logging and construction.
- Provides abatement assistance to employers who have received citations and provides compliance and technical assistance by phone.
- Inspects places of employment for occupational safety and health hazards and investigates workplace complaints and accidents.

Appeals, Informal Conferences

- Provides the opportunity for employers to hold informal meetings with Oregon OSHA on concerns about workplace safety and health.
- Discusses Oregon OSHA's requirements and clarifies workplace safety or health violations.
- Discusses abatement dates and negotiates settlement agreements to resolve disputed citations.

Standards & Technical Resources

- Develops, interprets, and provides technical advice on safety and health standards.
- Provides copies of all Oregon OSHA occupational safety and health standards.
- Publishes booklets, pamphlets, and other materials to assist in the implementation of safety and health standards and programs.
- Operates a Resource Center with video lending library, books, technical periodicals, and consensus standards.

Public Education & Conferences

- Conducts conferences, seminars, workshops, and rule forums.
- Coordinates and provides technical training on topics such as confined space, ergonomics, lockout/tagout, and excavations.
- Provides workshops covering management of basic safety and health programs, safety committees, accident investigation, and job safety analysis.
- Manages the Safety and Health Education and Training Grant Program, which awards grants to industrial and labor groups to develop training materials in occupational safety and health for Oregon workers.

For more information, call the Oregon OSHA office nearest you.

Salem Central Office
350 Winter St. NE, Rm. 430
Salem, OR 97301-3882
Phone: 503-378-3272

Toll-free: 800-922-2689
Fax: 503-947-7461
en Español: 800-843-8086
Web site: www.orosha.org

Portland
1750 NW Naito Parkway,
Ste. 112
Portland, OR 97209-2533
503-229-5910
Consultation: 503-229-6193

Salem
1340 Tandem Ave. NE,
Ste. 160
Salem, OR 97303
503-378-3274
Consultation: 503-373-7819

Eugene
1140 Willagillespie, Ste. 42
Eugene, OR 97401-2101
541-686-7562
Consultation: 541-686-7913

Bend
Red Oaks Square
1230 NE Third St.,
Ste. A-115
Bend, OR 97701-4374
541-388-6066
Consultation: 541-388-6068

Medford
1840 Barnett Road, Ste. D
Medford, OR 97504-8250
541-776-6030
Consultation: 541-776-6016

Pendleton
721 SE Third St., Ste. 306
Pendleton, OR 97801-3056
541-276-9175
Consultation: 541-276-2353

1859

Oregon
OSHA

EXCAVATIONS

ATTACHMENT 3

Chemical of Concern Concentrations

FIGURE 9

Groundwater Concentrations - Pentachlorophenol
Parcel 15 Investigation
Data Gaps Memorandum
Tacoma, WA

DRAFT

LEGEND

◐ Monitoring Well[1]

No Data[2]

Results from Most Recent Sampling Event[3]

All Other Features

Site Boundary

Cap[6]

Railroad

Watercourse

Waterbody

NOTES:
Location of all site features is approximate.
All results in ug/L.

SOURCE INFORMATION:
1. Monitoring wells "MW-1 through MW-6R" are from Figure 12 of the "Site Investigation Sampling and Monitoring Well Location Plan" (WES, 2009).
2. Wells not sampled for pentachlorophenol.
3. Results are concentrations from the three most recent sampling events, as presented in WES, 2013. Additional historic data from these locations are included in Attachment D.
6. Cap extent defined on Figure 2 of the Former Portac Inc. Site (AQEA, 2014).

N

0 150 300 450
Feet

MAP NOTES:
Date: October 29, 2015
Data Sources: PORTAC, Aerial photo taken in July of 2013 by the USDA

GSI Water Solutions, Inc.

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Document Path: P:\Portland\603-Port of Tacoma\GIS\Project_mxds\Data_Gaps_Memo\Figure10_GW_Arsenic_Concentrations.mxd

FIGURE 10

Groundwater Concentrations - Arsenic

Parcel 15 Investigation
Data Gaps Memorandum
Tacoma, WA

DRAFT

LEGEND

- Monitoring Well[1]
- ○ Soil Boring[2]
- No Recent Data[3]
- Total Arsenic Concentration[4]
- Dissolved Arsenic Concentration[5]

All Other Features

- Site Boundary
- Cap[6]
- Railroad
- Watercourse
- Waterbody

NOTES:

Location of all site features is approximate.
All results in ug/L.

SOURCE INFORMATION:

1. Monitoring wells "MW-1 through MW-6R" are from Figure 12 of the "Site Investigation Sampling and Monitoring Well Location Plan" (WES, 2009).
2. Borings notated "B-X-1987" are from Figure 1 of the "Groundwater Assessment" (HC, 1987).
3. The most recent data from these locations was collected prior to 2000, and current conditions are considered a data gap. Historic data for these wells are included in Attachment D.
4. Results are total arsenic concentrations from the three most recent sampling events, as presented in WES, 2013. Additional historic data from these locations are included in Attachment D.
5. Results are dissolved arsenic concentrations in groundwater collected as grab samples during the Portac Cap Subsurface Investigation (Landau 2014). Data table is included in Attachment D.
6. Cap extent defined on Figure 2 of the Former Portac Inc. Site (AQEA, 2014).

N

0 150 300 450
Feet

MAP NOTES:

Date: October 27, 2015
Data Sources: PORTAC, Aerial photo taken in July of 2013 by the USDA

GSI Water Solutions, Inc.

ATTACHMENT 4

Safety Data Sheets

Safety Data Sheet
according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), and GHS

Effective date: 05/12/2015 **Revision:** 05/12/2015

LIQUINOX

1 Identification of the Substance/mixture and of the Company/Undertaking

1.1 Product identifier

Trade name: LIQUINOX
Application of the substance / the preparation: Hand detergent.

1.2 Relevant identified uses of the substance or mixture and uses advised against:

No additional information available.

1.3 Details of the supplier of the Safety Data Sheet

Manufacturer/Supplier:

Alconox, Inc.
30 Glenn St., Suite 309
White Plains, NY 10603
Phone: 914-948-4040

Further information obtainable from: Product Safety Department.

1.4 Emergency telephone number:

ChemTel Inc.: (800)255-3924, +1 (813)248-0585

2 Hazards Identification

2.1 Classification of the substance or mixture

Classification according to Regulation (EC) No 1272/2008:

Classification according to Directive 67/548/EEC or Directive 1999/45/EC:

GHS07
Skin Irrit. 2, H315: Causes skin irritation.

Information concerning particular hazards for human and environment:

The product has to be labelled due to the calculation procedure of the "General Classification guideline for preparations of the EU" in the latest valid version.

Classification system:

The classification is according to the latest editions of the EU-lists, and extended by company and literature data

2.2 Label elements

Labelling according to Regulation (EC) No 1272/2008:

The product is classified and labelled according to the CLP regulation.

Hazard pictograms:

GHS07

Signal word: Warning

Hazard-determining components of labelling:

Alkyl benzene sulfonic acid, sodium salt.

Hazard statements:

H315: Causes skin irritation.

Precautionary statements:

P332+P313: If skin irritation occurs: Get medical advice/attention.

P302+P352: IF ON SKIN: Wash with plenty of soap and water.

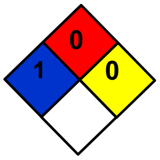
P501: Dispose of contents/container in accordance with local/regional/national/international regulations.

Other Hazard description:

WHMIS-classification and symbols:

D2B - Toxic material causing other toxic effects

NFPA ratings (scale 0 - 4)



Health = 1
Fire = 0
Reactivity = 0

HMIS-ratings (scale 0 - 4)

HEALTH	1	🟦	Health = 1
FIRE	0	🟥	Fire = 0
REACTIVITY	0	🟨	Reactivity = 0

2.3 Other hazards

Results of PBT and vPvB assessment

PBT: Not applicable.

vPvB: Not applicable.

3 Composition/Information on Ingredients

3.2 Chemical characterization: Mixture

Description: Hazardous ingredients of mixture listed below.

Identifying Nos.	Description	Wt. %
CAS: 68081-81-2	Alkyl benzene sulfonic acid, sodium salt	10 - 25%
CAS: 1300-72-7 EINECS: 215-090-9	Sodium xylene sulphonate	2.5 - 10%
CAS: 84133-50-6	Alcohol Ethoxylate	2.5 - 10%
CAS: 68603-42-9 EINECS: 271-657-0	Coconut diethanolamide	2.5 - 10%
CAS: 17572-97-3 EINECS: 241-543-5	Ethylenediaminetetraacetic acid, tripotassium salt	2.5 - 10%

Additional information: For the wording of the listed risk phrases refer to section 16.

4 First Aid Measures

4.1 Description of first aid measures

General information:

Take affected persons out into the fresh air.

After inhalation:

Supply fresh air; consult doctor in case of complaints.

After skin contact:

Immediately wash with water and soap and rinse thoroughly for 30 minutes. If skin irritation continues, consult a doctor.

After eye contact:

Remove contact lenses if worn.

Rinse opened eye for at least 30 minutes under running water, lifting upper and lower lids occasionally. Immediately consult a doctor.

After swallowing:

Do not induce vomiting; call for medical help immediately. Rinse out mouth and then drink plenty of water.

A person vomiting while laying on their back should be turned onto their side.

4.2 Most important symptoms and effects, both acute and delayed:

Irritating, all routes of exposure.

4.3 Indication of any immediate medical attention and special treatment needed:

No additional information available.

5 Firefighting Measures

5.1 Extinguishing media:

Suitable extinguishing agents:

CO2, powder or water spray. Fight larger fires with water spray or alcohol resistant foam.

5.2 Special hazards arising from the substance or mixture:

No additional information available.

5.3 Advice for firefighters:

Protective equipment:

Wear self-contained respiratory protective device.

Wear fully protective suit.

6 Accidental Release Measures

6.1 Personal precautions, protective equipment and emergency procedures:

Ensure adequate ventilation.

Particular danger of slipping on leaked/spilled product.

6.2 Environmental precautions:

Dilute with plenty of water.

Do not allow to enter sewers/ surface or ground water.

6.3 Methods and material for containment and cleaning up:

Absorb with liquid-binding material (sand, diatomite, acid binders, universal binders, sawdust).

Clean the affected area carefully; suitable cleaners are: Warm water

Dispose contaminated material as waste according to item 13. Ensure adequate ventilation.

6.4 Reference to other sections:

See Section 7 for information on safe handling.

See Section 8 for information on personal protection equipment.

See Section 13 for disposal information

7 Handling and Storage

7.1 Precautions for safe handling:

No special precautions are necessary if used correctly.

Information about fire - and explosion protection:

No special measures required.

7.2 Conditions for safe storage, including any incompatibilities:

Storage:

Requirements to be met by storerooms and receptacles: No special requirements.

Information about storage in one common storage facility: No special requirements.

Further information about storage conditions: None

7.3 Specific end use(s): No additional information available.

8 Exposure Controls/Personal Protection

8.1 Control parameters

Ingredients with limit values that require monitoring at the workplace:

The product does not contain any relevant quantities of materials with critical values that have to be monitored at the workplace.

Additional information: The lists valid during the making were used as basis.

8.2 Exposure controls:

Personal protective equipment:

General protective and hygienic measures:

Keep away from foodstuffs, beverages and feed.
Immediately remove all soiled and contaminated clothing.
Wash hands before breaks and at the end of work.
Avoid contact with the eyes and skin.

Respiratory protection:

Not required under normal conditions of use.

Protection of hands:

Protective gloves

The glove material has to be impermeable and resistant to the product. Selection of the glove material should be based on the penetration time, rates of diffusion and the degradation of the glove material.

Material of gloves:

The selection of a suitable gloves does not only depend on the material, but also on the quality, and varies from manufacturer to manufacturer.

Penetration time of glove material:

The exact break through time has to be determined by the manufacturer of the protective gloves. DO NOT exceed the breakthrough time set by the Manufacturer.

For long term contact, gloves made of the following materials are considered suitable:

Butyl rubber, BR
Nitrile rubber, NBR
Natural rubber (NR)
Neoprene gloves

Eye protection:

Safety glasses
Goggles recommended during refilling.

Body protection: Protective work clothing

9 Physical and Chemical Properties

9.1 Information on basic physical and chemical properties:

General Information:	
Appearance:	
Form:	Liquid
Color:	Light Yellow
Odor:	Odorless
Odor threshold:	Not determined.
pH-value:	8.5
Change in condition:	
Melting point/Melting range:	Not determined.
Boiling point/Boiling range:	100°C
Flash point:	Not applicable.
Flammability (solid, gaseous):	Not applicable.
Ignition temperature:	Not applicable.
Decomposition temperature:	Not determined.
Self-igniting:	Product is not selfigniting.
Danger of explosion:	Product does not present an explosion hazard.
Explosion limits:	
Lower:	Not determined.
Upper:	Not determined.
Vapor pressure at 20°C:	23 hPa
Density:	1.08 g/cm³
Relative density:	Not determined.
Vapor density:	Not determined.
Evaporation rate:	Not determined.
Solubility in / Miscibility with water:	Fully miscible.
Segregation coefficient (n-octanol/water):	Not determined.
Viscosity:	
Dynamic:	Not determined.
Kinematic:	Not determined.
Solvent content:	
Organic solvents:	Not determined.
Solids content:	Not determined.
9.2 Other information:	No additional information available.

10 Stability and Reactivity

10.1 Reactivity:

10.2 Chemical stability:

Thermal decomposition / conditions to be avoided:

No decomposition if used according to specifications.

10.3 Possibility of hazardous reactions:

Reacts with strong oxidizing agents. Reacts with strong acids.

10.4 Conditions to avoid:

No additional information available.

10.5 Incompatible materials:

No additional information available.

10.6 Hazardous decomposition products:

Carbon monoxide and carbon dioxide
Sulphur oxides (SOx)
Nitrogen oxides

11 Toxicological Information

11.1 Information on toxicological effects:

Toxicity data: Toxicity data is available for mixture:

Primary irritant effect:

On the skin: Irritating to skin and mucous membranes.

On the eye: Strong irritant with the danger of severe eye injury.

Sensitization: No sensitizing effects known.

Additional toxicological information:

The product shows the following dangers according to the calculation method of the General EU Classification Guidelines for Preparations as issued in the latest version: Irritant

12 Ecological Information

12.1 Toxicity:

Aquatic toxicity: No additional information available.

12.2 Persistence and degradability: Biodegradable.

12.3 Bioaccumulative potential: Does not accumulate in organisms.

12.4 Mobility in soil: No additional information available.

Additional ecological information:

General notes:

Water hazard class 1 (German Regulation) (Self-assessment): slightly hazardous for water.
Do not allow undiluted product or large quantities of it to reach ground water, water course or sewage system.
Must not reach sewage water or drainage ditch undiluted or un-neutralized.

12.5 Results of PBT and vPvB assessment:

PBT: Not applicable.

vPvB: Not applicable.

12.6 Other adverse effects: No additional information available.

13 Disposal Considerations

13.1 Waste treatment methods:

Recommendation:

Smaller quantities can be disposed of with household waste.
Small amounts may be diluted with plenty of water and washed away. Dispose of bigger amounts in accordance with Local Authority requirements.
The surfactant used in this product complies with the biodegradability criteria as laid down in Regulation (EC) No. 648/2004 on detergents. Data to support this assertion are held at the disposal of the competent authorities of the Member States and will be made available to them, at their direct request or at the request of a detergent manufacturer.

Uncleaned packaging:

Recommendation: Disposal must be made according to official regulations.

Recommended cleansing agents: Water, together with cleansing agents, if necessary.

14 Transport Information

14.1 UN-Number:

DOT, ADR, ADN, IMDG, IATA:	Not Regulated

14.2 UN proper shipping name:

DOT, ADR, IMDG, IATA:	Not Regulated

14.3 Transport hazard class(es):

DOT, ADR, IMDG, IATA:

Class:	Not Regulated
Label:	-

14.4 Packing group:

DOT, ADR, IMDG, IATA:	Not Regulated

14.5 Environmental hazards:

Marine pollutant:	No

14.6 Special precautions for user:	Not applicable.

14.7 Transport in bulk according to Annex II of MARPOL73/78 and the IBC Code: Not applicable.

UN "Model Regulation":	Not Regulated

15 Regulatory Information

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture:

United States (USA):

SARA:

Section 355 (extremely hazardous substances): None of the ingredient is listed.

Section 313 (Specific toxic chemical listings): None of the ingredient is listed.

TSCA (Toxic Substances Control Act): All ingredients are listed.

Proposition 65 (California):

Chemicals known to cause cancer: None of the ingredient is listed.

Chemicals known to cause reproductive toxicity for females: None of the ingredient is listed.

Chemicals known to cause reproductive toxicity for males: None of the ingredient is listed.

Chemicals known to cause developmental toxicity: None of the ingredient is listed.

Carcinogenic Categories:

EPA (Environmental Protection Agency): None of the ingredient is listed.

TLV (Threshold Limit Value established by ACGIH): None of the ingredient is listed.

NIOSH-Ca (National Institute for Occupational Safety and Health): None of the ingredient is listed.

OSHA-Ca (Occupational Safety & Health Administration): None of the ingredient is listed.

Canadá:

Canadian Domestic Substances List (DSL): All ingredients are listed.

Canadian Ingredient Disclosure list (limit 0.1%): None of the ingredient is listed.

Canadian Ingredient Disclosure list (limit 1%): None of the ingredient is listed.

15.2 Chemical safety assessment: A Chemical Safety Assessment has not been carried out.

16 Other Information

This information is based on our present knowledge. However, this shall not constitute a guarantee for any specific product features and shall not establish a legally valid contractual relationship.

Relevant phrases:

H315: Causes skin irritation.

Abbreviations and Acronyms:

ADR: European Agreement concerning the International Carriage of Dangerous Goods by Road.
IMDG: International Maritime Code for Dangerous Goods.
DOT: US Department of Transportation.
IATA: International Air Transport Association.
GHS: Globally Harmonized System of Classification and Labelling of Chemicals.
ACGIH: American Conference of Governmental Industrial Hygienists.
NFPA: National Fire Protection Association (USA).
HMIS: Hazardous Materials Identification System (USA).
WHMIS: Workplace Hazardous Materials Information System (Canada).
VOC: Volatile Organic Compounds (USA, EU).
LC50: Lethal concentration, 50 percent.
LD50: Lethal dose, 50 percent.

SDS Created by:

Global Safety Management, Inc.
10006 Cross Creek Blvd
Tampa, FL, 33647
Tel: 1-844-GSM-INFO (1-844-476-4636)
Website: www.GSMSDS.com

SAFETY DATA SHEET

Argon

Section 1. Identification

GHS product identifier : Argon

Chemical name : argon

Other means of identification : Argon.

Product use : Synthetic/Analytical chemistry.

Synonym : Argon.

SDS # : 001004

Supplier's details : Airgas USA, LLC and its affiliates
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

Emergency telephone number (with hours of operation) : 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 : Use and store only outdoors or in a well ventilated place.

Response : Not applicable.

Storage : Protect from sunlight. 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 : argon

Other means of identification : Argon.

CAS number/other identifiers

CAS number : 7440-37-1

Product code : 001004

Ingredient name	%	CAS number
Argon	100	7440-37-1

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.

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. Acts as a simple asphyxiant.

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 : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

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 : No specific data.

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.

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
Argon	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

Section 8. Exposure controls/personal 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.
Color	: Colorless.
Molecular weight	: 39.95 g/mole
Molecular formula	: Ar
Boiling/condensation point	: -185.9°C (-302.6°F)
Melting/freezing point	: -189.2°C (-308.6°F)
Critical temperature	: -122.4°C (-188.3°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	: 1.66 (Air = 1)
Specific Volume (ft ^{3}/lb)	: 9.7087
Gas Density (lb/ft ^{3})	: 0.103
Relative density	: Not applicable.
Solubility	: Not available.
Solubility in water	: Not available.
Partition coefficient: n-octanol/water	: 0.74
Auto-ignition temperature	: Not available.
Decomposition temperature	: Not available.

Section 9. Physical and chemical properties

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.
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 11. Toxicological information

Information on toxicological effects

Acute toxicity

Not available.

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.

Section 11. Toxicological information

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. Acts as a simple asphyxiant.
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.
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.

Section 12. Ecological information

Bioaccumulative potential

Product/ingredient name	**LogP$_{ow}$**	**BCF**	**Potential**
Argon	0.74	-	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	UN1006	UN1006	UN1006	UN1006	UN1006
UN proper shipping name	ARGON, COMPRESSED	ARGON, COMPRESSED	ARGON, COMPRESSED	ARGON, COMPRESSED	ARGON, COMPRESSED
Transport hazard class(es)	2.2 	2.2 	2.2 	2.2 	2.2 
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	**Explosive Limit and Limited Quantity Index** 0.125 **Passenger Carrying Road or Rail Index** 75 **Special provisions** 42	-	-	**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."

Section 14. Transport information

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
Argon	100	No.	Yes.	No.	No.	No.

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.

Canada inventory : This material is listed or exempted.

International regulations

Section 15. Regulatory information

International lists : **Australia inventory (AICS)**: This material is listed or exempted.
China inventory (IECSC): This material is listed or exempted.
Japan inventory: Not determined.
Korea inventory: This material is listed or exempted.
Malaysia Inventory (EHS Register): Not determined.
New Zealand Inventory of Chemicals (NZIoC): This material is listed or exempted.
Philippines inventory (PICCS): This material is listed or exempted.
Taiwan inventory (CSNN): Not determined.

Chemical Weapons Convention List Schedule I Chemicals : Not listed

Chemical Weapons Convention List Schedule II Chemicals : Not listed

Chemical Weapons Convention List Schedule III Chemicals : Not listed

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.

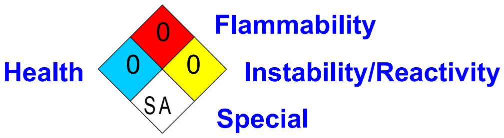
Hazardous Material Information System (U.S.A.)

Health	0
Flammability	0
Physical hazards	0

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.)



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Section 16. Other information

Copyright ©2001, National Fire Protection Association, Quincy, MA 02269. This warning system is intended to be interpreted and applied only by properly trained individuals to identify fire, health and reactivity hazards of chemicals. The user is referred to certain limited number of chemicals with recommended classifications in NFPA 49 and NFPA 325, which would be used as a guideline only. Whether the chemicals are classified by NFPA or not, anyone using the 704 systems to classify chemicals does so at their own risk.

History

Date of printing : 2/16/2015.

Date of issue/Date of revision : 2/16/2015.

Date of previous issue : 2/16/2015.

Version : 0.05

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 NationsACGIH – American Conference of Governmental Industrial Hygienists
AIHA – American Industrial Hygiene Association
CAS – Chemical Abstract Services
CEPA – Canadian Environmental Protection Act
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act (EPA)
CFR – United States Code of Federal Regulations
CPR – Controlled Products Regulations
DSL – Domestic Substances List
GWP – Global Warming Potential
IARC – International Agency for Research on Cancer
ICAO – International Civil Aviation Organisation
Inh – Inhalation
LC – Lethal concentration
LD – Lethal dosage
NDSL – Non-Domestic Substances List
NIOSH – National Institute for Occupational Safety and Health
TDG – Canadian Transportation of Dangerous Goods Act and Regulations
TLV – Threshold Limit Value
TSCA – Toxic Substances Control Act
WEEL – Workplace Environmental Exposure Level
WHMIS – Canadian Workplace Hazardous Material Information System

References : Not available.

◤ **Indicates information that has changed from previously issued version.**

Notice to reader

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. 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.

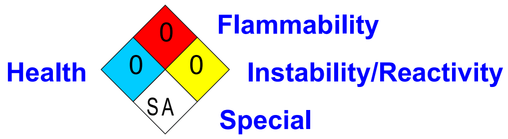
Hazardous Material Information System (U.S.A.)

Health	0
Flammability	0
Physical hazards	0

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.)



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Section 16. Other information

Copyright ©2001, National Fire Protection Association, Quincy, MA 02269. This warning system is intended to be interpreted and applied only by properly trained individuals to identify fire, health and reactivity hazards of chemicals. The user is referred to certain limited number of chemicals with recommended classifications in NFPA 49 and NFPA 325, which would be used as a guideline only. Whether the chemicals are classified by NFPA or not, anyone using the 704 systems to classify chemicals does so at their own risk.

Procedure used to derive the classification

Classification	Justification
Press. Gas Comp. Gas, H280	Expert judgment

History

Date of printing	:	8/7/2015
Date of issue/Date of revision	:	8/7/2015
Date of previous issue	:	No previous validation
Version	:	0.01

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.

SAFETY DATA SHEET

Carbon Dioxide, Solid or Dry Ice

Section 1. Identification

GHS product identifier : Carbon Dioxide, Solid or Dry Ice

Chemical name : Carbon dioxide

Other means of identification : carbonice ; dry ice 6

Product use : Synthetic/Analytical chemistry.

Synonym : carbonice ; dry ice 6

SDS # : 001091

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 : Not classified.

Classification of the substance or mixture : Not classified by Globally Harmonized System of Classification and Labeling (GHS).

GHS label elements

Signal word : Warning

Hazard statements : May displace oxygen and cause rapid suffocation.
May increase respiration and heart rate.
May cause frostbite.

Precautionary statements

General : Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand.

Prevention : Not applicable.

Response : Not applicable.

Storage : Not applicable.

Disposal : Not applicable.

Hazards not otherwise classified : Contact with cryogenic liquid can cause frostbite and cryogenic burns.

Section 3. Composition/information on ingredients

Substance/mixture : Substance

Chemical name : Carbon dioxide

Other means of identification : carbonice ; dry ice 6

CAS number/other identifiers

CAS number : 124-38-9

Product code : 001091

Ingredient name	%	CAS number
Carbon Dioxide	100	124-38-9

Any concentration shown as a range is to protect confidentiality or is due to batch variation.

Section 3. Composition/information on ingredients

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. Get medical attention if irritation occurs.
Inhalation	: Remove victim to fresh air and keep at rest in a position comfortable for breathing. Get medical attention if symptoms occur.
Skin contact	: Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur.
Ingestion	: Wash out mouth with water. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Do not induce vomiting unless directed to do so by medical personnel. Get medical attention if symptoms occur.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact	: May cause eye irritation.
Inhalation	: May be harmful if inhaled. May cause respiratory irritation.
Skin contact	: Harmful if absorbed through the skin. May cause skin irritation.
Frostbite	: Try to warm up the frozen tissues and seek medical attention.
Ingestion	: May be harmful if swallowed and enters airways.

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	: Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.
Specific treatments	: No specific treatment.
Protection of first-aiders	: No action shall be taken involving any personal risk or without suitable training.

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	: No specific fire or explosion hazard.
Hazardous thermal decomposition products	: Decomposition products may include the following materials: carbon dioxide carbon monoxide

Section 5. Fire-fighting measures

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.

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. Do not touch or walk through spilled material. 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 : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. 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 : Move containers from spill area. Vacuum or sweep up material and place in a designated, labeled waste container. Dispose of via a licensed waste disposal contractor.

Large spill : Move containers from spill area. Prevent entry into sewers, water courses, basements or confined areas. Vacuum or sweep up material and place in a designated, labeled waste container. Dispose of via a licensed waste disposal contractor. 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).

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 original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10) and food and drink. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Section 8. Exposure controls/personal protection

Ingredient name	Exposure limits
Carbon Dioxide	**ACGIH TLV (United States, 3/2015). Oxygen Depletion [Asphyxiant].** STEL: 54000 mg/m³ 15 minutes. STEL: 30000 ppm 15 minutes. TWA: 9000 mg/m³ 8 hours. TWA: 5000 ppm 8 hours. **NIOSH REL (United States, 10/2013).** STEL: 54000 mg/m³ 15 minutes. STEL: 30000 ppm 15 minutes. TWA: 9000 mg/m³ 10 hours. TWA: 5000 ppm 10 hours. **OSHA PEL (United States, 2/2013).** TWA: 9000 mg/m³ 8 hours. TWA: 5000 ppm 8 hours. **OSHA PEL 1989 (United States, 3/1989).** STEL: 54000 mg/m³ 15 minutes. STEL: 30000 ppm 15 minutes. TWA: 18000 mg/m³ 8 hours. TWA: 10000 ppm 8 hours.

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.

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, particulate filter 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	:	Solid. [WHITE SNOW-LIKE SOLID]
Color	:	White.
Molecular weight	:	44.01 g/mole
Molecular formula	:	C-O2
Melting/freezing point	:	Sublimation temperature: -78.5°C (-109.3 to °F)
Critical temperature	:	31°C (87.8°F)
Odor	:	Not available.
Odor threshold	:	Not available.
pH	:	Not available.
Flash point	:	Not available.
Burning time	:	Not available.
Burning rate	:	Not available.
Evaporation rate	:	Not available.
Flammability (solid, gas)	:	Not available.
Lower and upper explosive (flammable) limits	:	Not available.
Vapor pressure	:	Not available.
Vapor density	:	Not available.
Specific Volume (ft ^{3}/lb)	:	0.7407
Gas Density (lb/ft ^{3})	:	1.35
Relative density	:	Not available.
Solubility	:	Not available.
Solubility in water	:	Not available.
Partition coefficient: n-octanol/water	:	Not available.
Auto-ignition temperature	:	Not available.
Decomposition temperature	:	Not available.
SADT	:	Not available.
Viscosity	:	Not available.

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 11. Toxicological information

Information on toxicological effects

Acute toxicity

Not available.

IDLH : 40000 ppm

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 : May cause eye irritation.
Inhalation : May be harmful if inhaled. May cause respiratory irritation.
Skin contact : Harmful if absorbed through the skin. May cause skin irritation.
Ingestion : May be harmful if swallowed and enters airways.

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.

Section 11. Toxicological information

Potential chronic health effects

Not available.

General : No known significant effects or critical hazards.

Carcinogenicity : No known significant effects or critical hazards.

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

Not available.

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. 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. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Section 14. Transport information

Section 14. Transport information

	DOT	TDG	Mexico	IMDG	IATA
UN number	UN1845	UN1845	UN1845	UN1845	UN1845
UN proper shipping name	CARBON DIOXIDE, SOLID OR DRY ICE	CARBON DIOXIDE, SOLID; OR DRY ICE	CARBON DIOXIDE, SOLID OR DRY ICE	CARBON DIOXIDE, SOLID (DRY ICE)	CARBON DIOXIDE, SOLID
Transport hazard class(es)	9 	9 	9 	9 	9 
Packing group	III	III	-	III	III
Environment	Yes.	Yes.	Yes.	No.	No.
Additional information	**Limited quantity** Yes. **Packaging instruction** **Passenger aircraft** Quantity limitation: 200 kg **Cargo aircraft** Quantity limitation: 200 kg	Product classified as per the following sections of the Transportation of Dangerous Goods Regulations: 2.43-2.45 (Class 9). **Explosive Limit and Limited Quantity Index** 5 **Passenger Carrying Ship Index** 200 **Special provisions** 18	-	-	The environmentally hazardous substance mark may appear if required by other transportation regulations. **Passenger and Cargo Aircraft**Quantity limitation: 200 kg **Cargo Aircraft Only** Quantity limitation: 200 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

Section 15. Regulatory information

Composition/information on ingredients

No products were found.

SARA 304 RQ : Not applicable.

SARA 311/312

Classification : Immediate (acute) health hazard

Composition/information on ingredients

Name	%	Fire hazard	Sudden release of pressure	Reactive	Immediate (acute) health hazard	Delayed (chronic) health hazard
Carbon Dioxide (Dry Ice)	100%	No	No	No	Yes	No

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 : This material is listed or exempted.
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) : Not controlled under WHMIS (Canada).

CEPA Toxic substances: This material is 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 : Not controlled under WHMIS (Canada).

Hazardous Material Information System (U.S.A.)

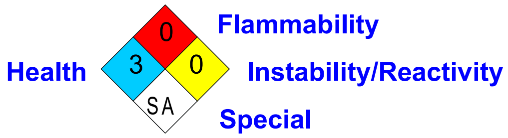
Health	*	3
Flammability		0
Physical hazards		0

Section 16. Other information

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.)



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Copyright ©2001, National Fire Protection Association, Quincy, MA 02269. This warning system is intended to be interpreted and applied only by properly trained individuals to identify fire, health and reactivity hazards of chemicals. The user is referred to certain limited number of chemicals with recommended classifications in NFPA 49 and NFPA 325, which would be used as a guideline only. Whether the chemicals are classified by NFPA or not, anyone using the 704 systems to classify chemicals does so at their own risk.

Procedure used to derive the classification

Classification	Justification
Not classified.	

History

Date of printing : 3/14/2016
Date of issue/Date of revision : 3/14/2016
Date of previous issue : 3/14/2016
Version : 0.03

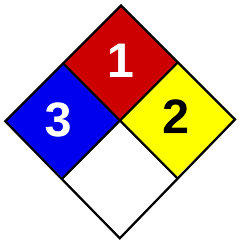
Key to abbreviations : ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm 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.



Health	3
Fire	1
Reactivity	2
Personal Protection	E

Material Safety Data Sheet

Arsenic MSDS

Section 1: Chemical Product and Company Identification

Product Name: Arsenic

Catalog Codes: SLA1006

CAS#: 7440-38-2

RTECS: CG0525000

TSCA: TSCA 8(b) inventory: Arsenic

CI#: Not applicable.

Synonym:

Chemical Name: Arsenic

Chemical Formula: As

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Arsenic	7440-38-2	100

Toxicological Data on Ingredients: Arsenic: ORAL (LD50): Acute: 763 mg/kg [Rat]. 145 mg/kg [Mouse].

Section 3: Hazards Identification

Potential Acute Health Effects:
Very hazardous in case of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant), of eye contact (irritant).

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Classified A1 (Confirmed for human.) by ACGIH. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance is toxic to kidneys, lungs, the nervous system, mucous membranes. Repeated or prolonged exposure to the substance can produce target organs damage.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention if irritation occurs.

Skin Contact: Wash with soap and water. Cover the irritated skin with an emollient. Get medical attention if irritation develops.

Serious Skin Contact: Not available.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Serious Inhalation:
Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek medical attention.

Ingestion:
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If large quantities of this material are swallowed, call a physician immediately. Loosen tight clothing such as a collar, tie, belt or waistband.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: May be combustible at high temperature.

Auto-Ignition Temperature: Not available.

Flash Points: Not available.

Flammable Limits: Not available.

Products of Combustion: Some metallic oxides.

Fire Hazards in Presence of Various Substances: Flammable in presence of open flames and sparks, of heat, of oxidizing materials.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions:
SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray, fog or foam. Do not use water jet.

Special Remarks on Fire Hazards:
Material in powder form, capable of creating a dust explosion. When heated to decomposition it emits highly toxic fumes.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill: Use appropriate tools to put the spilled solid in a convenient waste disposal container.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

Precautions:
Keep locked up.. Keep away from heat. Keep away from sources of ignition. Empty containers pose a fire risk, evaporate the residue under a fume hood. Ground all equipment containing material. Do not ingest. Do not breathe dust. Wear suitable

protective clothing. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Keep away from incompatibles such as oxidizing agents, acids, moisture.

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection: Safety glasses. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:
TWA: 0.01 from ACGIH (TLV) [United States] [1995] Consult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid. (Lustrous solid.)

Odor: Not available.

Taste: Not available.

Molecular Weight: 74.92 g/mole

Color: Silvery.

pH (1% soln/water): Not applicable.

Boiling Point: Not available.

Melting Point: Sublimation temperature: 615°C (1139°F)

Critical Temperature: Not available.

Specific Gravity: 5.72 (Water = 1)

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: Not available.

Solubility: Insoluble in cold water, hot water.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Not available.

Incompatibility with various substances: Reactive with oxidizing agents, acids, moisture.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Inhalation. Ingestion.

Toxicity to Animals: Acute oral toxicity (LD50): 145 mg/kg [Mouse].

Chronic Effects on Humans:
CARCINOGENIC EFFECTS: Classified A1 (Confirmed for human.) by ACGIH. Causes damage to the following organs: kidneys, lungs, the nervous system, mucous membranes.

Other Toxic Effects on Humans:
Very hazardous in case of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant).

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Not available.

Special Remarks on other Toxic Effects on Humans: Not available.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are as toxic as the original product.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Section 14: Transport Information

DOT Classification: CLASS 6.1: Poisonous material.

Identification: : Arsenic UNNA: UN1558 PG: II

Special Provisions for Transport: Not available.

Section 15: Other Regulatory Information

Federal and State Regulations:
California prop. 65: This product contains the following ingredients for which the State of California has found to cause cancer, birth defects or other reproductive harm, which would require a warning under the statute: Arsenic California prop. 65: This product contains the following ingredients for which the State of California has found to cause cancer which would require a warning under the statute: Arsenic Pennsylvania RTK: Arsenic Massachusetts RTK: Arsenic TSCA 8(b) inventory: Arsenic

Other Regulations: OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200).

Other Classifications:

WHMIS (Canada):
CLASS D-1A: Material causing immediate and serious toxic effects (VERY TOXIC). CLASS D-2A: Material causing other toxic effects (VERY TOXIC).

DSCL (EEC):
R22- Harmful if swallowed. R45- May cause cancer.

HMIS (U.S.A.):

Health Hazard: 3

Fire Hazard: 1

Reactivity: 2

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 3

Flammability: 1

Reactivity: 2

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Safety glasses.

Section 16: Other Information

References:
-Hawley, G.G.. The Condensed Chemical Dictionary, 11e ed., New York N.Y., Van Nostrand Reinold, 1987. -Liste des produits purs tératogènes, mutagènes, cancérogènes. Répertoire toxicologique de la Commission de la Santé et de la Sécurité du Travail du Québec. -Material safety data sheet emitted by: la Commission de la Santé et de la Sécurité du Travail du Québec. -SAX, N.I. Dangerous Properties of Indutrial Materials. Toronto, Van Nostrand Reinold, 6e ed. 1984. -The Sigma-Aldrich Library of Chemical Safety Data, Edition II. -Guide de la loi et du règlement sur le transport des marchandises dangeureuses au canada. Centre de conformité internatinal Ltée. 1986.

Other Special Considerations: Not available.

Created: 10/09/2005 04:16 PM

Last Updated: 05/21/2013 12:00 PM

SAFETY DATA SHEET

Methane

Section 1. Identification

GHS product identifier : Methane

Chemical name : methane

Other means of identification : Methane or natural gas; Marsh gas; Methyl hydride; CH4; Fire Damp;

Product use : Synthetic/Analytical chemistry.

Synonym : Methane or natural gas; Marsh gas; Methyl hydride; CH4; Fire Damp;
SDS # : 001033

Supplier's details : Airgas USA, LLC and its affiliates
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

Emergency telephone number (with hours of operation) : 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 : FLAMMABLE GASES - Category 1
GASES UNDER PRESSURE - Compressed gas

GHS label elements

Hazard pictograms :

Signal word : Danger

Hazard statements : Extremely flammable gas.
May form explosive mixtures with air.
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. Approach suspected leak area with caution.

Prevention : Never Put cylinders into unventilated areas of passenger vehicles. Keep away from heat, sparks, open flames and hot surfaces. - No smoking. Use and store only outdoors or in a well ventilated place.

Response : Leaking gas fire: Do not extinguish, unless leak can be stopped safely. Eliminate all ignition sources if safe to do so.

Storage : Protect from sunlight. Protect from sunlight when ambient temperature exceeds 52°C/125°F. Store in a well-ventilated place.

Disposal : Not applicable.

Section 2. Hazards identification

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 : methane

Other means of identification : Methane or natural gas; Marsh gas; Methyl hydride; CH4; Fire Damp;

CAS number/other identifiers

CAS number : 74-82-8

Product code : 001033

Ingredient name	%	CAS number
methane	100	74-82-8

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.

Skin contact : Wash contaminated skin with soap and water. Remove contaminated clothing and shoes. To avoid the risk of static discharges and gas ignition, soak contaminated clothing thoroughly with water before removing it. 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.

Section 4. First aid measures

Ingestion : No specific data.

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

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. Extremely flammable gas. In a fire or if heated, a pressure increase will occur and the container may burst, with the risk of a subsequent explosion.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
carbon dioxide
carbon monoxide

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. If involved in fire, shut off flow immediately if it can be done without risk. If this is impossible, withdraw from area and allow fire to burn. Fight fire from protected location or maximum possible distance. Eliminate all ignition sources if safe to do so.

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 : Accidental releases pose a serious fire or explosion hazard. No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Shut off all ignition sources. No flares, smoking or flames in hazard area. 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).

Section 6. Accidental release measures

Methods and materials for containment and cleaning up

Small spill : Immediately contact emergency personnel. Stop leak if without risk. Use spark-proof tools and explosion-proof equipment.

Large spill : Immediately contact emergency personnel. Stop leak if without risk. Use spark-proof tools and explosion-proof equipment. 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. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Do not enter storage areas and confined spaces unless adequately ventilated. Store and use away from heat, sparks, open flame or any other ignition source. Use explosion-proof electrical (ventilating, lighting and material handling) equipment. Use only non-sparking tools. 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.

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). Eliminate all ignition sources. 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
methane	**ACGIH TLV (United States, 3/2012).** TWA: 1000 ppm 8 hours.

Appropriate engineering controls : Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

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

Section 8. Exposure controls/personal protection

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. When there is a risk of ignition from static electricity, wear anti-static protective clothing. For the greatest protection from static discharges, clothing should include anti-static overalls, boots and gloves.
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	16.05 g/mole
Molecular formula	C-H4
Boiling/condensation point	-161.48°C (-258.7°F)
Melting/freezing point	-187.6°C (-305.7°F)
Critical temperature	-82.45°C (-116.4°F)
Odor	Odorless.
Odor threshold	Not available.
pH	Not available.
Flash point	Closed cup: -188.15°C (-306.7°F)
Burning time	Not applicable.
Burning rate	Not applicable.
Evaporation rate	Not available.
Flammability (solid, gas)	Extremely flammable in the presence of the following materials or conditions: open flames, sparks and static discharge and oxidizing materials.
Lower and upper explosive (flammable) limits	Lower: 1.8% Upper: 8.4%

Section 9. Physical and chemical properties

Vapor pressure	: Not available.
Vapor density	: 0.55 (Air = 1) Liquid Density@BP: 26.5 lb/ft3 (424.5 kg/m3)
Specific Volume (ft ^{3}/lb)	: 2.3641
Gas Density (lb/ft ^{3})	: 0.423 (25°C / 77 to °F)
Relative density	: Not applicable.
Solubility	: Not available.
Solubility in water	: 0.0244 g/l
Partition coefficient: n-octanol/water	: 1.09
Auto-ignition temperature	: 287°C (548.6°F)
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	: Avoid all possible sources of ignition (spark or flame). Do not pressurize, cut, weld, braze, solder, drill, grind or expose containers to heat or sources of ignition.
Incompatibility with various substances	: Extremely reactive or incompatible with the following materials: oxidizing materials.
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 11. Toxicological information

Information on toxicological effects

Acute toxicity

Not available.

Irritation/Corrosion

Not available.

Sensitization

Not available.

Mutagenicity

Not available.

Carcinogenicity

Section 11. Toxicological information

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.

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.

Section 11. Toxicological information

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
methane	1.09	-	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	UN1971	UN1971	UN1971	UN1971	UN1971
UN proper shipping name	Methane, compressed	Methane, compressed or Methane or Natural gas, compressed (with high methane content)	Methane, compressed	Methane, compressed	Methane, compressed
Transport hazard class(es)	2.1 	2.1 	2.1 	2.1 	2.1 

Section 14. Transport information

Packing group	-	-	-	-	-
Environment	No.	No.	No.	No.	No.
Additional information	-	**Explosive Limit and Limited Quantity Index** 0.125 **ERAP Index** 3000 **Passenger Carrying Ship Index** Forbidden **Passenger Carrying Road or Rail Index** Forbidden	-	-	**Passenger and Cargo Aircraft**Quantity limitation: 0 Forbidden **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**: Not determined

United States inventory (TSCA 8b): This material is listed or exempted.

Clean Air Act (CAA) 112 regulated flammable substances: methane

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 : Fire hazard
Sudden release of pressure

Composition/information on ingredients

Section 15. Regulatory information

Name	**%**	**Fire hazard**	**Sudden release of pressure**	**Reactive**	**Immediate (acute) health hazard**	**Delayed (chronic) health hazard**
methane	100	Yes.	Yes.	No.	No.	No.

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.
Canada inventory	:	This material is listed or exempted.

International regulations

International lists : **Australia inventory (AICS)**: This material is listed or exempted.
China inventory (IECSC): This material is listed or exempted.
Japan inventory: This material is listed or exempted.
Korea inventory: This material is listed or exempted.
Malaysia Inventory (EHS Register): Not determined.
New Zealand Inventory of Chemicals (NZIoC): This material is listed or exempted.
Philippines inventory (PICCS): This material is listed or exempted.
Taiwan inventory (CSNN): Not determined.

Chemical Weapons Convention List Schedule I Chemicals : Not listed

Chemical Weapons Convention List Schedule II Chemicals : Not listed

Chemical Weapons Convention List Schedule III Chemicals : Not listed

Canada

WHMIS (Canada) : Class A: Compressed gas.
Class B-1: Flammable gas.

CEPA Toxic substances: This material is listed.
Canadian ARET: This material is not listed.
Canadian NPRI: This material is 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.
Class B-1: Flammable gas.

Hazardous Material Information System (U.S.A.)

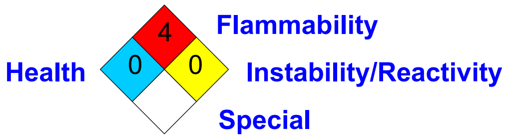
Health	0
Flammability	4
Physical hazards	3

Section 16. Other information

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.)



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Copyright ©2001, National Fire Protection Association, Quincy, MA 02269. This warning system is intended to be interpreted and applied only by properly trained individuals to identify fire, health and reactivity hazards of chemicals. The user is referred to certain limited number of chemicals with recommended classifications in NFPA 49 and NFPA 325, which would be used as a guideline only. Whether the chemicals are classified by NFPA or not, anyone using the 704 systems to classify chemicals does so at their own risk.

History

Date of printing : 5/20/2015.

Date of issue/Date of revision : 5/20/2015.

Date of previous issue : 1/27/2015.

Version : 0.04

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 NationsACGIH – American Conference of Governmental Industrial Hygienists
AIHA – American Industrial Hygiene Association
CAS – Chemical Abstract Services
CEPA – Canadian Environmental Protection Act
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act (EPA)
CFR – United States Code of Federal Regulations
CPR – Controlled Products Regulations
DSL – Domestic Substances List
GWP – Global Warming Potential
IARC – International Agency for Research on Cancer
ICAO – International Civil Aviation Organisation
Inh – Inhalation
LC – Lethal concentration
LD – Lethal dosage
NDSL – Non-Domestic Substances List
NIOSH – National Institute for Occupational Safety and Health

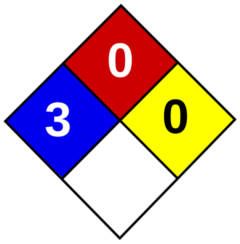
Section 16. Other information

TDG – Canadian Transportation of Dangerous Goods Act and Regulations
TLV – Threshold Limit Value
TSCA – Toxic Substances Control Act
WEEL – Workplace Environmental Exposure Level
WHMIS – Canadian Workplace Hazardous Material Information System

References : Not available.

◤ **Indicates information that has changed from previously issued version.**

Notice to reader



Health	3
Fire	0
Reactivity	0
Personal Protection	E

Material Safety Data Sheet

Pentachlorophenol MSDS

Section 1: Chemical Product and Company Identification

Product Name: Pentachlorophenol

Catalog Codes: SLP3943, SLP1126

CAS#: 87-86-5

RTECS: SM6300000

TSCA: TSCA 8(b) inventory: Pentachlorophenol

CI#: Not available.

Synonym:

Chemical Name: Not available.

Chemical Formula: C6Cl5OH

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Pentachlorophenol	87-86-5	100

Toxicological Data on Ingredients: Pentachlorophenol: ORAL (LD50): Acute: 27 mg/kg [Rat]. 117 mg/kg [Mouse]. VAPOR (LC50): Acute: 502 ppm 4 hour(s) [Rat].

Section 3: Hazards Identification

Potential Acute Health Effects:
Very hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion. Hazardous in case of skin contact (permeator), of inhalation. Slightly hazardous in case of skin contact (corrosive, sensitizer). Severe over-exposure can result in death. Inflammation of the eye is characterized by redness, watering, and itching. Skin inflammation is characterized by itching, scaling, reddening, or, occasionally, blistering.

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance is toxic to blood, kidneys, lungs, the nervous system, liver, mucous membranes. Repeated or prolonged exposure to the substance can produce target organs damage. Repeated exposure to an highly toxic material may produce general deterioration of health by an accumulation in one or many human organs.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used. Do not use an eye ointment. Seek medical attention.

Skin Contact:
After contact with skin, wash immediately with plenty of water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Be particularly careful to clean folds, crevices, creases and groin. Cover the irritated skin with an emollient. If irritation persists, seek medical attention.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.

Inhalation: Allow the victim to rest in a well ventilated area. Seek immediate medical attention.

Serious Inhalation:
Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek medical attention.

Ingestion:
Do not induce vomiting. Examine the lips and mouth to ascertain whether the tissues are damaged, a possible indication that the toxic material was ingested; the absence of such signs, however, is not conclusive. Loosen tight clothing such as a collar, tie, belt or waistband. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek immediate medical attention.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Non-flammable.

Auto-Ignition Temperature: Not applicable.

Flash Points: Not applicable.

Flammable Limits: Not applicable.

Products of Combustion: Not available.

Fire Hazards in Presence of Various Substances: Not applicable.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions: Not applicable.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill: Use appropriate tools to put the spilled solid in a convenient waste disposal container.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

Precautions:
Keep locked up Keep container dry. Do not ingest. Do not breathe dust. Never add water to this product In case of insufficient ventilation, wear suitable respiratory equipment If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes

Storage:
Keep container tightly closed. Keep in a cool, well-ventilated place. Highly toxic or infectious materials should be stored in a separate locked safety storage cabinet or room.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection:
Splash goggles. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:
TWA: 0.5 (mg/m3) from ACGIH Consult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid.

Odor: Pungent. (Strong.)

Taste: Not available.

Molecular Weight: 266.34 g/mole

Color: White.

pH (1% soln/water): Not available.

Boiling Point: Decomposes. (310°C or 590°F)

Melting Point: 188°C (370.4°F)

Critical Temperature: Not available.

Specific Gravity: 1.987 (Water = 1)

Vapor Pressure: Not applicable.

Vapor Density: 9.2 (Air = 1)

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: Not available.

Solubility: Very slightly soluble in cold water.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Not available.

Incompatibility with various substances: Not available.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: No.

Section 11: Toxicological Information

Routes of Entry: Dermal contact. Eye contact. Inhalation. Ingestion.

Toxicity to Animals:
WARNING: THE LC50 VALUES HEREUNDER ARE ESTIMATED ON THE BASIS OF A 4-HOUR EXPOSURE. Acute oral toxicity (LD50): 27 mg/kg [Rat]. Acute toxicity of the vapor (LC50): 502 ppm 4 hour(s) [Rat].

Chronic Effects on Humans: The substance is toxic to blood, kidneys, lungs, the nervous system, liver, mucous membranes.

Other Toxic Effects on Humans:
Very hazardous in case of skin contact (irritant), of ingestion. Hazardous in case of skin contact (permeator), of inhalation. Slightly hazardous in case of skin contact (corrosive, sensitizer).

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Not available.

Special Remarks on other Toxic Effects on Humans: Not available.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Section 14: Transport Information

DOT Classification: CLASS 6.1: Poisonous material.

Identification: : Chlorophenol, solid : UN2020 PG: III

Special Provisions for Transport: Marine Pollutant

Section 15: Other Regulatory Information

Federal and State Regulations:
California prop. 65: This product contains the following ingredients for which the State of California has found to cause cancer, birth defects or other reproductive harm, which would require a warning under the statute: Pentachlorophenol California prop. 65: This product contains the following ingredients for which the State of California has found to cause cancer which would require a warning under the statute: Pentachlorophenol Pennsylvania RTK: Pentachlorophenol Massachusetts RTK: Pentachlorophenol TSCA 8(b) inventory: Pentachlorophenol SARA 313 toxic chemical notification and release reporting: Pentachlorophenol

Other Regulations: OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200).

Other Classifications:

WHMIS (Canada):
CLASS D-1A: Material causing immediate and serious toxic effects (VERY TOXIC). CLASS D-2A: Material causing other toxic effects (VERY TOXIC).

DSCL (EEC):
R38- Irritating to skin. R41- Risk of serious damage to eyes. R48/20- Harmful: danger of serious damage to health by prolonged exposure through inhalation. R48/25- Toxic: danger of serious damage to health in case of prolonged exposure if swallowed.

HMIS (U.S.A.):

Health Hazard: 3

Fire Hazard: 0

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 3

Flammability: 0

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Splash goggles.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

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Last Updated: 05/21/2013 12:00 PM