Time Oil Bulk Terminal PPA

Supplemental Upland Remedial Investigation Work Plan

Prepared for

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2753 West 31st Street
Chicago, IL 60608

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The interpretations and conclusions contained in this report are based in part on site characterization data collected by others or obtained by publically available sources. Floyd|Snider cannot assure the accuracy of this information.

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List of Acronyms and Abbreviations

Acronym/ Abbreviation	Definition
AOC	Area of concern
ARAR	Applicable or Relevant and Appropriate Requirement
ASKO Property	ASKO Hydraulic Property
AST	Aboveground storage tank
bgs	Below ground surface
BNSF	BNSF Railway
Cantera	Cantera Development Group, LLC
CD	Consent Decree
COC	Chain-of-custody

Acronym/ Abbreviation	Definition
COPC	Chemical of potential concern
CSM	Conceptual site model
CUL	Cleanup level
cVOC	Chlorinated volatile organic compound
DNR	Washington State Department of Natural Resources
DRO	Diesel-range organics
Ecology	Washington State Department of Ecology
FBI	Friedman & Bruya, Inc.
FOE	Frequency of exceedance
FS	Feasibility Study
GRO	Gasoline-range organics
LCS	Laboratory control sample
LCSD	Laboratory control sample duplicate
LNAPL	Light non-aqueous-phase liquid
MCL	Maximum contaminant level
µg/L	Micrograms per liter
µg/m^3	Micrograms per cubic meter
mg/kg	Milligrams per kilogram
MS	Matrix spike
MSD	Matrix spike duplicate
MTCA	Model Toxics Control Act
NAVD 88	North American Vertical Datum 1988
ng/kg	Nanograms per kilogram
ORO	Oil-range organics
penta	Pentachlorophenol
PID	Photoionization detector
PPA	Prospective Purchaser Agreement
PQL	Practical quantitation limit
PSL	Preliminary screening level
QA	Quality assurance

Acronym/ Abbreviation	Definition
QAPP	Quality Assurance Project Plan
QC	Quality control
RAO	Remedial action objective
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RI Work Plan	Remedial Investigation Work Plan
ROW	Right-of-way
RPD	Relative percent difference
SAP	Sampling and Analysis Plan
SES	SoundEarth Strategies, Inc.
Site	Former TOC Holdings Co. Seattle Terminal Properties
SMS	Sediment Management Standards
TCE	Trichloroethene
TOC	Collectively, former TOC Holdings Co. and predecessor Time Oil Company
TPH	Total petroleum hydrocarbons
Trustee	Edmond J. Wood, acting as Chapter 7 Trustee of the Bankruptcy Estate of TOC Holdings Co.
USEPA	U.S. Environmental Protection Agency
UST	Underground storage tank
VCP	Voluntary Cleanup Program
VOC	Volatile organic compound
WAC	Washington Area Code
WBZ	Water-bearing zone

1.0 Introduction

This Supplemental Upland Remedial Investigation (RI) Work Plan (RI Work Plan) has been prepared for Cantera Development Group, LLC (Cantera) for the former TOC Holdings Co. (TOC) Seattle Terminal Properties (the Site) located on W. Commodore Way in Seattle, Washington. The term TOC collectively refers to TOC Holdings Co. and its predecessor entity Time Oil Company herein. The Site consists of four separate parcels (commonly identified as the Bulk Terminal Property, ASKO Hydraulic Property [ASKO Property], East Waterfront Property, and West Waterfront Property) located on W. Commodore Way. The former TOC Seattle Terminal also included one aquatic parcel leased from the Washington State Department of Natural Resources (DNR). W. Commodore Way, a City of Seattle perpetual use easement right-of-way (ROW), separates the Bulk Terminal and ASKO Properties from the East Waterfront and West Waterfront Properties, which are located adjacent to Salmon Bay. The location of the Site is shown on Figure 1.1, and the Site and its surroundings are shown on Figure 1.2. The final Site description is anticipated to be where contamination has come to be located and will be determined by the Washington State Department of Ecology (Ecology).

Three of the four parcels (all but the West Waterfront Property) were previously enrolled by TOC in Ecology's Voluntary Cleanup Program (VCP), under Facility Site No 75486194 (Bulk Terminal Property), Facility Site No. 78837111 (ASKO Property), and Facility Site No. 7417688 (East Waterfront Property).

SoundEarth Strategies, Inc. (SES) prepared separate RI and Feasibility Study (FS) reports for each of these three parcels, which were submitted to Ecology in 2014 (SES 2014a, 2014b, 2014c, 2014d, 2014e, 2014f). SES completed subsurface investigation activities for TOC until mid-2016, when TOC filed for bankruptcy.

1.1 PURPOSE

The former Site owner, TOC, filed a Chapter 7 liquidation bankruptcy, and the Site is currently for sale. The four former TOC parcels are currently owned by Edmond J. Wood, acting as Chapter 7 Trustee of the Bankruptcy Estate of TOC Holdings Co. (the Trustee). Cantera is a prospective purchaser and is currently in a due diligence process to evaluate environmental contamination and other feasibility issues associated with the Site prior to purchase. Cantera's objective is to obtain a Prospective Purchaser Agreement (PPA)/Consent Decree (CD) from Ecology; Cantera is not a potentially liable person for the Site.

As part of the due diligence process, Cantera enrolled all four parcels into the VCP in July 2018 (as a single Site). Ecology accepted the VCP application on July 10, 2018, and identified the Site name as Time Oil Bulk Terminal PPA with VCP Project No. NW3201.

The purpose of this RI Work Plan is to describe the supplemental investigation activities that will be completed to fill upland data gaps and to characterize the nature and extent (both vertically and horizontally) of contamination in environmental media to provide sufficient information to evaluate and select final cleanup actions. It also incorporates a summary of existing information collected during previous environmental investigation efforts at the Site.

This RI Work Plan includes a Sampling and Analysis Plan (SAP) section and Quality Assurance Project Plan (QAPP) section that describe the organization, objectives, and specific quality assurance (QA) and quality control (QC) procedures for field and laboratory activities associated with sample collection proposed for the RI data collection and analyses.

1.2 SEDIMENT EVALUATION

Due to the current status of discussions between Cantera and Ecology regarding the PPA/CD and the parallel nature of the sediment evaluation, details regarding evaluation of sediment are not included herein. A subset of surface sediment data was collected by Floyd|Snider in August 2018 in accordance with the Surface Sediment Quality Evaluation SAP/QAPP (hereafter referred to as the Surface Sediment SAP/QAPP) dated July 2018 (Floyd|Snider 2018). Additional sediment data were collected in March 2019 in accordance with an addendum to the Surface Sediment SAP/QAPP (Floyd|Snider 2019) and in consultation with Ecology. These sediment data will be presented in a data summary report, which will be provided to Ecology concurrent with the Supplemental Upland RI.

1.3 DOCUMENT ORGANIZATION

The following sections of this document are organized as follows:

- **Section 2.0—Site Description.** Describes the Site setting, including Site features and adjacent properties and former and current Site operations.
- **Section 3.0—Summary of Previous Investigations, Interim Actions, and COPC Screening.** Summarizes activities conducted on the Site by SES and others to date, including previous environmental investigations and interim cleanup actions conducted at the Site, and describes the chemical of potential concern (COPC) screening methodology used by SES.
- **Section 4.0—Preliminary Screening Level Development and COPC Identification.** Provides the rationale for the development of preliminary screening levels (PSLs) for each medium of concern and identifies COPCs based on screening current data against the PSLs.
- **Section 5.0—Summary of Site Conditions.** Provides a summary of the nature and extent of the COPCs by media and by parcel.
- **Section 6.0—Preliminary Conceptual Site Model.** Describes the physical setting of the Site, identifies areas of concern (AOCs), identifies potential release mechanisms and historical sources, and provides a summary of exposure pathway analysis.
- **Section 7.0—Supplemental Upland Remedial Investigation.** Provides a detailed description of the identified data gaps and approach to sample collection to fill these data gaps, including a SAP/QAPP for the proposed investigation.

- **Section 8.0—Feasibility Study.** Presents remedial action objectives (RAOs) for the Site and describes selection of the preferred alternative to be conducted in the FS.
- **Section 9.0—Reporting and Schedule**. Presents the schedule and reporting requirements for the Site.
- **Section 10.0—References.** Includes a list of references included in the RI Work Plan.

2.0 Site Description

The former TOC Seattle Terminal operated between 1941 and 2001, and operations included bulk petroleum storage in aboveground storage tanks (ASTs) and distribution of petroleum products via ships, rail, and trucks. Former key features of the former TOC Seattle Terminal included ASTs, barreling sheds, two barrel inclines, overhead loading racks, and an underground pipeline utilidor that extended beneath W. Commodore Way to the East Waterfront Property. The former bulk storage facility features, including fourteen ASTs on the central and eastern portion of the Bulk Terminal Property and their associated piping and infrastructure, were removed by TOC in 2006. The remaining Site buildings are currently vacant, with the exception of Marine Service & Supply, Inc., a tenant that uses a building on the southern portion of the Site for sales and storage of marine supplies.

A brief summary of the location and operations is included below for each of the parcels. Refer to the SES RI reports for a more comprehensive description of Site history and operations (SES 2014a, 2014b, and 2014c). Figures 2.1a and 2.1b show the former TOC Seattle Terminal historical features.

2.1 PROPERTY LOCATION AND ADJACENT PROPERTIES

The former TOC Seattle Terminal is located along the industrial waterfront area of Salmon Bay on the Lake Washington Ship Canal in the Magnolia neighborhood, and is within the Ballard Interbay North Manufacturing Industrial Center (SES 2014a).

The Bulk Terminal Property and the ASKO Property are located on the south side of W. Commodore Way (Figure 1.2). The Bulk Terminal Property is located at 2737 W. Commodore Way (King County Tax Parcel No. 1125039050) on 4.08 acres. The Bulk Terminal Property is bounded to the east by W. Fort Street and beyond by a multi-tenant warehouse building. The ASKO Property (King County Tax Parcel No. 4237900405) located at 2805 W. Commodore way is adjacent to and west of the Bulk Terminal Property on 1.59 acres. The ASKO Property is bound to the west by a multi-tenant warehouse building currently owned by Century Twenty-One Promotions and beyond by 31st Avenue West. Both properties are bound to the south by BNSF Railway (BNSF) railroad property and beyond by W. Government Way.

The East Waterfront and West Waterfront Properties are located north of The Bulk Terminal Property and the ASKO Property on the north side of W. Commodore Way (Figure 1.2). The East Waterfront Property is located at 2750 W. Commodore Way (King County Tax Parcel No. 1125039120) on 3.05 acres. The DNR Aquatic Lease Land Property (King County Tax Parcel No. 1125039113) extends into Salmon Bay from the property boundary of the East Waterfront Property. The Maritime Industrial Center is located on the east adjacent property at 2700 W. Commodore Way. The West Waterfront Property located at 2800 W. Commodore Way (King County Tax Parcel No. 1125039081) is on 1.69 acres and is adjacent to and west of the East Waterfront Property. The West Waterfront Property is bound to the west by Lockhaven Apartments and Marina and other residential properties beyond.

2.2 HISTORICAL AND CURRENT OWNERSHIP AND OPERATIONS

TOC's corporate predecessor, originally a local Seattle-based oil distributor in the 1930s, became one of the largest petroleum products companies on the West Coast by the late 1960s. TOC began operations at the TOC Seattle Terminal in the early 1940s primarily to support World War II efforts. TOC was also a major distributor of fuel for the military in Alaska. During that time TOC used a significant stretch of waterfront along the south shoreline of Salmon Bay for the storage of fuel drums being processed at the TOC Seattle Terminal. Barrels were loaded onto ships at the Shipping Terminal Dock. The TOC Seattle Terminal supported large quantities of fuel being stored and distributed during and after World War II. (Calkins 1950, Seattle Times 1953, Burchard 1968).

A brief summary of the operational history at the TOC Seattle Terminal Properties is included below. A more comprehensive history for each of the parcels was previously prepared by SES and is provided in the RI reports (SES 2014a, 2014b, and 2014c).

2.2.1 Bulk Terminal Property

The Bulk Terminal Property, originally two separate parcels owned by C.F. Anderson and H.D. Chaplin, was first developed for residential use in 1905. In the 1920s and 1930s, the property was used for furniture manufacturing by Salmon Bay Manufacturing Company and Rattan Furniture Manufacturing Company. Jobbers Petroleum Company, a distributor of Hancock gasoline and other petroleum products purchased the property in 1939. In March 1941, Jobbers Petroleum Company opened the company's new plant on the Bulk Terminal Property. To support their operations, Jobbers Petroleum Company constructed a 500-foot pier to accommodate large oil tankers, a two-story office building, and storage tanks for three million gallons of gasoline (Calkins 1941). TOC acquired the property the same year and between 1941 and 1950 continued development of the property with construction of additional infrastructure including barreling sheds, a barrel incline extending from a barreling shed to the East Waterfront Property, various structures, multiple ASTs in the Lower and Upper Tank Yards, and a pipeline utilidor extending underground from the Lower Tank Yard to the Shipping Terminal Dock located on the East Waterfront Property in support of the petroleum bulk storage facility operations. Four rail spurs entered onto the TOC Seattle Terminal from the main BNSF line behind the former barreling shed (refer to Figures 2.1a and 2.1b); one spur extended toward the south end of the Upper Tank Yard. As reported in a Phase I Environmental Site Assessment completed by Foster Wheeler (and based on interviews conducted with former and current employees), large volumes of fuel arrived on rail cars and was transferred from tanker cars via hoses to the tank farm (Foster Wheeler 2000). TOC operated the petroleum bulk storage facility until 2001, and the tank farm and associated infrastructure was removed in 2006. Currently, there are no active operations by the owner (the Trustee) located on the Bulk Terminal Property. The property is currently occupied by a vacant office building (former TOC office), a marine retail facility, and warehouse space.

2.2.2 ASKO Property

The ASKO Property was first developed for residential and agricultural use owned by G. Anderson in 1905. By the 1930s, the residential properties were removed. Between 1946 and 1950, TOC acquired the property to support the Bulk Terminal Property operations, and constructed drum storage, a barreling shed, and three 14,000-gallon ASTs used for the storing lube oil and/or motor oil. Four rail spurs entered the southern portion of the ASKO Property from the BNSF railroad. A fifth rail spur located next to the main line was used for extra storage of rail tanker cars (SES 2014a). From 1960 until 1974, the property was used as a truck storage area and parking lot for the Bulk Terminal Property. In 1964, a warehouse building was constructed on the northwest portion of the property for servicing TOC vehicles. It was reported that a 550-gallon fuel oil underground storage tank (UST) was located on the northeast side of the warehouse building. In 1974, TOC leased the warehouse to Precision Engineering Specialists, a marine and engine repair facility. From approximately 1976 until 1980, Select Industries leased the warehouse, where they operated a machine shop. In 1989, Select Industries reportedly became by ASKO Hydraulic Repair, later known as ASKO Industrial Repair, began operating a hydraulic repair shop on the property. ASKO Industrial Repair, leased the property from TOC and operated a hydraulic repair and machine shop until sometime between 2015 and 2017. Marine Service & Supply, a commercial fishing marine supply store, currently leases a 1940s-era building located on the southeast corner of the property for retail sales, storage, and equipment repair.

2.2.3 East Waterfront Property

The East Waterfront Property was first developed with a single structure, presumably a residence, owned by G. and C.F. Anderson from 1905 until the early 1920s. Between 1930 and 1944, the property, still owned by C.F. Anderson, was used as part of the Rattan Furniture Manufacturing facility present on the east adjacent property (the Maritime Industrial Center). During this time, a boiler room, sawmill, dry kiln, and warehouse building associated with Rattan's operations were located on the East Waterfront Property. Houseboats were also present along the shoreline area, and the northern portion of the property was used for log booming.

TOC reportedly acquired the Property in 1941. By the mid-1940s, all of the structures associated with Rattan Furniture had been removed. In 1943, the Shipping Terminal Dock (located within the DNR Aquatic Lease Land Property) was constructed for fueling transport ships using the pipeline utilidor from the Bulk Terminal Property. Drums were filled with fuel from the barreling sheds located on the ASKO Property and the Bulk Terminal Property and then then transferred via the drum incline from the Bulk Terminal Property to the Shipping Terminal Dock. During the 1950s, TOC constructed buildings to support their operations including a general storage building and a laboratory building used for paint storage. It was also reported that a garage was used for vehicle repair and equipment lubrication. In 1977 a small dock was added along the waterfront area.

TOC leased the property to a marine supply business, George Broom's Sons Inc., and a seafood company, Icicle Seafoods. From 1972 until 2011, George Broom's Sons Inc., a supplier of tug and barge rigging and safety nets and slings, leased the warehouse building for their sailing and rigging business. In 1980, TOC leased a portion of the East Waterfront Property located at 2752 W. Commodore Way to Icicle Seafoods, Inc. for use as a maintenance and repair base for a portion of their fishing fleet, until they vacated the property in 1992 (TOC 1993). Between 1980 and 1991, three docks were constructed along the shoreline area west of the Shipping Terminal Dock, and supported Icicle Seafoods operations. The TOC report stated that during a site visit with Icicle Seafood several small areas of surface soil staining were observed attributed to the storage of "dismantled hydraulic equipment and auto maintenance activities." Presumably, Icicle Seafoods used sandblast grit during their operations, as three areas of grit were located on the surface and in soil during previous environmental sampling and subsequent excavation completed on the property in 1992 and 1993 (TOC 1993).

Since 2005, ASKO Selective Plating, a company that provides electroplating of parts and equipment for aerospace, marine, electronics and commercial industries, has occupied the property located at 2752 W. Commodore Way.

2.2.4 West Waterfront Property

The West Waterfront Property was vegetated and vacant until TOC purchased the property sometime between 1946 and 1950. In 1946, vegetation was cleared and several sheds were constructed. Currently, and historically, the property is used for recreational boat moorage, storage, and parking. There were no historical operations conducted on this portion of the TOC Seattle Terminal. Three docks extend across the shoreline area from the West Waterfront Property, and are currently leased by Lockhaven Marina for house boats.

2.3 PHYSICAL SETTING, GEOLOGY, AND HYDROGEOLOGY

The Site is situated on the southern shoreline of Salmon Bay, a manmade embayment adjacent to the Hiram M. Chittenden locks which connect Lake Union to the Puget Sound. The Site slopes gently to the north, and is bordered to the south by steeper slopes comprising the Magnolia Bluff neighborhood of Seattle.

Soils at the Site generally consist of 2 to 5 feet of surficial fill underlain by interglacial deposits. Fill soils are composed of sand, silty sand and gravel and are presumed to consist of engineered fill as well as re-worked native soil. Shallow native soils below the fill are Olympia beds, which are interglacial deposits that pre-date the most recent Fraser Glaciation. The Olympia beds are approximately 20 feet thick at the Site and are composed of a silt unit with occasional sandy and gravelly lenses underlain by silty sand. Below the Olympia beds are older pre-glacial deposits of interbedded silt/clay and sand/silty sand.

A discontinuous zone of shallow perched water is encountered in sandy and gravelly layers within the shallow silt unit of the Olympia beds. The Perched Water-Bearing Zone (WBZ) is typically encountered between 6 and 10 feet below ground surface (bgs; corresponding to elevations between 50 and 46 feet North American Vertical Datum 1988 [NAVD 88]) and is present on the southern portion of the ASKO Property. The first continuous WBZ, referred to as the Shallow WBZ, is encountered Site-wide within the silty sand unit of the Olympia beds, at depths ranging from 10 to 30 feet bgs (between 42 and 19 feet NAVD 88). A second Site-wide WBZ, referred to as the Intermediate WBZ, is encountered in pre-glacial sand/silty sand deposits between 15 and

37 feet bgs (21 to 10 feet NAVD 88).[1] A third Site-wide WBZ, referred to as the Deep WBZ, has been documented in a limited number for borings. The Deep WBZ is present within deeper pre-glacial sand/silty sand deposits at an elevation of approximately 0 feet NAVD 88.[2] The silt and clay layers between the WBZs act as semiconfining units that slow migration between saturated zones.

Overall groundwater flow at the Site is to the northwest toward Salmon Bay. Downward vertical gradients have been measured between all WBZs, with the strongest downward gradients measured between the Perched and Shallow WBZs and the weakest downward gradients measured between the Intermediate and Deep WBZs. Lateral groundwater gradients have been documented most extensively in the Shallow WBZ. In this zone, although overall groundwater flow is to the northwest, secondary flow directions to the north and northeast have been observed. Water table elevations are highly irregular with elevation differences of 1 to 3 feet often observed between wells in close proximity to each other and steep gradients present to the south of and within the W. Commodore Way ROW.

The King County sewer line that runs beneath W. Commodore Way at the Site is situated at the approximate elevation of the Intermediate WBZ. There are a limited number of wells screened in the Intermediate WBZ at the Site, therefore it is not known whether groundwater in this zone is in hydraulic connection with the sewer line.

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[1] It is important to note that the Shallow and Intermediate WBZs do not overlap. There is a significant surface elevation difference across the Site from south to north sloping toward Salmon Bay.

[2] Data extrapolated from SES cross-sections included in the 2014 draft RI reports.

3.0 Summary of Previous Investigations, Interim Actions, and COPC Screening

This section provides a summary of environmental investigations and actions that have been completed to date at the Site, which resulted in the collection of a significant amount of groundwater and soil data. Comprehensive discussions of the data resulting from these investigations are presented in the RI reports (SES 2014a, 2014b, and 2014c). This section also provides a brief summary of the screening process used by SES in the RI reports to identify COPCs at the Site.

3.1 SITE INVESTIGATIONS

Numerous environmental investigations including collection of hundreds of samples have been conducted between 1991 and 2016 at the Site to assess the impacts from former operations. There have been more than 600 soil samples collected and there are more than 100 monitoring wells, with thousands of groundwater samples collected over the past several decades. The location of all soil borings that have been advanced at the Site are shown on SES figures included in Appendix A. The locations of monitoring wells, including what WBZ they are screened in, are shown on Figures 3.1a and 3.1b.

The results of previous investigations for the former TOC Seattle Terminal Properties are described in the RI reports, which were prepared by SES and submitted to Ecology in 2014 (SES 2014a, 2014b, and 2014c). The data presented in the RI reports do not necessarily represent current Site conditions as several investigations and interim cleanup actions have been conducted that were not fully documented in the RI reports. Additional investigations completed by SES included subsurface investigations at the Bulk Terminal and East Waterfront properties in 2015 (SES 2015a, 2015b), vapor intrusion assessments at the Bulk Terminal and ASKO Properties in 2015 (SES 2016a, 2016b), and several groundwater monitoring events at the Bulk Terminal, ASKO, and East Waterfront Properties in 2015 and 2016. The most recent groundwater sampling events were conducted in May 2016. The results from these events are summarized in the groundwater monitoring reports prepared for TOC (SES 2016c, 2016d, 2016e). A summary of current conditions is provided in Section 5.0.

3.2 INTERIM CLEANUP ACTIONS

There have been numerous targeted interim cleanup actions completed at the former TOC Seattle Terminal, dating back as early as 1991. A summary of the majority of these activities were included in Section 3.4 of the Bulk Terminal RI report (SES 2014a) and in Section 3.3 of the East Waterfront RI report (SES 2014c), with few exceptions noted below.[3] A brief summary is included below. Refer to Figure 3.2 for the locations of the soil excavations on the Bulk Terminal and Figure 3.3 for the locations of the soil excavations on the East Waterfront.

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[3] SES files were provided to Floyd|Snider in August 2018 and included information regarding an additional TPH excavation on the East Waterfront Property conducted in 2013, which was not described in the RI for the East Waterfront. In addition, some details regarding a groundwater and LNAPL extraction system were available, but did not include complete information regarding system construction or operation.

3.2.1 Bulk Terminal Property

The following interim cleanup actions have been completed at the Bulk Terminal Property:

- 1991: Removal of two USTs (one gasoline and one dual-compartment with gasoline and diesel) and associated total petroleum hydrocarbons (TPH)-contaminated soil; included the removal of 140 cubic yards of contaminated soil.
- 2002: Removal of 13 cubic yards of soil contaminated by a hydraulic fluid release from a truck. The specific area of this release and excavation is not known.
- 2002: Former pentachlorophenol (penta) mixing AST excavation; included the removal of 70 cubic yards of penta-contaminated soil.
- 2010: Combined chemical oxidation and thermal heating via electrical resistance heating to accelerate cleanup of penta in groundwater. Included the installation of 144 subsurface injection points for sodium persulfate injections, installation of a localized electrical resistance heating system to heat the subsurface as a chemical activator, and the subsequent injection of 302,500 gallons of sodium persulfate mixture (10 percent aqueous-phase sodium persulfate).
- 2011: Penta and dioxin/furan hot spot excavations; included the removal of 875 cubic yards of contaminated soil.
- 2012: Penta and dioxin/furan final excavation; included the removal of 2,700 cubic yards of contaminated soil. A summary of this excavation was included in the SES RI report (SES 2014a). All contaminated soil with penta concentrations greater than the Model Toxics Control Act (MTCA) Method B cleanup level (CUL) of 2.5 milligrams per kilogram (mg/kg) was removed as part of this interim cleanup action. In addition, all contaminated soil with dioxin/furan concentrations greater than the MTCA Method B CUL of 11 nanograms per kilogram (ng/kg) was removed, with exception of two locations on the eastern excavation boundary, which were greater than the MTCA Method B CUL but less than the remediation level of 46 ng/kg (City of Seattle Area background, refer to SES RI for details).
- Approximately 2012 through 2017: Groundwater and light non-aqueous-phase liquid (LNAPL) recovery system operation; included fluid extraction (groundwater and LNAPL) from a series of recovery wells, treatment, and permitted discharge to sanitary sewer. A summary of this treatment system was not included in the 2014 RI, and specific details regarding system installation and operations were not available for review in the SES files. Therefore, the duration of system operation and location of the recovery wells is not known.

There has also been a stormwater pretreatment system in operation at the Bulk Terminal since the 1970s; it remains operational and is being monitored by the Trustee with permitted discharge to sanitary sewer under a King County discharge permit (permit 4427-01).

In addition, in 2012, SES coordinated the removal of the pipeline utilidor within W. Commodore Way (between the Bulk Terminal and East Waterfront properties) with the City of Seattle.

Accessible TPH-contaminated soil identified during the pipeline removal was excavated during the pipeline removal (SES 2012).

3.2.2 East Waterfront Property

The following interim cleanup actions have been completed at the East Waterfront Property:

- 1991: Waste oil UST excavation; included the removal of 100 cubic yards of contaminated soil.
- 1992: Additional excavation in the vicinity of the former waste oil UST; included 150 cubic yards of contaminated soil.
- 1992: Localized surface excavations for sandblast grit (metals); included three separate excavations to remove sandblast grit (Excavation A through Excavation C).
- 1992: Localized TPH surface staining excavations (Pit 1 through Pit 5); included five separate targeted excavations in areas where TPH surface staining was identified.
- 2011: Gasoline UST excavation; included the removal of 20 cubic yards of petroleum-contaminated soil. The gasoline UST was not observed during excavation activities.
- 2013: TPH soil excavation; included the removal of 1,700 cubic yards of petroleum-contaminated soil. A summary of this excavation was not provided in the SES 2014 RI for the East Waterfront property. Post-excavation results indicated that residual TPH and benzene contaminated soil remained at concentrations greater than the MTCA Method A CULs on the eastern portion of the excavation and extended beneath the existing shed and garage.

3.3 CHEMICALS OF POTENTIAL CONCERN

A primary COPC is identified as a chemical that is expected to be a primary remedial driver for the Site due to known sources of release (i.e., petroleum ASTs), its nature and extent, elevated concentrations, frequency of exceedance (FOE), and distribution. All other COPCs identified in the SES RI reports (SES 2014a, 2014b, and 2014c) are considered secondary COPCs and are typically colocated and coincidental with known releases of TPH and are not expected to be remedial drivers at the Site.

The primary COPCs identified at the Site as part of previous investigations are TPH, including gasoline-, diesel-, and oil-range organics (GRO, DRO, and ORO; Site-wide); benzene (Site-wide); penta (Bulk Terminal); and chlorinated volatile organic compounds (cVOCs; ASKO).

In the RI reports, SES identified COPCs for soil and groundwater at each of the three parcels. To identify the COPCs, SES used preliminary CULs to screen the soil and groundwater analytical data. These preliminary CULs were based on MTCA Method A CULs for both groundwater and soil (unrestricted land use). MTCA Method B CULs were used for screening for chemicals where MTCA Method A CULs are not established. Chemicals that exceeded their respective CLs were identified as soil and groundwater COPCs, and are presented in the RI reports.

As described above, numerous environmental investigations and interim actions have been performed since the RI reports were issued. Therefore, to more accurately reflect current Site conditions, the most recent data for the SES-identified COPCs will be used to identify a final list of COPCs. These data will be compared against conservative PSLs that are protective of all exposure pathways potentially present at the Site. The derivation of the PSLs and the final COPC list for soil and groundwater is presented in Section 4.0.

4.0 Preliminary Screening Level Development and COPC Identification

This section provides a summary of the approach used by Floyd|Snider to identify the PSLs for soil and groundwater through evaluation of anticipated Applicable or Relevant and Appropriate Requirements (ARARs) and the available Site data. The primary cleanup regulations (chemical-specific ARARs) that apply to this Site are MTCA and its implementing regulations Washington Area Code (WAC) 173-340; Water Quality Standards for Surface Waters of the State of Washington (WAC 173-201A); and federal surface water quality ARARs for protection of the adjacent groundwater receiving waterbody, Salmon Bay.

Once PSLs for each medium are developed, Site COPCs were determined. It is important to note that updated COPCs are presented in this RI Work Plan from the prior SES 2014 RIs using the most recent available data. The outcome of this section is a list of applicable PSLs for various pathways and COPCs for soil and groundwater.

4.1 DEVELOPMENT OF PRELIMINARY SCREENING LEVELS BY MEDIA

Based on the ARARs, PSLs have been developed that are protective of both human health and ecological receptors for soil and groundwater. Table 4.1 and Table 4.2 present PSLs for each medium.

PSLs are protective of direct contact and select cross-media exposure scenarios. Cross-media protection pathways require that (1) the contaminant migrates from one medium (or location) to another and that (2) an exposure occurs between a receptor and the medium that is being protected. PSLs are inherently conservative because contaminant migration is modeled by simple equilibrium partitioning equations that are not typically calibrated to site-specific conditions. PSLs do not consider site-specific conditions that limit or eliminate contaminant migration and exposure, including natural attenuation processes and physical barriers to exposure. These two factors combine to create PSLs that are intentionally conservative, which ensures the use of analytical methods with appropriate sensitivity to assess risk, regardless of site-specific conditions.

The following sections identify potentially applicable exposure pathways and corresponding regulatory criteria considered in the development of PSLs for each of the potentially impacted media, as well as the source of background data and other considerations relevant to PSL development.

4.1.1 Preliminary Screening Level Development for Soil

Table 4.1 presents the PSLs for soil for each of these potential exposure pathways for chemicals that have previously been identified by SES as COPCs for the Site. The most stringent PSL is also identified for each soil zone (vadose zone and saturated zone) and is the value applied in the screening of COPCs, described in Section 4.2.

The complete exposure pathways considered in developing the PSLs for soil are presented below:

- **Protection of Human Health Direct Contact.** The Site is in an area zoned for commercial/industrial use. Therefore, the PSLs included are based on MTCA Method C standard formula table values for industrial land use or MTCA Method A table values for industrial land use where MTCA Method C values were not available (lead and TPH).
- **Protection of Terrestrial Ecological Receptors.** The terrestrial ecological evaluation PSL is the minimum of the values for protection of plants, soil biota, and wildlife in the site-specific terrestrial ecological evaluation under unrestricted land use (MTCA Table 749-3).
- **Protection of Sediment Quality.** Target sediment concentrations were identified as soil PSLs protective of potential bank erosion. Sediment concentrations are based on the Sediment Management Standards (SMS) Sediment Cleanup Objectives (SCOs) for freshwater.
- **Protection of Groundwater Quality.** PSLs that are protective of contaminants leaching from soil to groundwater were calculated using the fixed parameter three-phase partitioning model, MTCA Equation 747-1, and were developed separately for saturated and vadose zone soils. The basis of the groundwater PSLs used in the calculation is described in Section 4.2.2.

Additionally, two modifying factors were considered in establishing PSLs: natural background and practical quantitation limits (PQLs):

- **Natural Background.** A number of the chemicals detected at the Site are naturally occurring in the environment, and it is inappropriate to establish a PSL lower than the natural background concentrations. In soil, some metals and dioxins/furans have established statewide background concentrations. Values from Ecology's *Natural Background Soil Metals Concentrations in Washington State* (Ecology 1994) are used for the background concentrations for metals, and the value from Ecology's *Natural Background for Dioxins/Furans in Washington Soils—Technical Memorandum #8* (Ecology 2010) is used as a natural background number for dioxins/furans. Where the PSL is less than the natural background value, the PSL is adjusted upward to natural background.
- **Practical Quantitation Limits.** The PQL is the lowest concentration that can be reliably measured within specified limits of precision, accuracy, representativeness, completeness, and comparability during routine laboratory operating conditions, using approved methods. Table 4.1 presents the PQLs provided by Friedman & Bruya, Inc. (FBI) in September 2018. FBI will be analytical laboratory for the upland portion of the Site investigation and has a long history on the Site. Often, the PSLs are less than the identified PQL. In these cases, the PSL is adjusted upward to the PQL. It is critically important that the PQLs used to adjust the PSL upward (which is thereby the default PSL) are achievable with standard laboratory methodology.

4.1.2 Preliminary Screening Level Development for Groundwater

Table 4.2 presents the PSLs for groundwater for each of these exposure pathways. PSLs are presented for all chemicals that have previously been identified by SES as COPCs for the Site. PSLs are identified separately for wells located in the uplands versus shoreline wells. These values are applied in the screening of COPCs, described in Section 4.2. The exposure pathways considered potentially complete in developing PSLs for groundwater are presented below:

- **Protection of Drinking Water Quality.** Groundwater at the Site is considered potable; therefore, ARARs protective of drinking water quality apply. These include MTCA Method B CULs and maximum contaminant levels (MCLs) from the National Primary Drinking Water Regulations. Washington State MCLs have been substituted for the federal MCLs where they are more stringent (i.e., ethylbenzene).
- **Protection of Surface Water Quality.** Groundwater at the Site has the potential to migrate to the shoreline and discharge into Salmon Bay. Consistent with requirements in MTCA, groundwater that discharges into surface water must meet the surface water quality standards for protection of the adjacent groundwater receiving waterbody at the point where the discharge occurs, without taking dilution into account. ARARs to address this exposure pathway include the following:
    - Water Quality Standards for Surface Waters of the State of Washington (WAC 173-201A). These criteria are used for protection of acute and chronic effects to freshwater aquatic life and for protection of human health assuming fish and water consumption.
    - National Recommended Water Quality Criteria (Clean Water Act Section 304, 33 CFR 26.1314). These criteria are used for protection of acute and chronic effects to freshwater aquatic life and for protection of human health assuming fish and water consumption.
    - Washington Toxics Rule (40 CFR 131.45). In November 2016, the U.S. Environmental Protection Agency (USEPA) promulgated certain federal human health criteria applicable to Washington State surface water under the Clean Water Act. These criteria replace criteria in the National Toxics Rule (40 CFR 131).
- **Protection of Sediment Quality.** Sediment quality must be protected at the point where groundwater is discharged to sediment. To address this pathway, groundwater concentrations protective of freshwater sediments were calculated using the fixed parameter three-phase partitioning model, MTCA Equation 747-1, with the most stringent sediment PSLs (based on the SMS SCO freshwater criteria) as target sediment concentrations. Groundwater PSLs are therefore based on the concentration protective of the freshwater sediment PSL.
- **Protection of Soil Vapor.** Volatile contaminants in shallow groundwater have the potential to volatilize, rise through the soil column, and discharge to ambient air. PSLs for this pathway are based on the MTCA Method C values for industrial land use published in Ecology's *Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action* (Ecology 2018).

As with soil, natural background and PQLs are considered in establishing PSLs:

- **Natural Background.** For natural background in groundwater, the only value that has been established is for arsenic. This value is based on the 50th percentile natural background value for the Puget Sound Basin calculated for arsenic in Ecology's *Natural Background Groundwater Arsenic Concentrations in Washington State* (Ecology 2015a).
- **Practical Quantitation Limits.** Like soil, many of the PSLs in the summary tables are less than the PQL provided by FBI. In these cases, the PSL is adjusted upward to the PQL.

4.2 IDENTIFICATION OF COPCS BY PARCEL AND MEDIA

This section describes the screening of soil and groundwater data relative to the PSLs, which results in the identification of COPCs for each medium. The screening is presented in FOE tables, which include soil and groundwater tables that evaluate each of the three parcels separately (Bulk Terminal, ASKO, and East Waterfront; refer to Appendix B for all FOE tables). Based on a review of historical documents, the West Waterfront Property has been and is still used for boat moorage, storage, and parking. No industrial activities have taken place on this parcel, and there are no known sources of contamination. One Shallow WBZ well was installed at the property to evaluate downgradient groundwater quality at ASKO (refer to Section 5.2.4). Groundwater data from this well is included as part of the ASKO data evaluation.

The FOE tables summarize data for all chemicals of interest that were analyzed in Site soil and groundwater and only include data that are representative of current Site conditions. COPCs for each medium are identified based on the exceedance information presented in the tables. Chemicals that were not detected are not retained as COPCs. Chemicals were retained as COPCs if:

- Detected concentrations exceed the PSL in greater than 5 percent of sample results.
- The chemical has known sources specific to the parcel where the exceedances occurred.

4.2.1 Soil Results

Soil COPCs are identified in Tables B.1 through B.6. The most stringent PSL for each soil zone (vadose zone and saturated zone) was compared against maximum concentrations at each location. As described in Section 3.2, numerous soil excavations have been performed at the Site. The soil dataset used to screen for COPCs excludes any soil results known to have been removed from the Site during the interim cleanup actions. The COPCs identified in soil that were detected at the Site are summarized in Table 4.3.

Table 4.3
Soil Chemicals of Potential Concern

Chemical	Bulk Terminal	ASKO	East Waterfront
Vadose Zone			
TPH: GRO	✓	✓	✓
TPH: DRO	✓	✓	✓
TPH: ORO		✓	
Benzene	✓		
cis-1,2-Dichloroethene		✓	
Ethylbenzene	✓	✓	✓
TCE		✓	
Toluene	✓		
Total xylenes	✓		
Saturated Zone			
TPH: GRO	✓	✓	
TPH: DRO	✓		✓
Benzene	✓		
cis-1,2-Dichloroethene		✓	
Ethylbenzene	✓		✓
TCE		✓	
Toluene	✓		✓
Total xylenes	✓		

Abbreviation:
TCE Trichloroethene

4.2.2 Groundwater Results

Groundwater COPCs are identified in Tables B.7 through B.10. The most recent groundwater result for each chemical at each location was used for the COPC screening, in order to evaluate current Site conditions. For groundwater, two datasets were identified: uplands and shoreline. The upland wells were compared against potability PSLs because that is the only potential exposure pathway. The shoreline wells (decommissioned well 02MW02 and existing well 02MW07 on the East Waterfront Property) were compared against the most stringent PSL to ensure protection of groundwater discharge to surface water and sediments. The COPCs identified in groundwater that were detected at the Site are summarized in Table 4.4.

Table 4.4
Groundwater Chemicals of Potential Concern

Chemical	Bulk Terminal	ASKO	East Waterfront
Arsenic	✓	✓	
TPH: GRO, DRO, ORO	✓	✓	✓
Benzene	✓	✓	✓
1,2-Dibromoethane	✓	✓	
1,2-Dichloroethane	✓		
1,1-Dichloroethene		✓	
cis-1,2-Dichloroethene		✓	
Ethylbenzene	✓		✓
TCE		✓	
1,2,4-Trimethylbenzene	✓		
Vinyl chloride		✓	

4.2.4 Determination of Primary COPCs

The lists of COPCs determined above were further evaluated to determine which chemicals were likely to be remedial drivers, and therefore considered primary COPCs, due to their nature and extent, elevated concentrations, FOE, and distribution:

Based on this evaluation the primary COPCs for soil and groundwater for each parcel are as follows:

- Bulk Terminal soil: TPH (GRO and DRO) and benzene
- ASKO soil: TPH (GRO, DRO, and ORO), benzene, and cVOCs (*cis*-1,2-dichloroethene and TCE)
- East Waterfront soil: TPH (GRO and DRO) and ethylbenzene
- Bulk Terminal groundwater: TPH (GRO, DRO, and ORO); benzene and ethylbenzene
- ASKO groundwater: TPH (GRO, DRO, and ORO), benzene, and cVOCs (*cis*-1,2-dichloroethene, TCE, and vinyl chloride)
- East Waterfront groundwater: TPH (GRO, DRO, and ORO), benzene, and ethylbenzene

The remainder of the COPCs identified in Section 4.2 for soil and groundwater are considered secondary COPCs due to low frequency, relatively low concentrations, and limited distribution.

5.0 Summary of Site Conditions

This section provides a summary of the existing soil data for the primary Site COPCs and the most recent groundwater data collected at each monitoring well for the Site COPCs, which was typically between 2013 and 2016. The most recent groundwater sampling event conducted by SES was in May 2016.

5.1 SOIL

The RI Work Plan soil dataset includes the data presented in the 2014 RIs (SES 2014a, 2014b, 2014c), data from the subsurface investigations conducted by SES in 2014 and 2015 for the Bulk Terminal and East Waterfront Properties, and data from confirmation samples following the 2013 excavation conducted on the East Waterfront Property (SES 2015a, SES 2015b, SES 2016a and Appendix A).[4] COPCs in soil have been sufficiently characterized at the Site as documented in existing reports to evaluate the nature and extent of contamination and for the evaluation and selection of cleanup alternatives.

The soil data for the primary COPCs for the Bulk Terminal, ASKO, and East Waterfront Properties are summarized below. For a comprehensive evaluation of soil data, including summary tables and figures, refer to the reports noted above (SES 2014a, 2014b, 2014c, SES 2015a, SES 2015b, and Appendix A).

5.1.1 Bulk Terminal Property

The soil dataset for the Bulk Terminal Property includes samples collected between 1999 and 2012 which are described in the 2014 RI and presented in the RI tables and figures (SES 2014a). The soil dataset also includes soil data from confirmation samples collected from the excavation in 2012, but excludes data that was removed as part of the 2012 excavation as described below:

- As described in the RI and in Section 3.2, several interim actions were conducted to remove soil with concentrations of penta greater than the MTCA Method B CUL (2.5 mg/kg) and soil with concentrations of dioxins and furans greater than the MTCA Method B CUL (11 ng/kg) or greater than the Seattle-area background remediation level (46 ng/kg). To support the full-scale excavation conducted in 2012, four soil samples were analyzed for dioxin/furans and 23 soil samples were analyzed for penta. Soil with penta exceedances was removed and excavated areas were bounded by additional samples with penta concentrations that were less than the MTCA Method B CUL (SES 2014a). Dioxin/furan concentrations in two confirmation samples collected on the eastern side of the 2012 excavation were greater than the MTCA Method B CUL, but less than the Seattle area background remediation level for

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[4] Copies of the draft 2015 subsurface investigation reports were not submitted to Ecology by TOC or SES; however, Floyd|Snider informally provided copies of these draft reports to Ecology in August 2018. A data table and figure was prepared following the 2013 TPH excavation at the East Waterfront Property, however a report was not prepared to document the excavation. A copy of the draft table and figure prepared by SES is included in Appendix A.

the interim cleanup action. As reported in the 2014 RI, these results confirmed that penta and associated dioxins and furans in soil have been removed from the Site and are no longer COPCs (SES 2014a).

The dataset also includes data from two subsurface investigations conducted by SES in 2014 and 2015 (SES 2015a and SES 2016a) as described below:

- In 2014, 28 additional soil borings (B327 through B354) were advanced in the vicinity of the 2012 excavation to evaluate if any potential penta sources existed that could be acting as a source to groundwater. A total of 81 additional samples were collected and results indicated that penta was not present in soil at concentrations greater than the MTCA Method B CUL of 2.5 mg/kg.
- In 2015, 24 additional soil samples from seven borings B357 to B363 were collected to address a data gap identified in the RI and delineate the lateral and vertical extent of TPH in soil in the southeast corner of the Bulk Terminal Property. The soil sample from boring B362 collected from 2.5 feet bgs, had detected concentrations of DRO and ORO of 74 and 360 mg/kg, respectively, which were less than the MTCA Method A CULs, and the soil PSLs presented in Section 4.1. Concentrations of GRO and penta in the sample from B362 were non-detect. TPH, BTEX, and penta were non-detect in the remaining 23 samples.

Based on the results of the RI and supplemental subsurface investigations, the primary soil COPCs for the Bulk Terminal Property are TPH (GRO and DRO) and benzene, the soil data for these COPCs are summarized below:

- GRO was detected in 152 of 369 samples. Detected concentrations ranged from 3 to 755,000 mg/kg. The maximum concentration was from a sample collected from boring 01SB09 in 1999, which was located in the former pump island area.
- DRO was detected in 144 of 369 samples. Detected concentrations ranged from 10 to 33,900 mg/kg. The maximum concentration was from a sample collected from boring 01SB08 in 1999, which was located in the former diesel and gasoline UST area.
- Benzene was detected in 85 of 369 samples. Detected concentrations ranged from 0.00080 to 5,590 mg/kg. The maximum concentration was from a sample collected from boring 01SB09 in 1999, which was located in the former pump island area.

5.1.2 ASKO Property

The soil dataset for the ASKO Property includes samples collected between 2000 and 2013 which are described in the 2014 RI and presented in the RI tables and figures (SES 2014c). The primary soil COPCs for the ASKO Property are: TPH (GRO, DRO, and ORO), benzene, and cVOCs (*cis*-1,2-dichloroethene and TCE). The soil data for these COPCs are summarized below:

- GRO was detected in 52 of 169 samples. Detected concentrations ranged from 2.0 to 9,700 mg/kg. The maximum concentration was from a sample collected from boring B89 in 2008, which was located adjacent to the former barrel shed and the west barrel incline area.

- DRO was detected in 40 of 166 samples. Detected concentrations ranged from 8.1 to 10,000 mg/kg. The maximum concentration was from a sample collected from boring B90 in 2008, which was located adjacent to the former barrel shed and the west barrel incline area.
- ORO was detected in 21 of 166 samples. Detected concentrations ranged from 30 to 14,000 mg/kg. The maximum concentration was also from a sample collected from boring B90 in 2008.
- Benzene was detected in 9 of 187 samples. Detected concentrations ranged from 0.0024 to 0.61 mg/kg. The maximum concentration was from a sample collected from boring 01MW60 in 2008, which was located south of former barreling shed #2 and adjacent to a BNSF rail spur on the southern property line.
- *cis*-1,2-Dichloroethene was detected in 65 of 223 samples. Detected concentrations ranged from 0.009 to 1.7 mg/kg. The maximum concentration was from a sample collected from boring 01MW54 in 2008, which is located within Plume 1.
- TCE was detected in 114 of 235 samples. Detected concentrations ranged from 0.0031 to 120 mg/kg. The maximum concentration was from a sample collected from boring 01MW71 in 2010, which is located adjacent to a BNSF rail spur on the southern property line within Plume 1.

5.1.3 East Waterfront Property

The soil dataset for the East Waterfront Property includes samples collected between 1999 and 2015, which are described in the 2014 RI and presented in the RI tables and figures (SES 2014c), soil data from confirmation samples collected from the excavation in 2013, and data from a subsurface investigation conducted by SES in 2015 (SES 2015b). Data that were excavated in 2013 were not included. The primary soil COPCs for the East Waterfront Property are TPH (GRO and DRO) and ethylbenzene, the soil data for these COPCs are summarized below:

- GRO was detected in 64 of 106 samples. Detected concentrations ranged from 4.6 to 320 mg/kg. The maximum concentration was from a sample collected from boring B271 in 2013, which was collected from the northwestern portion of the property.
- DRO was detected in 20 of 133 samples. Detected concentrations ranged from 95 to 2,800 mg/kg. The maximum concentration was from a sample collected from boring B271 in 2013, which was collected from the northwestern portion of the property.
- Ethylbenzene was detected in 5 of 104 samples. Detected concentrations ranged from 0.06 to 3 mg/kg. The maximum concentration was from a sample collected from boring B314 in 2013, which was collected from the southeastern portion of the property adjacent to the former utilidor.

5.2 GROUNDWATER

Groundwater monitoring was performed by SES quarterly or semiannually from 2006 to 2016. The RI Work Plan groundwater dataset includes the most recent data collected for each well and for each analyte (after the 2014 RIs), which is between 2013 and 2016 for most analytes. Data from decommissioned wells, injection wells, and soil vapor extraction wells were not included. To characterize current Site conditions, the most recent groundwater data were compared to the Upland PSLs or Shoreline PSLs (refer to Table 4.2) as appropriate.

In addition, LNAPL distribution and thickness was evaluated for the Bulk Terminal Property, and LNAPL distribution and thickness is shown on Figure 5.1. Groundwater exceedances of the PSLs for the primary COPCs are shown on Figures 5.2 through 5.8.

The groundwater data for the COPCs for each parcel are summarized below. For a comprehensive evaluation of groundwater data, including summary tables and figures, refer to the 2014 RIs (SES 2014a, 2014c and 2014e), and the 2016 groundwater monitoring reports (SES 2016a, 2016b and 2016c). Refer to Figures 3.1a and 3.1b for the location of monitoring wells, including what WBZ they are screened in.

5.2.1 Bulk Terminal Property

The groundwater dataset includes data from 54 monitoring wells in the Bulk Terminal monitoring well network. There are 52 Shallow WBZ groundwater wells and two Intermediate WBZ wells. Certain monitoring wells were not sampled by SES due to the presence of LNAPL or insufficient water in the well during time of sampling. Based on groundwater elevation contours from May 2016, the general groundwater flow direction for Shallow WBZ groundwater is to the northwest toward Salmon Bay.

During the most recent groundwater monitoring event conducted in May 2016, LNAPL was measured in nine monitoring wells. LNAPL thickness ranged from 0.06 (01MW33) to 5.3 feet (01MW10; SES 2016c). LNAPL distribution and thickness is shown on Figure 5.1.

As described in Section 4.2, the primary groundwater COPCs for the Bulk Terminals property include: TPH (GRO, DRO, and ORO), benzene, and ethylbenzene.

Monitoring wells with exceedances of the primary COPCs (TPH, benzene, and ethylbenzene) are located primarily in the vicinity of the northern LNAPL plume (Figures 5.2 and 5.3). TPH and benzene exceedances near the northern LNAPL plume extend in the direction of groundwater flow to the northern most monitoring well, 01MW84, which is located on W. Commodore Way near the southern boundary of the East Waterfront Property. There are additional TPH exceedances located in the vicinity of the southern LNAPL plume, and in the vicinity of the former ASTs, but the plume does not extend off site to the south.

The range of analytical results for primary COPCs for the most recent monitoring event (Shallow and Intermediate WBZs) completed for the COPC are summarized below. The results of non-detects and field duplicates were not reported:

- GRO was detected in 15 of 45 monitoring wells. Detected concentrations ranged from 130 to 16,000 micrograms per liter (µg/L). The maximum concentration was detected in 2016 in monitoring well 01MW19, which is located in the northwestern portion of the parcel in the vicinity of the former pump island. 10 results exceeded the PSL of 800 µg/L during the most recent sampling event.
- DRO was detected in 42 of 46 monitoring wells. Detected concentrations ranged from 67 to 6,600 µg/L. The maximum concentration was detected in 2012 in monitoring well 01MW72, which is located within the southern LNAPL plume and had measurable LNAPL in 2016. Twenty-six results exceeded the PSL of 500 µg/L during the most recent sampling event.
- ORO was detected in 15 of 47 monitoring wells. Detected concentrations ranged from 280 to 1,400 µg/L. The maximum concentration was detected in monitoring well 01MW90, which is located south of the southern LNAPL plume, in 2016. 7 results exceeded the PSL of 500 µg/L during the most recent sampling event.
- Benzene was detected in 16 of 47 monitoring wells. Detected concentrations of benzene ranged from 1 to 2,600 µg/L. The maximum concentration was detected in 01MW19, which is located in the northwestern portion of the parcel in the vicinity of the former pump island, in 2016. 13 benzene results exceeded the PSL of 5 µg/L during the most recent sampling event.
- Ethylbenzene was detected in 16 of 46 monitoring wells. Detected concentrations of benzene ranged from 1.1 to 820 µg/L. The maximum concentration was also detected in 01MW19 in 2016. 5 ethylbenzene results exceeded the PSL of 70 µg/L during the most recent sampling event.

As noted above, two Intermediate WBZ wells (01MW48 and 01MW51) were installed at the Bulk Terminals Property. The 2016 DRO results from the two wells of 690 µg/L and 1,300 µg/L, exceeded the PSL of 500 µg/L. There were no other COPC exceedances in the Intermediate WBZ wells.

5.2.2 ASKO Property

The groundwater dataset includes data from 48 monitoring wells in the ASKO monitoring well network, including the Shallow WBZ monitoring well located on the West Waterfront Property. There are 8 Perched WBZ wells, 33 Shallow WBZ wells, 6 Intermediate WBZ wells, and one Deep WBZ well. The general Shallow WBZ groundwater flow direction is to the north/northwest. A discontinuous area of perched water is located beneath the BNSF parcel, the southern portion of the ASKO Property, and a localized area around MW03. The general direction of groundwater flow in the perched aquifer is northeast.

As described in Section 4.2, the primary groundwater COPCs for the ASKO Property include: TPH (GRO, DRO, and ORO); benzene; and cVOCs (*cis*-1,2-dichloroethene, TCE, and vinyl chloride). Exceedances of the Upland PSLs for the primary COPCs, TPH, benzene, and cVOCs, are shown on Figures 5.4 through 5.6.

Monitoring wells with TPH exceedances are located in the vicinity of the following areas: the former oil and solvent storage area (also known as the former barrel racks) and former steam cleaning area; the former AST area; the former barreling sheds #2 and #3; and the former rail spurs on the BNSF parcel (Figures 2.1b and 5.4). There were no TPH exceedances in the monitoring wells located to the north of the ASKO Property on W. Commodore Way, or the southern boundary wells located on the East and West Waterfront parcels.

Monitoring wells with benzene exceedances are located northeast of the former oil and solvent storage area, and in the vicinity of the former barreling sheds #2 and #3. There are no benzene exceedances north or south of the ASKO Property (Figure 2.1b and 5.5).

Monitoring wells with cVOC exceedances are located in the vicinity of the former rail spurs on the BNSF parcel and historical operations on the west/central portion of the ASKO Property. (Figure 5.6). These two distinct cVOC-impacted areas are referred to as Plume 1 and Plume 2.[5] One monitoring well located on W. Commodore Way (01MW85) has a concentration of vinyl chloride of 2.2 µg/L, which is slightly greater than the Upland PSL of 2.0 µg/L. There are no other offsite exceedances of cVOCs to the north of the ASKO Property on W. Commodore Way, or the wells located along the southern boundary of the East and West Waterfront parcels (Figure 5.6).

The range of analytical results for primary COPCs for the most recent monitoring event completed for the COPC are summarized below by WBZ. The results of non-detects and field duplicates were not reported.

5.2.2.1 Perched Water-Bearing Zone

Eight Perched WBZ groundwater monitoring wells are located within the monitoring network for the ASKO Property. The results of the primary COPCs are summarized below:

- GRO was detected in 6 of 8 monitoring wells. Detected concentrations ranged from 110 to 1,500 µg/L. The maximum concentration was detected in 2014 in monitoring well 01MW92, which is located on the BNSF property. Two results exceeded the PSL of 800 µg/L during the most recent sampling event.
- DRO was detected in all 8 monitoring wells. Detected concentrations ranged from 82 to 6,400 µg/L. The maximum concentration was detected in 2014 in monitoring well 01MW92, which is located on the BNSF property. Seven results exceeded the PSL of 500 µg/L during the most recent sampling event.

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[5] The SES ASKO RI report identifies these two distinct areas as “Site 1” and “Site 2.” To minimize confusion with the term “Site,” these distinct areas were renamed Plume 1 and Plume 2. The area boundaries were also adjusted for Plume 1 using more recent post-RI data (2013-2016).

- ORO was detected in 7 of 8 monitoring wells. Detected concentrations ranged from 290 to 2,300 µg/L. The maximum concentration was detected in 2016 in monitoring well 01MW71, which is located on the southern boundary of the ASKO Property near the former barreling sheds #2 and #3. Six results exceeded the PSL of 500 µg/L during the most recent sampling event.
- *cis*-1,2-Dichloroethene was detected in 7 of 8 monitoring wells. Detected concentrations ranged from 4.9 to 640 µg/L. The maximum concentration was detected in 2014 in monitoring well 01MW92, which is located on the BNSF property. Two results exceeded the PSL of 70 µg/L during the most recent sampling event.
- TCE was detected in 6 of 8 monitoring wells. Detected concentrations of ranged from 29 to 7,800 µg/L. The maximum concentration was detected in 2014 in monitoring well 01MW92, which is located on the BNSF property. All six results exceeded the PSL of 5 µg/L during the most recent sampling event.
- Vinyl chloride was detected in 5 of 8 monitoring wells. Detected concentrations of ranged from 0.75 to 12 µg/L. The maximum concentration was detected in 2016 in monitoring well 01MW71, which is located on the southern boundary of the ASKO Property near the former barreling sheds #2 and #3. Three results exceeded the PSL of 2 µg/L during the most recent sampling event.

5.2.2.2 Shallow Water-Bearing Zone

The ASKO Property monitoring well network has 33 Shallow WBZ wells. The results of the primary COPCs are summarized below:

- GRO was detected in 7 of 40 monitoring wells. Detected concentrations ranged from 130 to 1,300 µg/L. The maximum concentration was detected in 2016 in monitoring well 01MW63, which is located in the vicinity of the former barreling sheds #2 and #3. Two results exceeded the PSL of 800 µg/L during the most recent sampling event.
- DRO was detected in 26 of 40 monitoring wells. Detected concentrations ranged from 53 to 1,300 µg/L. The maximum concentration was detected in 2016 in three Shallow WBZ monitoring wells (01MW07, 01MW45, and 01MW56), which all are located on the northeast corner of the ASKO Property. Nine results exceeded the PSL of 500 µg/L during the most recent sampling event.
- ORO was detected in 4 of 40 monitoring wells. Detected concentrations ranged from 280 to 750 µg/L. The maximum concentration was detected in 2016 in monitoring well 01MW55, which is located in the vicinity of the former barreling sheds #2 and #3. Two results exceeded the PSL of 500 µg/L during the most recent sampling event.
- Benzene was detected in 10 of 40 monitoring wells. Detected concentrations of ranged from 1.1 to 15 µg/L. The maximum concentration was detected in 2016 in monitoring well 01MW44, which is located in the vicinity of the former barreling sheds #2 and #3. Three results exceeded the PSL of 5 µg/L during the most recent sampling event.

- *cis*-1,2-Dichloroethene was detected in 15 of 40 monitoring wells. Detected concentrations ranged from 0.2 to 440 µg/L. The maximum concentration was detected in 2016 in monitoring well 01MW63, which is located within Plume 1. Six results exceeded the PSL of 70 µg/L during the most recent sampling event.
- TCE was detected in 14 of 40 monitoring wells. Detected concentrations of ranged from 0.2 to 7,700 µg/L. The maximum concentration was detected in 2016 in monitoring well 01MW63, which is located within Plume 1. Nine results exceeded the PSL of 5 µg/L during the most recent sampling event.
- Vinyl chloride was detected in 16 of 40 monitoring wells. Detected concentrations of ranged from 0.2 to 81 µg/L. The maximum concentration was detected in 2016 in monitoring well 01MW63, which is located within Plume 1. Eleven results exceeded the PSL of 2 µg/L during the most recent sampling event.

5.2.2.3 Intermediate and Deep Water-Bearing Zone

There are four Intermediate and one Deep WBZ monitoring wells within Plume 1, and there is one intermediate well within the Site 2 plume. Refer to Figure 3.1b for locations. There were not exceedances of the Upland PSLs in groundwater collected from Intermediate or Deep WBZs.

5.2.3 East Waterfront Property

The groundwater dataset includes data from 15 monitoring wells in the East Waterfront monitoring well network. Monitoring wells 02MW11 and 02MW12 were decommissioned in 2013 prior to excavation activities; however, recent (2013) data were available and were included in the summary. As discussed in Section 4, monitoring well 02MW07 was located closest to the shoreline and was evaluated as a shoreline well. Decommissioned well 02MW02 was also evaluated as a shoreline well due to its close proximity to the shoreline. There is one Intermediate WBZ well located on the parcel (02MW05), and the remaining wells are Shallow WBZ wells. The general groundwater flow direction is north/northwest toward Salmon Bay.

As described in Section 4.2, primary groundwater COPCs for the East Waterfront property include: TPH (GRO, DRO, and ORO), benzene, and ethylbenzene. TPH, benzene, and ethylbenzene exceedances of the Upland PSLs were identified in three monitoring wells, existing well 02MW04 and decommissioned wells 02MW11 and 02MW12, both located adjacent to the former utilidor and former barrel incline (refer to Figures 2.1b, 5.7, and 5.8). There were no exceedances in the one Intermediate WBZ well.

The analytical results for the COPCs for the most recent monitoring event for the upland wells are summarized below. The results of non-detects and field duplicates were not reported:

- GRO was detected in 3 of 13 monitoring wells. Detected concentrations ranged from 920 to 5,700 µg/L. The maximum concentration of 5,700 µg/L was detected in 2013 in monitoring well 02MW12, which was located in the vicinity of the former utilidor and former barrel incline, but was decommissioned in 2013. Three results exceeded the PSL of 800 µg/L during the most recent sampling event for each well.

- DRO was detected in 8 of 13 monitoring wells. Detected concentrations ranged from 86 to 1,400 µg/L. The maximum concentration of 1,400 µg/L was detected in 2016 in monitoring well 02MW04, which is located in the vicinity of the former utilidor and former barrel incline. Two results exceeded the PSL of 500 µg/L during the most recent sampling event.
- ORO was detected in 1 of 13 monitoring wells. The only detected concentration of 620 µg/L was detected in 2016 in monitoring well 02MW04, which is located in the vicinity of the former utilidor and former barrel incline. The one result exceeded the PSL of 500 µg/L during the most recent sampling event.
- Benzene was detected in 3 of 13 monitoring wells. Detected concentrations ranged from 1.3 to 200 µg/L. The maximum concentration of 200 µg/L was detected in 2013 in monitoring well 02MW12, which was located in the vicinity of the former utilidor and former barrel incline, but was decommissioned in 2013. Two results exceeded the PSL of 5 µg/L during the most recent sampling event for each well.
- Ethylbenzene was detected in 3 of 13 monitoring wells. Detected concentrations ranged from 3.2 to 590 µg/L. The maximum concentration of 590 µg/L was detected in 2013 in monitoring well 02MW12, which was located in the vicinity of the former utilidor and former barrel incline, but was decommissioned in 2013. Two results exceeded the PSL of 70 µg/L during the most recent sampling event for each well.

Data from the shoreline wells (02MW02 and 02MW07) were compared to the Shoreline PSLs to ensure protection of groundwater discharge to surface water and sediments. All of the results were non-detect, except for one result for ORO from 02MW07 and low-level DRO in 02MW02. In 2016, ORO was detected in 02MW07 at a concentration of 160 µg/L and DRO was detected in 02MW02 at a concentration of 220 µg/L, which were both less than the Shoreline PSLs.

5.2.4 West Waterfront Property

One Shallow WBZ well, 02MW14, was installed at the West Waterfront Property. This well was installed to assess the lateral extent of the ASKO TCE plume and was included in the summary of the ASKO Shallow WBZ wells in Section 5.2.2 (refer to Figures 5.4 to 5.6). All results were non-detect from the most recent monitoring event, conducted in May 2016.

5.3 SOIL VAPOR

Soil vapor was retained in the 2014 RIs for the Bulk Terminal, ASKO, and East Waterfront parcels as a medium of concern based on concentrations of TPH in soil and groundwater (SES 2014a, 2014b, 2014c). Soil vapor and indoor air data for the Bulk Terminal and ASKO parcels are summarized below. Soil vapor data is not available for the East Waterfront parcel. As noted in the RIs, cleanup of the affected soil and groundwater at each parcel along with engineering controls anticipated to be installed during re-development in the future is expected to eliminate soil vapor as a medium of concern.

For a comprehensive evaluation of post-RI soil vapor and indoor air data, including summary tables and figures, refer to the Vapor Intrusion Assessments completed by SES (SES 2016a and 2016b).

5.3.1 Bulk Terminal Property

A vapor intrusion assessment was conducted by SES in 2015 to evaluate BTEX in soil vapor near the former TOC headquarters office building and the former marine service and supply office and store and directly above the dissolved-phase benzene plume. BTEX concentrations were non-detect and less than the MTCA Method B screening levels in both soil vapor samples (SES 2016a). Based on these results, SES concluded that the soil vapor to indoor air pathway was incomplete for the dissolved-phase benzene plume, and that no additional air sampling was necessary (SES 2016a).

In tandem with the vapor intrusion assessment for the Bulk Terminal Property, a similar assessment was conducted for the ASKO Property. To support the ASKO study, an indoor air sample was collected from the former TOC office building located on the Bulk Terminal parcel. TCE was detected in the indoor air sample from the former TOC office building at a concentration of 0.23 micrograms per cubic meter ($\mu g/m^3$). Although the concentration was less than the MTCA Method B CUL, and the USEPA Region 10 commercial indoor air screening level, it was slightly greater than the USEPA Region 10 residential indoor air screening level of 0.21 $\mu g/m^3$. SES concluded that additional investigation may be warranted should land use change in the future (SES 2016b).

5.3.2 ASKO Property

The ASKO vapor intrusion assessment was conducted by SES in 2015 to evaluate TCE and its degradation products and/or TPH in soil vapor near the following buildings: the industrial repair machine shop formerly occupied by ASKO; the warehouse occupied by Marine Service and Supply; the office building occupied by Marine Service and Supply; and the office building formerly occupied by TOC (located on the Bulk Terminal parcel and described in Section 5.3.1).

Sample collection included one soil gas sample, three indoor air, and three outdoor air samples. The soil gas sample was collected from the east side of the now former ASKO machine shop (it was still in use by ASKO during the assessment). Indoor air samples were collected from all of the buildings mentioned above except the ASKO machine shop because the machine shop was active at the time of sampling, and chemicals used in daily operations could have potentially contributed to indoor air contamination (SES 2016b).

In soil gas, concentrations of benzene, vinyl chloride, and 1,2-dichloroethane exceeded the MTCA Method B soil gas screening levels. Benzene concentrations also exceeded the MTCA Method B indoor air CUL in all three indoor air samples, and two of the outdoor air samples. However, when the concentration of benzene was adjusted to account for concentrations in the upwind outdoor air sample (as allowed by Ecology) the indoor air samples were less than the MTCA Method B CUL. No other chemicals were present at concentrations greater than the MTCA Method B indoor air CULs (SES 2016b).

6.0 Preliminary Conceptual Site Model

The preliminary conceptual site model (CSM) was developed for the Site and presented in the SES RIs based on findings from previous Site investigations and has been used to identify data gaps that will be discussed in Section 7.0. The CSM will be revised upon completion of the Supplemental Upland RI field activities and will inform the evaluation and selection of all appropriate cleanup actions for the Site.

A brief description of the key elements of the CSM is included below.

6.1 RELEASE MECHANISMS AND HISTORICAL SOURCES

The confirmed and suspected sources of historical contaminants in soil and groundwater at the Bulk Terminal, ASKO, and East Waterfront Properties are summarized below for each property; however, the specific release mechanisms are unknown. Sources of COPCs are described in detail in the 2014 RIs (SES 2014a, 2014c and 2014e).

6.1.1 Bulk Terminal Property

Soil and groundwater at the Bulk Terminal Property has primarily been contaminated with TPH, benzene, and penta. Interim cleanup actions completed on the Bulk Terminal have removed penta in soil and significantly reduced the concentrations and extent of penta in groundwater. Previous investigations have also identified a zone of LNAPL in groundwater on the Property. The impacted area at the Bulk Terminal Property extends from the southern edge of the former Upper Tank Yard area to the northern portion of the W. Commodore Way ROW, with LNAPL present in two separate areas as shown on Figure 5.1.

Former known sources of historical contamination at the Bulk Terminal Property are shown on Figure 2.1a and are:

- Former 14 ASTs located in the area of the Upper and Lower Tank Yards
- Former penta AST and mixing area
- Former underground distribution pipelines
- Former manifold pit
- Former gasoline and diesel USTs
- Former Fuel Loading Racks
- Former pump island
- Former pipeline utilidor
- Former East Barrel Incline
- Former Barreling Sheds

6.1.2 ASKO Property

Soil and groundwater at the ASKO Property has primarily been contaminated with TPH, benzene, and cVOCs. Two distinct cVOC-impacted areas in soil and groundwater have been identified on the ASKO Property; these two distinct areas are referred to as Plume 1 and Plume 2.

Plume 1 originates on the BNSF parcel and extends north onto the ASKO Property but does not extend into W. Commodore Way (refer to Figure 5.6). Former sources of historical contamination for Plume 1 at the ASKO Property are shown on Figure 2.1b and are:

- Former BNSF Rail Spurs
- Former Barreling Sheds #2 and #3
- Former West and East Barrel Inclines
- Former ASTs

Plume 2 is much smaller and originates just east of the former ASKO machine shop in the former steam cleaning area and extends north into W. Commodore Way (refer to Figure 5.6). Former sources of historical contamination for Plume 2 at the ASKO Property are shown on Figure 2.1b and include:

- Former vehicle maintenance facility
- Former ASKO machine shop
- Steam cleaning area
- General waste storage including oils and solvents (former barrel racks)
- Former heating oil and/or waste oil UST(s)

6.1.3 East Waterfront Property

Soil and groundwater at the East Waterfront Property has primarily been contaminated with TPH and benzene. Interim cleanup actions completed on the East Waterfront Property removed a significant portion of the TPH and benzene impacted soil. Former sources of historical contamination at the East Waterfront Property are shown on Figure 2.1b and are the former East and West Barrel Inclines, the former pipeline utilidor, and a former waste oil UST.

6.2 POTENTIAL MIGRATION PATHWAYS AND TRANSPORT

Contaminants in soil and groundwater at the Site have the potential to migrate through natural mechanisms that may result in exposure to human and ecological receptors. The primary potential migration pathways are the following:

- **Soil to Groundwater.** Releases of contamination to the surface and subsurface that occurred during historical Site operations could result in a continued release, or leaching, of contaminants entrained in soil to groundwater.

- **Groundwater to Surface Water/Sediments.** Contaminated groundwater beneath the Site has the potential to migrate through groundwater flow to Salmon Bay.
- **Soil to Sediments.** While some of the shoreline has been stabilized by rip rap, the majority is not stabilized and has the potential to erode into adjacent sediments.
- **Soil to Air.** Volatile contaminants in soil have the potential to volatilize to the vapor phase.
- **Groundwater to Air.** Volatile contaminants in shallow groundwater have the potential to volatilize to the vapor phase.

6.3 POTENTIAL EXPOSURE PATHWAYS AND RECEPTORS

Potential receptors exposed to upland media contamination include both human and ecological receptors. The potential exposure pathways and receptors at the Site include:

- **Human Exposure via Direct Contact.**
    - Soil. This pathway focuses on direct contact exposure to utility or construction workers entering the subsurface for construction or maintenance activities and directly contacting contaminated soil and/or groundwater during these activities.
    - Groundwater. Groundwater at the Site is considered potable and therefore use as a domestic water supply is considered. However, there are no known current or anticipated future uses of the Site as a domestic water supply.
    - Air. Volatile contaminants in shallow groundwater have the potential to volatilize and rise through the soil column and discharge into indoor air.
- **Aquatic Receptor Exposure via Groundwater Discharge or Bank Soil Erosion to Surface Water.** Contamination has the ability to be transported via groundwater to discharge to Salmon Bay or erode from areas of the shoreline that are not stabilized. Chemical discharge has the potential to expose aquatic species in surface water to acute or chronic health effects.
- **Benthic Receptor Exposure via Groundwater Discharge or Soil Erosion to Sediment.** Chemical discharge to Salmon Bay has the potential to expose benthic species in sediments to acute or chronic health effects.
- **Terrestrial Receptor Exposure via Direct Contact.** All of the parcels include unpaved areas and vegetation, therefore exposure to terrestrial receptors is considered a complete pathway.

6.4 AREAS AND MEDIA OF CONCERN

The AOCs for the Site include the Bulk Terminal Property, the ASKO Property, BNSF, and the East Waterfront Property. The Bulk Terminal Property, the ASKO Property, and the East Waterfront Property are defined by their parcel boundaries and include the W. Commodore Way ROW. The BNSF AOC is located in a portion of the rail spur area south of the eastern portion of the ASKO Property. Refer to Figure 6.1 for the AOC boundaries.

There were no historical industrial operations conducted on the West Waterfront Property of the former TOC Seattle Terminal and there are no known or suspected former or current potential sources of contamination. Therefore, the West Waterfront Property is not considered an AOC.

The media of concern for each AOC are as follows:

- Bulk Terminal AOC: soil and groundwater
- ASKO AOC: soil, groundwater, and soil vapor
- BNSF AOC: soil and groundwater
- East Waterfront AOC: soil and groundwater

7.0 Supplemental Upland Remedial Investigation

The Supplemental Upland RI field investigation will be completed to collect soil and groundwater data in order to fill the remaining data gaps and prepare a comprehensive Supplemental Upland RI/FS for the Site. Additional data needs were also identified by Ecology in comments issued pursuant to their review of prior RI/FSs submitted by TOC/SES (Ecology 2015b, 2015c, 2015d). Data gaps have also been identified during a review of existing data and current conditions in consultation with Ecology. A detailed description of the identified data gaps, and approach to sample collection to fill these data gaps, is presented in the following sections.

7.1 DATA GAPS EVALUATION

A significant amount of data from various media have been collected from the Site by various consultants over the past several decades. Several data gaps have been identified based on a thorough review of historical data and will be further evaluated as part of the Supplemental Upland RI. Additional data needs identified by Ecology in their comments on the prior RI/FSs (Ecology 2015b, 2015c, 2015d) were reviewed and incorporated into the data gap evaluation. Data gaps are described by AOC in the following sections. The locations of the proposed monitoring wells and surface soil sample locations are shown on Figures 7.1 and 7.2, and a summary of data gaps is included in Table 7.1. Specific details regarding sample collection and analyses are included in Section 7.2.

7.1.1 Site-Wide

Site-wide data gaps regarding groundwater quality and potential for contaminant migration are summarized below. Specific details are provided in Section 7.2.4:

- Comprehensive water level measurements are necessary to evaluate groundwater flow patterns under static conditions given that a groundwater pump and treat system was operational through June 2017.
- The last groundwater monitoring events were completed by SES in May 2016. A Site-wide semi-comprehensive groundwater sampling event is needed to understand current conditions regarding the nature and extent of COPCs in each upland AOC.

7.1.2 Bulk Terminal Property

Soil has been sampled extensively on the Bulk Terminal Property, and COPCs in soil are sufficiently characterized to evaluate the nature and extent of contamination and for the evaluation and selection of cleanup alternatives (refer to Appendix A for previous soil investigation locations). Existing soil data will be presented in detail in the Supplemental Upland RI. Data gaps identified at the Bulk Terminal Property regarding groundwater quality and potential contaminant migration are summarized below. Refer to Figure 7.1 for proposed sample locations:

- A comprehensive LNAPL evaluation is necessary to evaluate current conditions and LNAPL distribution. LNAPL thickness measurements will be completed in the area of recent and historical LNAPL.

- The installation of an additional shallow monitoring well (01MW101) downgradient of 01MW10, which has approximately 5 feet of LNAPL, is necessary to evaluate potential LNAPL migration.
- Two additional Shallow WBZ wells (01MW102 and 01MW103) are proposed to be installed along the northern portion of W. Commodore Way to evaluate the extent of the downgradient TPH plume and verify that the plume does not extend to the property across W. Commodore Way. The existing Shallow WBZ wells in the vicinity (01MW34, 01MW35, 01MW36, and 01MW88) are screened too shallow and are often dry.
- One additional Intermediate WBZ well (01MW104) is proposed to be installed in the northern portion of W. Commodore Way and collocated with proposed shallow monitoring well 01MW101 to verify that the intermediate groundwater plume does not extend to the property across W. Commodore Way. There are no existing Intermediate WBZ wells along the north side of the roadway.
- One additional Shallow WBZ well (01MW105) is proposed to be installed on the northeastern portion of the Bulk Terminal Property to confirm the estimated eastern extent of the TPH plume along W. Commodore Way.
- Contingency: if the TPH plume is found to extend downgradient in the Shallow WBZ to the northeast of the Bulk Terminal Property on the north side of the W. Commodore Way ROW, an additional Intermediate WBZ well may be installed adjacent to 01MW103 to assess the downgradient extent of the TPH plume in the Intermediate WBZ.

7.1.3 ASKO Property

Soil has been sampled extensively on the ASKO Property, and COPCs in soil are sufficiently characterized to evaluate the nature and extent of contamination and for the evaluation and selection of cleanup alternatives (refer to Appendix A for previous soil investigation locations). Existing soil data will be presented in detail in the Supplemental Upland RI. Data gaps identified at the ASKO Property regarding groundwater quality are summarized below. Refer to Figure 7.2 for proposed sample locations:

- TCE and vinyl chloride exceedances are present in the Shallow WBZ along the ASKO Property line and extend into W. Commodore Way. Although the downgradient well 02MW14 (located on the West Waterfront Property) provides a downgradient boundary for Plume 2, two additional Shallow WBZ wells (01MW106 and 01MW107) are proposed in the northern portion of W. Commodore Way to confirm the downgradient extent of Plume 2.
- TCE in groundwater appears to be migrating downward vertically in the downgradient direction of Plume 1 (BNSF) as evidenced by cVOC detections in groundwater previously collected from the Intermediate WBZ well (01MW76). TCE exceeded the PSLs in this well between 2012 and 2014. Given this vertical migration, an Intermediate WBZ monitoring well (01MW108) should be installed along the north

property line to determine the extent of Plume 1 cVOCs downgradient in the Intermediate WBZ and to evaluate vertical gradient(s).

- Contingency: if cVOCs are found to extend to the northern portion of W. Commodore Way in the Intermediate WBZ, an additional Deep WBZ well may be installed adjacent to 01MW107 to evaluate the downgradient extent of the cVOC plume in the Deep WBZ.

7.1.4 East Waterfront Property

Data gaps identified at the East Waterfront Property regarding soil and groundwater quality are summarized below. Refer to Figure 7.2 for proposed sample locations:

- The previous sandblast grit excavation report (TOC 1993) did not include the depth of the excavations or locations of the confirmation samples. All confirmation samples had arsenic, cadmium, and chromium concentrations less than MTCA Method A CULs that had been established at the time of the excavation, but some results for arsenic and cadmium are greater than the current MTCA Method A CULs. Three additional surface soil samples (SS-01, 02MW18, and 02MW19) will be collected in these areas (identified as Excavation A, B, and C on Figure 7.2) to confirm that current metals concentrations are less than the PSLs. Arsenic, cadmium, and chromium were the metals identified in the pure sandblast grit.
- A shoreline monitoring well network is necessary to evaluate groundwater quality at the likely proposed conditional point of compliance (where groundwater discharges to surface water). Four Shallow WBZ monitoring wells (02MW17 through 01MW20) and two Intermediate WBZ wells (02MW21 and 02MW22) are proposed along the shoreline to evaluate groundwater quality at the conditional point of compliance.
- Contingency: if the ASKO property cVOC plume is found to extend to the northern portion of W. Commodore Way in the Intermediate WBZ, an additional Intermediate WBZ well may be installed adjacent to proposed Shallow WBZ well 02MW18 or 02MW19 to confirm that the plume does not reach the shoreline. Post-TPH excavation (2013) data indicate that TPH and benzene remain in the subsurface at concentrations greater than the PSLs in close proximity to the shoreline. A minimum of one soil sample will be collected and analyzed for TPH and benzene from proposed well location 02MW20 to evaluate post-excavation soil conditions along the shoreline. Additional soil samples may be collected as discussed in Section 7.2.3.

7.2 SUPPLEMENTAL UPLAND REMEDIAL INVESTIGATION SAMPLING AND ANALYSIS PLAN

The Supplemental Upland RI will include collection of additional soil and groundwater samples in the upland area of the Site to fill the data gaps identified in Section 7.1 and summarized in Table 7.1. Floyd|Snider's standard guidelines for soil and groundwater sample collection (included in Appendix C) provide general details regarding field procedures, sample collection and processing, decontamination, and field documentation. All work will additionally be performed in accordance with a site-specific Health and Safety Plan. Specific details regarding sample collection that are not described in Appendix C are included in the following sections. Specific details regarding laboratory methods are included in Section 7.3.

7.2.1 Proposed Monitoring Well Installation and Development

A total of 14 monitoring wells (10 shallow and 4 intermediate) are proposed to be installed to fill data gaps identified in Section 7.1. Refer to Figures 7.1 and 7.2 for the proposed monitoring well locations.

Monitoring well construction and development will be performed in accordance with the Floyd|Snider monitoring well construction and development standard guidelines (included in Appendix C). A 2-inch-diameter polyvinyl chloride well with a 10-foot-long screen will be installed using hollow-stem auger drilling methods unless the field geologist indicates otherwise based on the material encountered in the subsurface. The screened interval will be determined in the field based on field observations and designed to intercept the specific WBZ (shallow, intermediate, or deep). Wells will be completed with flush-mounted monuments.

Following installation, monitoring wells will be developed to remove fine-grained material by purging with a submersible pump and surging with the pump or a surge block in order to move water through the sand pack and surrounding soil formation. Wells will be developed until the purge water achieves visual clarity. Existing wells will also be evaluated for the presence of excessive sedimentation (i.e., greater than 0.05 feet of accumulated material) and may be redeveloped if necessary to remove accumulated fine-grained material. Purge water will be collected in 55-gallon drums and may require offsite disposal depending on groundwater analytical data.

All new monitoring wells will subsequently be surveyed and tied into the existing monitoring well network to facilitate evaluation of groundwater elevation and preparation of contour maps. Monitoring well completion logs will be prepared and provided in the Supplemental Upland RI report.

7.2.2 Field Screening during Monitoring Well Installation

During monitoring well installation, soils will be inspected for visual (e.g., LNAPL, staining, or sheen) and olfactory indicators of contamination. Soil headspace will be screened for volatile organic compounds (VOCs) such as petroleum using a photoionization detector (PID). Soil from approximately 2.0foot or smaller representative intervals will be collected in a sealed and labeled bag or jar for field measurement of VOCs. After soil vapor has had time to approach equilibration with headspace gas, soil headspace will be screened with the PID; results will be noted on the field log. Other field observations, such as staining or odor, will also be noted on the field log.

7.2.3 Proposed Soil Data Collection

Soil samples will be collected to fill data gaps identified in Section 7.1. Proposed soil investigation locations are shown on Figures 7.1 and 7.2. Soil samples will be collected in accordance with Floyd|Snider’s Standard Guidelines included in Appendix C.

Three surface soil samples are proposed on the East Waterfront Property. Samples will be analyzed for the Resource Conservation and Recovery Act (RCRA) list of eight metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver). In addition, a minimum of one soil sample will be collected from proposed well 02MW20 for TPH analyses. In addition, if field observations of petroleum contamination are observed during well installation activities at the East Waterfront Property, soil sample(s) will be collected from the interval(s) that appear to be most impacted. Soil sample(s) will be analyzed for TPH and benzene.

As a contingency, additional soil samples may be collected during the installation of monitoring wells in the W. Commodore Way ROW. If evidence of petroleum contamination is observed in unsaturated soil during the installation of these monitoring wells, soil sample(s) will be collected for TPH (including VPH and EPH) analyses as described in Table 7.1.

7.2.4 Proposed Groundwater Data Collection

In order to fill the data gaps identified in Section 7.1, groundwater samples will be collected Site-wide from 80 of the 106 existing monitoring wells (94 of 120 with the proposed wells) to assess current groundwater quality and to define the nature and extent of groundwater contamination for primary COPCs for upland AOCs at the Site. Secondary COPCs will only be tested if no recent data are available. In addition, selected monitoring wells will also be analyzed for penta to evaluate the effectiveness of the previous interim soil and groundwater cleanup actions at the Bulk Terminal Property. Proposed groundwater investigation locations are shown on Figures 7.1 and 7.2, and a detailed sample collection and analysis program for groundwater is presented in Table 7.2.

Groundwater sampling will be completed a minimum of 1 week following the development of the new monitoring wells. All wells will be purged and sampled using low-flow procedures in accordance with the Floyd|Snider low-flow groundwater sample collection guidelines (included in Appendix C). If turbidity of 5 nephelometric turbidity units cannot be achieved during low-flow sampling, samples may be centrifuged at the laboratory to remove turbidity prior to analysis.

During the groundwater sampling event, the depth to groundwater for each well will be collected prior to sampling in order to determine groundwater elevations, refine groundwater flow direction, and determine the magnitude of hydraulic gradients at the Site. Separate assessments will be completed for each WBZ (perched, shallow, intermediate, and deep).

7.2.5 Proposed LNAPL Evaluation

LNAPL measurements will be completed to fill data gaps identified in Section 7.1. LNAPL measurements will be collected in accordance with Floyd|Snider's Standard Guideline Special Conditions included in Appendix C. LNAPL measurements will be collected from monitoring wells within and immediately adjacent to the LNAPL plume (refer to Figure 5.1).

7.2.7 Sample Collection, Identification, and Analyses

The additional characterization data collection will involve collecting soil and groundwater samples for laboratory analyses at the locations shown on Figures 7.1 and 7.2, with general sampling procedures described below, including field methodology, sample nomenclature, and sample handling and custody documentation. Additional details regarding soil and groundwater sampling procedures are included in the Standard Guidelines included in Appendix C.

7.2.8 Sample Identification

Samples collected as part of this investigation will be identified and labeled as follows:

- **Surface soil samples:**
  SS location number-sample depth or interval (i.e., SS01-0-1)
- **Subsurface soil samples:**
  Soil-location number-sample depth or interval (i.e., Soil-02MW20-0-2)
- **Groundwater samples:**
  Groundwater well location number-month/day/year of collection. For example, a groundwater sample collected from 01MW01 on November 20, 2018, would be labeled 01MW01-112018.

A field duplicate will be identified by adding a “D” to the station ID. For example, a field duplicate from location 01MW01 would be designated as 01MW01D. Sufficient volume for analysis, including laboratory QA analyses, will be collected from each location in accordance with the laboratory and analytical method requirements.

7.2.9 Sample Handling

Sample possession and handling must be traceable from the time of sample collection, through laboratory and data analysis, to the time sample results are reported. Samples will be delivered to the analytical laboratory under chain-of-custody (COC) protocol following completion of sampling activities. The designated sample receiver at the laboratory will accept custody of the samples and verify that the COC Forms match the samples received. The laboratory sample receiver will ensure that the COC Forms are properly signed upon receipt of the samples and will note questions or observations concerning sample integrity on the COC Forms.

7.3 SUPPLEMENTAL UPLAND REMEDIAL INVESTIGATION QUALITY ASSURANCE PROJECT PLAN

This section describes the analytical program to be conducted for each sample, as well as the laboratory QA objectives and QC procedures required to be met to achieve technically sound and useable data. Analytical methods were selected to ensure that reporting limits are less than the applicable PSLs, where feasible.

7.3.1 Chemical Laboratory Analyses Program

Soil and groundwater samples will be submitted to FBI. Samples will be analyzed for following chemicals using the laboratory methodologies below.

7.3.1.1 Soil

- Metals (RCRA 8) by USEPA Method 6020
- TPH (GRO) and BTEX by NWTPH-Gx
- TPH (DRO and ORO) by NWTPH-Dx
- Extractable petroleum hydrocarbons (EPH) by NWTPH-EPH
- Volatile petroleum hydrocarbons (VPH) by NWTPH-VPH

7.3.1.2 Groundwater

- Metals (RCRA 8) by USEPA Method 6020
- TPH (GRO) by NWTPH-Gx
- TPH (DRO and ORO) by NWTPH-Dx
- VOCs by USEPA Method 8260
- Penta by USEPA Method 8270
- Polycyclic aromatic hydrocarbons by USEPA Method 8270
- EPH by NWTPH-EPH
- VPH by NWTPH-VPH

Sample containers and preservation requirements are presented in Table 7.3.

7.3.2 Reporting Limits

The analytical methods identified above result in method detection limits and PQLs that are less than the PSLs (presented in Tables 4.1 and 4.2). In some cases, the PSLs were less than the PQLs are therefore defaulted upward to the PQL. Table 7.4 presents the target method detection limits and PQLs for each analytical method as performed by FBI. These PQLs are goals only, insofar as instances may arise where high sample concentrations, non-homogeneity of samples, or matrix interferences preclude achieving the desired reporting limit and associated QA/QC criteria. In such instances, the laboratory will report the reason for any deviation from these reporting limits.

7.3.3 Laboratory Data Quality Objectives

Laboratory QA/QC objectives include obtaining data that are technically sound and properly documented, having been evaluated against established criteria for the principle data quality indicators (i.e., precision, accuracy, representativeness, completeness, and comparability) as defined in Ecology and USEPA guidance (Ecology 2016 and USEPA 2002). Specific data QA criteria for each analysis method are presented in Table 7.5.

7.3.3.1 Precision

Precision measures the reproducibility of measurements under a given set of conditions. Specifically, precision is a quantitative measure of the variability of a group of measurements compared to their average values. Analytical precision is measured by matrix spike (MS)/matrix spike duplicate (MSD) samples for organic analyses and by laboratory duplicate samples for inorganic analyses.

Analytical precision measurements will be carried out on project-specific samples at a minimum laboratory duplicate frequency of one per laboratory analysis group or 1 in 20 samples, whichever is more frequent per matrix analyzed, as practical. Laboratory precision will be evaluated against quantitative relative percent difference (RPD) performance criteria.

Field precision will be evaluated by the collection of field duplicates at a minimum frequency of one per laboratory analysis group or 1 in 20 samples. Currently, no performance criteria have been established for field duplicates. Field duplicate precision will therefore be screened against an RPD of 75 percent for all samples. However, data will not be qualified based solely on field duplicate precision.

Precision measurements can be affected by the nearness of a chemical concentration to the method detection limit, where the percent error (expressed as RPD) increases. The equation used to express precision is as follows:

$$\mathrm{RPD} = \frac{(C_1 - C_2) \times 100\%}{(C_1 + C_2)/2}$$

Where:

C_1 = Larger of the two observed values
C_2 = Smaller of the two observed values

7.3.3.2 Accuracy

Accuracy is an expression of the degree to which a measured or computed value represents the true value. Analytical accuracy may be assessed by analyzing “spiked” samples with known standards (surrogates, laboratory control samples [LCSs], and/or MS samples) and measuring the percent recovery. Accuracy measurements on MS samples will be carried out at a minimum frequency of 1 in 20 samples per matrix analyzed. Because MSs/MSDs measure the effects of potential matrix interferences of a specific matrix, the laboratory will perform MSs/MSDs only on samples from this investigation and not from other projects. Surrogate recoveries will be determined for every sample analyzed for organic compounds.

Laboratory accuracy will be evaluated against quantitative LCS, MS, and surrogate spike recoveries using limits for each applicable analyte. Accuracy can be expressed as a percentage of the true or reference value, or as a percent recovery in those analyses where reference materials are not available and spiked samples are analyzed. The equation used to express accuracy is as follows:

$$\%R = 100\% \times (S - U)/C_{sa}$$

Where:

$\%R$ = Percent recovery
S = Measured concentration in the spiked aliquot
U = Measured concentration in the unspiked aliquot
C_{sa} = Actual concentration of spike added

7.3.3.3 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Care will be taken in the design of the sampling program to ensure that sample locations are properly selected, sufficient numbers of samples are collected to accurately reflect conditions at the location(s), and samples are representative of the sampling location(s). A sufficient volume of sample will be collected at each sampling location to minimize bias or errors associated with sample particle size and heterogeneity.

7.3.3.4 Comparability

Comparability is a qualitative parameter expressing the confidence with which one dataset can be compared to another. In order to ensure that results are comparable, samples will be analyzed using standard USEPA methods and protocols. Calibration and reference standards will be traceable to certified standards, and standard data reporting formats will be used. Data will also be reviewed to verify that precision and accuracy criteria were achieved and, if not, that data were appropriately qualified.

7.3.3.5 Completeness

Completeness is a measure of the amount of data that is determined to be valid in proportion to the amount of data collected. Completeness will be calculated as follows:

$$C = \frac{\text{(Number of acceptable data points)} \times 100}{\text{(Total number of data points)}}$$

The data quality objective for completeness for all components of this project is 95 percent. Data that were qualified as estimated because the QC criteria were not met will be considered valid for the purpose of assessing completeness. Data that were qualified as rejected will not be considered valid for the purpose of assessing completeness.

7.3.4 Laboratory and Field Quality Assurance/Quality Control Procedures

The quality of analytical data generated is assessed by both the implementation of field QC procedures, and by the frequency and type of internal laboratory QA/QC checks developed for analysis type and method. Field QC is evaluated through the analysis of trip blanks and field duplicates. Field duplicates are collected to evaluate the efficiency of field decontamination procedures, variability from sample handling, and sample heterogeneity. Laboratory results will be evaluated by reviewing analytical results of method blanks, MS/MSD, field duplicate samples, LCS, calibrations, performance evaluation samples, and interference checks as specified by the specific analytical methods.

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

All primary chemical standards and standard solutions used in this project will be traceable to documented and reliable commercial sources. Standards will be validated to determine their accuracy by comparison with an independent standard. Any impurities identified in the standard will be documented.

The procedures that will be used to assess data quality throughout sample analysis are summarized below.

7.3.4.1 Laboratory Duplicates

Analytical duplicates provide information on the precision of the analysis and are useful in assessing potential sample heterogeneity and matrix effects. Analytical duplicates are subsamples of the original sample that are prepared and analyzed as a separate sample. A minimum of one duplicate will be analyzed per laboratory analysis group. When there are fewer than 20 samples, a laboratory duplicate will still be analyzed.

7.3.4.2 Matrix Spikes and Matrix Spike Duplicates

Analysis of MS samples provides information on the extraction efficiency of the method on the sample matrix. By performing MSD analyses, information on the precision of the method is also provided for organic analyses. A minimum of one MS/MSD will be analyzed for every laboratory analysis group for which MS/MSD sample analysis is applicable per the approved method. MS/MSD analyses will be performed on project-specific samples. When there are fewer than 20 samples, a MS/MSD will still be analyzed.

7.3.4.3 Laboratory Control Samples and Laboratory Control Sample Duplicates

An LCS is a method blank sample carried throughout the same process as the samples to be analyzed, with a known amount of standard added. The blank spike compound recovery assesses analytical accuracy in the absence of any sample heterogeneity or matrix effects. All LCS and LCS duplicate (LCSD) data for metals and organic compounds will be reported. The LCS/LCSD will be performed once per laboratory analysis group.

7.3.4.4 Surrogate Spikes

All project samples analyzed for organic compounds will be spiked with appropriate surrogate compounds as defined in the analytical methods. Surrogate recoveries will be reported by the laboratories; however, no sample result will be corrected for recovery using these values.

7.3.4.5 Method Blanks

Method blanks are analyzed to assess possible laboratory contamination at all stages of sample preparation and analysis. A minimum of one method blank will be analyzed for every extraction batch.

7.3.5 Data Reduction and Reporting

The laboratory will be responsible for internal checks on data reporting and will correct errors identified during the QA review. Close contact will be maintained with the laboratories to resolve any QC problems in a timely manner. The analytical laboratories will be required, where applicable, to report the following:

- **Project Narrative.** This summary, in the form of a cover letter, will discuss problems, if any, encountered during any aspect of analysis. This summary should discuss, but not be limited to, QC, sample shipment, sample storage, and analytical difficulties. Any problems encountered (actual or perceived) and their resolutions will be documented in as much detail as necessary.
- **Sample IDs.** Records will be produced that clearly match all field duplicate QA samples with laboratory sample IDs.
- **Chain-of-Custody Records.** Legible copies of the custody forms will be provided as part of the data package. This documentation will include the time of receipt and condition of each sample received by the laboratory. Additional internal tracking of sample custody by the laboratory will also be documented.
- **Sample Results.** The data package will summarize the results for each sample analyzed. The summary will include the following information when applicable:
    - Field sample identification code and the corresponding laboratory identification code:
        - Sample matrix
        - Date of sample extraction

    - Date and time of analysis
    - Weight and/or volume used for analysis
    - Final dilution volumes or concentration factor for the sample
    - Percent moisture in solid samples
    - Identification of the instrument used for analysis
    - Method reporting and quantitation limits
  - Analytical results reported with reporting units identified
  - All data qualifiers and their definitions
  - Electronic data deliverables
- **Quality Assurance/Quality Control Summaries.** This section will contain the results of all QA/QC procedures. Each QA/QC sample analysis will be documented with the same information required for the sample results (refer to previous bullet). No recovery or blank corrections will be made by the laboratory. The required summaries are listed below; additional information may be requested:
  - **Method Blank Analysis.** The method blank analyses associated with each sample and the concentration of all compounds of interest identified in these blanks will be reported.
  - **Surrogate Spike Recovery.** All surrogate spike recovery data for organic compounds will be reported. The name and concentration of all compounds added, percent recoveries, and range of recoveries will be listed.
  - **Matrix Spike Recovery.** All MS recovery data for metals and organic compounds will be reported. The name and concentration of all compounds added, percent recoveries, and range of recoveries will be listed. The RPD for all duplicate analyses will be reported.
  - **Matrix Duplicate.** The RPD for all matrix duplicate analyses will be reported.
  - **Field Duplicates.** Field duplicates will be reported in the same format as any other sample. RPDs will be calculated for duplicate samples and evaluated as part of the data quality review.

7.3.6 Data Validation

Once data are received from the laboratory, a number of QC procedures will be followed to provide an accurate evaluation of the data quality. Specific procedures will be followed to assess data precision, accuracy, and completeness.

A data quality review of the analytical data will follow USEPA National Functional Guidelines in accordance with the QAPP limits (USEPA 2017a and 2017b). All chemical data will be reviewed with regard to the following:

- COC/documentation
- Sample preservation and holding times

- Instrument performance (calibration, tuning, sensitivity)
- Method blanks
- Method reporting limits
- Surrogate recoveries
- MS/MSD recoveries
- LCS recoveries
- Laboratory and field duplicate RPD

A Level II summary validation will be performed on all data except dioxins/furans. A Level IV full validation will be performed for dioxin/furan data, when dioxins/furans are detected at concentrations greater than the laboratory reporting limit.

8.0 Feasibility Study

Additional data will be gathered as part of the Supplemental Upland RI to further characterize soil and groundwater conditions to fill existing data gaps. The additional Site characterization outlined in Section 7.0 will provide sufficient information for a comprehensive understanding of the nature and extent of contamination and will inform development of an updated CSM. The complete Site characterization will allow definition of chemicals of concern and identification of AOCs relative to cleanup standards.

The Supplemental Upland RI/FS will define RAO for the Site as a mechanism for meeting the requirements of the MTCA Cleanup Regulations (WAC 173-340). RAOs define the objectives that must be met by the selected remedy to ensure substantive compliance with the cleanup goals established for the Site. RAOs are simple statements that clearly define what the remedy must accomplish to address the concerns identified in the CSM. RAOs are used to facilitate development and evaluation of remedial alternatives. Preliminary RAOs for the Site include the following:

- Remediate soil and groundwater, as necessary, to meet MTCA cleanup standards and other standards applicable to the Site
- Control contaminant migration pathways
- Select remedial actions that can be implemented and effectively maintained in conjunction with the anticipated future Site use

These preliminary RAOs will be developed further in the Supplemental Upland RI/FS report, following completion of the Supplemental Upland RI field activities proposed in this RI Work Plan. To support the definition of RAOs, the FS will refine the previously identified AOCs that can be characterized by specific physical and contaminant conditions.

The results of the Supplemental Upland RI will be used in the FS to establish CULs and points of compliance for cleanup actions at the Site. Remedial technologies will be identified and screened for each impacted medium to determine applicability to the individual AOCs. Remedial alternatives will be screened and those that meet MTCA threshold criteria and the Site-specific RAOs will be further evaluated. A preferred alternative will be selected for the Site based on this evaluation and will be presented in the FS along with remedy selection criteria.

9.0 Reporting and Schedule

The schedule presented below provides anticipated submittal dates for field investigation activities and major deliverables associated with the Supplemental Upland RI/FS. In addition to the milestones in the schedule, analytical data will be submitted to Ecology in both printed and electronic formats in accordance with Ecology's Toxics Cleanup Program Policy 840 (Data Submittal Requirements).

Deliverable/Milestone	Date
Implement Supplemental Upland RI Work Plan	Immediately upon receipt of Ecology written approval of this Supplemental Upland RI Work Plan
Agency Review Supplemental Upland RI/FS and draft Cleanup Action Plan	75 calendar days after the receipt of validated Supplemental Upland RI data
Public Review Supplemental Upland RI/FS, draft Cleanup Action Plan, and PPA/CD	30 calendar days after receipt of Ecology comments on agency review draft Supplemental Upland RI/FS

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Time Oil Bulk Terminal PPA

Supplemental Upland Remedial Investigation Work Plan

Tables

Table 4.1
Soil Preliminary Screening Levels[1]

Chemicals of Potential Concern	CAS No.	MTCA Method C Cleanup Levels—Direct Contact[2]	Terrestrial Ecological Indicator Soil Concentrations[3]	Bank Erosion—Freshwater SMS[4]	Protect Surface Water/Drinking Water via Groundwater—Vadose Zone[5]	Protect Surface Water/Drinking Water via Groundwater—Saturated Zone[5]	Washington State Natural Background[6]	Practical Quantitation Limit[7]	Most Stringent Preliminary Screening Level—Vadose Zone[8]	Most Stringent Preliminary Screening Level—Saturated Zone[8]
Metals										
Arsenic	7440-38-2	8.8E+01	7.0E+00	1.4E+01	4.7E+00	2.3E-01	2.0E+01	1.0E+00	2.0E+01	2.0E+01
Barium	7440-39-3	7.0E+05	1.0E+02	na	1.6E+03	8.3E+01	na	1.0E+00	1.0E+02	8.3E+01
Cadmium	7440-43-9	3.5E+03	4.0E+00	2.1E+00	5.1E-02	2.6E-03	7.7E-01	5.0E-01	7.7E-01	7.7E-01
Chromium(III)	16065-83-1	5.3E+06	na	na	2.1E+06	1.0E+05	4.8E+01	1.0E+00	2.1E+06	1.0E+05
Chromium (total)	7440-47-3	na	4.2E+01	7.2E+01	1.8E+06	9.0E+04	4.8E+01	1.0E+00	4.8E+01	4.8E+01
Lead	7439-92-1	1.0E+03	5.0E+01	2.5E+02	1.1E+02	5.4E+00	2.4E+01	1.0E+00	5.0E+01	2.4E+01
Mercury	7439-97-6	2.0E+00	1.0E-01	6.6E-01	1.0E-01	5.2E-03	7.0E-02	2.5E-01	2.5E-01	2.5E-01
Selenium	7782-49-2	1.8E+04	3.0E-01	1.1E+01	5.2E-01	2.6E-02	na	5.0E-01	5.0E-01	5.0E-01
Silver	7440-22-4	1.8E+04	2.0E+00	5.7E-01	5.4E-02	2.7E-03	na	1.0E-01	1.0E-01	1.0E-01
Total Petroleum Hydrocarbons										
Gasoline-range organics[9]	TPHG	3.0E+01	1.0E+02	na	na	na	na	5.0E+00	3.0E+01	3.0E+01
Diesel-range organics	TPHD	2.0E+03	2.6E+02	3.4E+02	na	na	na	5.0E+01	2.6E+02	2.6E+02
Oil-range organics	TPHO	2.0E+03	na	3.6E+03	na	na	na	2.5E+02	2.0E+03	2.0E+03
Volatile Organic Compounds										
Acetone	67-64-1	3.2E+06	na	na	2.9E+01	2.1E+00	na	5.0E-01	2.9E+01	2.1E+00
Benzene	71-43-2	2.4E+03	na	na	2.4E-03	1.5E-04	na	2.0E-02	2.0E-02	2.0E-02
n-Butylbenzene	104-51-8	1.8E+05	na	na	na	na	na	5.0E-01	1.8E+05	1.8E+05
sec-Butylbenzene	135-98-8	3.5E+05	na	na	na	na	na	5.0E-02	3.5E+05	3.5E+05
tert-Butylbenzene	98-06-6	3.5E+05	na	na	na	na	na	5.0E-02	3.5E+05	3.5E+05
1,2-Dibromoethane	106-93-4	6.6E+01	na	na	na	na	na	5.0E-02	6.6E+01	6.6E+01
1,2-Dichloroethane	107-06-2	1.4E+03	na	na	4.8E-03	3.2E-04	na	2.0E-02	2.0E-02	2.0E-02
1,1-Dichloroethene	75-35-4	1.8E+05	na	na	4.4E-02	2.4E-03	na	2.0E-02	4.4E-02	2.0E-02
cis-1,2-Dichloroethene	156-59-2	7.0E+03	na	na	7.8E-02	5.2E-03	na	2.0E-02	7.8E-02	2.0E-02
trans-1,2-Dichloroethene	156-60-5	7.0E+04	na	na	5.2E-01	3.2E-02	na	2.0E-02	5.2E-01	3.2E-02
Ethanol	64-17-5	na	na	na	na	na	na	5.0E+02	na	na
Ethylbenzene	100-41-4	3.5E+05	na	na	2.4E-01	1.4E-02	na	2.0E-02	2.4E-01	2.0E-02
Isopropylbenzene	98-82-8	3.5E+05	na	na	na	na	na	5.0E-02	3.5E+05	3.5E+05
p-Isopropyltoluene	99-87-6	na	na	na	na	na	na	5.0E-02	na	na
Methyl ethyl ketone	78-93-3	2.1E+06	na	na	na	na	na	5.0E-01	2.1E+06	2.1E+06
Methyl tert-butyl ether	1634-04-4	7.3E+04	na	na	1.0E-01	7.2E-03	na	5.0E-02	1.0E-01	5.0E-02
n-Propylbenzene	103-65-1	3.5E+05	na	na	na	na	na	5.0E-02	3.5E+05	3.5E+05
Tetrachloroethene	127-18-4	2.1E+04	na	na	2.4E-02	1.3E-03	na	2.5E-02	2.5E-02	2.5E-02
Trichloroethene	79-01-6	1.8E+03	na	na	3.1E-03	1.9E-04	na	2.0E-02	2.0E-02	2.0E-02
1,2,4-Trimethylbenzene	95-63-6	3.5E+04	na	na	na	na	na	5.0E-02	3.5E+04	3.5E+04
1,3,5-Trimethylbenzene	108-67-8	3.5E+04	na	na	na	na	na	5.0E-02	3.5E+04	3.5E+04

Table 4.1
Soil Preliminary Screening Levels[1]

Chemicals of Potential Concern	CAS No.	MTCA Method C Cleanup Levels—Direct Contact[2]	Terrestrial Ecological Indicator Soil Concentrations[3]	Bank Erosion—Freshwater SMS[4]	Protect Surface Water/Drinking Water via Groundwater—Vadose Zone[5]	Protect Surface Water/Drinking Water via Groundwater—Saturated Zone[5]	Washington State Natural Background[6]	Practical Quantitation Limit[7]	Most Stringent Preliminary Screening Level—Vadose Zone[8]	Most Stringent Preliminary Screening Level—Saturated Zone[8]
Volatile Organic Compounds (cont.)										
Toluene	108-88-3	2.8E+05	2.0E+02	na	4.0E-01	2.4E-02	na	2.5E-02	4.0E-01	2.5E-02
Vinyl chloride	75-01-4	1.1E+04	na	na	1.2E-03	6.1E-05	na	2.5E-02	2.5E-02	2.5E-02
Total xylenes	1330-20-7	7.0E+05	na	na	1.4E+01	8.3E-01	na	1.5E+00	1.4E+01	1.5E+00
Semivolatile Organic Compounds—PAHs[10]										
Acenaphthene	83-32-9	2.1E+05	2.0E+01	na	3.1E+00	1.6E-01	na	1.0E-02	3.1E+00	1.6E-01
Acenaphthylene	208-96-8	na	na	na	na	na	na	1.0E-02	na	na
Anthracene	120-12-7	1.1E+06	na	na	4.7E+01	2.4E+00	na	1.0E-02	4.7E+01	2.4E+00
Benzo(a) anthracene	56-55-3	1.3E+02	na	4.2E+01	4.3E-01	2.1E-02	na	1.0E-02	4.3E-01	2.1E-02
Benzo(b) fluoranthene	205-99-2	1.3E+02	na	4.2E+01	1.5E+00	7.4E-02	na	1.0E-02	1.5E+00	7.4E-02
Benzo(k) fluoranthene	207-08-9	1.3E+02	na	4.2E+03	1.5E+00	7.4E-02	na	1.0E-02	1.5E+00	7.4E-02
Benzo(g,h,i)perylene	191-24-2	na	na	na	na	na	na	1.0E-02	na	na
Benzo(a)pyrene	50-32-8	1.3E+01	1.2E+01	4.2E+00	1.2E+00	5.8E-02	na	1.0E-02	1.2E+00	5.8E-02
Chrysene	218-01-9	1.3E+03	na	4.2E+03	4.8E-01	2.4E-02	na	1.0E-02	4.8E-01	2.4E-02
Dibenz(a,h) anthracene	53-70-3	1.3E+02	na	4.2E+00	2.1E+00	1.1E-01	na	1.0E-02	2.1E+00	1.1E-01
Fluoranthene	206-44-0	1.4E+05	na	na	5.9E+00	3.0E-01	na	1.0E-02	5.9E+00	3.0E-01
Fluorene	86-73-7	1.4E+05	3.0E+01	na	1.6E+00	8.0E-02	na	1.0E-02	1.6E+00	8.0E-02
Indeno(1,2,3-c,d)pyrene	193-39-5	1.3E+02	na	4.2E+01	4.2E+00	2.1E-01	na	1.0E-02	4.2E+00	2.1E-01
1-Methylnaphthalene	90-12-0	4.5E+03	na	na	na	na	na	1.0E-02	4.5E+03	4.5E+03
2-Methylnaphthalene	91-57-6	1.4E+04	na	na	na	na	na	1.0E-02	1.4E+04	1.4E+04
Naphthalene	91-20-3	7.0E+04	na	na	2.5E+00	1.3E-01	na	1.0E-02	2.5E+00	1.3E-01
Phenanthrene	85-01-8	na	na	na	na	na	na	1.0E-02	na	na
Pyrene	129-00-0	1.1E+05	na	na	1.1E+01	5.5E-01	na	1.0E-02	1.1E+01	5.5E-01
Total PAHs	TPAH	na	na	1.7E+01	na	na	na	1.0E-02	1.7E+01	1.7E+01
cPAH TEQ[11]	CPAHTEQ	1.3E+01	1.2E+01	4.2E+00	1.2E+00	5.8E-02	na	1.0E-02	1.2E+00	5.8E-02
Semivolatile Organic Compounds—Other										
Pentachlorophenol	87-86-5	3.3E+02	3.0E+00	1.2E+00	3.2E-03	1.8E-04	na	5.0E-02	5.0E-02	5.0E-02
Phenol	108-95-2	1.1E+06	3.0E+01	1.2E-01	na	na	na	5.0E-02	1.2E-01	1.2E-01
2-Chlorophenol	95-57-8	1.8E+04	na	na	na	na	na	5.0E-02	1.8E+04	1.8E+04
2,4-Dichlorophenol	120-83-2	1.1E+04	na	na	na	na	na	5.0E-02	1.1E+04	1.1E+04
2,6-Dichlorophenol	87-65-0	na	na	na	na	na	na	5.0E-02	na	na
3-Chlorophenol	108-43-0	na	7.0E+00	na	na	na	na	5.0E-02	7.0E+00	7.0E+00
4-Chlorophenol	106-48-9	na	na	na	na	na	na	5.0E-02	na	na
2,5-Dichlorophenol	583-78-8	na	na	na	na	na	na	5.0E-02	na	na
2,3,5-Trichlorophenol	933-78-8	na	na	na	na	na	na	5.0E-02	na	na
2,4,6-Trichlorophenol	88-06-2	3.5E+03	1.0E+01	na	na	na	na	5.0E-02	1.0E+01	1.0E+01

Table 4.1
Soil Preliminary Screening Levels[1]

Chemicals of Potential Concern	CAS No.	MTCA Method C Cleanup Levels—Direct Contact[2]	Terrestrial Ecological Indicator Soil Concentrations[3]	Bank Erosion—Freshwater SMS[4]	Protect Surface Water/Drinking Water via Groundwater—Vadose Zone[5]	Protect Surface Water/Drinking Water via Groundwater—Saturated Zone[5]	Washington State Natural Background[6]	Practical Quantitation Limit[7]	Most Stringent Preliminary Screening Level—Vadose Zone[8]	Most Stringent Preliminary Screening Level—Saturated Zone[8]
Semivolatile Organic Compounds—Other (cont.)										
2,4,5-Trichlorophenol	95-95-4	3.5E+05	4.0E+00	na	na	na	na	5.0E-02	4.0E+00	4.0E+00
2,3,4-Trichlorophenol	15950-66-0	na	na	na	na	na	na	5.0E-02	na	na
3,5-Dichlorophenol	591-35-5	na	na	na	na	na	na	5.0E-02	na	na
2,3,6-Trichlorophenol	933-75-5	na	na	na	na	na	na	5.0E-02	na	na
3,4-Dichlorophenol	95-77-2	na	2.0E+01	na	na	na	na	5.0E-02	2.0E+01	2.0E+01
2,3,4,6-Tetrachlorophenol	58-90-2	1.1E+05	na	na	na	na	na	5.0E-02	1.1E+05	1.1E+05
2,3,4,5-Tetrahlorophenol	4901-51-3	na	2.0E+01	na	na	na	na	5.0E-02	2.0E+01	2.0E+01
2,3,5,6-Tetrahlorophenol	935-95-5	na	na	na	na	na	na	5.0E-02	na	na
3,4,5-Trichlorophenol	609-19-8	na	na	na	na	na	na	5.0E-02	na	na
Dioxins/Furans										
Dioxin/furan TEQ[11]	DFTEQ	1.7E-03	2.0E-06	6.2E-05	na	na	5.2E-06	na	5.2E-06	5.2E-06

Notes:

🟧 Most stringent PSL is based on the PQL provided by Fremont Analytical, Inc., and Frideman & Bruya, Inc.

1 Concentrations are presented in mg/kg. PSLs have been rounded to two significant digits.

2 MTCA Method A has been used where MTCA Method C is not available (applies to lead, mercury, and total petroleum hydrocarbons).

3 The TEEs are based on MTCA Table 749-3 with the lowest of the plant, soil biota, and wildlife screening levels selected.

4 Based on the freshwater sediment cleanup objectives (WAC 173-204-562 Table 8-1).

5 PSLs for protection of surface water via groundwater discharge and drinking water are based on the MTCA fixed parameter three-phase partitioning model (WAC 173-340-747, equation 747-1). The lower of the groundwater PSL for protection of surface water via groundwater discharge and drinking water was selected as the target concentration.

6 Values from Ecology’s Natural Background Soil Metals Concentrations in Washington State (Ecology 1994) are used for the metals with the exception of arsenic and the value from Ecology’s Natural Background for Dioxins/Furans in Washington Soils—Technical Memorandum #8 (Ecology 2010) is used as a natural background number for dioxins/furans. The MTCA Method A background value of 20 mg/kg has been used for arsenic.

7 PQL values from Friedman & Bruya, Inc., of Seattle, Washington.

8 The PSL for each chemical is based on the lowest of the ARARs for the appropriate soil zone, adjusted for background and the PQL in accordance with WAC 173-340-705(6), as appropriate.

9 MTCA Method A cleanup level for gasoline-range hydrocarbons has assumed that benzene is present.

10 MTCA Method C cleanup levels for cPAHs were calculated using the revised cancer slope factor of benzo(a)pyrene from 2017 in IRIS.

11 Representative PQLs were not provided for dioxin/furan TEQ or for cPAH TEQ. PQLs for 2,3,7,8-tetrachlorodibenzodioxin and benzo(a)pyrene, respectively, were used as surrogates.

Abbreviations:

ARAR	Applicable or Relevant and Appropriate Requirement
CAS	Chemical Abstracts Service
cPAH	Carcinogenic polycyclic aromatic hydrocarbon
Ecology	Washington State Department of Ecology
IRIS	Integrated Risk Information System
mg/kg	Milligrams per kilogram
MTCA	Model Toxics Control Act
na	Not available
PAH	Polycyclic aromatic hydrocarbon
PSL	Preliminary screening level
PQL	Practical quantitation limit
TEE	Terrestrial Ecological Evaluation
TEQ	Toxic equivalent
WAC	Washington Administrative Code

Table 4.2
Groundwater Preliminary Screening Levels[1]

		Protection of Drinking Water		Protection of Surface Water					Protection of Sediment	Protection of Ambient Air	Adjustment Factors			
				Protection of Aquatic Life		Protection of Human Health								
Chemicals of Potential Concern	CAS No.	MTCA Method B Cleanup Levels[2]	Maximum Contaminant Level	WA WQS—Freshwater Chronic WAC 173-201A[3]	NRWQC—Freshwater Chronic CWA Section 304[3]	NRWQC CWA Section 304	WA WQS Consumption of Water + Organisms WAC 173-201A	WA Toxics Rule Consumption of Water + Organisms 40 CFR 131.45	Porewater Screening Level Protective of the Lesser of SMS SCO and Human Health Direct Contact Criteria[4]	MTCA Method C Groundwater Screening Level Protective of Volatilization to Soil Vapor then Ambient Air[5]	Natural Background[6]	Practical Quantitation Limit[7]	Upland Preliminary Screening Level[8]	Shoreline Preliminary Screening Level[9]
Metals[10]														
Arsenic	7440-38-2	5.8E-02	1.0E+01	1.9E+02	1.5E+02	na	1.0E+01	1.8E-02	4.7E+02	na	8.0E+00	1.0E+00	1.0E+01	8.0E+00
Barium	7440-39-3	3.2E+03	2.0E+03	na	na	na	na	na	na	na	na	1.0E+00	2.0E+03	2.0E+03
Cadmium	7440-43-9	8.0E+00	5.0E+00	3.7E-01	7.2E-01	na	na	na	2.9E+02	na	na	2.0E-01	5.0E+00	3.7E-01
Chromium(III)	16065-83-1	2.4E+04	na	5.7E+01	7.4E+01	na	na	na	na	na	na	1.0E+00	2.4E+04	5.7E+01
Chromium (total)	7440-47-3	5.0E+01	1.0E+02	na	na	na	na	na	7.2E+01	na	na	1.0E+00	1.0E+02	5.0E+01
Lead	7439-92-1	1.5E+01	1.5E+01	5.4E-01	2.5E+00	na	na	na	2.5E+01	na	na	5.0E-01	1.5E+01	5.4E-01
Mercury	7439-97-6	2.0E+00	2.0E+00	1.2E-02	7.7E-01	na	Fish tissue based	Fish tissue based	1.3E+01	1.9E+00	na	1.0E-01	2.0E+00	1.0E-01
Selenium	7782-49-2	8.0E+01	5.0E+01	5.0E+00	na	na	1.2E+02	6.0E+01	2.0E+03	na	na	1.0E+00	5.0E+01	5.0E+00
Silver	7440-22-4	8.0E+01	na	3.2E-01	3.2E+00	na	na	na	6.4E+01	na	na	2.5E-01	8.0E+01	3.2E-01
Total Petroleum Hydrocarbons														
Gasoline-range organics[11]	TPHG	8.0E+02	na	na	na	na	na	na	na	na	na	1.0E+02	8.0E+02	8.0E+02
Diesel-range organics	TPHD	5.0E+02	na	na	na	na	na	na	na	na	na	5.0E+01	5.0E+02	5.0E+02
Oil-range organics	TPHO	5.0E+02	na	na	na	na	na	na	na	na	na	2.5E+02	5.0E+02	5.0E+02
Volatile Organic Compounds														
Acetone	67-64-1	7.2E+03	na	na	na	na	na	na	na	na	na	1.0E+01	7.2E+03	7.2E+03
Benzene	71-43-2	8.0E-01	5.0E+00	na	na	0.58-2.1	4.4E-01	4.4E-01	na	2.4E+01	na	3.5E-01	5.0E+00	4.4E-01
n-Butylbenzene	104-51-8	4.0E+02	na	na	na	na	na	na	na	na	na	1.0E+01	4.0E+02	4.0E+02
sec-Butylbenzene	135-98-8	8.0E+02	na	na	na	na	na	na	na	na	na	1.0E+00	8.0E+02	8.0E+02
tert-Butylbenzene	98-06-6	8.0E+02	na	na	na	na	na	na	na	na	na	1.0E+00	8.0E+02	8.0E+02
1,2-Dibromoethane	106-93-4	2.2E-02	5.0E-02	na	na	na	na	na	na	2.8E+00	na	1.0E+00	1.0E+00	1.0E+00
1,2-Dichloroethane	107-06-2	4.8E-01	5.0E+00	na	na	9.9E+00	9.3E+00	8.9E+00	na	4.2E+01	na	1.0E+00	5.0E+00	1.0E+00
1,1-Dichloroethene	75-35-4	4.0E+02	7.0E+00	na	na	3.0E+02	1.2E+03	7.0E+02	na	2.8E+02	na	1.0E+00	7.0E+00	7.0E+00
cis-1,2-Dichloroethene	156-59-2	1.6E+01	7.0E+01	na	na	na	na	na	na	na	na	1.0E+00	7.0E+01	1.6E+01
trans-1,2-Dichloroethene	156-60-5	1.6E+02	1.0E+02	na	na	1.0E+02	6.0E+02	2.0E+02	na	na	na	1.0E+00	1.0E+02	1.0E+02
Ethanol	64-17-5	na	na	na	na	na	na	na	na	na	na	1.0E+04	na	na
Ethylbenzene[12]	100-41-4	8.0E+02	7.0E+01	na	na	6.8E+01	2.0E+02	2.9E+01	na	6.1E+03	na	1.0E+00	7.0E+01	2.9E+01
n-Hexane	110-54-3	4.8E+02	na	na	na	na	na	na	na	1.7E+01	na	1.0E+00	4.8E+02	1.7E+01
Isopropylbenzene	98-82-8	8.0E+02	na	na	na	na	na	na	na	1.6E+03	na	1.0E+00	8.0E+02	8.0E+02
p-Isopropyltoluene	99-87-6	na	na	na	na	na	na	na	na	na	na	1.0E+01	na	na
Methyl ethyl ketone	78-93-3	4.8E+03	na	na	na	na	na	na	na	3.8E+06	na	1.0E+01	4.8E+03	4.8E+03

Table 4.2
Groundwater Preliminary Screening Levels[1]

		Protection of Drinking Water		Protection of Surface Water					Protection of Sediment	Protection of Ambient Air	Adjustment Factors			
				Protection of Aquatic Life		Protection of Human Health								
Chemicals of Potential Concern	CAS No.	MTCA Method B Cleanup Levels[2]	Maximum Contaminant Level	WA WQS—Freshwater Chronic WAC 173-201A[3]	NRWQC—Freshwater Chronic CWA Section 304[3]	NRWQC CWA Section 304	WA WQS Consumption of Water + Organisms WAC 173-201A	WA Toxics Rule Consumption of Water + Organisms 40 CFR 131.45	Porewater Screening Level Protective of the Lesser of SMS SCO and Human Health Direct Contact Criteria[4]	MTCA Method C Groundwater Screening Level Protective of Volatilization to Soil Vapor then Ambient Air[5]	Natural Background[6]	Practical Quantitation Limit[7]	Upland Preliminary Screening Level[8]	Shoreline Preliminary Screening Level[9]
Volatile Organic Compounds (cont.)														
Methyl tert-butyl ether	1634-04-4	2.4E+01	na	na	na	na	na	na	na	6.1E+03	na	1.0E+00	2.4E+01	2.4E+01
n-Propylbenzene	103-65-1	8.0E+02	na	na	na	na	na	na	na	na	na	1.0E+00	8.0E+02	8.0E+02
Tetrachloroethene	127-18-4	2.1E+01	5.0E+00	na	na	1.0E+01	4.9E+00	2.4E+00	na	9.5E+01	na	1.0E+00	5.0E+00	2.4E+00
Trichloroethene	79-01-6	5.4E-01	5.0E+00	na	na	6.0E-01	3.8E-01	3.0E-01	na	8.4E+00	na	5.0E-01	5.0E+00	5.0E-01
1,2,4 Trimethylbenzene	95-63-6	8.0E+01	na	na	na	na	na	na	na	6.2E+01	na	1.0E+00	8.0E+01	6.2E+01
1,3,5 Trimethylbenzene	108-67-8	8.0E+01	na	na	na	na	na	na	na	na	na	1.0E+00	8.0E+01	8.0E+01
Toluene	108-88-3	6.4E+02	1.0E+03	na	na	5.7E+01	1.8E+02	7.2E+01	na	3.4E+04	na	1.0E+00	1.0E+03	5.7E+01
Vinyl chloride	75-01-4	2.4E+01	2.0E+00	na	na	2.2E-02	2.0E-02	2.0E-02	na	3.5E+00	na	2.0E-01	2.0E+00	2.0E-01
Total xylenes	1330-20-7	1.6E+03	1.0E+04	na	na	na	na	na	na	na	na	3.0E+00	1.0E+04	1.6E+03
Semivolatile Organic Compounds—PAHs														
Acenaphthene	83-32-9	9.6E+02	na	na	na	7.0E+01	1.1E+02	3.0E+01	na	na	na	6.0E-02	9.6E+02	3.0E+01
Acenaphthylene	208-96-8	na	na	na	na	na	na	na	na	na	na	6.0E-02	na	na
Anthracene	120-12-7	4.8E+03	na	na	na	3.0E+02	3.1E+03	1.0E+02	na	na	na	6.0E-02	4.8E+03	1.0E+02
Benz(a) anthracene	56-55-3	8.8E-01	na	na	na	1.2E-03	1.4E-02	1.6E-04	na	na	na	6.0E-02	8.8E-01	6.0E-02
Benzo(b) fluoranthene	205-99-2	8.8E-01	na	na	na	1.2E-03	1.4E-02	1.6E-04	na	na	na	6.0E-02	8.8E-01	6.0E-02
Benzo(k) fluoranthene	207-08-9	8.8E-01	na	na	na	1.2E-02	1.4E-02	1.6E-03	na	na	na	6.0E-02	8.8E-01	6.0E-02
Benzo(g,h,i)perylene	191-24-2	na	na	na	na	na	na	na	na	na	na	6.0E-02	na	na
Benzo(a)pyrene	50-32-8	8.8E-02	2.0E-01	na	na	1.2E-04	1.4E-03	1.6E-05	na	na	na	6.0E-02	2.0E-01	6.0E-02
Chrysene	218-01-9	8.8E+00	na	na	na	1.2E-01	1.4E+00	1.6E-02	na	na	na	6.0E-02	8.8E+00	6.0E-02
Dibenz(a,h) anthracene	53-70-3	8.8E-01	na	na	na	1.2E-04	1.4E-03	1.6E-05	na	na	na	6.0E-02	8.8E-01	6.0E-02
Fluoranthene	206-44-0	6.4E+02	na	na	na	2.0E+01	1.6E+01	6.0E+00	na	na	na	6.0E-02	6.4E+02	6.0E+00
Fluorene	86-73-7	6.4E+02	na	na	na	5.0E+01	4.2E+02	1.0E+01	na	na	na	6.0E-02	6.4E+02	1.0E+01
Indeno(1,2,3-c,d)pyrene	193-39-5	8.8E-01	na	na	na	1.2E-03	1.4E-02	1.6E-04	na	na	na	6.0E-02	8.8E-01	6.0E-02
1-Methylnaphthalene	90-12-0	1.5E+00	na	na	na	na	na	na	na	na	na	6.0E-02	1.5E+00	1.5E+00
2-Methylnaphthalene	91-57-6	3.2E+01	na	na	na	na	na	na	na	na	na	6.0E-02	3.2E+01	3.2E+01
Naphthalene	91-20-3	1.6E+02	na	na	na	na	na	na	na	8.9E+01	na	6.0E-02	1.6E+02	8.9E+01
Phenanthrene	85-01-8	na	na	na	na	na	na	na	na	na	na	6.0E-02	na	na
Pyrene	129-00-0	4.8E+02	na	na	na	2.0E+01	3.1E+02	8.0E+00	na	na	na	6.0E-02	4.8E+02	8.0E+00
Total PAHs	TPAH	na	na	na	na	na	na	na	na	na	na	6.0E-02	na	na
cPAH TEQ[13]	CPAHTEQ	8.8E-02	2.0E-01	na	na	1.2E-04	1.4E-03	1.6E-05	4.3E+00	na	na	6.0E-02	2.0E-01	6.0E-02

Table 4.2

Groundwater Preliminary Screening Levels[1]

		Protection of Drinking Water		Protection of Surface Water					Protection of Sediment	Protection of Ambient Air	Adjustment Factors			
				Protection of Aquatic Life		Protection of Human Health								
Chemicals of Potential Concern	CAS No.	MTCA Method B Cleanup Levels[2]	Maximum Contaminant Level	WA WQS—Freshwater Chronic WAC 173-201A[3]	NRWQC—Freshwater Chronic CWA Section 304[3]	NRWQC CWA Section 304	WA WQS Consumption of Water + Organisms WAC 173-201A	WA Toxics Rule Consumption of Water + Organisms 40 CFR 131.45	Porewater Screening Level Protective of the Lesser of SMS SCO and Human Health Direct Contact Criteria[4]	MTCA Method C Groundwater Screening Level Protective of Volatilization to Soil Vapor then Ambient Air[5]	Natural Background[6]	Practical Quantitation Limit[7]	Upland Preliminary Screening Level[8]	Shoreline Preliminary Screening Level[9]
Semivolatile Organic Compounds—Other														
Pentachlorophenol	87-86-5	2.2E-01	1.0E+00	1.3E+01	1.5E+01	3.0E-02	4.6E-02	2.0E-03	na	na	na	2.0E-01	1.0E+00	2.0E-01
Dioxins/Furans														
Dioxin/furan TEQ[13]	DFTEQ	6.7E-07	3.0E-05	na	na	5.0E-09	6.4E-08	1.3E-08	na	na	na	5.0E-06	3.0E-05	5.0E-06

Notes:

▨ Most stringent PSL is based on the PQL provided by Fremont Analytical, Inc. and Friedman & Bruya, Inc.

1 Concentrations are presented in µg/L. PSLs have been rounded to two significant digits.

2 MTCA Method A has been used where MTCA Method B is not available.

3 This column uses the chronic criteria, which are protective of freshwater acute criteria. For metals, the criteria assume a default hardness of 100 mg/L.

4 This value takes the most stringent screening level for sediment from Table 4.3 and uses equilibrium partitioning: Cw (porewater) = (sediment screening level in dry weight) / K_d to develop a screening level for porewater where groundwater is discharging. This exposure is based on direct contact with human and benthic organisms along the shoreline.

5 Groundwater PSLs for vapor intrusion were calculated per Ecology's 2018 guidance, as updated (Appendix B of Ecology 2018).

6 The Puget Sound-wide background arsenic concentration from Washington State Department of Ecology's Lower Duwamish Waterway Preliminary Cleanup Level Workbook (Ecology 2018). Proposal of natural background concentrations for other chemicals may be appropriate per WAC 173-340-709.

7 PQLs from Fremont Analytical, Inc., of Seattle, Washington.

8 The upland PSL is based on the MCL, if available, and the MTCA Method B Cleanup Level for Protection of Drinking Water where an MCL is not available. The PSL for each chemical was adjusted for the PQL in accordance with WAC 173-340-705(6), as appropriate.

9 The shoreline PSL is based on the lowest of the ARARs for site groundwater, which include federal and state marine surface water concentrations protective of aquatic life and human health from drinking water and the consumption of seafood, protection of sediment, and protection of ambient air. The PSL for each chemical was adjusted for background and the PQL in accordance with WAC 173-340-705(6), as appropriate.

10 Metals criteria may apply to either the dissolved metals fraction or total metals fraction. For metals for which the basis of the PSL is a promulgated surface water criterion, the applicable fraction is identified in the surface water regulation. Subsequent evaluation of groundwater data relative to the PSL will be performed relative to the fraction regulated in surface water.

11 MTCA Method A cleanup level for gasoline-range hydrocarbons has assumed that benzene is present.

12 The federal MCL for ethylbenzene is less stringent than the Washington State MCL; therefore the Washington State MCL is applied here.

13 Representative PQLs were not provided for dioxin/furan TEQ or for cPAH TEQ. PQLs provided for 2,3,7,8-tetrachlorodibenzodioxin and benzo(a)pyrene, respectively, were used as surrogates.

Abbreviations:

ARAR	Applicable or Relevant and Appropriate Requirement	NRWQC	National Recommended Water Quality Criteria
CAS	Chemical Abstracts Service	PAH	Polycyclic aromatic hydrocarbon
CFR	Code of Federal Regulations	PSL	Preliminary screening level
cPAH	Carcinogenic polycyclic aromatic hydrocarbon	PQL	Practical quantitation limit
CWA	Clean Water Act	SMS SCO	Sediment Management Standards Sediment Cleanup Objective
MCL	Maximum contaminant level	TEQ	Toxic equivalent
µg/L	Micrograms per liter	WA	Washington State
MTCA	Model Toxics Control Act	WAC	Washington Administrative Code
na	Not available	WQS	Water Quality Standard

Table 7.1
Proposed Supplemental Remedial Field Investigation

Location ID[1]	Purpose/Objectives	Sample Collection[2]	Laboratory Analysis[3]
Bulk Terminal			
01MW101	• To evaluate the downgradient extent of LNAPL in W. Commodore Way in the Shallow WBZ	• LNAPL Measurements • Groundwater	• NWTPH-Gx and -Dx • PAHs and penta by USEPA Method 8270
01MW102 01MW103	• To evaluate the downgradient extent of the TPH plume in the Shallow WBZ along the northern W. Commodore Way ROW	• LNAPL Measurements • Groundwater	• NWTPH-Gx and -Dx • BTEX by USEPA Method 8260 • PAHs by USEPA Method 8270
01MW104	• To evaluate the downgradient extent of the TPH plume in the Intermediate WBZ along the northern W. Commodore Way ROW	• Groundwater	• NWTPH-Gx and -Dx • BTEX by USEPA Method 8260 • Penta by USEPA Method 8270
01MW105	• To evaluate the eastern extent of the TPH plume in the Shallow WBZ	• Groundwater	• NWTPH-Gx and -Dx • BTEX by USEPA Method 8260 • PAHs by USEPA Method 8270
Contingency well	• To evaluate the downgradient extent of the TPH plume in the Intermediate WBZ along the northern W. Commodore Way ROW adjacent to 01MW103, if TPH contamination is present in the Shallow WBZ	• Groundwater • Soil (as contingency)[4]	• NWTPH-Gx and -Dx • BTEX by USEPA Method 8260 • PAHs by USEPA Method 8270 (as contingency)[5]
ASKO Hydraulic			
01MW106 01MW107	• To evaluate the downgradient extent of the cVOC plume in the Shallow WBZ	• Groundwater	• cVOCs by USEPA Method 8260
01MW108	• To evaluate the downgradient extent of the cVOC plume associated with Site 1 in the Intermediate WBZ	• Groundwater	• cVOCs by USEPA Method 8260
Contingency well	• To evaluate the downgradient extent of the cVOC plume associated with Site 2 in the Deep WBZ adjacent to 01MW108, if cVOC contamination is present in the Intermediate WBZ	• Groundwater	• cVOCs by USEPA Method 8260
East Waterfront			
02MW17	• Replace Shallow WBZ well 01MW02, which was decommissioned during 2013 TPH excavation	• Groundwater	• NWTPH-Gx and -Dx • BTEX by USEPA Method 8260 • RCRA 8 Metals by USEPA Method 6020 • PAHs by USEPA Method 8270
02MW18 02MW19	• Install Shallow WBZ monitoring wells along the western shoreline; collect surface soil samples to evaluate metals concentrations in former sand blast grit excavation areas	• Groundwater • Surface Soil	• NWTPH-Gx and -Dx • RCRA 8 Metals by USEPA Method 6020 • PAHS by USEPA Method 8270
02MW20	• Install Shallow WBZ monitoring well along the eastern shoreline, and collect unsaturated soil data to confirm post-excavation conditions along the shoreline	• Groundwater • Soil	• NWTPH-Gx and -Dx • Benzene by USEPA Method 8260 • RCRA 8 Metals by USEPA Method 6020 • PAHs by USEPA Method 8270
02MW21 02MW22	• Install Intermediate WBZ monitoring wells along the eastern shoreline	• Groundwater	• NWTPH-Gx and -Dx • BTEX by USEPA Method 8260
Contingency well	• Install Intermediate WBZ well adjacent to 02MW19, if Intermediate WBZ contamination from the ASKO Property is identified upgradient in the W. Commodore Way ROW	• Groundwater	• cVOCs by USEPA Method 8260
SS-01	• Surface soil samples to evaluate metals concentrations in former sand blast grit excavation locations	• Soil	• RCRA 8 Metals by USEPA Method 6020

Table 7.1
Proposed Supplemental Remedial Field Investigation

Location ID[1]	Purpose/Objectives	Sample Collection[2]	Laboratory Analysis[3]
Contingency Soil Sampling/W. Commodore Way ROW			
01MW101 01MW102 01MW103 01MW104 01MW105	• Additional soil data collection if field screening evidence (visual, olfactory, or PID) indicates petroleum contamination in unsaturated soil during monitoring well installation	• Soil	• NWTPH-Gx and -Dx • VPH/EPH

Notes:

1 Refer to Figures 7.1 and 7.2 for proposed locations.
2 Refer to Table 7.2 for Site-wide groundwater monitoring details.
3 Refer to Tables 7.3 through 7.5 for additional information regarding sample collection.
4 If evidence of soil contamination is observed in unsaturated soil (i.e., elevated PID reading), a soil sample will be collected for TPH-Gx and TPH-Dx.
5 If PAHs are detected in groundwater at 01MW103, PAHs will also be analyzed in groundwater at the Intermediate WBZ contingency well adjacent to 01MW103.

Abbreviations:

BTEX	Benzene, toluene, ethylbenzene, and xylenes
cVOC	Chlorinated volatile organic compound
EPH	Extractable petroleum hydrocarbon
LNAPL	Light non-aqueous-phase liquid
PAH	Polycyclic aromatic hydrocarbon
Penta	Pentachlorophenol
PID	Photoionization detector
RCRA	Resource Conservation and Recovery Act
ROW	Right-of-way
TPH	Total petroleum hydrocarbons
USEPA	U.S. Environmental Protection Agency
VPH	Volatile petroleum hydrocarbon
WBZ	Water-bearing zone

Table 7.2
Proposed Comprehensive Groundwater Monitoring Event

					Analyses									
Well ID	**WBZ**	**Location**	**Status**	**Sample**	**NWTPH-Gx**	**NWTPH-Dx**	**BTEX**	**Penta**	**cVOCs**	**VPH**	**EPH**	**Metals**	**PAHs**	**Notes**
01MW01	Shallow	BT	Existing	Y	x	x	x	x						
01MW02	Shallow	ROW	Existing	Y	x	x	x							
01MW03	Shallow	ROW	Existing	Y	x	x	x							
01MW04	Shallow	BT	Existing	N										Not a critical location, recent data collected
01MW05	Shallow	BT	Existing	N										Not sampled due to LNAPL
01MW06	Shallow	BT	Existing	Y	x	x	x							
01MW07	Shallow	ASKO	Existing	Y		x	x		x					
01MW08	Shallow	BT	Existing	N										Not a critical location, recent data collected
01MW09	Shallow	ROW	Existing	N										Not a critical location, recent data collected
01MW10	Shallow	ROW	Existing	N										Not sampled due to LNAPL
01MW11	Shallow	ROW	Existing	Y		x								
01MW12	Shallow	BT	Existing	Y	x	x	x							
01MW13	Shallow	BT	Existing	Y	x	x	x							
01MW14	Shallow	BT	Existing	N										Decommissioned
01MW15	Shallow	ASKO	Existing	Y	x	x	x		x					
01MW16	Shallow	ROW	Existing	N										Not sampled due to LNAPL
01MW17	Shallow	BT	Existing	N										Not a critical location, recent data collected
01MW18	Shallow	BT	Existing	N										Not a critical location, recent data collected
01MW19	Shallow	BT	Existing	Y	x	x	x			x	x			
01MW20	Shallow	BT	Existing	N										Not a critical location, recent data collected
01MW21	Shallow	BT	Existing	N										Decommissioned
01MW22	Shallow	BT	Existing	N										Decommissioned
01MW23	Shallow	BT	Existing	N										Decommissioned
01MW24	Shallow	BT	Existing	Y	x	x	x							
01MW25	Shallow	BT	Existing	N										Decommissioned
01MW26	Shallow	BT	Existing	N										Decommissioned
01MW27	Shallow	BT	Existing	Y	x	x	x	x						
01MW28	Shallow	BT	Existing	N										Not sampled due to LNAPL
01MW29	Shallow	BT	Existing	N										Not sampled due to LNAPL
01MW30	Shallow	ROW	Existing	N										Not a critical location, recent data collected
01MW31	Shallow	ROW	Existing	N										Never been sampled due to insufficient water or dry
01MW32	Shallow	ROW	Existing	N										
01MW33	Shallow	ROW	Existing	N										Not sampled due to LNAPL
01MW34	Shallow	ROW	Existing	Y		x								
01MW35	Shallow	ROW	Existing	Y	x	x	x							
01MW36	Shallow	ROW	Existing	Y		x								
01MW37	Shallow	BT	Existing	Y		x								
01MW38	Shallow	BT	Existing	Y		x	x							
01MW39	Shallow	BT	Existing	Y		x								
01MW40	Shallow	BT	Existing	Y		x	x							
01MW41	Shallow	BT	Existing	N										Decommissioned

Table 7.2
Proposed Comprehensive Groundwater Monitoring Event

					Analyses									
Well ID	**WBZ**	**Location**	**Status**	**Sample**	**NWTPH-Gx**	**NWTPH-Dx**	**BTEX**	**Penta**	**cVOCs**	**VPH**	**EPH**	**Metals**	**PAHs**	**Notes**
01MW42	Shallow	BT	Existing	Y		x								
01MW43	Shallow	BT	Existing	N										Not sampled due to LNAPL
01MW44	Shallow	ASKO	Existing	Y	x	x	x		x					
01MW45	Shallow	ASKO	Existing	Y	x	x	x		x					
01MW46	Shallow	ASKO	Existing	Y		x	x		x					
01MW47	Shallow	ROW	Existing	Y						x	x			
01MW48	Intermediate	ROW	Existing	Y	x	x	x	x						
01MW49	Shallow	ROW	Existing	N										Not a critical location, recent data collected
01MW50	Shallow	ROW	Existing	Y		x								
01MW51	Intermediate	ROW	Existing	Y	x	x	x							
01MW52	Shallow	ROW	Existing	N										Only sampled twice (2010 and 2016). No detects on any COPCs. Not a downgradient perimeter well for known COPC contamination.
01MW53	Shallow	ROW	Existing	Y		x	x		x					
01MW54	Intermediate	ASKO	Existing	Y					x					
01MW55	Shallow	ASKO	Existing	Y	x	x	x		x					
01MW56	Shallow	ASKO	Existing	Y		x	x		x					
01MW57	Intermediate	ASKO	Existing	N										
01MW58	Shallow	ASKO	Existing	Y		x			x					
01MW59	Shallow	BT	Existing	Y		x								
01MW60	Shallow	ASKO	Existing	Y		x			x					
01MW61	Shallow	ASKO	Existing	N										Not a critical location, recent data collected
01MW62	Shallow	ASKO	Existing	Y	x	x	x		x					
01MW63	Shallow	ASKO	Existing	Y	x	x	x		x					
01MW64	Shallow	ASKO	Existing	Y		x								
01MW65	Deep	ASKO	Existing	Y					x					
01MW66	Shallow	BT	Existing	Y	x	x	x	x						
01MW67	Shallow	BT	Existing	Y		x		x						
01MW68	Shallow	BT	Existing	N										Not sampled due to LNAPL
01MW69	Shallow	BT	Existing	Y				x		x	x			
01MW70	Perched	ASKO	Existing	Y	x	x			x					
01MW71	Perched	ASKO	Existing	Y					x	x	x			
01MW72	Shallow	BT	Existing	N										Not sampled due to LNAPL
01MW73	Shallow	BT	Existing	N										Not sampled due to LNAPL
01MW74	Shallow	BT	Existing	Y	x	x	x	x						
01MW75	Shallow	BT	Existing	Y		x	x							
01MW76	Intermediate	ASKO	Existing	Y		x			x					
01MW77	Intermediate	ASKO	Existing	Y					x					
01MW78	Intermediate	ASKO	Existing	Y					x					
01MW79	Perched	ASKO	Existing	Y	x	x			x					
01MW80	Shallow	ASKO	Existing	Y		x	x		x					
01MW81	Shallow	ASKO	Existing	N										Never sampled, installed for tracer analysis

Table 7.2
Proposed Comprehensive Groundwater Monitoring Event

					Analyses									
Well ID	**WBZ**	**Location**	**Status**	**Sample**	**NWTPH-Gx**	**NWTPH-Dx**	**BTEX**	**Penta**	**cVOCs**	**VPH**	**EPH**	**Metals**	**PAHs**	**Notes**
01MW82	Shallow	ASKO	Existing	N										Never sampled, installed for tracer analysis
01MW83	Shallow	EW	Existing	N										Not a critical location, recent data collected
01MW84	Shallow	ROW	Existing	Y	x	x	x						x	
01MW85	Shallow	ROW	Existing	Y		x			x					
01MW86	Shallow	ROW	Existing	Y	x	x	x							
01MW87	Shallow	ROW	Existing	Y		x								
01MW88	Shallow	ROW	Existing	Y		x							x	
01MW89	Shallow	ROW	Existing	Y		x								
01MW90	Shallow	BT	Existing	Y						x	x			
01MW91	Shallow	BT	Existing	N										Only sampled once in 2012. Non-detect for all analytes except DRO. Not a critical location.
01MW92	Perched	BNSF	Existing	Y	x	x	x		x					
01MW93	Shallow	BNSF	Existing	Y					x					
01MW94	Shallow	BNSF	Existing	Y		x			x					
01MW95	Shallow	BNSF	Existing	Y					x					
01MW96	Perched	BNSF	Existing	Y		x	x		x					
01MW97	Perched	BNSF	Existing	Y	x	x			x					
01MW98	Perched	BNSF	Existing	Y	x	x			x					
01MW99	Shallow	BT	Existing	Y		x								
01MW100	Shallow	BT	Existing	Y		x								
01MW101	Shallow	ROW	Proposed	Y	x	x		x					x	
01MW102	Shallow	ROW	Proposed	Y	x	x	x						x	
01MW103	Shallow	ROW	Proposed	Y	x	x	x						x	
01MW104	Intermediate	BT	Proposed	Y	x	x	x	x						
01MW105	Shallow	BT	Proposed	Y	x	x	x							
01MW106	Shallow	ASKO	Proposed	Y					x					
01MW107	Shallow	ASKO	Proposed	Y					x					
01MW108	Intermediate	ASKO	Proposed	Y					x					
02MW01	Shallow	EW	Existing	N										Not a critical location, recent data collected
02MW02	Shallow	EW	Existing	N										Decommissioned
02MW03	Shallow	EW	Existing	Y	x	x	x							
02MW04	Shallow	EW	Existing	Y						x	x			
02MW05	Intermediate	EW	Existing	Y	x	x	x							
02MW06	Shallow	EW	Existing	Y		x								
02MW07	Shallow	EW	Existing	Y		x						x	x	
02MW08	Shallow	EW	Existing	Y		x								
02MW09	Shallow	EW	Existing	Y		x	x							
02MW10	Shallow	EW	Existing	N										
02MW11	Shallow	EW	Existing	N										Decommissioned
02MW12	Shallow	EW	Existing	N										Decommissioned
02MW13	Shallow	EW	Existing	N										Not a critical location, recent data collected

Table 7.2
Proposed Comprehensive Groundwater Monitoring Event

					Analyses									
Well ID	**WBZ**	**Location**	**Status**	**Sample**	**NWTPH-Gx**	**NWTPH-Dx**	**BTEX**	**Penta**	**cVOCs**	**VPH**	**EPH**	**Metals**	**PAHs**	**Notes**
02MW14	Shallow	WW	Existing	N										
02MW15	Shallow	EW	Existing	N										Not a critical location, recent data collected
02MW16	Shallow	EW	Existing	Y		x								
02MW17	Shallow	EW	Proposed	Y	x	x	x					x	x	
02MW18	Shallow	EW	Proposed	Y	x	x						x	x	
02MW19	Shallow	EW	Proposed	Y	x	x						x	x	
02MW20	Shallow	EW	Proposed	Y	x	x	x					x	x	
02MW21	Intermediate	EW	Proposed	Y	x	x	x							
02MW22	Intermediate	EW	Proposed	Y	x	x	x							
MW01	Shallow	ASKO	Existing	Y					x					
MW02	Shallow	ASKO	Existing	Y					x					
MW03	Perched	ASKO	Existing	Y					x	x	x	x		Arsenic only
MW04	Shallow	ASKO	Existing	Y			x		x					
MW05	Shallow	ASKO	Existing	Y	x	x	x		x					
MW06	Shallow	ASKO	Existing	Y		x	x		x					

Notes:

🟧 Decommissioned well.

1 Laboratory analysis methods were chosen for each location by removing COPCs from the analysis list if the analyte was not detected during any sampling event between 2013 to 2016 and the analyte was sampled for at least once during each of those 4 years. If the analyte was not sampled for annually between 2013 and 2016, then the analyte was removed if there were at least three consecutive sampling events that were non-detect using data prior to 2013 and no detections in samples after the non-detect events.

Abbreviations:

ASKO	ASKO Hydraulic Property
BNSF	BNSF Property
BT	Bulk Terminal Property
BTEX	Benzene, toluene, ethylbenzene, and xylenes
COPC	Chemical of potential concern
cVOC	Chlorinated volatile organic compound
DRO	Diesel-range organics
EPH	Extractable petroleum hydrocarbons
EW	East Waterfront Property
GRO	Gasoline-range organics
LNAPL	Light non-aqueous-phase liquid
Penta	Pentachlorophenol
ROW	W. Commodore Way right-of-way
VPH	Volatile petroleum hydrocarbons
WBZ	Water-bearing zone
WW	West Waterfront Property

Table 7.3
Analytical Requirements, Methods, Preservation, Bottle Type, and Holding Times

Chemical	Analytical Method	Bottle Type	Preservative	Holding Time
Soil				
Metals (RCRA 8)	USEPA Method 6020B	One 4-oz WMG	None, cool to <6 °C	6 months
Total petroleum hydrocarbons: gasoline-range and VOCs	NWTPH-Gx/ USEPA Method 8260C	Four pre-tared 40-mL VOA	None, cool to <6 °C for up to 48 hours	Freeze to <-7 °C within 48 hours, 14 days to analyze
Total petroleum hydrocarbons: diesel- and oil-range	NWTPH-Dx	One 4-oz WMG	None, cool to <6 °C	14 days to extract, then 40 days to analyze
Extractable petroleum hydrocarbons	NWTPH-EPH	(sample volume from total petroleum hydrocarbon containers)	None, cool to <6 °C	14 days to extract, then 40 days to analyze
Volatile petroleum hydrocarbons	NWTPH-VPH		None, cool to <6 °C for up to 48 hours	Freeze to <-7 °C within 48 hours, 14 days to analyze
Groundwater				
Metals (RCRA 8)	USEPA Method 6020B/USEPA Method 1631E for mercury	One 250-mL HDPE One 500-mL amber glass for mercury	HDPE: HNO_3 to pH<2 amber glass: none Cool to <6 °C	6 months 28 days for mercury
Total petroleum hydrocarbons: gasoline-range	NWTPH-Gx	Three 40-mL VOA	Cool to <6 °C, HCl to pH<2, no headspace	14 days
Total petroleum hydrocarbons: diesel- and oil-range	NWTPH-Dx	One 500-ml amber glass	None, cool to <6 °C	7 days to extract, then 40 days to analyze
Extractable petroleum hydrocarbons	NWTPH-EPH	One 1000-ml amber glass	None, cool to <6 °C	7 days to extract, then 40 days to analyze
Volatile petroleum hydrocarbons	NWTPH-VPH	(sample volume taken from total petroleum hydrocarbon containers)	Cool to <6 °C, HCl to pH<2, no headspace	14 days
Volatile organic compounds	USEPA Method 8260C	Three 40-mL VOA	Cool to <6 °C, HCl to pH<2, no headspace	14 days
Semivolatile organic compounds	USEPA Method 8270D/SIM	Two 1,000-mL amber glass	None, cool to <6 °C	7 days to extract, then 40 days to analyze

Abbreviations:

°C	Degrees Celsius	RCRA	Resource Conservation and Recovery Act
HCl	Hydrogen chloride	USEPA	U.S. Environmental Protection Agency
HDPE	High-density polyethylene	VOA	Volatile organic analysis
mL	Milliliters	VOC	Volatile organic compound
oz	Ounces	WMG	Wide-mouth glass jar

Table 7.4
Analytical Methods, Detection Limits, and Reporting Limits

Chemical	Units	Analytical Method	Method Detection Limit	Practical Quantitation Limit
Soil				
Metals				
Arsenic	mg/kg	USEPA 6020B	0.150	1.0
Barium	mg/kg	USEPA 6020B	0.030	1.0
Cadmium	mg/kg	USEPA 6020B	0.020	0.5
Chromium[1]	mg/kg	USEPA 6020B	0.11	1.0
Lead	mg/kg	USEPA 6020B	0.020	1.0
Mercury	mg/kg	USEPA 1631E	0.0023	0.25
Selenium	mg/kg	USEPA 6020B	0.11	0.50
Silver	mg/kg	USEPA 6020B	0.04	0.10
Total Petroleum Hydrocarbons				
Gasoline-range organics	mg/kg	NWTPH-Gx	0.19	5.0
Diesel-range organics	mg/kg	NWTPH-Dx	1.3	50
Oil-range organics	mg/kg	NWTPH-Dx	39	250
Extractable Petroleum Hydrocarbons/Volatile Petroleum Hydrocarbons				
Aliphatic Hydrocarbons (C8-C34)	mg/kg	NWTPH-EPH	1.1 to 2.1	10 to 20
Aromatic Hydrocarbons (C8-C34)	mg/kg	NWTPH-EPH	0.86 to 1.5	10
Aliphatic Hydrocarbons (C5-C12)	mg/kg	NWTPH-VPH	0.48 to 0.82	1.5 to 2.5
Aromatic Hydrocarbons (C8-C13)	mg/kg	NWTPH-VPH	0.19 to 2.2	0.6 to 7.0
Ethylbenzene	mg/kg	USEPA 8260C	0.0051	0.020
Toluene	mg/kg	USEPA 8260C	0.0061	0.025
Xylenes	mg/kg	USEPA 8260C	0.15	1.50
tert-Butyl Methyl Ether	mg/kg	USEPA 8260C	0.0048	0.050
Volatile Organic Compounds				
Benzene	mg/kg	USEPA 8260C	0.0064	0.020
Groundwater				
Metals				
Arsenic	µg/L	USEPA 6020B	0.049	1.0
Barium	µg/L	USEPA 6020B	0.028	1.0
Cadmium	µg/L	USEPA 6020B	0.049	0.20
Chromium[1]	µg/L	USEPA 6020B	0.074	1.0
Lead	µg/L	USEPA 6020B	0.074	0.5
Mercury	µg/L	USEPA 1631E	0.0003	0.1
Selenium	µg/L	USEPA 6020B	0.12	1.0
Silver	µg/L	USEPA 6020B	0.042	0.25
Total Petroleum Hydrocarbons				
Gasoline-range hydrocarbons	µg/L	NWTPH-Gx	11	100
Diesel-range hydrocarbons	µg/L	NWTPH-Dx	5.3	50
Oil-range hydrocarbons	µg/L	NWTPH-Dx	52	250
Extractable Petroleum Hydrocarbons/Volatile Petroleum Hydrocarbons				
Aliphatic hydrocarbons (C8-C34)	µg/L	NWTPH-EPH	5.9 to 8.9	20 to 40
Aromatic hydrocarbons (C8-C34)	µg/L	NWTPH-EPH	2.9 to 8.0	20
Aliphatic hydrocarbons (C5-C12)	µg/L	NWTPH-VPH	4.9 to 9.1	15 to 40
Aromatic hydrocarbons (C8-C13)	µg/L	NWTPH-VPH	1.4 to 18	10 to 40
Toluene	µg/L	USEPA 8260	0.030	1.0
Xylenes	µg/L	USEPA 8260	0.11	3.0
tert-Butyl Methyl Ether	µg/L	USEPA 8260	0.028	1.0
Volatile Organic Compounds				
Benzene	µg/L	USEPA 8260C	0.017	0.35
1,2-Dichloroethane	µg/L	USEPA 8260C	0.035	1.0
1,1-Dichloroethene	µg/L	USEPA 8260C	0.050	1.0
cis-1,2-Dichloroethene	µg/L	USEPA 8260C	0.025	1.0
Ethylbenzene	µg/L	USEPA 8260C	0.019	1.0
Trichloroethene	µg/L	USEPA 8260C	0.037	0.5
Vinyl chloride	µg/L	USEPA 8260C	0.067	0.2

Table 7.4
Analytical Methods, Detection Limits, and Reporting Limits

Chemical	Units	Analytical Method	Method Detection Limit	Practical Quantitation Limit
Groundwater (cont.)				
Semivolatile Organic Compounds				
Pentachlorophenol	µg/L	USEPA 8270D/SIM	0.15	0.20
Acenaphthene	µg/L	USEPA 8270D/SIM	0.00063	0.060
Acenaphthylene	µg/L	USEPA 8270D/SIM	0.00035	0.060
Anthracene	µg/L	USEPA 8270D/SIM	0.00045	0.060
Benz(a) anthracene	µg/L	USEPA 8270D/SIM	0.0015	0.060
Benzo(b) fluoranthene	µg/L	USEPA 8270D/SIM	0.00098	0.060
Benzo(k) fluoranthene	µg/L	USEPA 8270D/SIM	0.0010	0.060
Benzo(g,h,i)perylene	µg/L	USEPA 8270D/SIM	0.00098	0.060
Benzo(a)pyrene	µg/L	USEPA 8270D/SIM	0.00070	0.060
Chrysene	µg/L	USEPA 8270D/SIM	0.0011	0.060
Dibenz(a,h) anthracene	µg/L	USEPA 8270D/SIM	0.00068	0.060
Fluoranthene	µg/L	USEPA 8270D/SIM	0.00065	0.060
Fluorene	µg/L	USEPA 8270D/SIM	0.00035	0.060
Semivolatile Organic Compounds				
Indeno(1,2,3-c,d)pyrene	µg/L	USEPA 8270D/SIM	0.00095	0.060
1-Methylnaphthalene	µg/L	USEPA 8270D/SIM	0.00063	0.060
2-Methylnaphthalene	µg/L	USEPA 8270D/SIM	0.00063	0.060
Naphthalene	µg/L	USEPA 8270D/SIM	0.014	0.060
Phenanthrene	µg/L	USEPA 8270D/SIM	0.012	0.060
Pyrene	µg/L	USEPA 8270D/SIM	0.00060	0.060

Note:

1 Chromium present in Site soil is presumed to be chromium(III) because there were no documented potential sources of other species of chromium, such as leather tanning or electroplating. The results of total chromium analysis will be compared to preliminary screening levels for both chromium(III) and total chromium.

Abbreviations:

µg/L	Micrograms per liter
mg/kg	Milligrams per kilogram

Table 7.5
Data Quality Assurance Criteria

Chemical	Precision[1]	Accuracy	Completeness	Reference
Soil				
Metals (RCRA 8)	±20% RPD	80–120%	95%	USEPA 6020B/1631E
Mercury	± 20% RPD	80–120%	95%	USEPA 7471
Total petroleum hydrocarbons gasoline-range	±30% RPD	65–135%	95%	NWTPH-Gx
Total petroleum hydrocarbons: diesel- and oil-range	±30% RPD	65–135%	95%	NWTPH-Dx
Extractable petroleum hydrocarbons	±30% RPD	65–135%	95%	NWTPH-EPH
Volatile petroleum hydrocarbons	±30% RPD	65–135%	95%	NWTPH-VPH
Volatile organic compounds	±30% RPD	65–135%	95%	USEPA 8260C
Groundwater				
Metals (RCRA 8)	±20% RPD	80–120%	95%	USEPA 6020B/1631E
Total petroleum hydrocarbons: gasoline-range	±30% RPD	65–135%	95%	NWTPH-Gx
Total petroleum hydrocarbons: diesel- and oil-range	±30% RPD	65–135%	95%	NWTPH-Dx
Extractable petroleum hydrocarbons	±30% RPD	65–135%	95%	NWTPH-EPH
Volatile petroleum hydrocarbons	±30% RPD	65–135%	95%	NWTPH-VPH
Volatile organic compounds	±30% RPD	65–135%	95%	USEPA 8260C
Semivolatile organic compounds	±30% RPD	65–135%	95%	USEPA 8270D SIM

Note:

[1] Precision criteria apply to analytical precision only. Field duplicate precision will be screened against an RPD of 75%.

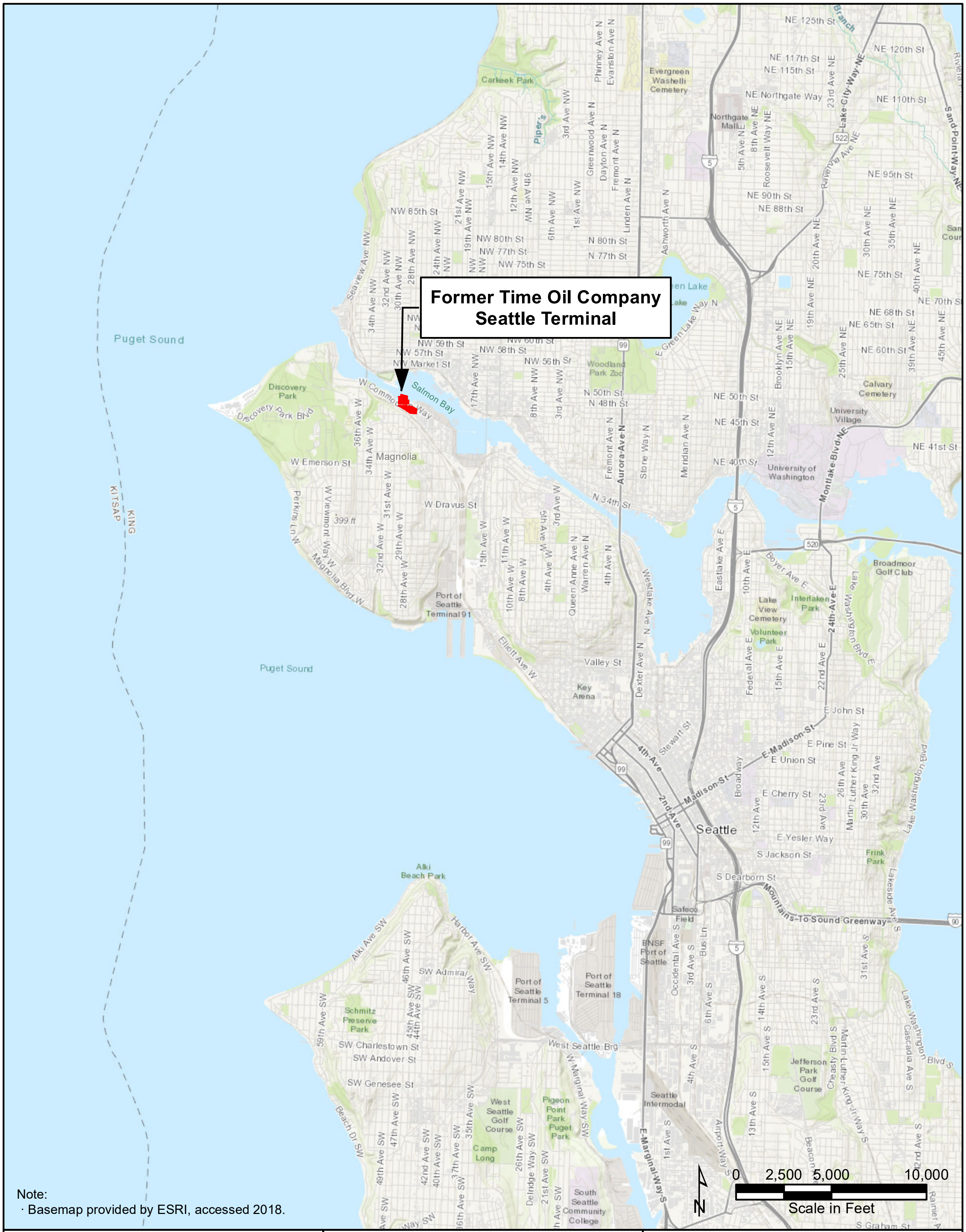
Abbreviations:

RCRA	Resource Conservation and Recovery Act
RPD	Relative percent difference

Time Oil Bulk Terminal PPA

Supplemental Upland Remedial Investigation Work Plan

Figures



Note:
· Basemap provided by ESRI, accessed 2018.

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Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 1.1
Site Location Map

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3/8/2019

Notes:
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviation:
DNR = Washington State Department of Natural Resources

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Seattle, Washington

Figure 1.2
Site Vicinity Map

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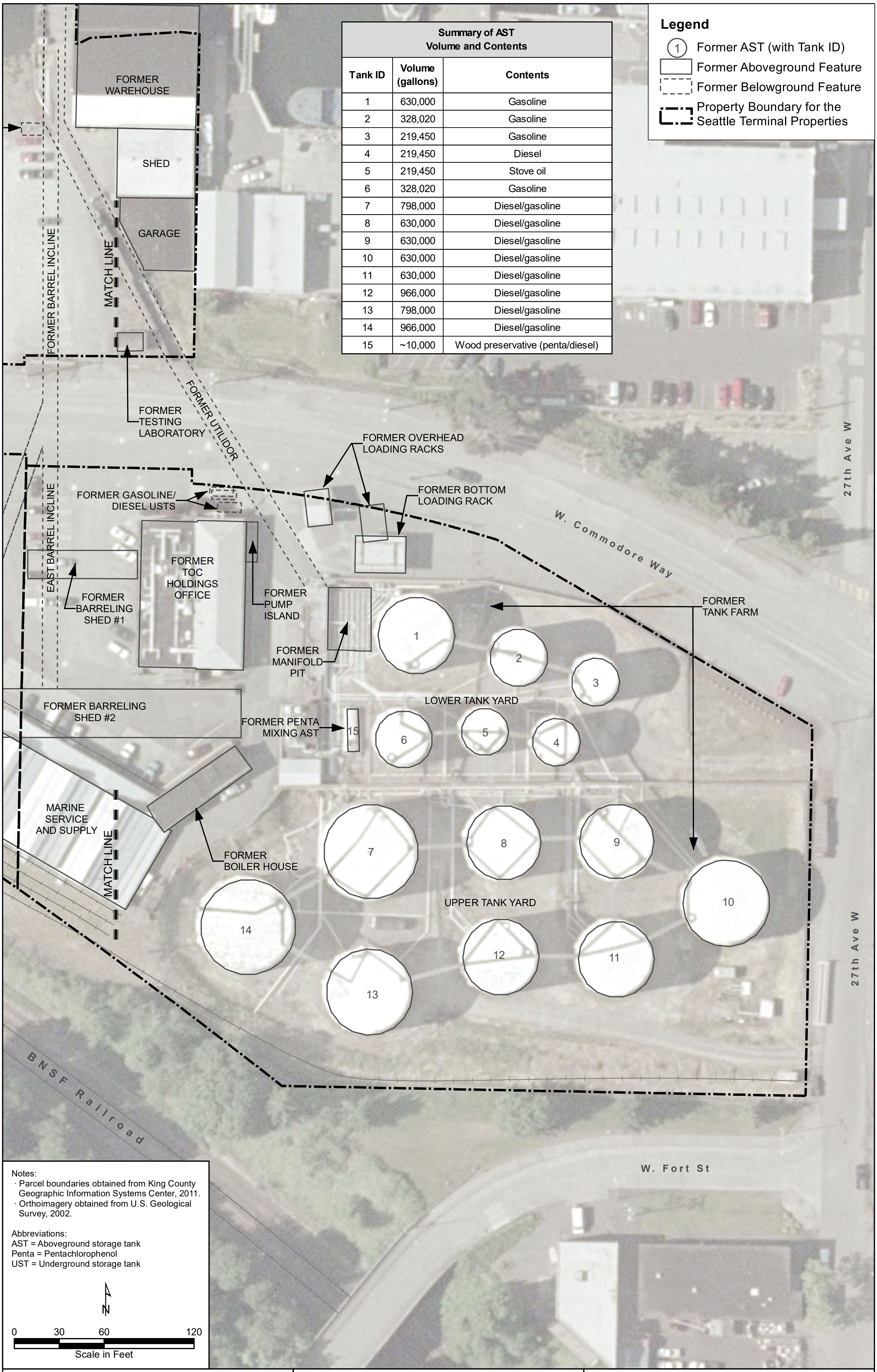
3/8/2019



Summary of AST Volume and Contents

Tank ID	Volume (gallons)	Contents
1	630,000	Gasoline
2	328,020	Gasoline
3	219,450	Gasoline
4	219,450	Diesel
5	219,450	Stove oil
6	328,020	Gasoline
7	798,000	Diesel/gasoline
8	630,000	Diesel/gasoline
9	630,000	Diesel/gasoline
10	630,000	Diesel/gasoline
11	630,000	Diesel/gasoline
12	966,000	Diesel/gasoline
13	798,000	Diesel/gasoline
14	966,000	Diesel/gasoline
15	~10,000	Wood preservative (penta/diesel)

Legend

①	Former AST (with Tank ID)
▭	Former Aboveground Feature
⬚	Former Belowground Feature
▭	Property Boundary for the Seattle Terminal Properties

Notes:
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011.
- Orthoimagery obtained from U.S. Geological Survey, 2002.

Abbreviations:
AST = Aboveground storage tank
Penta = Pentachlorophenol
UST = Underground storage tank

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Seattle, Washington

Figure 2.1a
Former TOC Seattle Terminal Features

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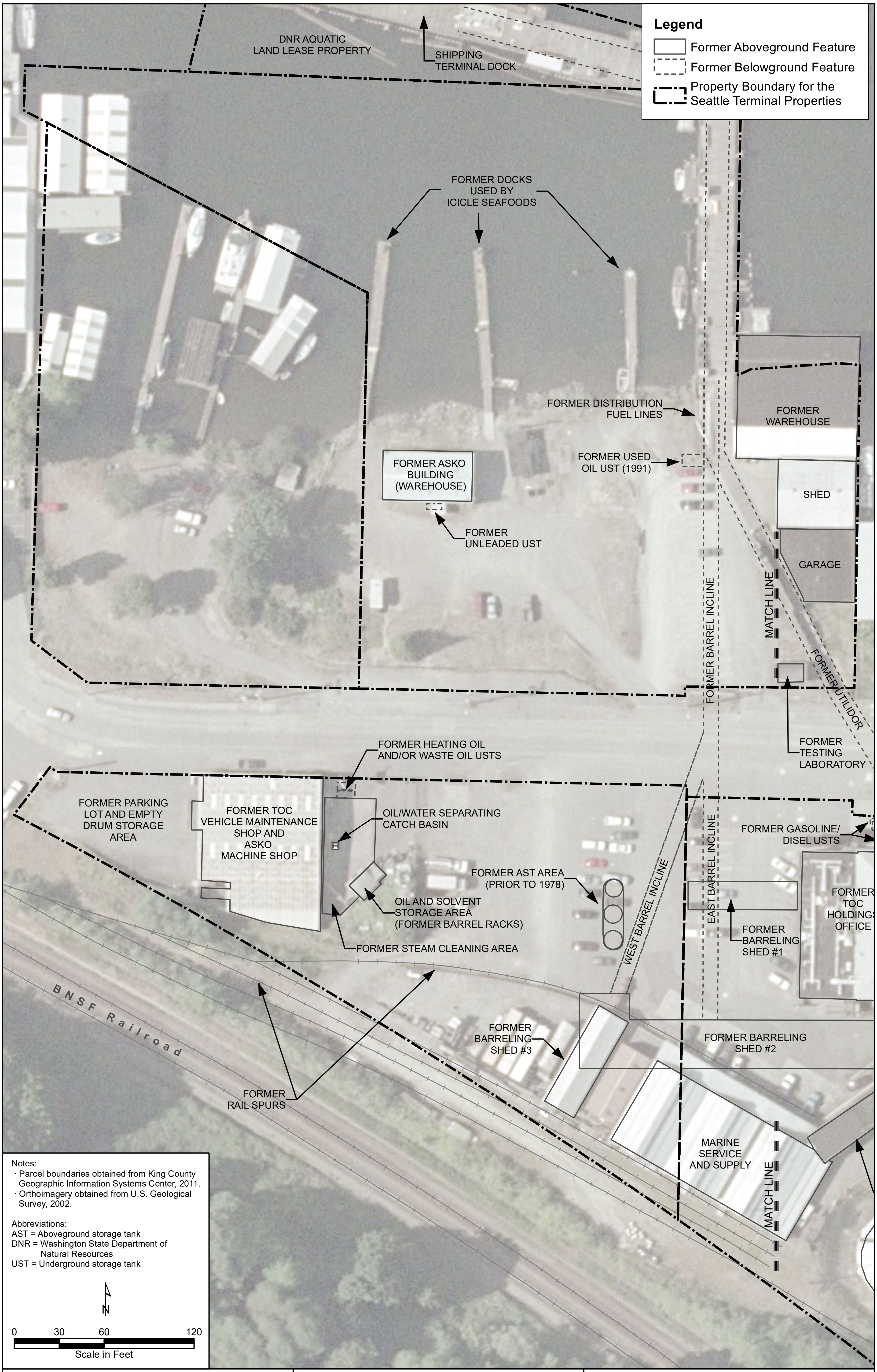
3/8/2019



Notes:
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011.
- Orthoimagery obtained from U.S. Geological Survey, 2002.

Abbreviations:
AST = Aboveground storage tank
DNR = Washington State Department of Natural Resources
UST = Underground storage tank

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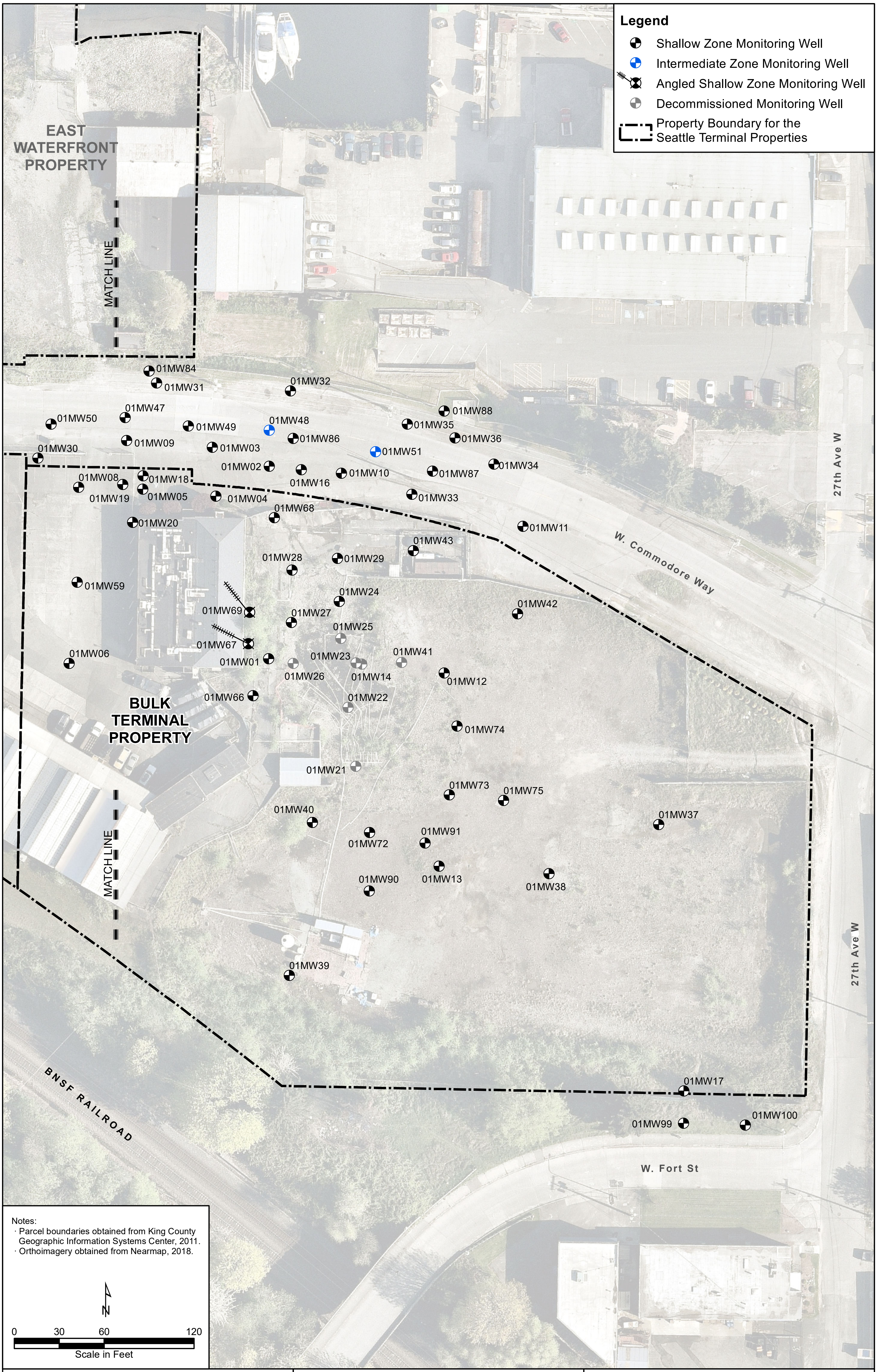
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 2.1b
Former TOC Seattle Terminal Features



Notes:
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011.
· Orthoimagery obtained from Nearmap, 2018.

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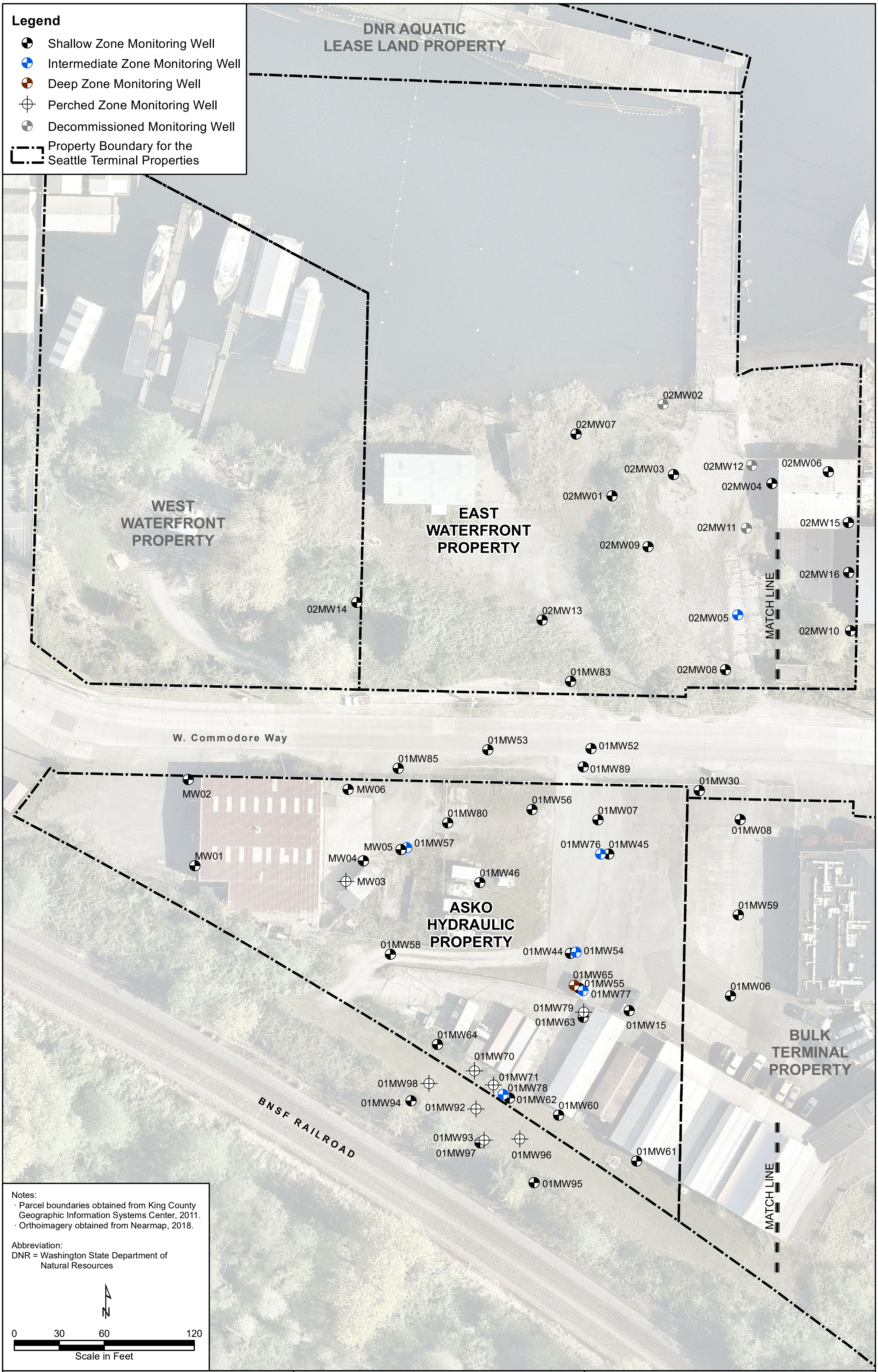
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 3.1a
Bulk Terminal Property
Monitoring Well Locations

I:\GIS\Projects\Cantera-TOC\MXD\RI\RI Work Plan\Figure 3.1a Bulk Terminal Property Monitoring Well Locations.mxd
3/8/2019



Legend

- ● Shallow Zone Monitoring Well
- ● Intermediate Zone Monitoring Well
- ● Deep Zone Monitoring Well
- ⊕ Perched Zone Monitoring Well
- ● Decommissioned Monitoring Well
- ▭ Property Boundary for the Seattle Terminal Properties

Notes:
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviation:
DNR = Washington State Department of Natural Resources

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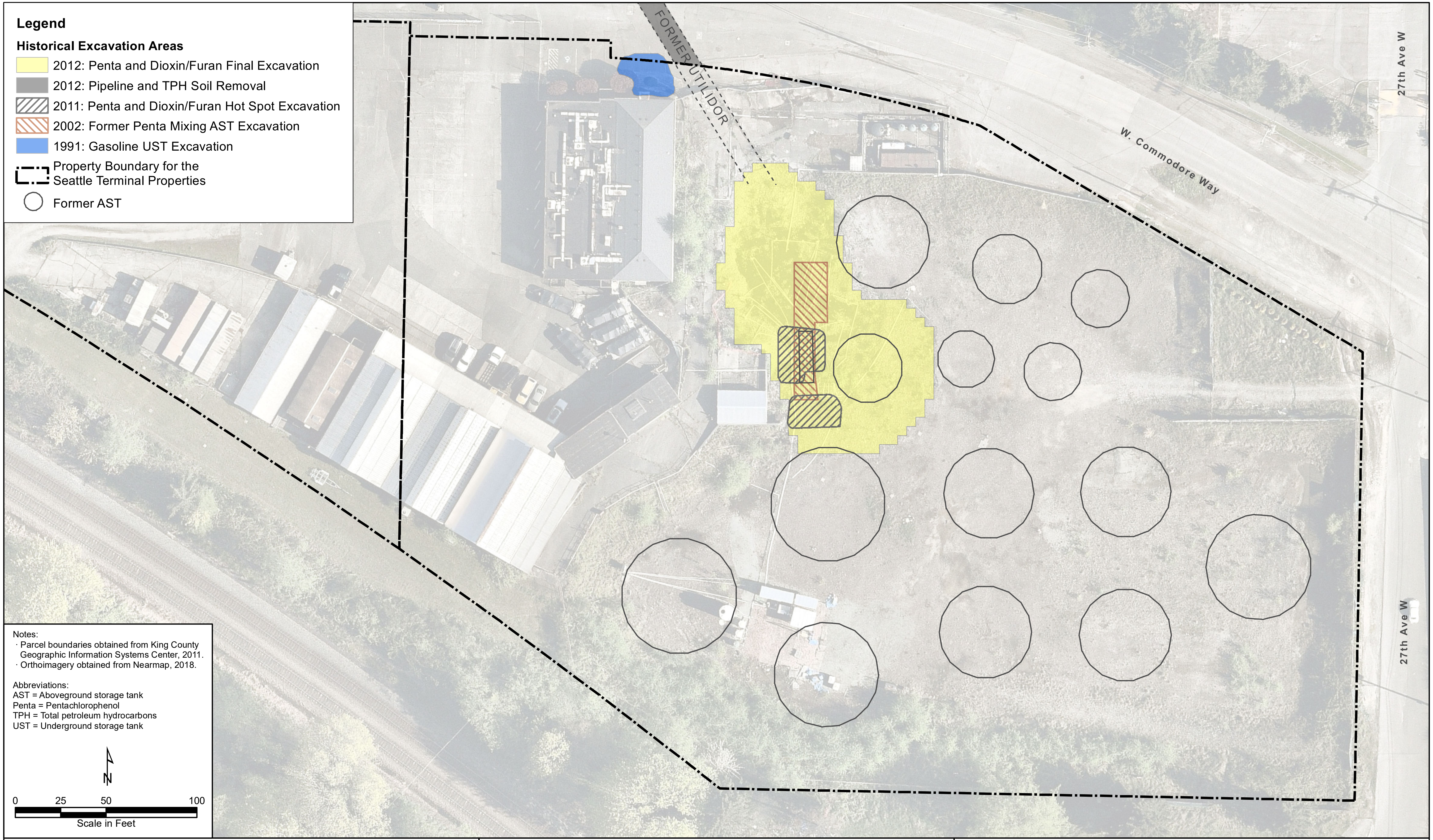
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 3.1b
ASKO and East Waterfront Properties
Monitoring Well Locations

I:\GIS\Projects\Cantera-TOC\MXD\RI\RI Work Plan\Figure 3.1b ASKO and East Waterfront Monitoring Well Locations.mxd
3/8/2019



Notes:
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
AST = Aboveground storage tank
Penta = Pentachlorophenol
TPH = Total petroleum hydrocarbons
UST = Underground storage tank

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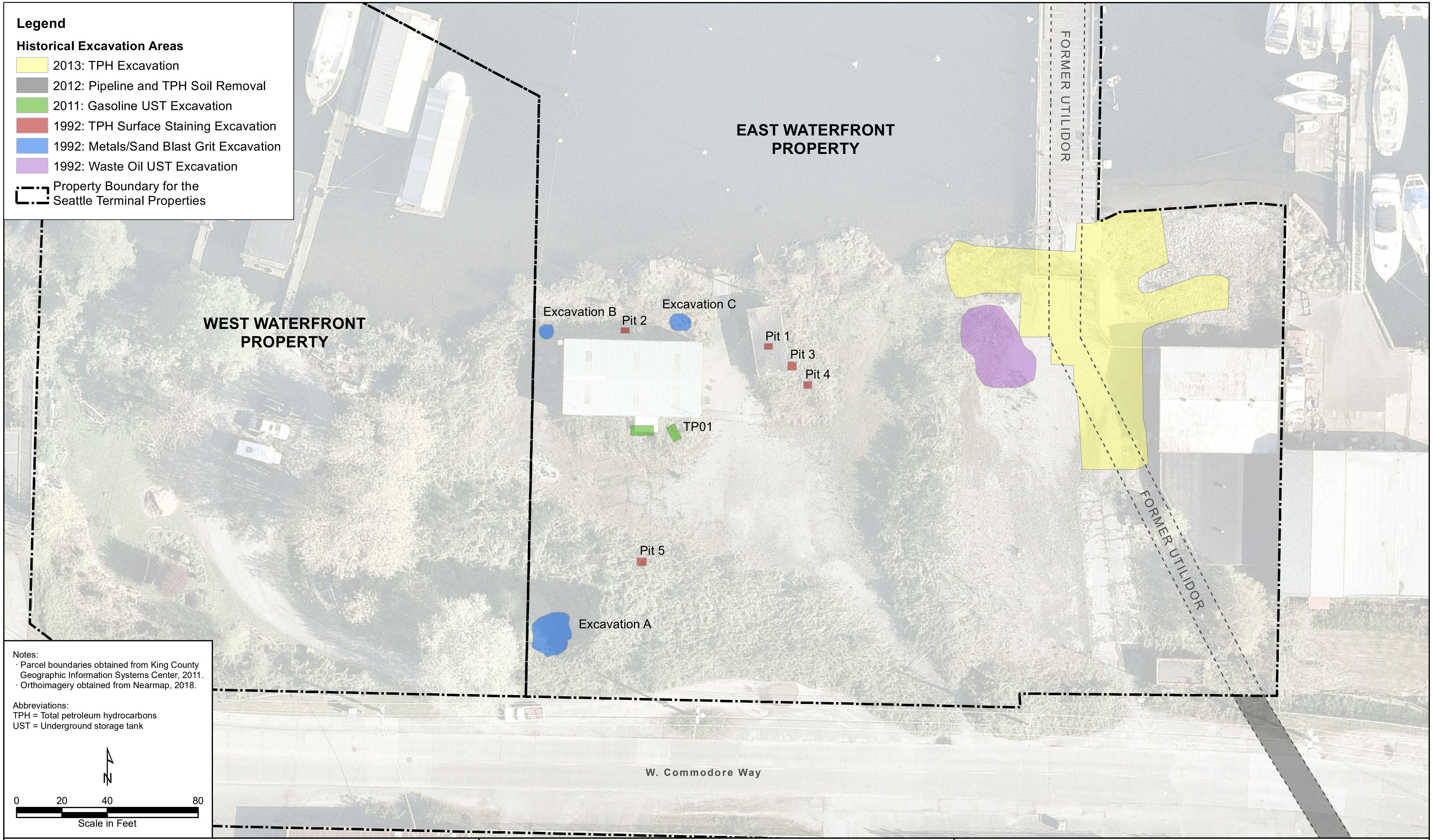
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 3.2
Historical Soil Excavation Locations
on the Bulk Terminal Property

I:\GIS\Projects\Cantera-TOC\MXD\RI\RI Work Plan\Figure 3.2 Historical Soil Excavation Locations on the BT.mxd
3/8/2019



Legend

Historical Excavation Areas

- 🟨 2013: TPH Excavation
- ▨ 2012: Pipeline and TPH Soil Removal
- 🟩 2011: Gasoline UST Excavation
- 🟥 1992: TPH Surface Staining Excavation
- 🟦 1992: Metals/Sand Blast Grit Excavation
- 🟪 1992: Waste Oil UST Excavation
- ▭ Property Boundary for the Seattle Terminal Properties

Notes:
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
TPH = Total petroleum hydrocarbons
UST = Underground storage tank

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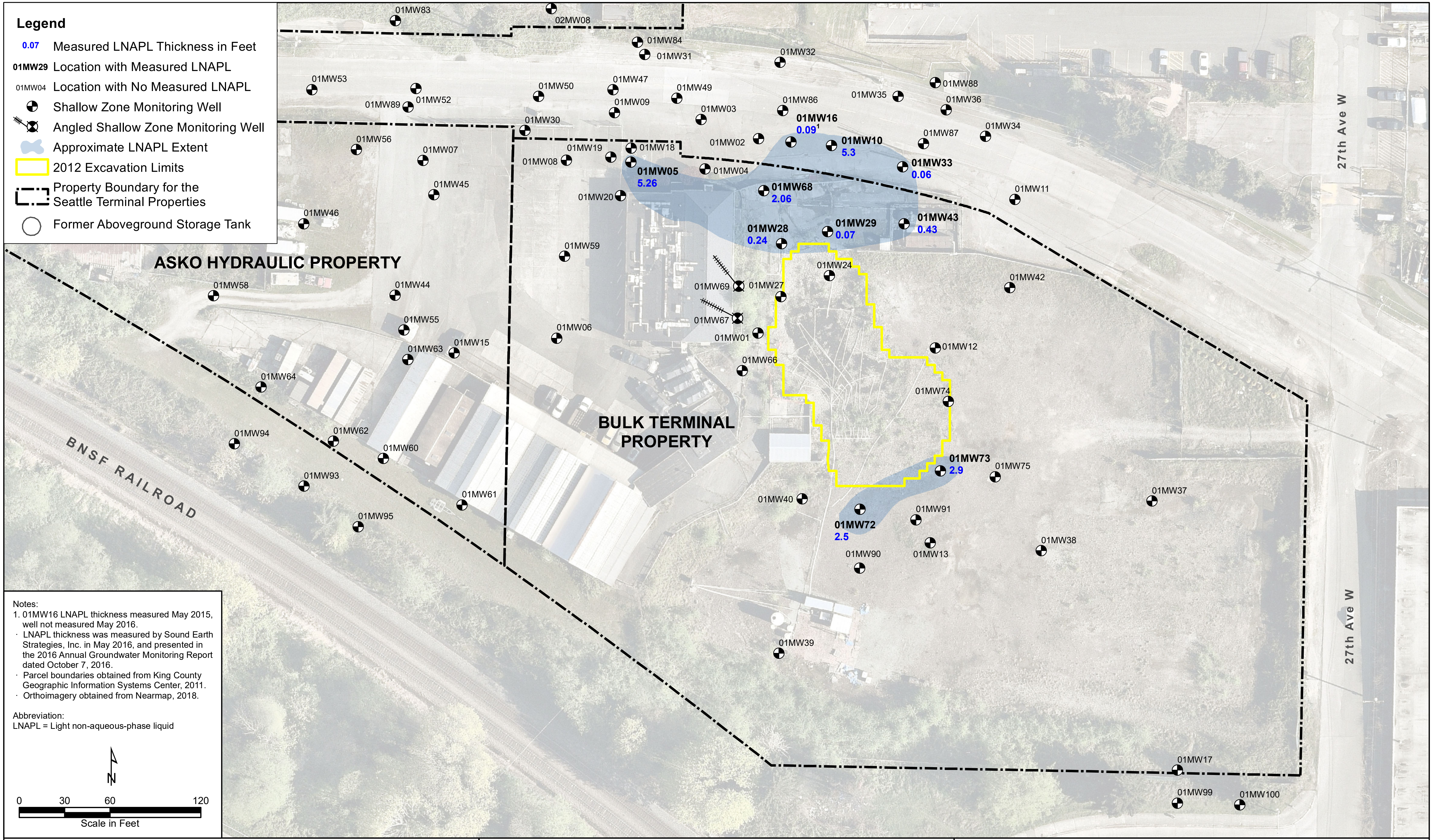
Seattle, Washington

Figure 3.3
Historical Soil Excavation Areas
on the East Waterfront Property



Notes:

1. 01MW16 LNAPL thickness measured May 2015, well not measured May 2016.

- LNAPL thickness was measured by Sound Earth Strategies, Inc. in May 2016, and presented in the 2016 Annual Groundwater Monitoring Report dated October 7, 2016.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviation:
LNAPL = Light non-aqueous-phase liquid

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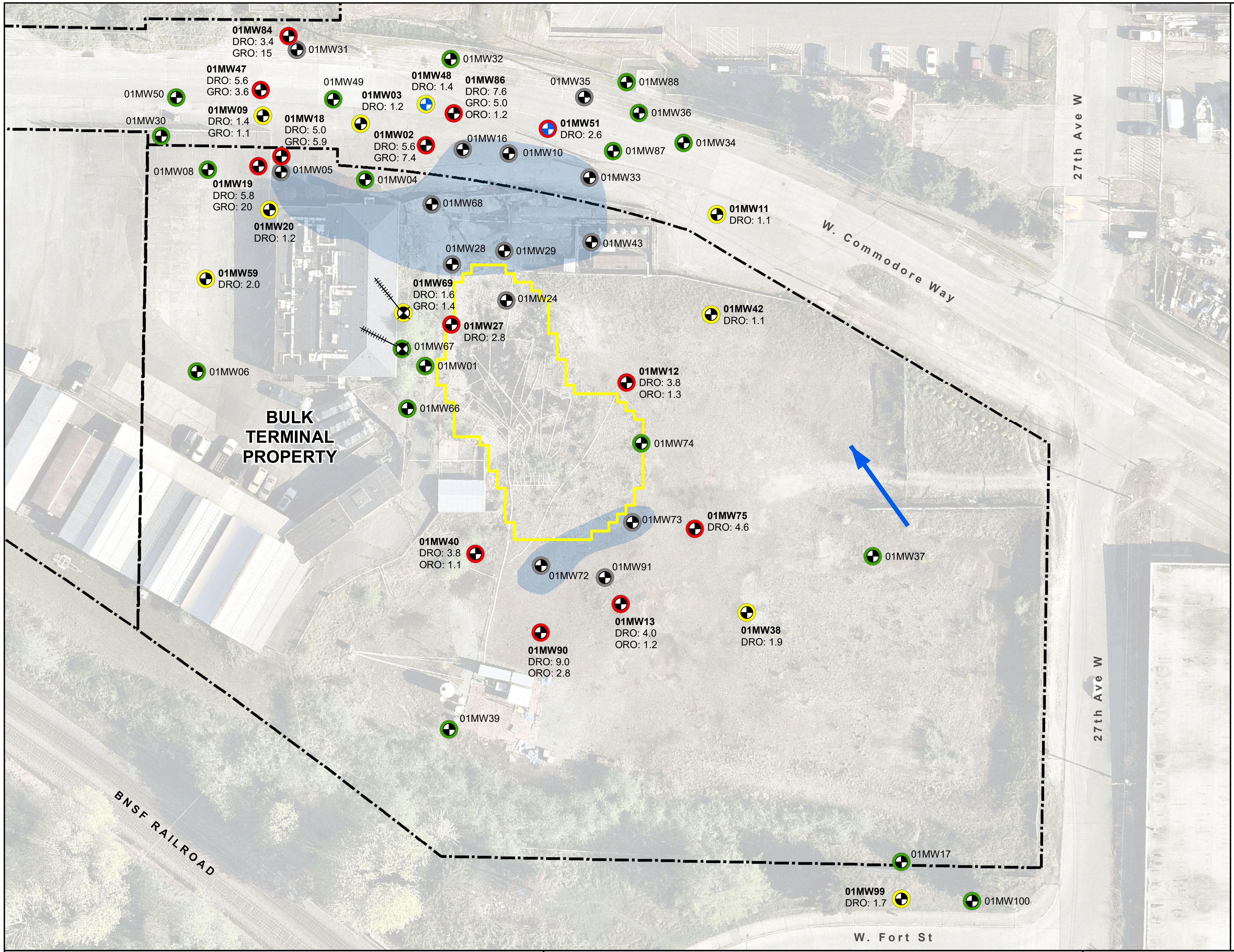
Seattle, Washington

Figure 5.1
Bulk Terminal Property
LNAPL Distribution and Thickness

I:\GIS\Projects\Cantera-TOC\MXD\RI\RI Work Plan\Figure 5.1 Bulk Terminal Property LNAPL Distribution and Thickness.mxd
3/8/2019



Legend

Monitoring Well Location with Water-Bearing Zone

- ⊕ Shallow Zone Monitoring Well
- ⊕ Intermediate Zone Monitoring Well
- ⊗ Angled Shallow Zone Monitoring Well

Groundwater Sample Results

(Chemical results presented as exceedance factors)[1]

- 🟢 All Chemicals Less Than Criteria
- 🟡 One or More Chemicals Greater Than Criteria by ≤2 times
- 🔴 One or More Chemicals Greater Than Criteria by >2 times
- ⚫ Not Analyzed for Specific Chemicals

Other Property Features

- ← Predominant Shallow Groundwater Flow Direction (SES 2014a)
- Approximate LNAPL Extent
- 2012: Penta and Dioxin/Furan Final Excavation Extent
- Property Boundary for the Seattle Terminal Properties

Screening Criteria:

Chemical	Upland PSL (µg/L)
DRO	500
GRO	800
ORO	500

Notes:

1. Exceedance factor is the most recent detection divided by the criteria rounded to two significant figures. Exceedance factors are only presented where the result exceeds the criterion.

- The Upland PSLs are a compilation of the federal or state Maximum Contaminant Levels (whichever is most conservative) and the MTCA Method B criteria. Where MTCA Method B criteria were not available, MTCA Method A criteria were selected.
- The most recent groundwater result for each chemical at each location was used for screening. The most recent samples were collected between 2013 and 2016.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:

DRO = Diesel-range organics
GRO = Gasoline-range organics
LNAPL = Light non-aqueous-phase liquid
µg/L = Micrograms per liter
MTCA = Model Toxics Control Act
ORO = Oil-range organics
PSL = Preliminary Screening Level
TPH = Total petroleum hydrocarbons

N
0 30 60 120
Scale in Feet

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Time Oil Bulk Terminal PPA
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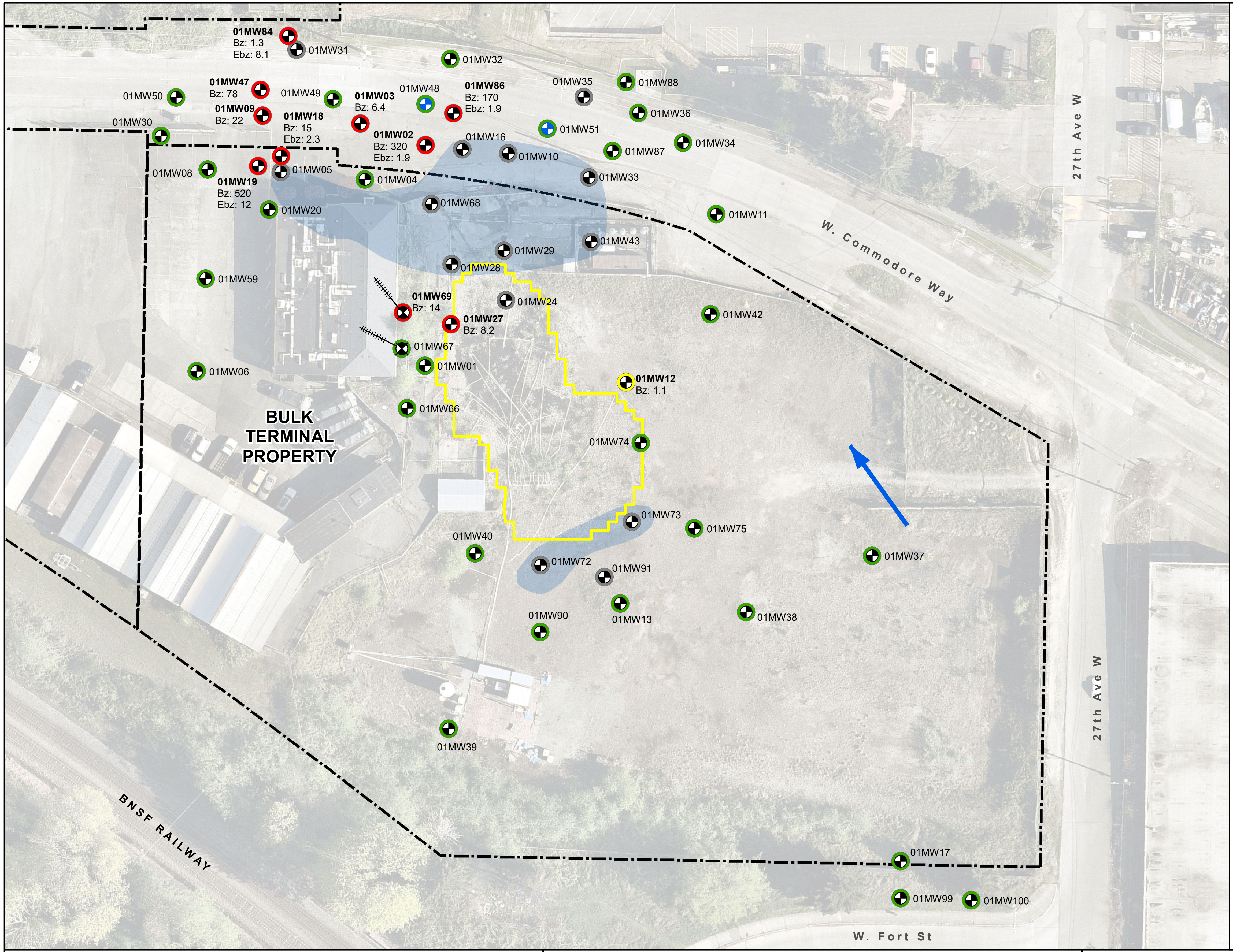
Figure 5.2
Bulk Terminal Property
TPH Distribution in Groundwater (2013–2016)

I:\GIS\Projects\Cantera-TOC\MXD\RI\RI Work Plan\Figure 5.2 Bulk Terminal TPH Distribution in Groundwater (2013–2016).mxd
3/8/2019



Legend

Monitoring Well Location with Water-Bearing Zone

⊕ Shallow Zone Monitoring Well

⊕ Intermediate Zone Monitoring Well

⊗ Angled Shallow Zone Monitoring Well

Groundwater Sample Results

(Chemical results presented as exceedance factors)[1]

🟢 All Chemicals Less Than Criteria

🟡 One or More Chemicals Greater Than Criteria by ≤2 times

🔴 One or More Chemicals Greater Than Criteria by >2 times

● Not Analyzed for Specific Chemicals

Other Property Features

← Predominant Shallow Groundwater Flow Direction (SES 2014a)

▨ Approximate LNAPL Extent

▭ 2012: Penta and Dioxin/Furan Final Excavation Extent

▭ Property Boundary for the Seattle Terminal Properties

Screening Criteria:

Chemical	Upland PSL (µg/L)
Benzene	5.0
Tolune	1,000
Ethylbenzene	70
Xylene (Total)	10,000

Notes:

1. Exceedance factor is the most recent detection divided by the criteria rounded to two significant figures. Exceedance factors are only presented where the result exceeds the criterion.

- The Upland PSLs are a compilation of the federal or state Maximum Contaminant Levels (whichever is most conservative) and the MTCA Method B criteria. Where MTCA Method B criteria were not available, MTCA Method A criteria were selected.
- The most recent groundwater result for each chemical at each location was used for screening. The most recent samples were collected between 2013 and 2016.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:

BTEX = Benzene, toluene, ethylbenzene, and xylenes
Bz = Benzene
Ebz = Ethylbenzene
LNAPL = Liquid non-aqueous-phase liquid
µg/L = Micrograms per liter
MTCA = Model Toxics Control Act
PSL = Preliminary Screening Level

N

0 30 60 120
Scale in Feet

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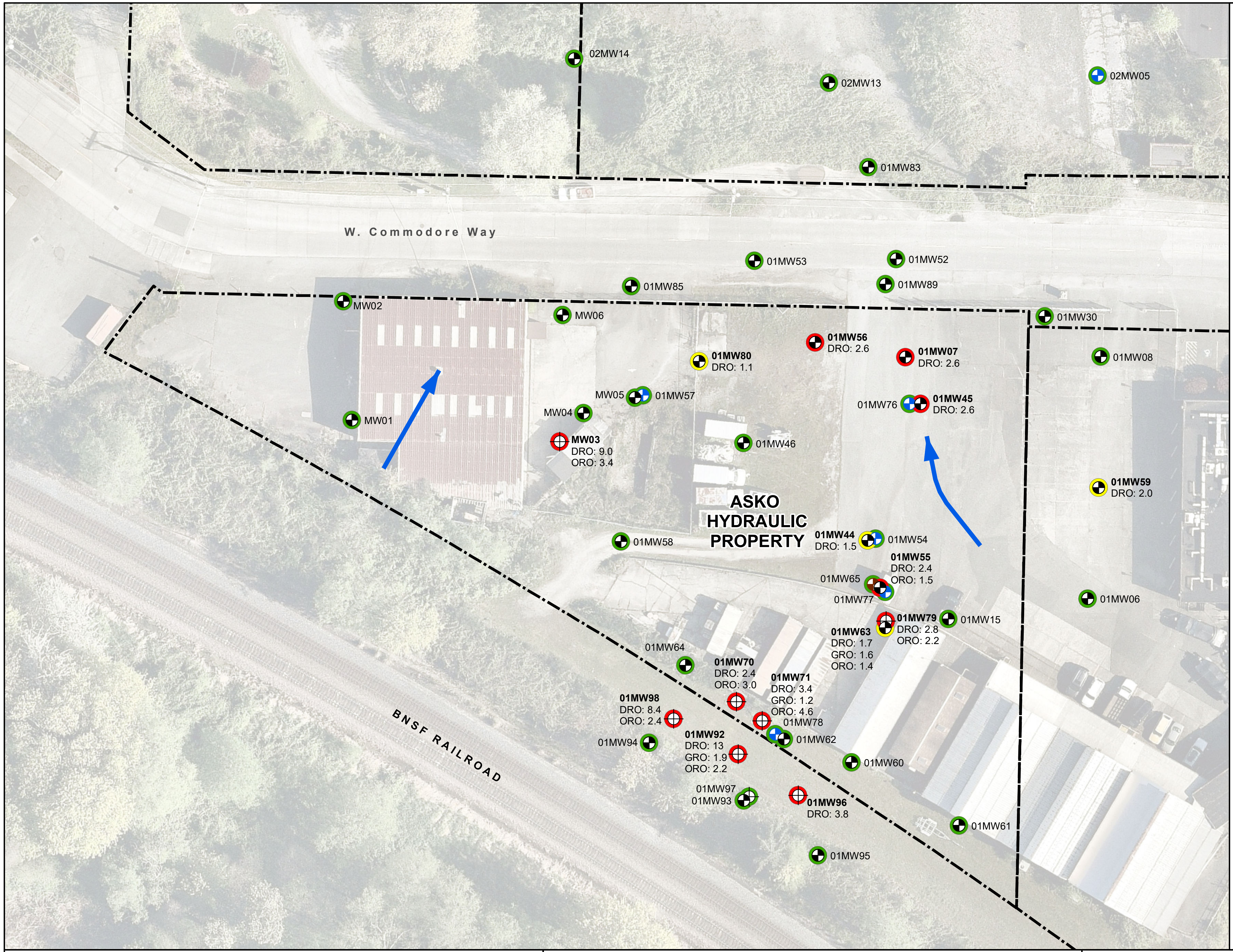
Figure 5.3
Bulk Terminal Property
BTEX Distribution in Groundwater (2013–2016)

I:\GIS\Projects\Cantera-TOC\MXD\RI\RI Work Plan\Figure 5.3 Bulk Terminal BTEX Distribution in Groundwater (2013–2016).mxd
3/8/2019



Legend

Monitoring Well Location with Water-Bearing Zone

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- ⊕ Perched Zone Monitoring Well

Groundwater Sample Results

(Chemical results presented as exceedance factors)[1]

- 🟢 All Chemicals Less Than Criteria
- 🟡 One or More Chemicals Greater Than Criteria by ≤2 times
- 🔴 One or More Chemicals Greater Than Criteria by >2 times

Other Property Features

- ← Predominant Shallow Groundwater Flow Direction (SES 2014b)
- Property Boundary for the Seattle Terminal Properties

Screening Criteria:

Chemical	Upland PSL (µg/L)
DRO	500
GRO	800
ORO	500

Notes:

1. Exceedance factor is the most recent detection divided by the criteria rounded to two significant figures. Exceedance factors are only presented where the result exceeds the criterion.

- The Upland PSLs are a compilation of the federal or state Maximum Contaminant Levels (whichever is most conservative) and the MTCA Method B criteria. Where MTCA Method B criteria were not available, MTCA Method A criteria were selected.
- The most recent groundwater result for each chemical at each location was used for screening. The most recent samples were collected between 2013 and 2016.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
DRO = Diesel-range organics
GRO = Gasoline-range organics
µg/L = Micrograms per liter
MTCA = Model Toxics Control Act
ORO = Oil-range organics
PSL = Preliminary Screening Level
TPH = Total petroleum hydrocarbons

N
0 25 50 100
Scale in Feet

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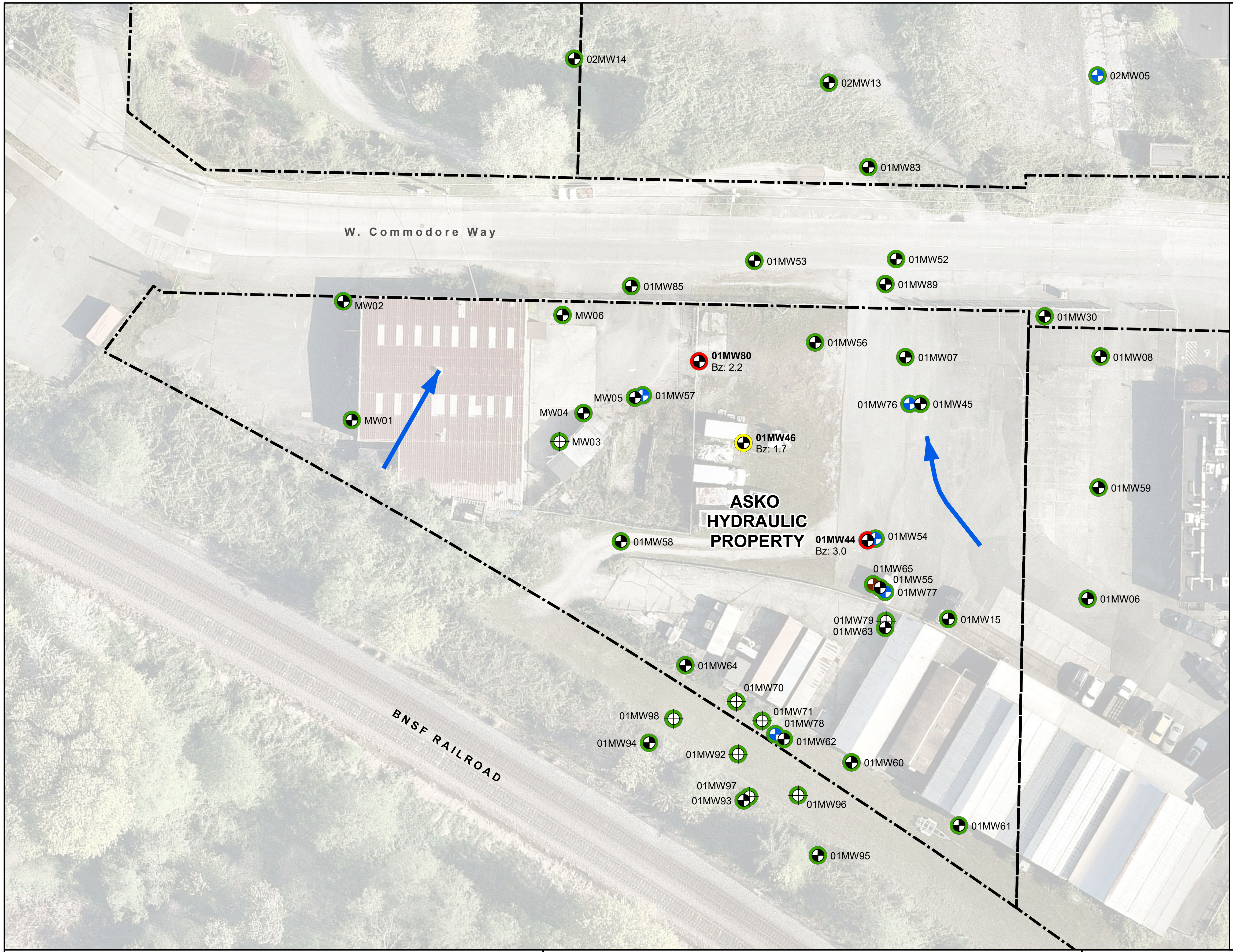
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 5.4
ASKO Property
TPH Distribution in Groundwater (2013–2016)

I:\GIS\Projects\Cantera-TOC\MXD\RI\RI Work Plan\Figure 5.4 ASKO TPH Distribution in Groundwater (2013–2016).mxd
3/8/2019



Legend

Monitoring Well Location with Water-Bearing Zone

- ● Shallow Zone Monitoring Well
- ● Intermediate Zone Monitoring Well
- ● Deep Zone Monitoring Well
- ⊕ Perched Zone Monitoring Well

Groundwater Sample Results

(Chemical results presented as exceedance factors)[1]

- 🟢 All Chemicals Less Than Criteria
- 🟡 One or More Chemicals Greater Than Criteria by ≤2 times
- 🔴 One or More Chemicals Greater Than Criteria by >2 times

Other Property Features

- ← Predominant Shallow Groundwater Flow Direction (SES 2014b)
- ▭ Property Boundary for the Seattle Terminal Properties

Screening Criteria:

Chemical	Upland PSL (µg/L)
Benzene	5.0
Tolune	1,000
Ethylbenzene	70
Xylene (Total)	10,000

Notes:

1. Exceedance factor is the most recent detection divided by the criteria rounded to two significant figures. Exceedance factors are only presented where the result exceeds the criterion.

- The Upland PSLs are a compilation of the federal or state Maximum Contaminant Levels (whichever is most conservative) and the MTCA Method B criteria. Where MTCA Method B criteria were not available, MTCA Method A criteria were selected.
- The most recent groundwater result for each chemical at each location was used for screening. The most recent samples were collected between 2013 and 2016.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:

BTEX = Benzene, toluene, ethylbenzene, and xylenes
Bz = Benzene
µg/L = Micrograms per liter
MTCA = Model Toxics Control Act
PSL = Preliminary Screening Level

N

0 25 50 100
Scale in Feet

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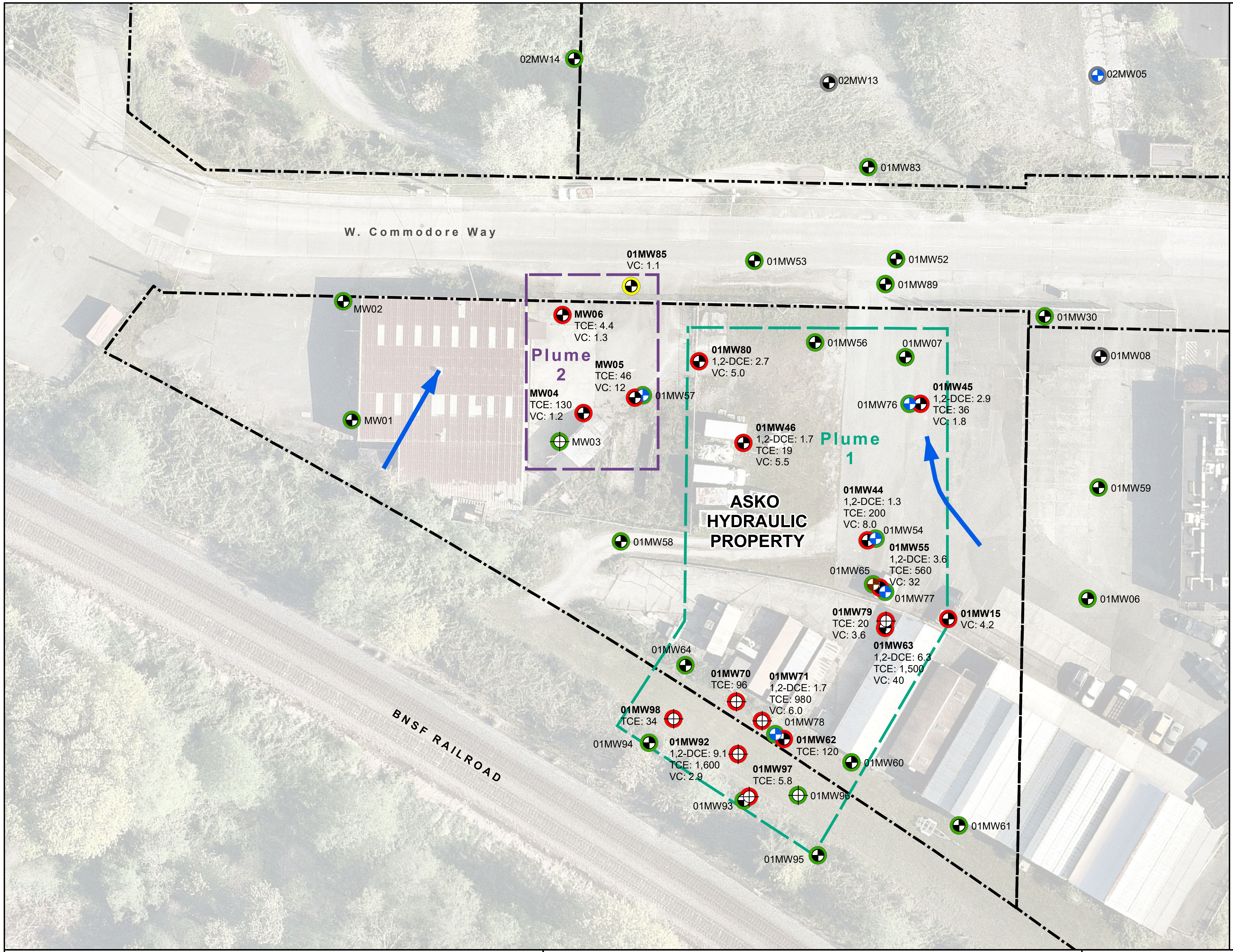
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 5.5
ASKO Property
BTEX Distribution in Groundwater (2013–2016)

I:\GIS\Projects\Cantera-TOC\MXD\RI\RI Work Plan\Figure 5.5 ASKO BTEX Distribution in Groundwater (2013–2016).mxd
3/8/2019



Legend

Monitoring Well Location with Water-Bearing Zone

- ◐ Shallow Zone Monitoring Well
- ◐ Intermediate Zone Monitoring Well
- ◐ Deep Zone Monitoring Well
- ⊕ Perched Zone Monitoring Well

Groundwater Sample Results

(Chemical results presented as exceedance factors)[1]

- 🟢 All Chemicals Less Than Criteria
- 🟡 One or More Chemicals Greater Than Criteria by ≤2 times
- 🔴 One or More Chemicals Greater Than Criteria by >2 times
- ⚫ Not Analyzed for Specific Chemicals

Other Property Features

- ← Predominant Shallow Groundwater Flow Direction (SES 2014b)
- ▭ Plume 1: BNSF Plume[2]
- ▭ Plume 2: ASKO Plume[2]
- ▭ Property Boundary for the Seattle Terminal Properties

Screening Criteria:

Chemical	Upland PSL (µg/L)
1,2-DCE	70
TCE	5.0
VC	2.0

Notes:

1. Exceedance factor is the most recent detection divided by the criteria rounded to two significant figures. Exceedance factors are only presented where the result exceeds the criterion.
2. Site 1 and Site 2 plume boundaries were defined by SoundEarth Strategies in their 2014 ASKO Remedial Investigation Report. These boundaries were adjusted based on recent data and were renamed Plume 1 and Plume 2. The final configuration of Plumes 1 and 2 will be provided in the Supplemental RI Report.

- The Upland PSLs are a compilation of the federal or state Maximum Contaminant Levels (whichever is most conservative) and the MTCA Method B criteria. Where MTCA Method B criteria were not available, MTCA Method A criteria were selected.
- The most recent groundwater result for each chemical at each location was used for screening. The most recent samples were collected between 2013 and 2016.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
1,2-DCE = *cis*-1,2,-Dichloroethene
cVOC = Chlorinated volatile organic compound
µg/L = Micrograms per liter
MTCA = Model Toxics Control Act
PSL = Preliminary Screening Level
TCE = Trichloroethene
VC = Vinyl Chloride

N

0 25 50 100
Scale in Feet

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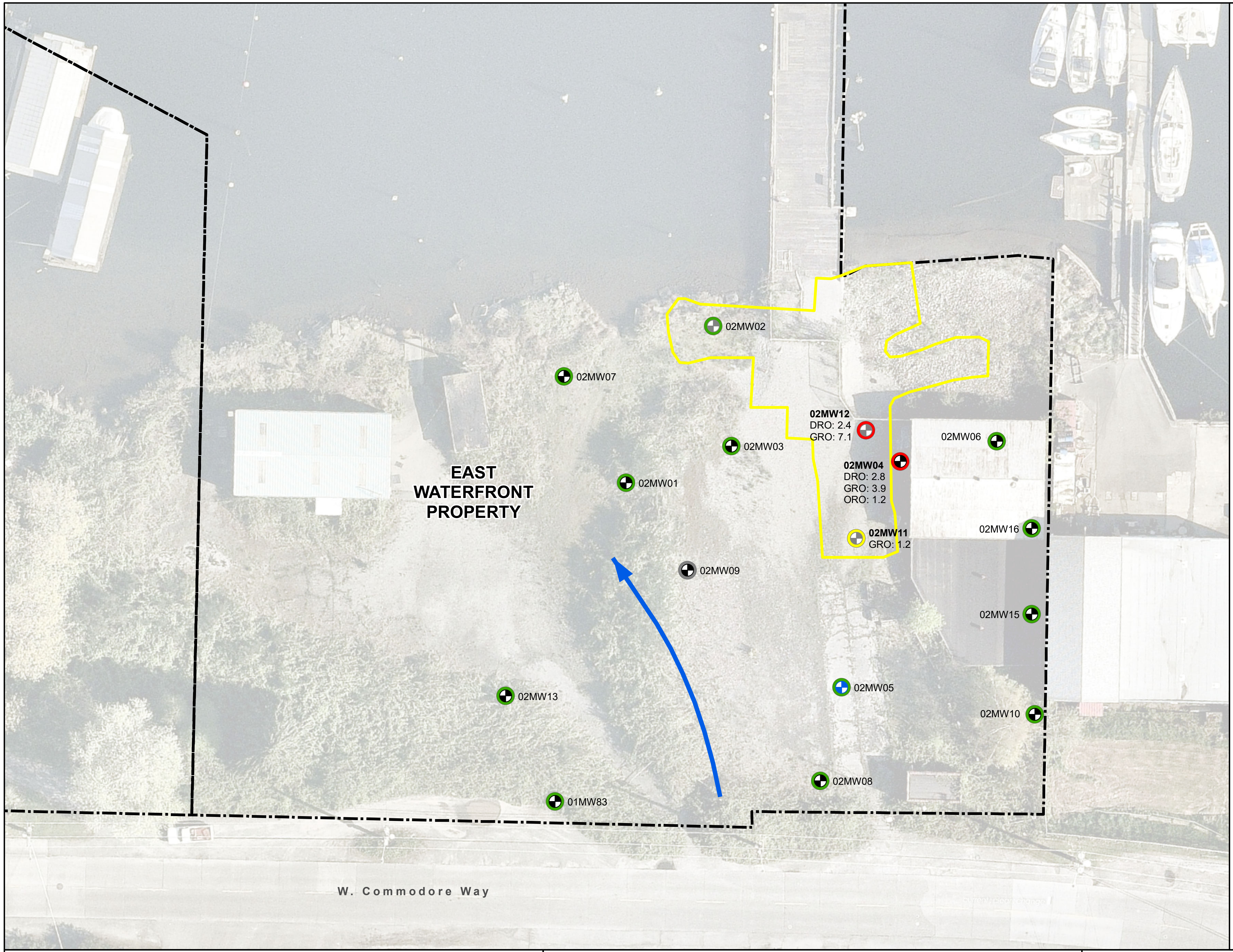
Figure 5.6
ASKO Property
cVOC Distribution in Groundwater (2013–2016)

I:\GIS\Projects\Cantera-TOC\MXD\RI\RI Work Plan\Figure 5.6 ASKO cVOC Distribution in Groundwater (2013–2016).mxd
3/8/2019



Legend

Monitoring Well Location with Water-Bearing Zone

- ⊕ Shallow Zone Monitoring Well
- ⊕ Intermediate Zone Monitoring Well
- ⊕ Decommissioned Monitoring Well

Groundwater Sample Results

(Chemical results presented as exceedance factors)[1]

- 🟢 All Chemicals Less Than Criteria
- 🟡 One or More Chemicals Greater Than Criteria by ≤2 times
- 🔴 One or More Chemicals Greater Than Criteria by >2 times
- ● Not Analyzed for Specific Chemicals

Other Property Features

- ← Predominant Shallow Groundwater Flow Direction (SES 2014c)
- ▭ 2013: TPH Excavation Extent
- ▭ Property Boundary for the Seattle Terminal Properties

Screening Criteria:

Chemical	Upland PSL (µg/L)	Shoreline PSL (µg/L)
DRO	500	500
GRO	800	800
ORO	500	500

Notes:

1. Exceedance factor is the most recent detection divided by the criteria rounded to two significant figures. Exceedance factors are only presented where the result exceeds the criterion.

- Monitoring wells 02MW07 and 02MW02 are located closest to the shoreline. Data were compared to the Shoreline PSLs, which are in some cases more stringent than the Upland PSLs. Data from all other wells were compared to the Upland PSLs.
- The Upland PSLs are a compilation of the federal or state Maximum Contaminant Levels (whichever is most conservative) and the MTCA Method B criteria. Where MTCA Method B criteria were not available, MTCA Method A criteria were selected.
- The Shoreline PSLs are the lowest of the ARARs, which include federal and state marine surface water concentrations protective of aquatic life and human health from drinking water and the consumption of seafood, protection of sediment, and protection of ambient air. The Shoreline PSL for each chemical was adjusted for background and the PQL in accordance with WAC 173-340-705(6), as appropriate.
- The most recent groundwater result for each chemical at each location was used for screening. The most recent samples were collected between 2013 and 2016.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:

ARAR = Applicable or Relevant and Appropriate Requirements	MTCA = Model Toxics Control Act
DRO = Diesel-range organics	ORO = Oil-range organics
GRO = Gasoline-range organics	PQL = Practical Quantitation Limit
µg/L = Micrograms per liter	PSL = Preliminary Screening Level
	TPH = Total petroleum hydrocarbons

N
0 20 40 80
Scale in Feet

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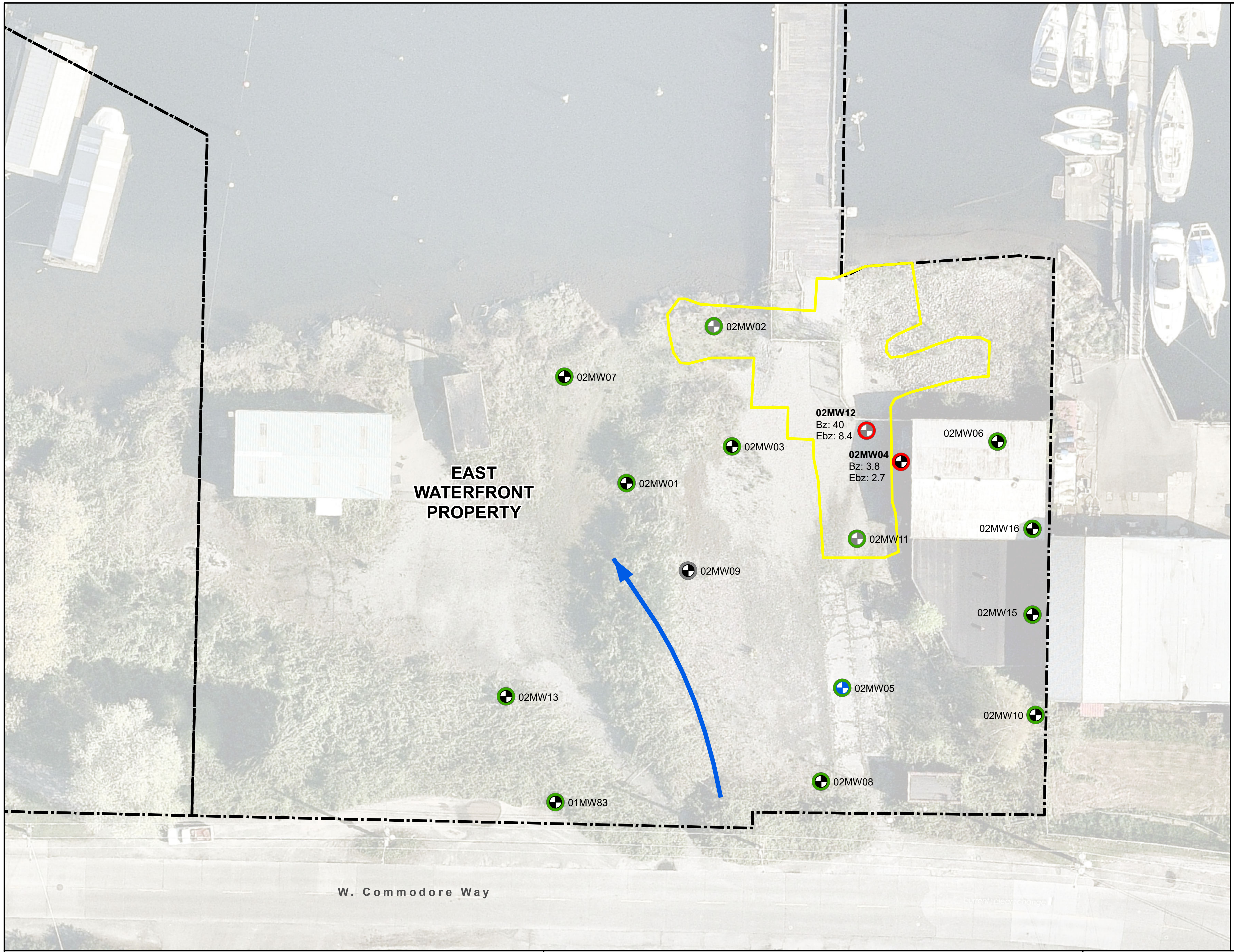
Figure 5.7
East Waterfront Property
TPH Distribution in Groundwater (2013–2016)

I:\GIS\Projects\Cantera-TOC\MXD\RI\RI Work Plan\Figure 5.7 East Waterfront TPH Distribution in Groundwater (2013–2016).mxd
3/8/2019



Legend

Monitoring Well Location with Water-Bearing Zone

- ◕ Shallow Zone Monitoring Well
- ◕ Intermediate Zone Monitoring Well
- ◕ Decommissioned Monitoring Well

Groundwater Sample Results

(Chemical results presented as exceedance factors)[1]

- 🟢 All Chemicals Less Than Criteria
- 🟡 One or More Chemicals Greater Than Criteria by ≤2 times
- 🔴 One or More Chemicals Greater Than Criteria by >2 times
- ● Not Analyzed for Specific Chemicals

Other Property Features

- ← Predominant Shallow Groundwater Flow Direction (SES 2014c)
- ▭ 2013: TPH Excavation Extent
- ▭ Property Boundary for the Seattle Terminal Properties

Screening Criteria:

Chemical	Upland PSL (µg/L)	Shoreline PSL (µg/L)
Benzene	5.0	0.44
Tolune	1,000	57
Ethylbenzene	70	29
Xylene (Total)	10,000	1,600

Notes:

1. Exceedance factor is the most recent detection divided by the criteria rounded to two significant figures. Exceedance factors are only presented where the result exceeds the criterion.

- Monitoring wells 02MW07 and 02MW02 are located closest to the shoreline. Data were compared to the Shoreline PSLs, which are in some cases more stringent than the Upland PSLs. Data from all other wells were compared to the Upland PSLs.
- The Upland PSLs are a compilation of the federal or state Maximum Contaminant Levels (whichever is most conservative) and the MTCA Method B criteria. Where MTCA Method B criteria were not available, MTCA Method A criteria were selected.
- The Shoreline PSLs are the lowest of the ARARs, which include federal and state marine surface water concentrations protective of aquatic life and human health from drinking water and the consumption of seafood, protection of sediment, and protection of ambient air. The Shoreline PSL for each chemical was adjusted for background and the PQL in accordance with WAC 173-340-705(6), as appropriate.
- The most recent groundwater result for each chemical at each location was used for screening. The most recent samples were collected between 2013 and 2016.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:

ARAR = Applicable or Relevant and Appropriate Requirements
BTEX = Benzene, toluene, ethylbenzene, and xylenes
Bz = Benzene
Ebz = Ethylbenzene
µg/L = Micrograms per liter
MTCA = Model Toxics Control Act
PQL = Practical Quantitation Limit
PSL = Preliminary Screening Level

N

0 20 40 80
Scale in Feet

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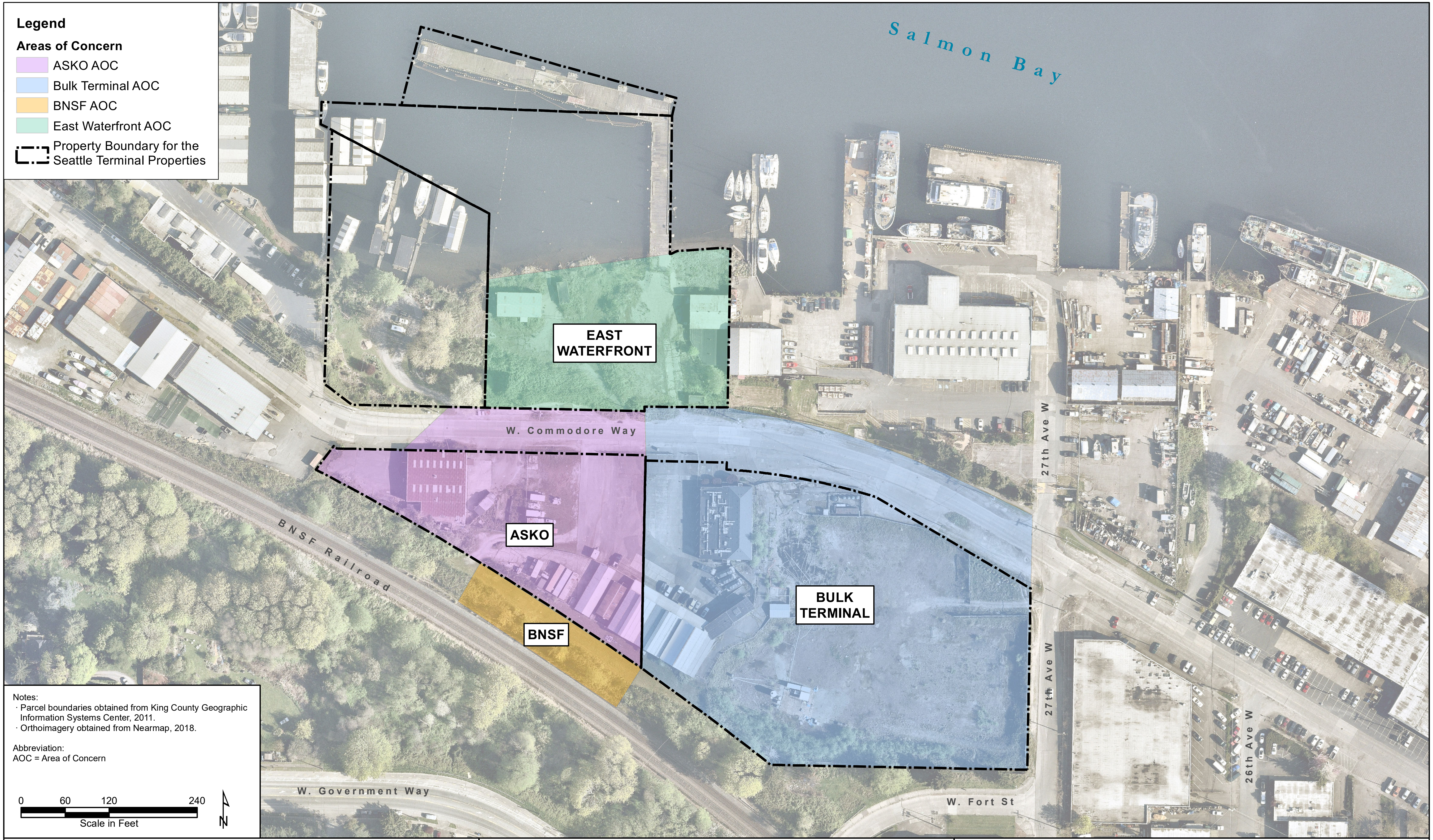
Supplemental Upland Remedial Investigation Work Plan
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 5.8
East Waterfront Property
BTEX Distribution in Groundwater (2013–2016)

I:\GIS\Projects\Cantera-TOC\MXD\RI\RI Work Plan\Figure 5.8 East Waterfront BTEX Distribution in Groundwater (2013–2016).mxd
3/8/2019



Notes:
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviation:
AOC = Area of Concern

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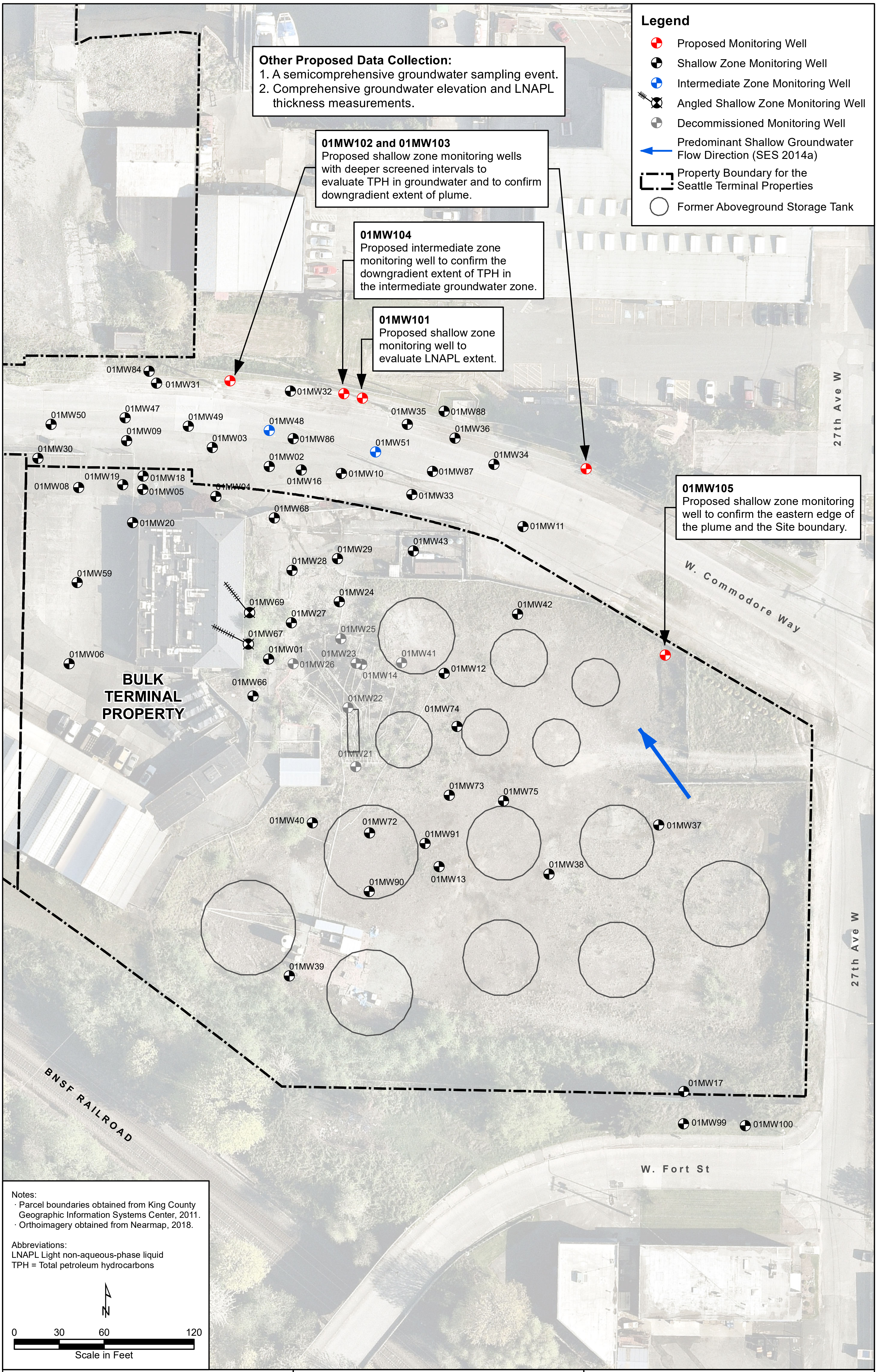
Supplemental Upland Remedial Investigation Work Plan
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 6.1
Areas of Concern

I:\GIS\Projects\Cantera-TOC\MXD\RI\RI Work Plan\Figure 6.1 Areas of Concern.mxd
3/8/2019



Legend

- 🔴 Proposed Monitoring Well
- ● Shallow Zone Monitoring Well
- 🔵 Intermediate Zone Monitoring Well
- ⊗ Angled Shallow Zone Monitoring Well
- ● Decommissioned Monitoring Well
- ← Predominant Shallow Groundwater Flow Direction (SES 2014a)
- ▭ Property Boundary for the Seattle Terminal Properties
- ○ Former Aboveground Storage Tank

Other Proposed Data Collection:

1. A semicomprehensive groundwater sampling event.
2. Comprehensive groundwater elevation and LNAPL thickness measurements.

01MW102 and 01MW103
Proposed shallow zone monitoring wells with deeper screened intervals to evaluate TPH in groundwater and to confirm downgradient extent of plume.

01MW104
Proposed intermediate zone monitoring well to confirm the downgradient extent of TPH in the intermediate groundwater zone.

01MW101
Proposed shallow zone monitoring well to evaluate LNAPL extent.

01MW105
Proposed shallow zone monitoring well to confirm the eastern edge of the plume and the Site boundary.

Notes:
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
LNAPL Light non-aqueous-phase liquid
TPH = Total petroleum hydrocarbons

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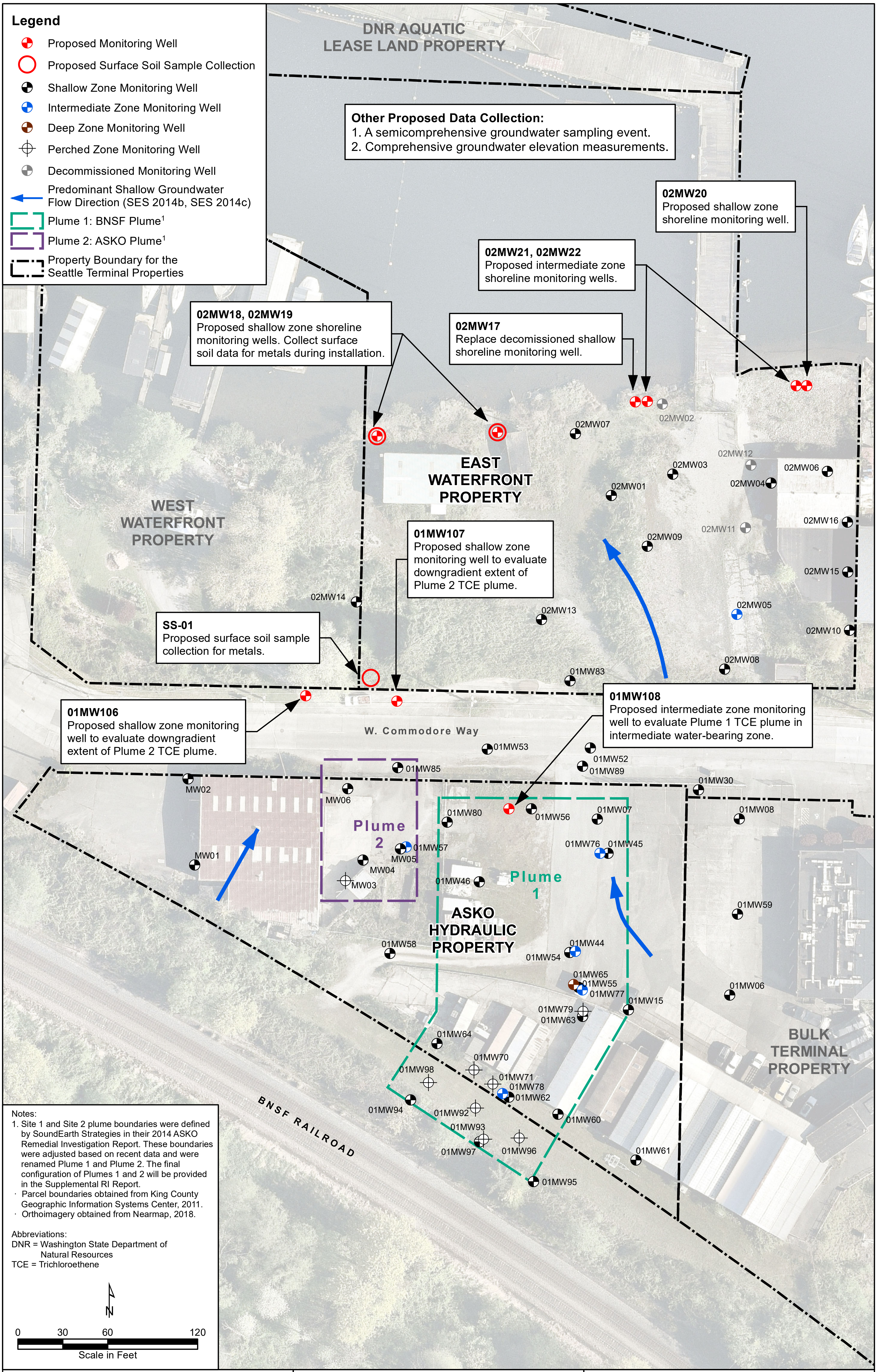
Supplemental Upland Remedial Investigation Work Plan
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 7.1
Bulk Terminal Data Gaps—
Proposed Supplemental Investigation

I:\GIS\Projects\Cantera-TOC\MXD\RI\RI Work Plan\Figure 7.1 Bulk Terminal Data Gaps-Proposed Supplemental Investigation.mxd
3/8/2019



Legend

●	Proposed Monitoring Well
○	Proposed Surface Soil Sample Collection
●	Shallow Zone Monitoring Well
●	Intermediate Zone Monitoring Well
●	Deep Zone Monitoring Well
⊕	Perched Zone Monitoring Well
●	Decommissioned Monitoring Well
←	Predominant Shallow Groundwater Flow Direction (SES 2014b, SES 2014c)
🟩	Plume 1: BNSF Plume[1]
🟪	Plume 2: ASKO Plume[1]
▭	Property Boundary for the Seattle Terminal Properties

Other Proposed Data Collection:
1. A semicomprehensive groundwater sampling event.
2. Comprehensive groundwater elevation measurements.

02MW20
Proposed shallow zone shoreline monitoring well.

02MW21, 02MW22
Proposed intermediate zone shoreline monitoring wells.

02MW18, 02MW19
Proposed shallow zone shoreline monitoring wells. Collect surface soil data for metals during installation.

02MW17
Replace decomissioned shallow shoreline monitoring well.

01MW107
Proposed shallow zone monitoring well to evaluate downgradient extent of Plume 2 TCE plume.

SS-01
Proposed surface soil sample collection for metals.

01MW108
Proposed intermediate zone monitoring well to evaluate Plume 1 TCE plume in intermediate water-bearing zone.

01MW106
Proposed shallow zone monitoring well to evaluate downgradient extent of Plume 2 TCE plume.

Notes:
1. Site 1 and Site 2 plume boundaries were defined by SoundEarth Strategies in their 2014 ASKO Remedial Investigation Report. These boundaries were adjusted based on recent data and were renamed Plume 1 and Plume 2. The final configuration of Plumes 1 and 2 will be provided in the Supplemental RI Report.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
DNR = Washington State Department of Natural Resources
TCE = Trichloroethene

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Supplemental Upland Remedial Investigation Work Plan
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 7.2
ASKO and East Waterfront Properties Data Gaps—Proposed Supplemental Investigation

I:\GIS\Projects\Cantera-TOC\MXD\RI\RI Work Plan\Figure 7.2 ASKO and East Waterfront Properties Data Gaps- Proposed Supplemental Investigation.mxd
3/8/2019

Time Oil Bulk Terminal PPA

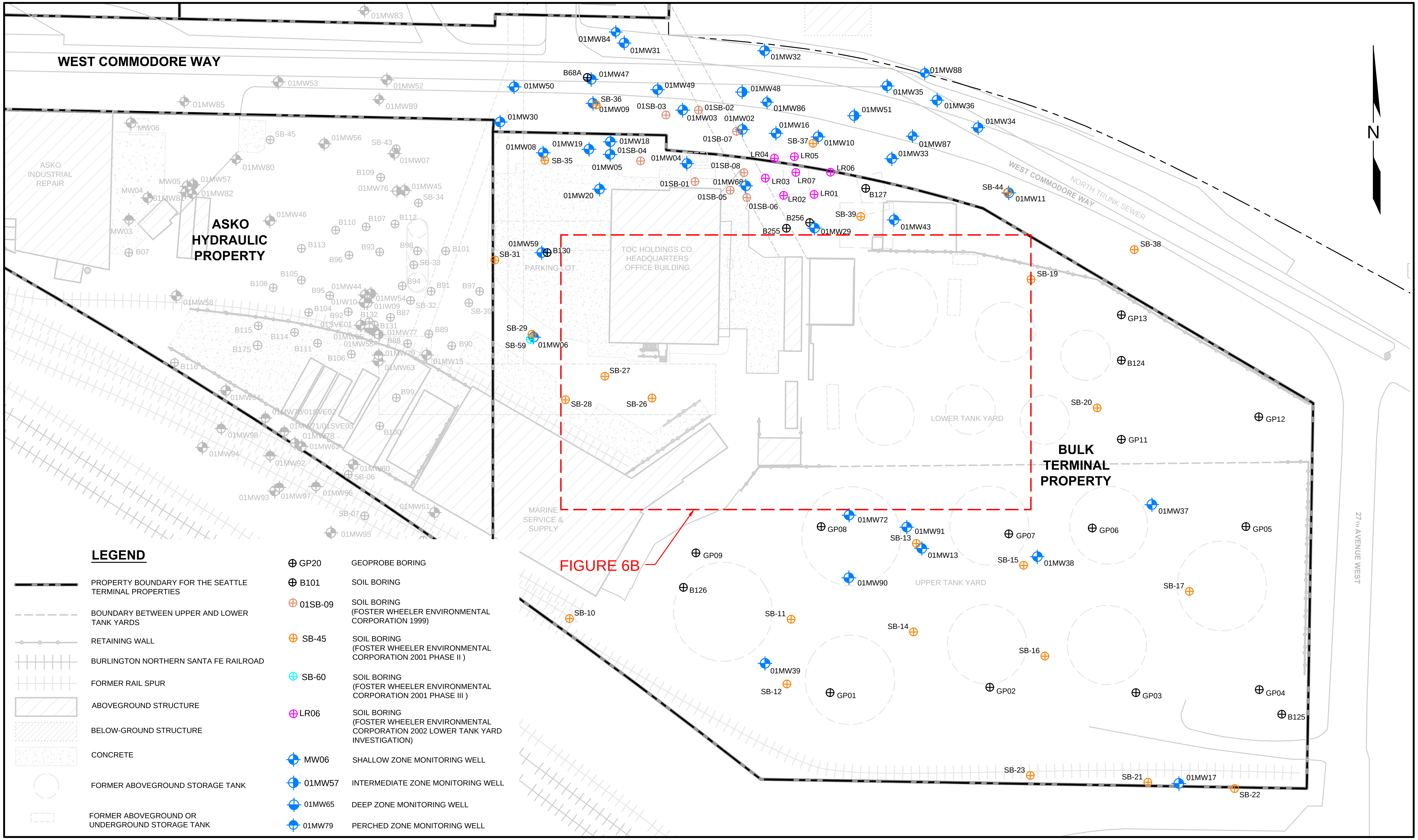
Supplemental Upland Remedial Investigation Work Plan

Appendix A

SoundEarth Strategies Figures and Tables from Remedial Investigation Reports

6/18/2014

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\BTP\RI\01-600_2014RI_EL_F.DWG



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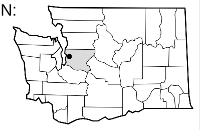
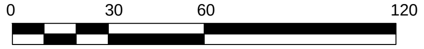
DATE: 06/28/13
DRAWN BY: NAC
CHECKED BY: JAB/TSB
CAD FILE: 01-600_2014RI_EL

PROJECT NAME: TOC HOLDINGS CO. BULK TERMINAL PROPERTY
SES PROJECT NUMBER: 0440-004
STREET ADDRESS: 2737 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

REGION:



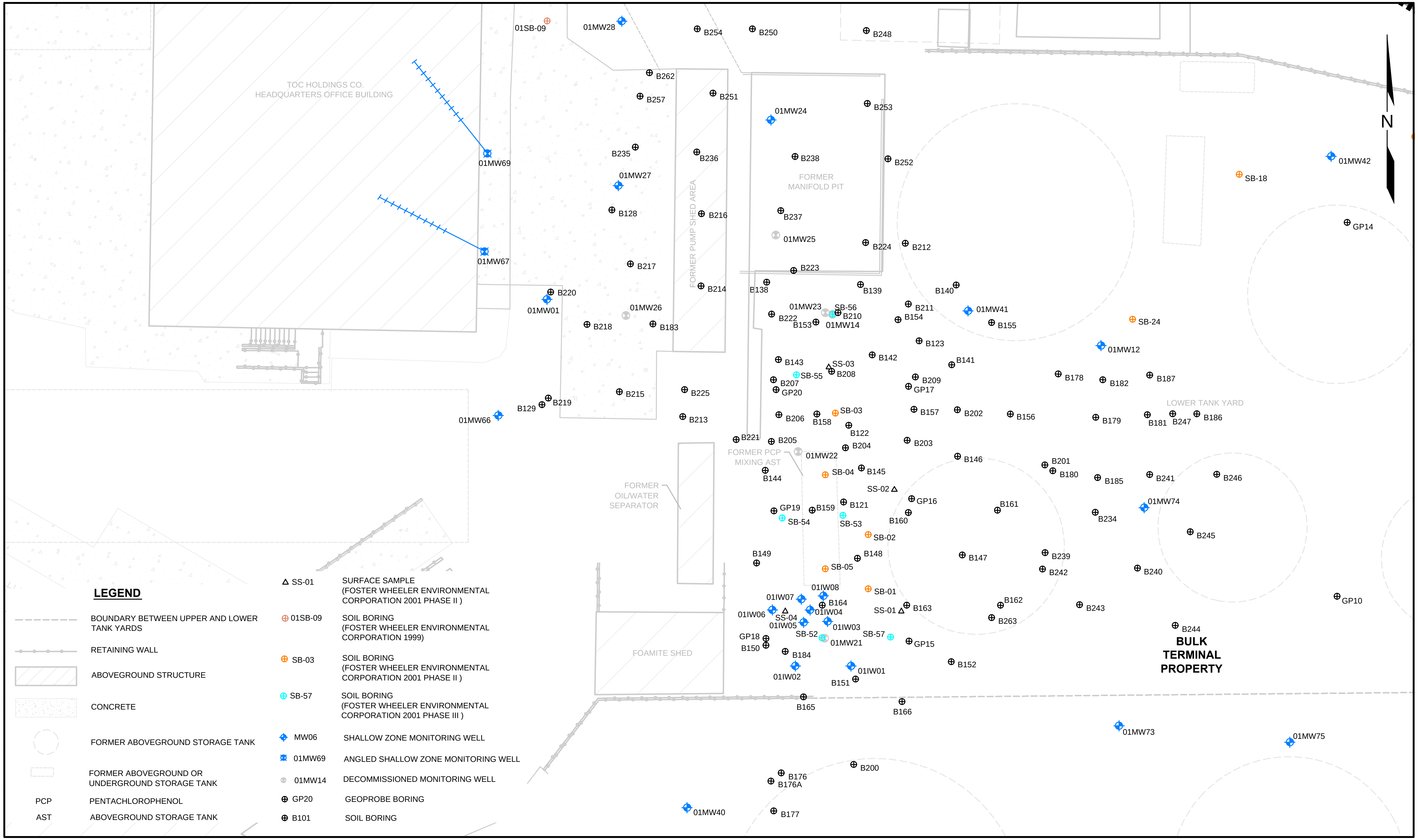


APPROXIMATE SCALE IN FEET

FIGURE 6A
SOIL BORING AND MONITORING WELL LOCATIONS

6/18/2014

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\BTP\RI\01-600_2014RI_EL_Z_F.DWG



LEGEND

- - - - -	BOUNDARY BETWEEN UPPER AND LOWER TANK YARDS
-·-·-·-	RETAINING WALL
▨	ABOVEGROUND STRUCTURE
░	CONCRETE
◌	FORMER ABOVEGROUND STORAGE TANK
▭	FORMER ABOVEGROUND OR UNDERGROUND STORAGE TANK
PCP	PENTACHLOROPHENOL
AST	ABOVEGROUND STORAGE TANK

△ SS-01	SURFACE SAMPLE (FOSTER WHEELER ENVIRONMENTAL CORPORATION 2001 PHASE II)
⊕ 01SB-09	SOIL BORING (FOSTER WHEELER ENVIRONMENTAL CORPORATION 1999)
⊕ SB-03	SOIL BORING (FOSTER WHEELER ENVIRONMENTAL CORPORATION 2001 PHASE II)
⊕ SB-57	SOIL BORING (FOSTER WHEELER ENVIRONMENTAL CORPORATION 2001 PHASE III)
◆ MW06	SHALLOW ZONE MONITORING WELL
⊠ 01MW69	ANGLED SHALLOW ZONE MONITORING WELL
● 01MW14	DECOMMISSIONED MONITORING WELL
⊕ GP20	GEOPROBE BORING
⊕ B101	SOIL BORING

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DATE: 06/28/13
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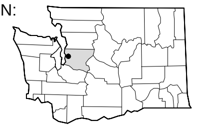
CHECKED BY: JAB/TSB
CAD FILE: 01-600_2014RI_EL_Z

PROJECT NAME: TOC HOLDINGS CO. BULK TERMINAL PROPERTY
SES PROJECT NUMBER: 0440-004
STREET ADDRESS: 2737 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

REGION:

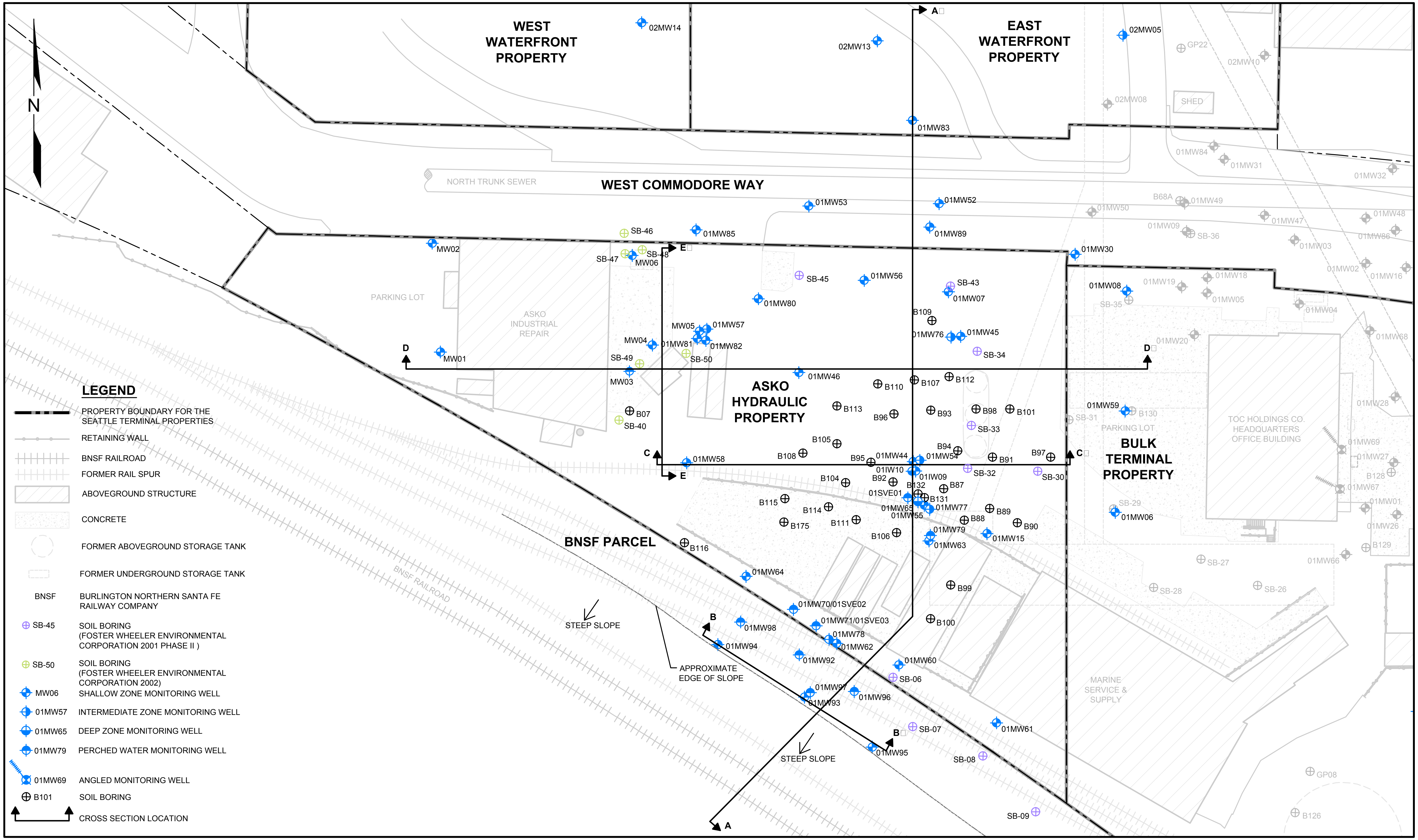


0 10 20 40
APPROXIMATE SCALE IN FEET

FIGURE 6B
SOIL BORING AND MONITORING WELL LOCATIONS - ZOOM IN

5/14/2014

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2013\ASKO\RI\01-600_2013RI_BASE_ASKO_F.DWG



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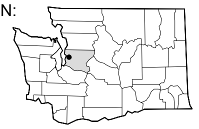
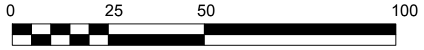
DATE: 05/14/14
DRAWN BY: NAC/BLR
CHECKED BY: PJK/TSB
CAD FILE: 01-600_2013RI_BASE_ASKO

PROJECT NAME: TOC HOLDINGS CO. ASKO HYDRAULIC PROPERTY
PROJECT NUMBER: 0440-004
STREET ADDRESS: 2805 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

REGION:



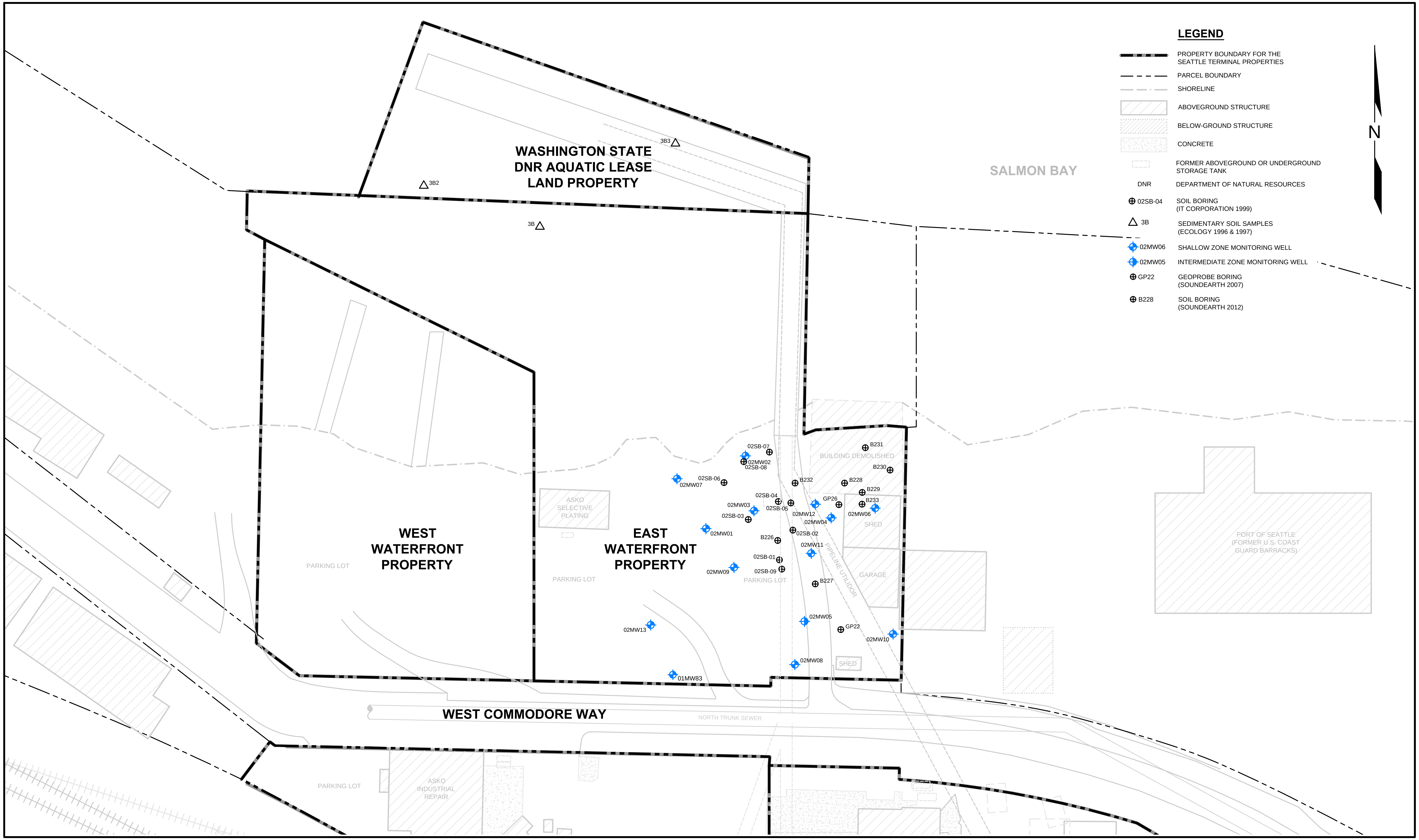


APPROXIMATE SCALE IN FEET

FIGURE 5
EXPLORATION LOCATION PLAN

7/21/2014

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\EWP\RI\01-600_2014RI_EL.DWG



SoundEarth Strategies
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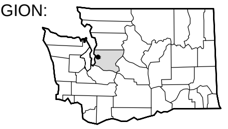
DATE: 11/19/12
DRAWN BY: NAC
CHECKED BY: PJK/TSB
CAD FILE: 01-600_2014RI_EL

PROJECT NAME: EAST WATERFRONT PROPERTY
SES PROJECT NUMBER: 0440-004
STREET ADDRESS: 2750 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

REGION:



0 40 80 160
APPROXIMATE SCALE IN FEET

FIGURE 7
SOIL BORING AND MONITORING WELL LOCATIONS

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10/24/2016

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2016\TECHMEMO\01-600_2016_FIG3.DWG

LEGEND

━━	PROPERTY BOUNDARY FOR THE SEATTLE TERMINAL PROPERTIES
2012	EXCAVATION ELEVATION:
🟩	GREATER THAN 45 FEET
🟪	GREATER THAN OR EQUAL TO 44 FEET
🟦	GREATER THAN OR EQUAL TO 42 FEET
🟨	GREATER THAN OR EQUAL TO 41 FEET
🟫	GREATER THAN OR EQUAL TO 39 FEET
🟧	GREATER THAN OR EQUAL TO 37 FEET
🟥	GREATER THAN OR EQUAL TO 32 FEET
⬜	2011 HOT SPOT EXCAVATION AREA
- - -	DISSOLVED-PHASE PCP TREATMENT AREA AND POINT OF COMPLIANCE BOUNDARY
⊕ B101	SOIL BORING
⊕ GP17	GEOPROBE BORING
▲ P7-EX01-SSW01	2011 HOT SPOT EXCAVATION SAMPLE POINT
△ PEC-SS-02	CONFIRMATION SAMPLE LOCATION (FOSTER WHEELER 2002)
⊞ SS-01	SURFACE SAMPLE LOCATION (FOSTER WHEELER 2001)
⊕ SB-01	SOIL BORING (FOSTER WHEELER 2001)
○	2014 SOIL BORING
CONCENTRATIONS OF PCP IN SOIL:	
●	BELOW MTCA METHOD B CLEANUP LEVEL (2.5 mg/kg)
mg/kg	MILLIGRAMS PER KILOGRAM
MTCA	WASHINGTON STATE MODEL TOXICS CONTROL ACT
NAVD88	NORTH AMERICAN VERTICAL DATUM 1988
PCP	PENTACHLOROPHENOL
□	DETECTED, BUT BELOW TREATMENT STANDARDS FOR HAZARDOUS WASTES (7.4 mg/kg) AND LESS THAN 10 TIMES THE UNIVERSAL TREATMENT STANDARD

ELEVATION IN FEET ABOVE MEAN SEA LEVEL (NAVD88)

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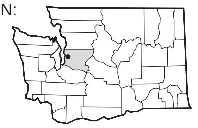
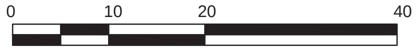
DATE: 10/21/16
DRAWN BY: NAC
CHECKED BY: TSB
CAD FILE: 01-600_2016_TECHMEMO

PROJECT NAME: BULK TERMINAL PROPERTY
PROJECT NUMBER: 0440-004
STREET ADDRESS: 2737 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

REGION:



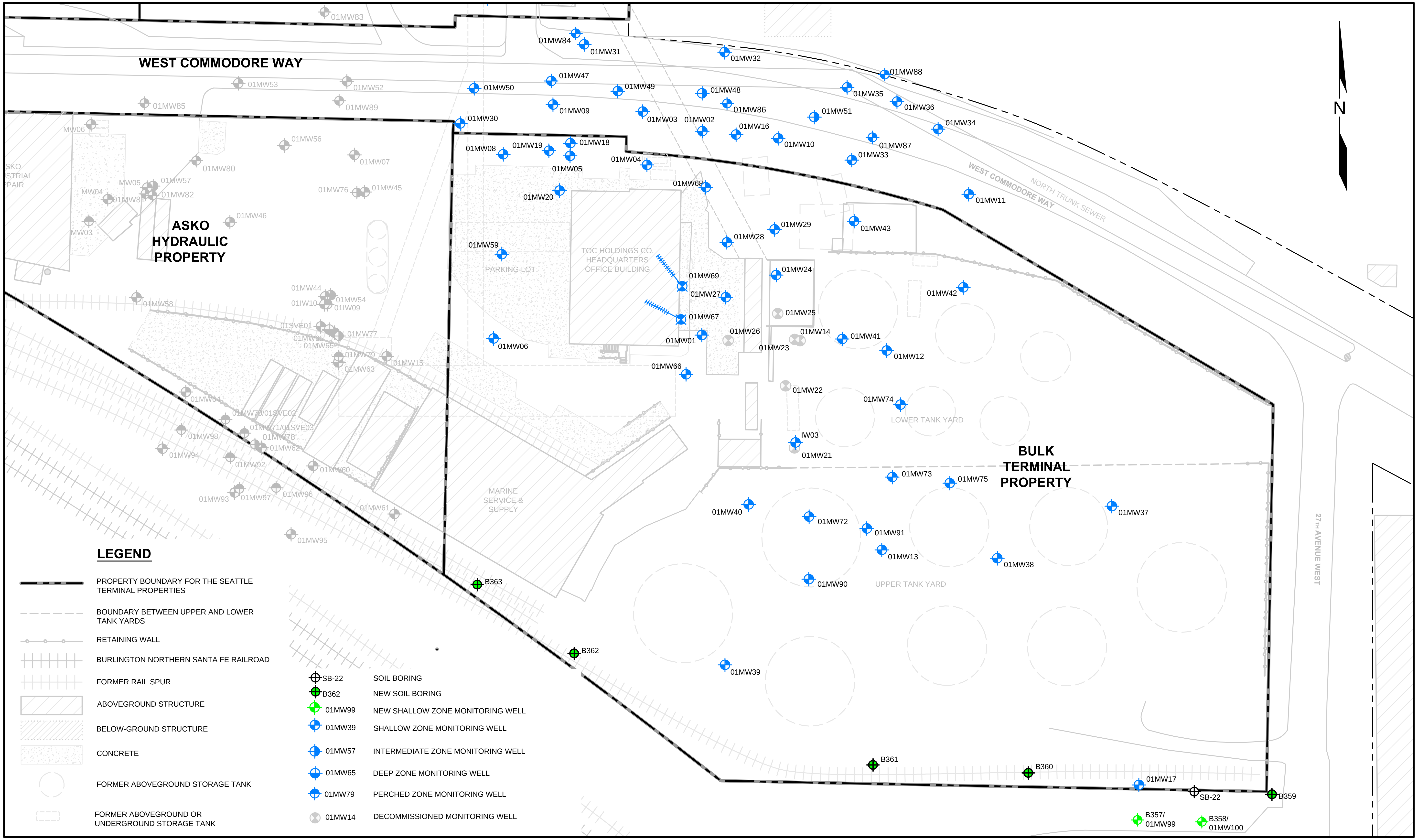


APPROXIMATE SCALE IN FEET

FIGURE 3

SITE PLAN WITH SOIL SAMPLE LOCATIONS FOR 2011/2012 EXCAVATIONS AND 2014 SUBSURFACE INVESTIGATION FOR PCP

SOUNDEARTHINC.COM



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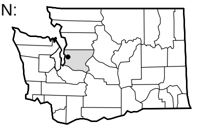
DATE: 4/14/15
DRAWN BY: NAC/JQC
CHECKED BY: JAB/TSB
CAD FILE: 01-600_BTP_2015SI_FIG2

PROJECT NAME: TOC HOLDINGS CO. BULK TERMINAL PROPERTY
PROJECT NUMBER: 0440-004
STREET ADDRESS: 2737 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

REGION:



0 30 60 120
APPROXIMATE SCALE IN FEET

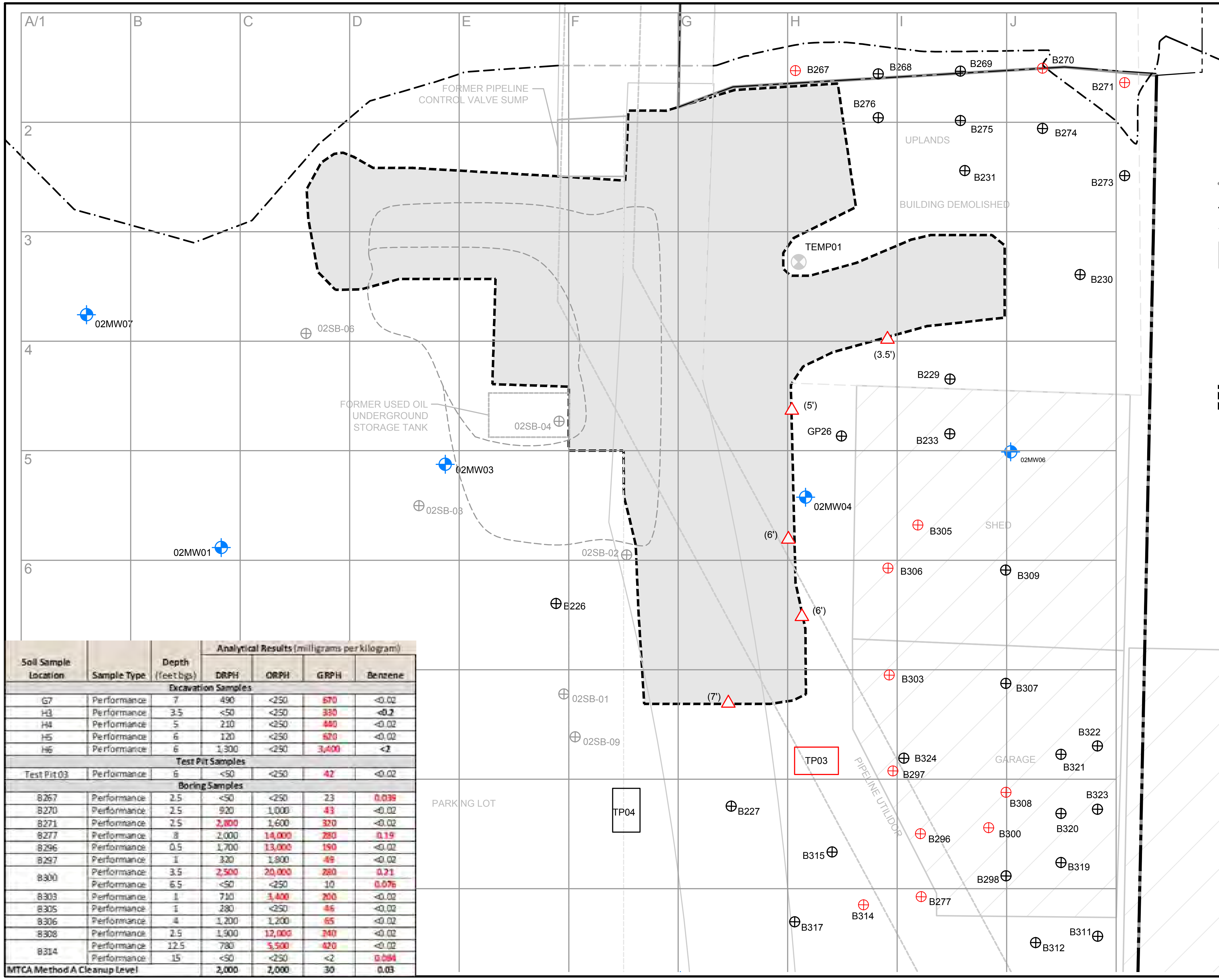
FIGURE 2
EXPLORATION LOCATION PLAN

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2015\BTP\SI\01-600_BTP_2015SI_FIG2.DWG
7/28/2015

2/20/2015

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\EWP\IA\01-600_2014IA_RPC.DWG

DRAFT- ISSUED FOR CLIENT REVIEW



Soil Sample Location	Sample Type	Depth (feet bgs)	Analytical Results (milligrams per kilogram)			
			DRPH	ORPH	GRPH	Benzene
Excavation Samples						
G7	Performance	7	490	<250	670	<0.02
H3	Performance	3.5	<50	<250	330	<0.2
H4	Performance	5	210	<250	440	<0.02
H5	Performance	6	120	<250	620	<0.02
H6	Performance	6	1,300	<250	3,400	<2
Test Pit Samples						
Test Pit 03	Performance	6	<50	<250	42	<0.02
Boring Samples						
B267	Performance	2.5	<50	<250	23	0.039
B270	Performance	2.5	920	1,000	43	<0.02
B271	Performance	2.5	2,800	1,600	320	<0.02
B277	Performance	8	2,000	14,000	280	0.19
B296	Performance	0.5	1,700	13,000	190	<0.02
B297	Performance	1	320	1,800	49	<0.02
B300	Performance	3.5	2,500	20,000	280	0.21
	Performance	6.5	<50	<250	10	0.076
B303	Performance	1	710	3,400	200	<0.02
B305	Performance	1	280	<250	46	<0.02
B306	Performance	4	1,200	1,200	65	<0.02
B308	Performance	2.5	1,900	12,000	240	<0.02
B314	Performance	12.5	780	5,500	420	<0.02
	Performance	15	<50	<250	<2	0.084
MTCA Method A Cleanup Level			2,000	2,000	30	0.03

N

LEGEND

▬ ▬	PROPERTY BOUNDARY
— · —	SHORELINE (ORDINARY HIGH WATER)
- - -	EXTENT OF FORMER EXCAVATION
▨	ABOVEGROUND STRUCTURE
⊕ 02MW06	SHALLOW ZONE MONITORING WELL
⊕ 02MW05	INTERMEDIATE ZONE MONITORING WELL
⊕ B233	BORING
⊕ 02SB-04	BORING
▨	FINAL 2013 EXCAVATION AREA
△	2013 PERFORMANCE SAMPLE LOCATION (DEPTH)
TP01	2013 TEST PIT
A/1	20' X 20' SOIL SAMPLING GRID
MTCA	WASHINGTON STATE MODEL TOXICS CONTROL ACT
DRPH	DIESEL-RANGE PETROLEUM HYDROCARBONS
ORPH	OIL-RANGE PETROLEUM HYDROCARBONS
GRPH	GASOLINE-RANGE PETROLEUM HYDROCARBONS
RED	PERFORMANCE SAMPLE LOCATIONS/ CONCENTRATION DETECTED ABOVE MTCA METHOD A CLEANUP LEVEL

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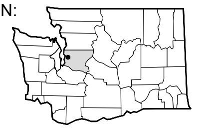
DATE: 02/18/15
DRAWN BY: NAC/JQC
CHECKED BY: PJK/TSB
CAD FILE: 01-600_2014IA_RPC

PROJECT NAME: EAST WATERFRONT PROPERTY
PROJECT NUMBER: 0440-004
STREET ADDRESS: 2750 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

REGION:



0 10 20 40
APPROXIMATE SCALE IN FEET

FIGURE 8
EXCAVATION AND BORING SAMPLE LOCATIONS WITH RESIDUAL PETROLEUM CONTAMINATION

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SoundEarth Strategies

DFCR

Table 3
Interim Action
Soil Analytical Results for TPH, BTEX, and MTBE
TOC Holdings Co.
East Waterfront Property
2750 West Commodore Way
Seattle, Washington

Grid Location	Interim Action Location	Soil Sample ID	Sample Type	Sampled By	Date Sampled	Depth (feet bgs)	**Analytical Results** (milligrams per kilogram)							
							DRPH(1)	ORPH(1)	GRPH(2)	Benzene(3)	Toluene(3)	Ethylbenzene(3)	Total Xylenes(3)	MTBE(3)
C2	Excavation EX01	C02-EX01-NSW01-05.5	Confirmation	SoundEarth	10/28/2013	5.5	<50	<250	4.7	<0.02	<0.02	<0.02	<0.06	--
		C02-EX01-WSW01-03.5	Confirmation			3.5	<50	<250	15	<0.02	<0.02	0.10	0.088	--
		C02-EX01-BTM01-06.5	Confirmation			6.5	<50	<250	12	<0.02	<0.02	0.067	<0.06	--
C3		C03-EX01-SSW01-03.5	Confirmation		10/28/2013	3.5	200[x]	1,300	15	<0.02	<0.02	<0.02	<0.06	--
D2		D02-EX01-NSW01-03	Confirmation		10/28/2013	3	570[x]	1,500	12	<0.02	<0.02	<0.02	<0.06	--
D3		D03-EX01-SSW01-04	Confirmation		10/28/2013	4	140[x]	<250	13	<0.02	<0.02	0.13	0.083	--
E2		E02-EX01-NSW03-05	Confirmation		10/28/2013	5	95	<250	10	<0.02	<0.02	<0.02	<0.06	--
E3		E03-EX01-WSW01-07	Confirmation		10/10/2013	7	<50	<250	4.2	<0.02	<0.02	<0.02	<0.06	--
		E03-EX01-BTM01-04	Performance			4	1,500	<250	**660**	<0.02[j]	<0.05	<0.05	<0.2	<0.05
		E03-EX01-BTM02-08.5	Confirmation		10/11/2013	8.5	<50	<250	5.9	<0.02	<0.02	<0.02	0.076	--
		E03-EX01-BTM04-09	Confirmation		10/28/2013	9	<50	<250	<2	<0.02	<0.02	<0.02	<0.06	--
E4		E04-EX01-WSW02-07	Performance		10/11/2013	7	100[x]	<250	**120**	<0.02	<0.02	1.1	1.3	--
		E04-EX01-BTM01-07.5	Confirmation		10/16/2013	7.5	<50	<250	<2	<0.02	<0.02	<0.02	<0.06	--
F1		F01-EX01-NSW01-07	Confirmation		10/3/2013	7	<50	<250	17	<0.02	0.093	0.18	0.14	--
F2		F02-EX01-NSW03-03	Confirmation		10/28/2013	3	<50	<250	15	<0.02	0.16	0.10	0.17	--
		F02-EX01-WSW01-05	Performance		10/9/2013	5	940[x]	<250	**2,300**	<0.03	0.12	**24**	**14**	<0.05
		F02-EX01-WSW01-06	Confirmation		10/3/2013	6	<50	<250	9.0	<0.02	0.063	0.17	0.11	--
		F02-EX01-BTM01-10	Confirmation			10	<50	<250	<2	<0.02	<0.02	<0.02	<0.06	--
F3		F03-EX01-BTM01-07	Performance		10/9/2013	7	2,000[x]	<250	**3,300**	**<2**	**24**	**88**	**15**	--
		F03-EX01-BTM02-11	Performance		10/10/2013	11	<50	<250	18	**0.54**	0.24	0.39	0.73	--
		F03-EX01-BTM03-12	Confirmation		10/24/2013	12	<50	<250	<2	<0.02	<0.02	<0.02	<0.06	--
F4		F04-EX01-BTM02-07	Performance		10/10/2013	7	<50	<250	**120**	**0.30**	1.1	2.6	1.8	--
		F04-EX01-BTM03-08	Performance		10/16/2013	8	<50	<250	10	**0.14**	0.16	0.073	0.16	--
		F04-EX01-BTM04-15	Confirmation		10/17/2013	15	<50	<250	<2	<0.02	<0.02	<0.02	<0.06	--
F5		F05-EX01-BTM04-11	Confirmation		10/11/2013	11	<50	<250	2.7	<0.02	<0.02	<0.02	<0.06	--
		F05-EX01-WSW01-07	Confirmation		10/14/2013	7	<50	<250	<2	<0.02	<0.02	<0.02	<0.06	--
F6		F06-EX01-BTM01-07	Performance		10/11/2013	7	84[x]	<250	**2,100**	**<2**	6.7	**28**	**180**	--
		F06-EX01-BTM03-11	Confirmation			11	<50	<250	<2	<0.02	<0.02	<0.02	<0.06	--
		F06-EX01-BTM02-12	Confirmation		10/14/2013	12	<50	<250	<2	<0.02	<0.02	<0.02	<0.06	
		F06-EX01-SSW01-08	Confirmation			8	<50	<250	5.0	<0.02	<0.02	<0.02	<0.06	--
G2		G02-EX01-BTM01-07	Confirmation		10/7/2013	7	<50	<250	<2	<0.02	<0.02	<0.02	<0.06	--
G3		G03-EX01-BTM01-08	Performance		10/8/2013	8	960[x]	<250	**3,100**	**<1**	**17**	**41**	**19**	--
		G03-EX01-BTM02-12.5	Confirmation			12.5	<50	<250	<2	<0.02	<0.02	<0.02	<0.06	--
G4		G04-EX01-BTM01-12	Confirmation		10/8/2013	12	<50	<250	<2	<0.02	<0.02	<0.02	<0.06	--
		G04-EX01-BTM02-03	Performance		10/10/2013	3	230[x]	<250	**780**	**<0.2**	<0.2	**8.7**	7.3	--
		G04-EX01-BTM03-13.5	Performance		10/11/2013	13.5	<50	<250	**82**	**0.21**	0.51	5.5	1.0	--
		G04-EX01-BTM04-14	Confirmation		10/16/2013	14	<50	<250	<2	<0.02	<0.02	<0.06	0.2	--
MTCA Cleanup Level for Soil(4)							**2,000**	**2,000**	**30**	**0.03**	**7**	**6**	**9**	**0.1**

DFCR

Table 3
Interim Action
Soil Analytical Results for TPH, BTEX, and MTBE
TOC Holdings Co.
East Waterfront Property
2750 West Commodore Way
Seattle, Washington

Grid Location	Interim Action Location	Soil Sample ID	Sample Type	Sampled By	Date Sampled	Depth (feet bgs)	Analytical Results (milligrams per kilogram)							
							DRPH(1)	ORPH(1)	GRPH(2)	Benzene(3)	Toluene(3)	Ethylbenzene(3)	Total Xylenes(3)	MTBE(3)
G5	Excavation EX01	G05-EX01-BTM03-06	Confirmation	SoundEarth	10/10/2013	6	<50	<250	24	<0.02	0.11	0.32	0.16	--
		G05-EX01-BTM03-06	Confirmation			6	<50	<250	24	<0.02	0.11	0.32	0.16	--
		G05-EX01-BTM05-07	Performance			7	<50	<250	200	<0.02	0.60	1.6	1.7	--
		G05-EX01-BTM07-11	Performance		10/14/2013	11	<50	<250	<2	0.044	<0.02	0.10	0.25	--
		G05-EX01-BTM09-12	Performance		10/16/2013	12	<50	<250	2.9	0.033	<0.02	0.14	0.20	--
		G05-EX01-BTM11-16	Confirmation		10/17/2013	16	<50	<250	2.6	<0.02	<0.02	0.029	<0.06	--
		G05-EX01-ESW02-07	Confirmation		10/10/2013	7	<50	<250	2.5	<0.02	<0.02	<0.02	<0.06	--
G6		G06-EX01-BTM03-10.5	Confirmation		10/14/2013	10.5	<50	<250	<2	<0.02	<0.02	0.092	<0.06	--
G7		G07-EX01-BTM01-12	Confirmation		10/15/2013	12	<50	<250	<2	<0.02	<0.02	<0.02	<0.06	--
		G07-EX01-SSW01-07	Performance			7	490	<250	670	<0.02	<0.02	1.8	1.5	--
H2		H02-EX01-BTM01-05	Confirmation		10/7/2013	5	<50	<250	<2	<0.02	<0.02	<0.02	<0.06	--
		H02-EX01-ESW01-04	Confirmation			4	<50	<250	3.5	<0.02	0.040	0.068	<0.06	--
H3		H03-EX01-NSW01-05.5	Confirmation		10/8/2013	5.5	<50	<250	<2	<0.02	<0.02	<0.02	<0.06	--
		H03-EX01-SSW01-3.5	Performance			3.5	<50	<250	330	**<0.2**	1.2	3.9	4.2	--
		H03-EX01-BTM01-06.5	Confirmation			6.5	<50	<250	<2	<0.02	<0.02	<0.02	<0.06	--
H4		H04-EX01-ESW01-05	Performance		10/10/2013	5	210[x]	<250	440	<0.02	0.89	3.9	4.7	--
H5		H05-EX01-ESW01-06	Performance		10/10/2013	6	120[x]	<250	620	<0.02[j]	<0.05	5.2	0.14	<0.05
H6		H06-EX01-ESW02-06	Performance		10/15/2013	6	1,300[x]	<250	3,400	**<2**	<2	23	49	--
		H06-EX01-ESW01-08	Confirmation			8	<50	<250	<2	<0.02	0.030	<0.02	<0.06	--
		H06-EX01-ESW03-15	Confirmation			15	<50	<250	<2	<0.02	<0.02	<0.02	<0.06	--
		H06-EX01-ESW04-16	Confirmation			16	<50	<250	3.2	<0.02	<0.02	0.039	<0.06	--
I3		I03-EX01-ESW01-05	Confirmation		10/7/2013	5	<50	<250	<2	<0.02	<0.02	<0.02	<0.06	--
		I03-EX01-NSW01-05	Confirmation			5	<50	<250	<2	<0.02	<0.02	<0.02	<0.06	--
		I03-EX01-BTM01-06	Confirmation			6	<50	<250	<2	<0.02	<0.02	<0.02	<0.06	--
		I03-EX01-SSW01-05	Confirmation			5	<50	<250	<2	<0.02	<0.02	<0.02	<0.06	--
MTCA Cleanup Level for Soil(4)							**2,000**	**2,000**	**30**	**0.03**	**7**	**6**	**9**	**0.1**

NOTES:

Bold denotes concentration below laboratory detection limit, but exceeding the MTCA cleanup level for soil; the detection limit has been raised due to high concentrations of associated analytes requiring dilution.

Red denotes concentration exceeds MTCA cleanup level.

Sample analyses conducted by Friedman & Bruya, Inc. of Seattle, Washington.

(1) Analyzed by Method NWTPH-Dx.

(2) Analyzed by Method NWTPH-Gx.

(3) Analyzed by EPA Method 8021B or 8260B.

(4) MTCA Cleanup Regulation, Chapter 173-340-900 of WAC, Table 740-1 Method A Soil Cleanup Levels for Unrestricted Land Uses.

Laboratory Note:

[j] The result is below normal reporting limits. The value reported is an estimate.

[x] The sample chromatographic pattern does not resemble the fuel standard used for quantitation.

-- = not analyzed/not applicable

< = not detected at a concentration exceeding the laboratory reporting limit

bgs = below ground surface

BTEX = benzene, toluene, ethylbenzene, and total xylenes

DRPH = diesel-range petroleum hydrocarbons

EPA = United States Environmental Protection Agency

GRPH = gasoline-range petroleum hydrocarbons

MTBE = methyl tertiary-butyl ether

MTCA = Washington State Model Toxics Control Act

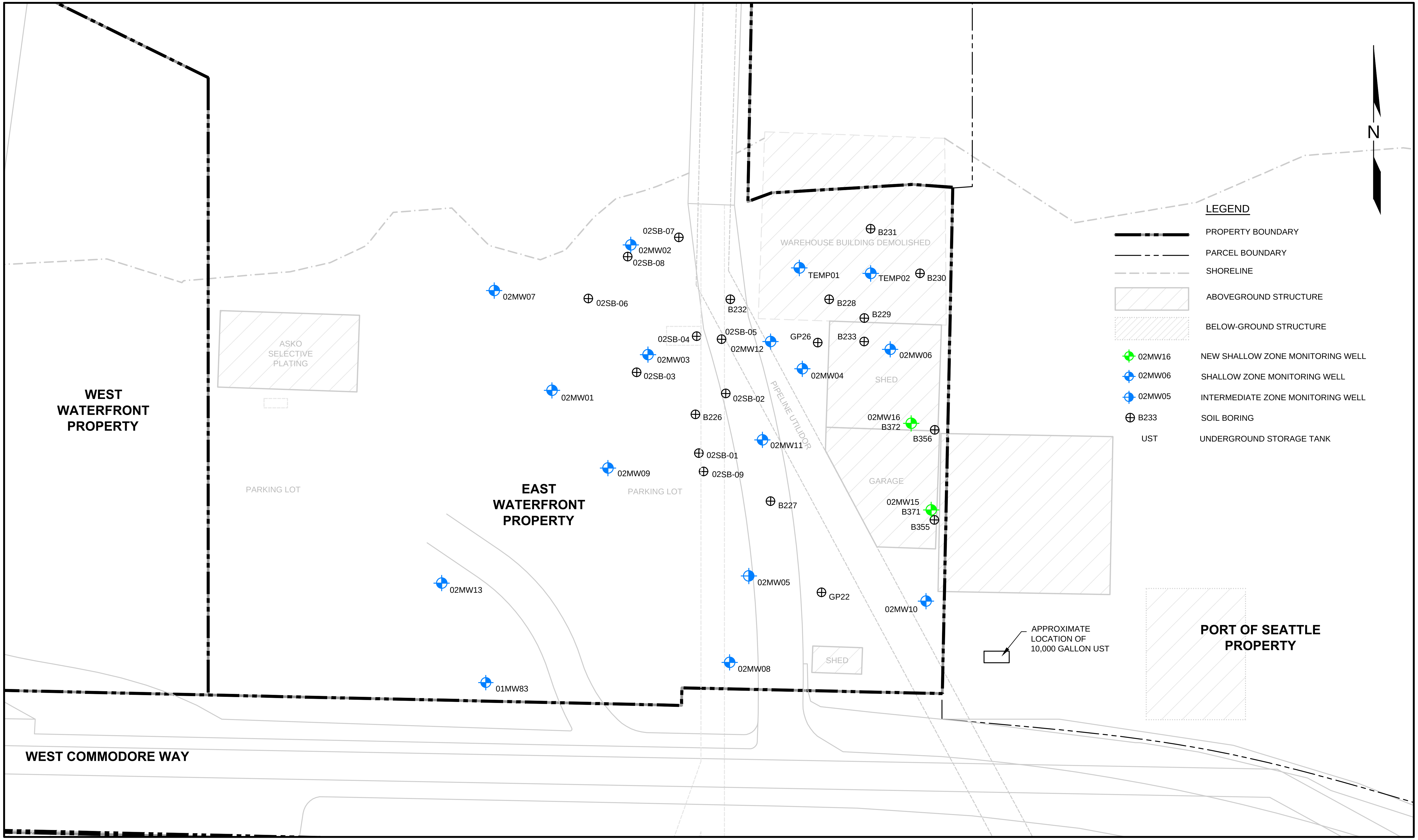
NWTPH = Northwest Total Petroleum Hydrocarbon

ORPH = oil-range petroleum hydrocarbons

SoundEarth = SoundEarth Strategies, Inc.

TPH = total petroleum hydrocarbons

WAC = Washington Administrative Code



P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2015\EWP\SI\01-600_2015_EL.DWG

10/28/2015

SoundEarth Strategies
WWW.SOUNDEARTHINC.COM

DATE: 07/27/15
DRAWN BY: NAC/JQC
CHECKED BY: PJK/TSB
CAD FILE: 01-600_2015_EL

PROJECT NAME: EAST WATERFRONT PROPERTY
SES PROJECT NUMBER: 0440-004
STREET ADDRESS: 2750 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

REGION:

0 20 40 80
APPROXIMATE SCALE IN FEET

FIGURE 2
EXPLORATION LOCATION PLAN

Time Oil Bulk Terminal PPA

Supplemental Upland Remedial Investigation Work Plan

Appendix B

Identification of Site COPCs

Table B.1

Frequency of Exceedance for Bulk Terminal Property Vadose Zone Soil^{1}

			Information about Dataset					Information about Detected Exceedances			Information about Non-Detects		
Analytes	CAS No.	Unit	Number of Results	Percent Detected	Maximum Detected Value^{2}	Location of Maximum Detect	Depth of Maximum Detect	Most Stringent Preliminary Screening Level - Vadose Zone^{3}	Percent of Detects Exceeding Criteria	Exceedance Factor^{4}	Number of Non-Detects	Percent of Non-Detects	Retained as a COPC?
Metals													
Arsenic	7440-38-2	mg/kg	15	93%	14	GP04	8 feet	20	None	None	1	6.7%	No; no exceedances.
Barium	7440-39-3	mg/kg	15	100%	140	GP04	8 feet	100	33%	1.4	None	None	No; no sources present on Bulk Terminal.
Cadmium	7440-43-9	mg/kg	15	None	None	None	None	0.77	None	None	15	100%	No; no exceedances.
Chromium Total	7440-47-3	mg/kg	15	100%	58	GP02	8 feet	48	33%	1.2	None	None	No; no sources present on Bulk Terminal.
Lead	7439-92-1	mg/kg	15	100%	5.8	GP08	2.5 feet	50	None	None	None	None	No; no exceedances.
Mercury	7439-97-6	mg/kg	15	None	None	None	None	0.25	None	None	15	100%	No; no exceedances.
Selenium	7782-49-2	mg/kg	15	None	None	None	None	0.5	None	None	15	100%	No; no exceedances.
Silver	7440-22-4	mg/kg	15	None	None	None	None	0.1	None	None	15	100%	No; no exceedances.
Total Petroleum Hydrocarbons													
Gasoline-Range Organics	TPHG	mg/kg	109	39%	9,300	GP10	7 feet	30	28%	310	66	61%	Yes.
Diesel-Range Organics	TPHD	mg/kg	111	33%	32,000	B336	7 feet	260	31%	120	74	67%	Yes.
Oil-Range Organics	TPHO	mg/kg	111	11.7%	13,000	B330	1 feet	2,000	3.6%	6.5	98	88%	No; exceeds in less than 5 percent of samples.
Volatile Organic Compounds													
Acetone	67-64-1	mg/kg	33	21%	10	GP10	7 feet	29	None	None	26	79%	No; no exceedances.
Benzene	71-43-2	mg/kg	109	21%	86	B338	5 feet	0.02	18%	4,300	86	79%	Yes.
n-Butylbenzene	104-51-8	mg/kg	33	24%	6.1	GP10	7 feet	180,000	None	None	25	76%	No; no exceedances.
sec-Butylbenzene	135-98-8	mg/kg	33	24%	3.3	GP10	7 feet	350,000	None	None	25	76%	No; no exceedances.
tert-Butylbenzene	98-06-6	mg/kg	33	6.1%	0.26	GP10	7 feet	350,000	None	None	31	94%	No; no exceedances.
1,2-Dibromoethane	106-93-4	mg/kg	35	None	None	None	None	66	None	None	35	100%	No; no exceedances
1,2-Dichloroethane	107-06-2	mg/kg	38	5.3%	0.0026	01MW41	7.5 feet	0.02	None	None	36	95%	No; no exceedances
1,1-Dichloroethene	75-35-4	mg/kg	36	None	None	None	None	0.044	None	None	36	100%	No; no exceedances
cis-1,2-Dichloroethene	156-59-2	mg/kg	36	None	None	None	None	0.078	None	None	36	100%	No; no exceedances
trans-1,2-Dichloroethene	156-60-5	mg/kg	36	None	None	None	None	0.52	None	None	36	100%	No; no exceedances.
Ethanol	64-17-5	mg/kg	16	None	None	None	None	--	NA	NA	16	100%	No; no criteria.
Ethylbenzene	100-41-4	mg/kg	109	31%	86	B346	9 feet	0.24	20%	360	75	69%	Yes.
Isopropylbenzene	98-82-8	mg/kg	33	24%	6	GP10	7 feet	350,000	None	None	25	76%	No; no exceedances.
p-Isopropyltoluene	99-87-6	mg/kg	33	18%	4.4	GP10	7 feet	--	NA	NA	27	82%	No; no criteria.
Methyl ethyl ketone	78-93-3	mg/kg	33	12%	2.1	GP10	7 feet	2,100,000	None	None	29	88%	No; no exceedances.
Methyl tert-butyl ether	1634-04-4	mg/kg	35	None	None	None	None	0.1	None	None	35	100%	No; no exceedances
n-Propylbenzene	103-65-1	mg/kg	33	27%	13	GP10	7 feet	350,000	None	None	24	73%	No; no exceedances.
Tetrachloroethene	127-18-4	mg/kg	36	None	None	None	None	0.025	None	None	36	100%	No; no exceedances
Trichloroethene	79-01-6	mg/kg	36	None	None	None	None	0.02	None	None	36	100%	No; no exceedances
1,2,4-Trimethylbenzene	95-63-6	mg/kg	33	30%	93	GP10	7 feet	35,000	None	None	23	70%	No; no exceedances.
1,3,5-Trimethylbenzene	108-67-8	mg/kg	33	24%	29	GP10	7 feet	35,000	None	None	25	76%	No; no exceedances.
Toluene	108-88-3	mg/kg	109	22%	100	B181	2.5 feet	0.4	13%	250	85	78%	Yes.
Vinyl Chloride	75-01-4	mg/kg	36	None	None	None	None	0.025	None	None	36	100%	No; no exceedances.
Total Xylenes	1330-20-7	mg/kg	106	31%	520	B346	9 feet	14	10%	37	73	69%	Yes.
Semivolatile Organic Compounds - PAHs													
Naphthalene	91-20-3	mg/kg	33	18%	27	GP10	7 feet	2.5	9.1%	11	27	82%	No; associated with known TPH source and not retained separately.
Semivolatile Organic Compounds - Other													
Pentachlorophenol	87-86-5	mg/kg	61	3%	0.28	B342	9 feet	0.05	3.0%	5.6	59	97%	No; exceeds in less than 5 percent of samples.
Phenol	108-95-2	mg/kg	5	None	None	None	None	0.12	None	None	5	100%	No; no exceedances.
2-Chlorophenol	95-57-8	mg/kg	5	None	None	None	None	18,000	None	None	5	100%	No; no exceedances.

Table B.1

Frequency of Exceedance for Bulk Terminal Property Vadose Zone Soil[1]

			Information about Dataset					Information about Detected Exceedances			Information about Non-Detects		
Analytes	CAS No.	Unit	Number of Results	Percent Detected	Maximum Detected Value[2]	Location of Maximum Detect	Depth of Maximum Detect	Most Stringent Preliminary Screening Level - Vadose Zone[3]	Percent of Detects Exceeding Criteria	Exceedance Factor[4]	Number of Non-Detects	Percent of Non-Detects	Retained as a COPC?
Semivolatile Organic Compounds - Other (cont.)													
2,6-Dichlorophenol	87-65-0	mg/kg	5	None	None	None	None	--	NA	NA	5	100%	No; no criteria.
2,5-Dichlorophenol	583-78-8	mg/kg	5	None	None	None	None	--	NA	NA	5	100%	No; no criteria.
2,3,5-Trichlorophenol	933-78-8	mg/kg	5	None	None	None	None	--	NA	NA	5	100%	No; no criteria.
2,4,6-Trichlorophenol	88-06-2	mg/kg	19	None	None	None	None	10	None	None	19	100%	No; no exceedances.
2,4,5-Trichlorophenol	95-95-4	mg/kg	19	None	None	None	None	4	None	None	19	100%	No; no exceedances.
2,3,4-Trichlorophenol	15950-66-0	mg/kg	5	None	None	None	None	--	NA	NA	5	100%	No; no criteria.
3,5-Dichlorophenol	591-35-5	mg/kg	5	None	None	None	None	--	NA	NA	5	100%	No; no criteria.
2,3,6-Trichlorophenol	933-75-5	mg/kg	5	None	None	None	None	--	NA	NA	5	100%	No; no criteria.
3,4-Dichlorophenol	95-77-2	mg/kg	5	None	None	None	None	20	None	None	5	100%	No; no exceedances.
2,3,4,6-Tetrachlorophenol	58-90-2	mg/kg	19	None	None	None	None	110,000	None	None	19	100%	No; no exceedances.
3,4,5-Trichlorophenol	609-19-8	mg/kg	5	None	None	None	None	--	NA	NA	5	100%	No; no criteria.
Dioxins/Furans													
Dioxin/furan TEQ[5]	DFTEQ	ng/kg	5	100%	26.9	B342	9 feet	5.2	60%	5.2	None	None	No, interim action completed and soil cleanup objectives were met.

Notes:

-- Not available.

🟧 Greater than 5 percent of detected concentrations exceed PSL; retained as a COPC.

1 Only samples between 0 and 10 feet bgs were considered to be in the vadose zone.

2 Results have been rounded to two significant figures.

3 PSLs for vadose zone soil were developed and presented in Table 4.1.

4 The exceedance factor is calculated by dividing the maximum detected value by the PSL. Only values greater than one (indicating an exceedance of the PSL) are displayed. Exceedance factors have been rounded to two significant figures.

5 World Health Organization 2005 toxic equivalent factors used for calculation of dioxin/furan TEQ (van den Berg et al. 2006). Calculated using detected dioxin/furan concentrations plus one-half the detection limit for dioxins/furans that were not detected.

Abbreviations:

bgs	Below ground surface
CAS	Chemical Abstracts Service
COPC	Chemical of potential concern
mg/kg	Milligrams per kilogram
NA	Not applicable
ng/kg	Nanograms per kilogram
PAH	Polycyclic aromatic hydrocarbon
PSL	Preliminary screening level
TEQ	Toxic equivalent

Table B.2

Frequency of Exceedance for Bulk Terminal Property Saturated Zone Soil[1]

			Information about Dataset					Information about Detected Exceedances			Information about Non-Detects		
Analytes	**CAS No.**	**Unit**	**Number of Results**	**Percent Detected**	**Maximum Detected Value[2]**	**Location of Maximum Detect**	**Depth of Maximum Detect**	**Most Stringent Preliminary Screening Level - Saturated Zone[3]**	**Percent of Detects Exceeding Criteria**	**Exceedance Factor[4]**	**Number of Non-Detects**	**Percent of Non-Detects**	**Retained as a COPC?**
Metals													
Arsenic	7440-38-2	mg/kg	1	100%	6.3	GP12	12 feet	20	None	None	None	None	No; no exceedances.
Barium	7440-39-3	mg/kg	1	100%	140	GP12	12 feet	83	100%	1.7	None	None	No; no sources present on Bulk Terminal.
Cadmium	7440-43-9	mg/kg	1	None	None	None	None	0.77	None	None	1	100%	No; no exceedances.
Chromium Total	7440-47-3	mg/kg	1	100%	76	GP12	12 feet	48	100%	1.6	None	None	No; no sources present on Bulk Terminal.
Lead	7439-92-1	mg/kg	1	100%	7.1	GP12	12 feet	24	None	None	None	None	No; no exceedances.
Mercury	7439-97-6	mg/kg	1	None	None	None	None	0.25	None	None	1	100%	No; no exceedances.
Selenium	7782-49-2	mg/kg	1	None	None	None	None	0.5	None	None	1	100%	No; no exceedances.
Silver	7440-22-4	mg/kg	1	None	None	None	None	0.1	None	None	1	100%	No; no exceedances.
Total Petroleum Hydrocarbons													
Gasoline-Range Organics	TPHG	mg/kg	92	25%	14,000	B348	12 feet	30	14%	470	69	75%	Yes.
Diesel-Range Organics	TPHD	mg/kg	91	18%	11,000	01MW47 B342	13 feet 12 feet	260	14%	42	75	82%	Yes.
Oil-Range Organics	TPHO	mg/kg	91	1.1%	430	G9-SE-EX03-ESW01	36 feet	2,000	None	None	90	99%	No; no exceedances.
Volatile Organic Compounds													
Acetone	67-64-1	mg/kg	35	2.9%	0.041	01MW43	12.5 feet	2.1	None	None	34	97%	No; no exceedances.
Benzene	71-43-2	mg/kg	94	21%	86	B352	12 feet	0.02	17%	4,300	74	79%	Yes.
n-Butylbenzene	104-51-8	mg/kg	33	3.0%	0.13	01MW35	16 feet	180,000	None	None	32	97%	No; no exceedances.
sec-Butylbenzene	135-98-8	mg/kg	35	2.9%	0.2	01MW35	16 feet	350,000	None	None	34	97%	No; no exceedances.
tert-Butylbenzene	98-06-6	mg/kg	35	None	None	None	None	350,000	None	None	35	100%	No; no exceedances.
1,2-Dibromoethane	106-93-4	mg/kg	56	None	None	None	None	66	None	None	56	100%	No; no exceedances.
1,2-Dichloroethane	107-06-2	mg/kg	56	7.1%	0.058	01MW41	12.5 feet	0.02	1.8%	2.9	52	93%	No; exceeds in less than 5 percent of samples.
1,1-Dichloroethene	75-35-4	mg/kg	35	None	None	None	None	0.02	None	None	35	100%	No; no exceedances.
cis-1,2-Dichloroethene	156-59-2	mg/kg	35	None	None	None	None	0.02	None	None	35	100%	No; no exceedances.
trans-1,2-Dichloroethene	156-60-5	mg/kg	35	None	None	None	None	0.032	None	None	35	100%	No; no exceedances.
Ethanol	64-17-5	mg/kg	35	None	None	None	None	--	NA	NA	35	100%	No; no criteria.
Ethylbenzene	100-41-4	mg/kg	94	18%	140	B348	12 feet	0.02	18%	7,000	77	82%	Yes.
Isopropylbenzene	98-82-8	mg/kg	35	2.9%	0.0039	GP10	15 feet	350,000	None	None	34	97%	No; no exceedances.
p-Isopropyltoluene	99-87-6	mg/kg	35	None	None	None	None	--	NA	NA	35	100%	No; no criteria.
Methyl ethyl ketone	78-93-3	mg/kg	35	None	None	None	None	2,100,000	None	None	35	100%	No; no exceedances.
Methyl tert-butyl ether	1634-04-4	mg/kg	57	1.8%	0.00076	GP10	15 feet	0.05	None	None	56	98%	No; no exceedances.
n-Propylbenzene	103-65-1	mg/kg	35	2.9%	0.005	GP10	15 feet	350,000	None	None	34	97%	No; no exceedances.
Tetrachloroethene	127-18-4	mg/kg	35	None	None	None	None	0.025	None	None	35	100%	No; no exceedances.
Trichloroethene	79-01-6	mg/kg	35	None	None	None	None	0.02	None	None	35	100%	No; no exceedances.
1,2,4-Trimethylbenzene	95-63-6	mg/kg	35	2.9%	0.016	GP10	15 feet	35,000	None	None	34	97%	No; no exceedances.
1,3,5-Trimethylbenzene	108-67-8	mg/kg	35	2.9%	0.0097	GP10	15 feet	35,000	None	None	34	97%	No; no exceedances.
Toluene	108-88-3	mg/kg	94	15%	310	B348	12 feet	0.025	14%	12,000	80	85%	Yes.
Vinyl Chloride	75-01-4	mg/kg	35					0.025	None	None	35	100%	No; no exceedances.
Total Xylenes	1330-20-7	mg/kg	83	18%	960	B348	12 feet	1.5	10%	640	68	82%	Yes.
Semivolatile Organic Compounds - PAHs													
Naphthalene	91-20-3	mg/kg	36	2.8%	0.031	GP10	15 feet	0.13	None	None	35	97%	No; no exceedances.
Semivolatile Organic Compounds - Other													
Pentachlorophenol	87-86-5	mg/kg	40	18%	0.24	B338 B352	14 feet 14 feet	0.05	15%	4.8	33	83%	No, interim action completed and soil cleanup objectives were met.
2,4,6-Trichlorophenol	88-06-2	mg/kg	10	None	None	None	None	10	None	None	10	100%	No; no exceedances.
2,4,5-Trichlorophenol	95-95-4	mg/kg	10	None	None	None	None	4	None	None	10	100%	No; no exceedances.
2,3,4,6-Tetrachlorophenol	58-90-2	mg/kg	10	None	None	None	None	110,000	None	None	10	100%	No; no exceedances.

Table B.2

Frequency of Exceedance for Bulk Terminal Property Saturated Zone Soil[1]

			Information about Dataset					Information about Detected Exceedances			Information about Non-Detects		
Analytes	CAS No.	Unit	Number of Results	Percent Detected	Maximum Detected Value[2]	Location of Maximum Detect	Depth of Maximum Detect	Most Stringent Preliminary Screening Level - Saturated Zone[3]	Percent of Detects Exceeding Criteria	Exceedance Factor[4]	Number of Non-Detects	Percent of Non-Detects	Retained as a COPC?
Dioxins/Furans													
Dioxin/furan TEQ[5]	DFTEQ	ng/kg	7	100%	10.9	B338	14 feet	5.2	86%	2.1	None	None	No, interim action completed and soil cleanup objectives were met.

Notes:

-- Not available.

🟧 Greater than 5 percent of detected concentrations exceed PSL; retained as a COPC.

1 Only samples greater than 10 feet bgs deep were considered to be in the saturated zone.

2 Results have been rounded to two significant figures.

3 PSLs for saturated zone soil were developed and presented in Table 4.1.

4 The exceedance factor is calculated by dividing the maximum detected value by the PSL. Only values greater than one (indicating an exceedance of the PSL) are displayed. Exceedance factors have been rounded to two significant figures.

5 World Health Organization 2005 toxic equivalent factors used for calculation of dioxin/furan TEQ (van den Berg et al. 2006). Calculated using detected dioxin/furan concentrations plus one-half the detection limit for dioxins/furans that were not detected.

Abbreviations:

bgs	Below ground surface
CAS	Chemical Abstracts Service
COPC	Chemical of potential concern
mg/kg	Milligrams per kilogram
NA	Not applicable
ng/kg	Nanograms per kilogram
PAH	Polycyclic aromatic hydrocarbon
PSL	Preliminary screening level
TEQ	Toxic equivalent

Table B.3

Frequency of Exceedance for ASKO Hydraulic Property Vadose Zone Soil[1]

			Information about Dataset					Information about Detected Exceedances			Information about Non-Detects		
Analytes	**CAS No.**	**Unit**	**Number of Results**	**Percent Detected**	**Maximum Detected Value[2]**	**Location of Maximum Detect**	**Depth of Maximum Detect**	**Most Stringent Preliminary Screening Level - Vadose Zone[3]**	**Percent of Detects Exceeding Criteria**	**Exceedance Factor[4]**	**Number of Non-Detects**	**Percent of Non-Detects**	**Retained as a COPC?**
Metals													
Arsenic	7440-38-2	mg/kg	7	100%	9.8	MW03	6 feet	20	None	None	None	None	No; no exceedances.
Barium	7440-39-3	mg/kg	7	100%	220	MW05	1.5 feet	100	43%	2.2	None	None	No; no sources present on ASKO.
Cadmium	7440-43-9	mg/kg	7	None	None	None	None	0.77	None	None	7	100%	No; no exceedances.
Chromium Total	7440-47-3	mg/kg	7	100%	60	MW03	6 feet	48	29%	1.3	None	None	No; no sources present on ASKO.
Lead	7439-92-1	mg/kg	7	100%	27	MW05	1.5 feet	50	None	None	None	None	No; no exceedances.
Mercury	7439-97-6	mg/kg	7	None	None	None	None	0.25	None	None	7	100%	No; no exceedances.
Selenium	7782-49-2	mg/kg	7	None	None	None	None	0.5	None	None	7	100%	No; no exceedances.
Silver	7440-22-4	mg/kg	7	14%	3.3	MW04	1 feet	0.1	14%	33	6	86%	No; no sources present on ASKO.
Total Petroleum Hydrocarbons													
Gasoline-Range Organics	TPHG	mg/kg	43	49%	4,700	MW03	6 feet	30	37%	160	22	51%	Yes.
Diesel-Range Organics	TPHD	mg/kg	41	49%	10,000	B90	3 feet	260	34%	38	21	51%	Yes.
Oil-Range Organics	TPHO	mg/kg	41	29%	14,000	B90	3 feet	2,000	7.3%	7	29	71%	Yes.
Volatile Organic Compounds													
Acetone	67-64-1	mg/kg	10	50%	0.21	MW05	1.5 feet	29	None	None	5	50%	No; no exceedances.
Benzene	71-43-2	mg/kg	46	4.3%	0.081	B90	3 feet	0.02	4.3%	4.1	44	96%	No; exceeds in less than 5 percent of samples.
n-Butylbenzene	104-51-8	mg/kg	13	31%	6.6	MW03	6 feet	180,000	None	None	9	69%	No; no exceedances.
sec-Butylbenzene	135-98-8	mg/kg	13	31%	2.8	MW03	6 feet	350,000	None	None	9	69%	No; no exceedances.
tert-Butylbenzene	98-06-6	mg/kg	13	8%	0.16	MW03	6 feet	350,000	None	None	12	92%	No; no exceedances.
1,2-Dibromoethane	106-93-4	mg/kg	13	None	None	None	None	66	None	None	13	100%	No; no exceedances.
1,2-Dichloroethane	107-06-2	mg/kg	51	None	None	None	None	0.02	None	None	51	100%	No; no exceedances.
1,1-Dichloroethene	75-35-4	mg/kg	51	None	None	None	None	0.044	None	None	51	100%	No; no exceedances.
cis-1,2-Dichloroethene	156-59-2	mg/kg	51	16%	0.85	B90	3 feet	0.078	5.9%	11	43	84%	Yes.
trans-1,2-Dichloroethene	156-60-5	mg/kg	51	None	None	None	None	0.52	None	None	51	100%	No; no exceedances.
Ethanol	64-17-5	mg/kg	3	None	None	None	None	--	NA	NA	3	100%	No; no criteria.
Ethylbenzene	100-41-4	mg/kg	46	22%	3	B90	3 feet	0.24	15%	13	36	78%	Yes.
Isopropylbenzene	98-82-8	mg/kg	13	31%	0.9	MW03	6 feet	350,000	None	None	9	69%	No; no exceedances.
p-Isopropyltoluene	99-87-6	mg/kg	10	40%	1	MW03	6 feet	--	NA	NA	6	60%	No; no criteria.
Methyl ethyl ketone	78-93-3	mg/kg	10	30%	0.056	MW05	1.5 feet	2,100,000	None	None	7	70%	No; no exceedances.
Methyl tert-butyl ether	1634-04-4	mg/kg	10	None	None	None	None	0.1	None	None	10	100%	No; no exceedances.
n-Propylbenzene	103-65-1	mg/kg	13	31%	3.3	MW03	6 feet	350,000	None	None	9	69%	No; no exceedances.
Tetrachloroethene	127-18-4	mg/kg	51	3.9%	0.17	B90	3 feet	0.025	3.9%	6.8	49	96%	No; exceeds in less than 5 percent of samples.
Trichloroethene	79-01-6	mg/kg	51	27%	44	01MW64	2.5 feet	0.02	27%	2200	37	73%	Yes.
1,2,4-Trimethylbenzene	95-63-6	mg/kg	13	54%	20	MW03	6 feet	35,000	None	None	6	46%	No; no exceedances.
1,3,5-Trimethylbenzene	108-67-8	mg/kg	13	23%	7.9	MW03	6 feet	35,000	None	None	10	77%	No; no exceedances.
Toluene	108-88-3	mg/kg	46	6.5%	2.8	B90	3 feet	0.4	4.3%	7	43	93%	No; exceeds in less than 5 percent of samples.
Vinyl Chloride	75-01-4	mg/kg	51	None	None	None	None	0.025	None	None	51	100%	No; no exceedances.
Total Xylenes	1330-20-7	mg/kg	37	22%	4.3	01MW94	5 feet	14	None	None	29	78%	No; no exceedances.
Semivolatile Organic Compounds - PAHs													
Acenaphthene	83-32-9	mg/kg	6	None	None	None	None	3.1	None	None	6	100%	No; no exceedances.
Acenaphthylene	208-96-8	mg/kg	6	None	None	None	None	--	NA	NA	6	100%	No; no criteria.
Anthracene	120-12-7	mg/kg	6	None	None	None	None	47	None	None	6	100%	No; no exceedances.

Table B.3

Frequency of Exceedance for ASKO Hydraulic Property Vadose Zone Soil[1]

			Information about Dataset					Information about Detected Exceedances			Information about Non-Detects		
Analytes	CAS No.	Unit	Number of Results	Percent Detected	Maximum Detected Value[2]	Location of Maximum Detect	Depth of Maximum Detect	Most Stringent Preliminary Screening Level - Vadose Zone[3]	Percent of Detects Exceeding Criteria	Exceedance Factor[4]	Number of Non-Detects	Percent of Non-Detects	Retained as a COPC?
Semivolatile Organic Compounds - PAHs (cont.)													
Benzo(a) anthracene	56-55-3	mg/kg	6	None	None	None	None	0.43	None	None	6	100%	No; no exceedances.
Benzo(b) fluoranthene	205-99-2	mg/kg	6	None	None	None	None	1.5	None	None	6	100%	No; no exceedances.
Benzo(k) fluoranthene	207-08-9	mg/kg	6	None	None	None	None	1.5	None	None	6	100%	No; no exceedances.
Benzo(g,h,i)perylene	191-24-2	mg/kg	6	None	None	None	None	--	NA	NA	6	100%	No; no criteria.
Benzo(a)pyrene	50-32-8	mg/kg	6	None	None	None	None	1.2	None	None	6	100%	No; no exceedances.
Chrysene	218-01-9	mg/kg	6	None	None	None	None	0.48	None	None	6	100%	No; no exceedances.
Dibenz(a,h) anthracene	53-70-3	mg/kg	6	None	None	None	None	2.1	None	None	6	100%	No; no exceedances.
Fluoranthene	206-44-0	mg/kg	6	None	None	None	None	5.9	None	None	6	100%	No; no exceedances.
Fluorene	86-73-7	mg/kg	6	17%	0.44	MW03	6 feet	1.6	None	None	5	83%	No; no exceedances.
Indeno(1,2,3-cd)pyrene	193-39-5	mg/kg	6	None	None	None	None	4.2	None	None	6	100%	No; no exceedances.
1-Methylnaphthalene	90-12-0	mg/kg	6	17%	0.79	MW03	6 feet	4,500	None	None	5	83%	No; no exceedances.
2-Methylnaphthalene	91-57-6	mg/kg	6	17%	0.84	MW03	6 feet	14,000	None	None	5	83%	No; no exceedances.
Naphthalene	91-20-3	mg/kg	19	21%	1.7	MW03	6 feet	2.5	None	None	15	79%	No; no exceedances.
Phenanthrene	85-01-8	mg/kg	6	17%	0.69	MW03	6 feet	--	NA	NA	5	83%	No; no criteria.
Pyrene	129-00-0	mg/kg	6	None	None	None	None	11	None	None	6	100%	No; no exceedances.
cPAH TEQ[5]	CPAHTEQ	mg/kg	6	None	None	None	None	1.2	None	None	6	100%	No; no exceedances.
Semivolatile Organic Compounds - Other													
Pentachlorophenol	87-86-5	mg/kg	6	None	None	None	None	0.05	None	None	6	100%	No; no exceedances.
Phenol	108-95-2	mg/kg	6	None	None	None	None	0.12	None	None	6	100%	No; no exceedances.
2-Chlorophenol	95-57-8	mg/kg	6	None	None	None	None	18,000	None	None	6	100%	No; no exceedances.
2,4-Dichlorophenol	120-83-2	mg/kg	6	None	None	None	None	11,000	None	None	6	100%	No; no exceedances.
2,4,6-Trichlorophenol	88-06-2	mg/kg	6	None	None	None	None	10	None	None	6	100%	No; no exceedances.
2,4,5-Trichlorophenol	95-95-4	mg/kg	6	None	None	None	None	4	None	None	6	100%	No; no exceedances.

Notes:

-- Not available.

🟧 Greater than 5 percent of detected concentrations exceed PSL; retained as a COPC.

1 Only samples between 0 and 6 feet bgs were considered to be in the vadose zone.

2 Results have been rounded to two significant figures.

3 PSLs for vadose zone soil were developed and presented in Table 4.1.

4 The exceedance factor is calculated by dividing the maximum detected value by the PSL. Only values greater than one (indicating an exceedance of the PSL) are displayed. Exceedance factors have been rounded to two significant figures.

5 Calculation of cPAH TEQ concentrations is performed using the California Environmental Protection Agency 2005 TEFs as presented in Table 708-2 of WAC 173-340-900. Calculated using detected cPAH concentrations plus one-half the reporting limit for cPAHs that were not detected.

Abbreviations:

bgs	Below ground surface
CAS	Chemical Abstracts Service
COPC	Chemical of potential concern
cPAH	Carcinogenic polycyclic aromatic hydrocarbon
mg/kg	Milligrams per kilogram
NA	Not applicable
PAH	Polycyclic aromatic hydrocarbon
PSL	Preliminary screening level
TEF	Toxic equivalent factor
TEQ	Toxic equivalent

Table B.4

Frequency of Exceedance for ASKO Hydraulic Property Saturated Zone Soil[1]

			Information about Dataset					Information about Detected Exceedances			Information about Non-Detects		
Analytes	**CAS No.**	**Unit**	**Number of Results**	**Percent Detected**	**Maximum Detected Value[2]**	**Location of Maximum Detect**	**Depth of Maximum Detect**	**Most Stringent Preliminary Screening Level - Saturated Zone[3]**	**Percent of Detects Exceeding Criteria**	**Exceedance Factor[4]**	**Number of Non-Detects**	**Percent of Non-Detects**	**Retained as a COPC?**
Metals													
Arsenic	7440-38-2	mg/kg	8	100%	5.6	MW01	11 feet	20	None	None	None	None	No; no exceedances.
Barium	7440-39-3	mg/kg	8	100%	100	MW03	16 feet	83	13%	1.2	None	None	No; no sources present on ASKO.
Cadmium	7440-43-9	mg/kg	8	None	None	None	None	0.77	None	None	8	100%	No; no exceedances.
Chromium Total	7440-47-3	mg/kg	8	100%	39	MW03	16 feet	48	None	None	None	None	No; no exceedances.
Lead	7439-92-1	mg/kg	14	100%	4.2	01MW53	40 feet	24	None	None	None	None	No; no exceedances.
Mercury	7439-97-6	mg/kg	8	None	None	None	None	0.25	None	None	8	100%	No; no exceedances.
Selenium	7782-49-2	mg/kg	8	None	None	None	None	0.5	None	None	8	100%	No; no exceedances.
Silver	7440-22-4	mg/kg	8	None	None	None	None	0.1	None	None	8	100%	No; no exceedances.
Total Petroleum Hydrocarbons													
Gasoline-Range Organics	TPHG	mg/kg	71	24%	9700	B89	13 feet	30	5.6%	320	54	76%	Yes.
Diesel-Range Organics	TPHD	mg/kg	70	7.1%	4300	B89	13 feet	260	4.3%	17	65	93%	No; exceeds in less than 5 percent of samples.
Oil-Range Organics	TPHO	mg/kg	70	2.9%	1700	01MW60 B89	7.5 feet 13 feet	2,000	None	None	65	97%	No; no exceedances.
Volatile Organic Compounds													
Acetone	67-64-1	mg/kg	20	5.0%	0.13	01MW45	25 feet	2.1	None	None	19	95%	No; no exceedances.
Benzene	71-43-2	mg/kg	102	4.9%	0.61	01MW60	7.5 feet	0.02	2.9%	31	97	95%	No; exceeds in less than 5 percent of samples.
n-Butylbenzene	104-51-8	mg/kg	40	None	None	None	None	180,000	None	None	40	100%	No; no exceedances.
sec-Butylbenzene	135-98-8	mg/kg	46	None	None	None	None	350,000	None	None	46	100%	No; no exceedances.
tert-Butylbenzene	98-06-6	mg/kg	46	None	None	None	None	350,000	None	None	46	100%	No; no exceedances.
1,2-Dibromoethane	106-93-4	mg/kg	46	None	None	None	None	66	None	None	46	100%	No; no exceedances.
1,2-Dichloroethane	107-06-2	mg/kg	124	None	None	None	None	0.02	None	None	124	100%	No; no exceedances.
1,1-Dichloroethene	75-35-4	mg/kg	124	None	None	None	None	0.02	None	None	124	100%	No; no exceedances.
cis-1,2-Dichloroethene	156-59-2	mg/kg	124	36%	1.7	01MW54	10 feet	0.02	36%	85	79	64%	Yes.
trans-1,2-Dichloroethene	156-60-5	mg/kg	124	0.81%	0.15	01MW70	10.5 feet	0.032	0.81%	4.7	123	99%	No; exceeds in less than 5 percent of samples.
Ethanol	64-17-5	mg/kg	12	None	None	None	None	--	NA	NA	12	100%	No; no criteria.
Ethylbenzene	100-41-4	mg/kg	102	3.9%	22	B89	13 feet	0.02	3.9%	1100	98	96%	No; exceeds in less than 5 percent of samples.
Isopropylbenzene	98-82-8	mg/kg	46	None	None	None	None	350,000	None	None	46	100%	No; no exceedances.
p-Isopropyltoluene	99-87-6	mg/kg	20	None	None	None	None	--	NA	NA	20	100%	No; no criteria.
Methyl ethyl ketone	78-93-3	mg/kg	20	5.0%	0.032	01MW45	25 feet	2,100,000	None	None	19	95%	No; no exceedances.
Methyl tert-butyl ether	1634-04-4	mg/kg	20	None	None	None	None	0.05	None	None	20	100%	No; no exceedances.
n-Propylbenzene	103-65-1	mg/kg	46	None	None	None	None	350,000	None	None	46	100%	No; no exceedances.
Tetrachloroethene	127-18-4	mg/kg	124	0.81%	0.24	01MW54	10 feet	0.025	0.81%	9.6	123	99%	No; exceeds in less than 5 percent of samples.
Trichloroethene	79-01-6	mg/kg	124	56%	120	01MW71	20 feet	0.02	55%	6000	55	44%	Yes.
1,2,4-Trimethylbenzene	95-63-6	mg/kg	46	None	None	None	None	35,000	None	None	46	100%	No; no exceedances.
1,3,5-Trimethylbenzene	108-67-8	mg/kg	46	None	None	None	None	35,000	None	None	46	100%	No; no exceedances.
Toluene	108-88-3	mg/kg	102	3.9%	0.93	01MW60	7.5 feet	0.025	3.9%	37	98	96%	No; exceeds in less than 5 percent of samples.
Vinyl Chloride	75-01-4	mg/kg	124	2.4%	0.13	B106	20 feet	0.025	1.6%	5.2	121	98%	No; exceeds in less than 5 percent of samples.
Total Xylenes	1330-20-7	mg/kg	83	1.2%	1.1	01MW80	7.5 feet	1.5	None	None	82	99%	No; no exceedances.

Table B.4

Frequency of Exceedance for ASKO Hydraulic Property Saturated Zone Soil[1]

			Information about Dataset					Information about Detected Exceedances			Information about Non-Detects		
Analytes	**CAS No.**	**Unit**	**Number of Results**	**Percent Detected**	**Maximum Detected Value[2]**	**Location of Maximum Detect**	**Depth of Maximum Detect**	**Most Stringent Preliminary Screening Level - Saturated Zone[3]**	**Percent of Detects Exceeding Criteria**	**Exceedance Factor[4]**	**Number of Non-Detects**	**Percent of Non-Detects**	**Retained as a COPC?**
Semivolatile Organic Compounds - PAHs													
Acenaphthene	83-32-9	mg/kg	8	None	None	None	None	0.16	None	None	8	100%	No; no exceedances.
Acenaphthylene	208-96-8	mg/kg	8	None	None	None	None	--	NA	NA	8	100%	No; no criteria.
Anthracene	120-12-7	mg/kg	8	None	None	None	None	2.4	None	None	8	100%	No; no exceedances.
Benzo(a) anthracene	56-55-3	mg/kg	8	None	None	None	None	0.021	None	None	8	100%	No; no exceedances.
Benzo(b) fluoranthene	205-99-2	mg/kg	8	None	None	None	None	0.074	None	None	8	100%	No; no exceedances.
Benzo(k) fluoranthene	207-08-9	mg/kg	8	None	None	None	None	0.074	None	None	8	100%	No; no exceedances.
Benzo(g,h,i)perylene	191-24-2	mg/kg	8	None	None	None	None	--	NA	NA	8	100%	No; no criteria.
Benzo(a)pyrene	50-32-8	mg/kg	8	None	None	None	None	0.058	None	None	8	100%	No; no exceedances.
Chrysene	218-01-9	mg/kg	8	None	None	None	None	0.024	None	None	8	100%	No; no exceedances.
Dibenz(a,h) anthracene	53-70-3	mg/kg	8	None	None	None	None	0.11	None	None	8	100%	No; no exceedances.
Fluoranthene	206-44-0	mg/kg	8	None	None	None	None	0.3	None	None	8	100%	No; no exceedances.
Fluorene	86-73-7	mg/kg	8	None	None	None	None	0.08	None	None	8	100%	No; no exceedances.
Indeno(1,2,3-cd)pyrene	193-39-5	mg/kg	8	None	None	None	None	0.21	None	None	8	100%	No; no exceedances.
1-Methylnaphthalene	90-12-0	mg/kg	8	None	None	None	None	4,500	None	None	8	100%	No; no exceedances.
2-Methylnaphthalene	91-57-6	mg/kg	8	None	None	None	None	14,000	None	None	8	100%	No; no exceedances.
Naphthalene	91-20-3	mg/kg	55	None	None	None	None	0.13	None	None	55	100%	No; no exceedances.
Phenanthrene	85-01-8	mg/kg	8	None	None	None	None	--	NA	NA	8	100%	No; no criteria.
Pyrene	129-00-0	mg/kg	8	None	None	None	None	0.55	None	None	8	100%	No; no exceedances.
cPAH TEQ[5]	CPAHTEQ	mg/kg	8	None	None	None	None	0.058	None	None	8	100%	No; no exceedances.
Semivolatile Organic Compounds - Other													
Pentachlorophenol	87-86-5	mg/kg	8	None	None	None	None	0.05	None	None	8	100%	No; no exceedances.
Phenol	108-95-2	mg/kg	8	None	None	None	None	0.12	None	None	8	100%	No; no exceedances.
2-Chlorophenol	95-57-8	mg/kg	8	None	None	None	None	18,000	None	None	8	100%	No; no exceedances.
2,4-Dichlorophenol	120-83-2	mg/kg	8	None	None	None	None	11,000	None	None	8	100%	No; no exceedances.
2,4,6-Trichlorophenol	88-06-2	mg/kg	8	None	None	None	None	10	None	None	8	100%	No; no exceedances.
2,4,5-Trichlorophenol	95-95-4	mg/kg	8	None	None	None	None	4	None	None	8	100%	No; no exceedances.

Notes:

-- Not available.

🟧 Greater than 5 percent of detected concentrations exceed PSL; retained as a COPC.

[1] Only samples greater than 6 feet bgs deep were considered to be in the saturated zone.

[2] Results have been rounded to two significant figures.

[3] PSs for saturated zone soil were developed and presented in Table 4.1.

[4] The exceedance factor is calculated by dividing the maximum detected value by the PSL. Only values greater than one (indicating an exceedance of the PSL) are displayed. Exceedance factors have been rounded to two significant figures.

[5] Calculation of cPAH TEA concentrations is performed using the California Environmental Protection Agency 2005 Tiffs as presented in Table 708-2 of WAC 173-340-900. Calculated using detected cPAH concentrations plus one-half the reporting limit for cash that were not detected.

Abbreviations:

bgs	Below ground surface	NA	Not applicable
CAS	Chemical Abstracts Service	PAH	Polycyclic aromatic hydrocarbon
COPC	Chemical of potential concern	PSL	Preliminary screening level
cPAH	Carcinogenic polycyclic aroma	TEE	Toxic equivalent factor
mg/kg	Milligrams per kilogram	TEA	Toxic equivalent

Table B.5

Frequency of Exceedance for East Waterfront Property Vadose Zone Soil[1]

			Information about Dataset					Information about Detected Exceedances			Information about Non-Detects		
Analytes	CAS No.	Unit	Number of Results	Percent Detected	Maximum Detected Value[2]	Location of Maximum Detect	Depth of Maximum Detect	Most Stringent Preliminary Screening Level - Vadose Zone[3]	Percent of Detects Exceeding Criteria	Exceedance Factor[4]	Number of Non-Detects	Percent of Non-Detects	Retained as a COPC?
Metals													
Lead	7439-92-1	mg/kg	5	100%	8	GP26	5 feet	50	None	None	None	None	No; no exceedances.
Total Petroleum Hydrocarbons													
Gasoline-Range Organics	TPHG	mg/kg	104	37%	320	B271	2.5 feet	30	11%	11	66	63%	Yes.
Diesel-Range Organics	TPHD	mg/kg	105	16%	2,800	B271	2.5 feet	260	11%	11	88	84%	Yes.
Oil-Range Organics	TPHO	mg/kg	105	11%	20,000	B300	3.5 feet	2,000	4.7%	10	93	89%	No; exceeds in less than 5 percent of samples.
Volatile Organic Compounds													
Acetone	67-64-1	mg/kg	2	None	None	None	None	29	None	None	2	100%	No; no exceedances.
Benzene	71-43-2	mg/kg	104	3.9%	0.21	B300	3.5 feet	0.02	3.9%	11	100	96%	No; exceeds in less than 5 percent of samples.
sec-Butylbenzene	135-98-8	mg/kg	2	None	None	None	None	350,000	None	None	2	100%	No; no exceedances.
tert-Butylbenzene	98-06-6	mg/kg	2	None	None	None	None	350,000	None	None	2	100%	No; no exceedances.
1,2-Dibromoethane	106-93-4	mg/kg	2	None	None	None	None	66	None	None	2	100%	No; no exceedances.
1,2-Dichloroethane	107-06-2	mg/kg	16	None	None	None	None	0.02	None	None	16	100%	No; no exceedances.
1,1-Dichloroethene	75-35-4	mg/kg	16	None	None	None	None	0.044	None	None	16	100%	No; no exceedances.
cis-1,2-Dichloroethene	156-59-2	mg/kg	16	None	None	None	None	0.078	None	None	16	100%	No; no exceedances.
trans-1,2-Dichloroethene	156-60-5	mg/kg	16	None	None	None	None	0.52	None	None	16	100%	No; no exceedances.
Ethanol	64-17-5	mg/kg	2	None	None	None	None	--	NA	NA	2	100%	No; no criteria.
Ethylbenzene	100-41-4	mg/kg	104	23%	2.2	B277	8 feet	0.24	7.7%	9.2	80	77%	Yes.
Isopropylbenzene	98-82-8	mg/kg	2	None	None	None	None	350,000	None	None	2	100%	No; no exceedances.
p-Isopropyltoluene	99-87-6	mg/kg	2	None	None	None	None	--	NA	NA	2	100%	No; no criteria.
Methyl ethyl ketone	78-93-3	mg/kg	2	None	None	None	None	2,100,000	None	None	2	100%	No; no exceedances.
Methyl tert-butyl ether	1634-04-4	mg/kg	2	None	None	None	None	0.1	None	None	2	100%	No; no exceedances.
n-Propylbenzene	103-65-1	mg/kg	2	None	None	None	None	350,000	None	None	2	100%	No; no exceedances.
Tetrachloroethene	127-18-4	mg/kg	16	None	None	None	None	0.025	None	None	16	100%	No; no exceedances.
Trichloroethene	79-01-6	mg/kg	16	None	None	None	None	0.02	None	None	16	100%	No; no exceedances.
1,2,4-Trimethylbenzene	95-63-6	mg/kg	2	None	None	None	None	35,000	None	None	2	67%	No; no exceedances.
1,3,5-Trimethylbenzene	108-67-8	mg/kg	2	None	None	None	None	35,000	None	None	2	67%	No; no exceedances.
Toluene	108-88-3	mg/kg	104	16%	1	B277	8 feet	0.4	1.9%	2.5	87	84%	No; exceeds in less than 5 percent of samples.
Vinyl Chloride	75-01-4	mg/kg	16	None	None	None	None	0.025	None	None	16	100%	No; no exceedances.
Total Xylenes	1330-20-7	mg/kg	101	21%	4	B300	3.5 feet	14	None	none	80	79%	No; no exceedances.
Semivolatile Organic Compounds - PAHs													
Naphthalene	91-20-3	mg/kg	2	None	None	None	None	2.5	None	None	2	100%	No; no exceedances.

Notes:

-- Not available.

▨ Greater than 5 percent of detected concentrations exceed PSL; retained as a COPC.

1 Only samples between 0 and 10 feet bgs were considered to be in the vadose zone.

2 Results have been rounded to two significant figures.

3 PSLs for vadose zone soil were developed and presented in Table 4.1.

4 The exceedance factor is calculated by dividing the maximum detected value by the PSL. Only values greater than one (indicating an exceedance of the PSL) are displayed. Exceedance factors have been rounded to two significant figures.

Abbreviations:

bgs	Below ground surface
CAS	Chemical Abstracts Service
COPC	Chemical of potential concern
mg/kg	Milligrams per kilogram
NA	Not applicable
PAH	Polycyclic aromatic hydrocarbon
PSL	Preliminary screening level

Table B.6

Frequency of Exceedance for East Waterfront Property Saturated Zone Soil[1]

			Information about Dataset					Information about Detected Exceedances			Information about Non-Detects		
Analytes	**CAS No.**	**Unit**	**Number of Results**	**Percent Detected**	**Maximum Detected Value[2]**	**Location of Maximum Detect**	**Depth of Maximum Detect**	**Most Stringent Preliminary Screening Level - Saturated Zone**	**Percent of Detects Exceeding Criteria**	**Exceedance Factor[4]**	**Number of Non-Detects**	**Percent of Non-Detects**	**Retained as a COPC?**
Metals													
Lead	7439-92-1	mg/kg	1	100%	4.9	02MW13	12.5 feet	24	None	None	None	None	No; no exceedances.
Total Petroleum Hydrocarbons													
Gasoline-Range Organics	TPHG	mg/kg	27	19%	420	B314	12.5 feet	30	3.7%	14	22	81%	No; exceeds in less than 5 percent of samples.
Diesel-Range Organics	TPHD	mg/kg	27	7.4%	780	B314	12.5 feet	260	7.4%	3	25	93%	Yes.
Oil-Range Organics	TPHO	mg/kg	27	3.7%	5,500	B314	12.5 feet	2,000	3.7%	2.8	26	96%	No; exceeds in less than 5 percent of samples.
Volatile Organic Compounds													
Acetone	67-64-1	mg/kg	1	None	None	None	None	2.1	None	None	1	100%	No; no exceedances.
Benzene	71-43-2	mg/kg	28	3.6%	0.084	B314	15 feet	0.02	3.6%	4.2	27	96%	No; exceeds in less than 5 percent of samples.
sec-Butylbenzene	135-98-8	mg/kg	1	None	None	None	None	350,000	None	None	1	100%	No; no exceedances.
tert-Butylbenzene	98-06-6	mg/kg	1	None	None	None	None	350,000	None	None	1	100%	No; no exceedances.
1,2-Dibromoethane	106-93-4	mg/kg	2	None	None	None	None	66	None	None	2	100%	No; no exceedances.
1,2-Dichloroethane	107-06-2	mg/kg	4	None	None	None	None	0.02	None	None	4	100%	No; no exceedances.
1,1-Dichloroethene	75-35-4	mg/kg	3	None	None	None	None	0.02	None	None	3	100%	No; no exceedances.
cis-1,2-Dichloroethene	156-59-2	mg/kg	3	None	None	None	None	0.02	None	None	3	100%	No; no exceedances.
trans-1,2-Dichloroethene	156-60-5	mg/kg	3	None	None	None	None	0.032	None	None	3	100%	No; no exceedances.
Ethanol	64-17-5	mg/kg	1	None	None	None	None	--	NA	NA	1	100%	No; no criteria.
Ethylbenzene	100-41-4	mg/kg	28	14%	3	B314	12.5 feet	0.02	14%	150	24	86%	Yes.
Isopropylbenzene	98-82-8	mg/kg	1	None	None	None	None	350,000	None	None	1	100%	No; no exceedances.
p-Isopropyltoluene	99-87-6	mg/kg	1	None	None	None	None	--	NA	NA	1	100%	No; no criteria.
Methyl ethyl ketone	78-93-3	mg/kg	1	None	None	None	None	2,100,000	None	None	1	100%	No; no exceedances.
Methyl tert-butyl ether	1634-04-4	mg/kg	2	None	None	None	None	0.05	None	None	2	100%	No; no exceedances.
n-Propylbenzene	103-65-1	mg/kg	1	None	None	None	None	350,000	None	None	1	100%	No; no exceedances.
Tetrachloroethene	127-18-4	mg/kg	3	None	None	None	None	0.025	None	None	3	100%	No; no exceedances.
Trichloroethene	79-01-6	mg/kg	3	None	None	None	None	0.02	None	None	3	100%	No; no exceedances.
1,2,4-Trimethylbenzene	95-63-6	mg/kg	2	None	None	None	None	35,000	None	None	2	100%	No; no exceedances.
1,3,5-Trimethylbenzene	108-67-8	mg/kg	2	None	None	None	None	35,000	None	None	2	100%	No; no exceedances.
Toluene	108-88-3	mg/kg	28	7.1%	0.97	B314	12.5 feet	0.025	7.1%	39	26	93%	Yes.
Vinyl Chloride	75-01-4	mg/kg	3	None	None	None	None	0.025	None	None	3	100%	No; no exceedances.
Total Xylenes	1330-20-7	mg/kg	25	4.0%	2.7	B314	12.5 feet	1.5	4.0%	1.8	24	96%	No; exceeds in less than 5 percent of samples.

Table B.6

Frequency of Exceedance for East Waterfront Property Saturated Zone Soil[1]

			Information about Dataset					Information about Detected Exceedances			Information about Non-Detects		
Analytes	**CAS No.**	**Unit**	**Number of Results**	**Percent Detected**	**Maximum Detected Value[2]**	**Location of Maximum Detect**	**Depth of Maximum Detect**	**Most Stringent Preliminary Screening Level - Saturated Zone**	**Percent of Detects Exceeding Criteria**	**Exceedance Factor[4]**	**Number of Non-Detects**	**Percent of Non-Detects**	**Retained as a COPC?**
Semivolatile Organic Compounds - PAHs													
Benzo(a) anthracene	56-55-3	mg/kg	1	100%	0.046	B314	12.5 feet	0.021	100%	2.2	None	None	No; associated with known TPH source and not retained separately.
Benzo(b) fluoranthene	205-99-2	mg/kg	1	100%	0.029	B314	12.5 feet	0.074	None	None	None	None	No; no exceedances.
Benzo(k) fluoranthene	207-08-9	mg/kg	1	100%	0.034	B314	12.5 feet	0.074	None	None	None	None	No; no exceedances.
Benzo(a)pyrene	50-32-8	mg/kg	1	None	None	None	None	0.058	None	None	1	100%	No; no exceedances.
Chrysene	218-01-9	mg/kg	1	100%	0.11	B314	12.5 feet	0.024	100%	4.6	None	None	No; associated with known TPH source and not retained separately.
Dibenz(a,h) anthracene	53-70-3	mg/kg	1	None	None	None	None	0.11	None	None	1	100%	No; no exceedances.
Indeno(1,2,3-cd)pyrene	193-39-5	mg/kg	1	100%	0.037	B314	12.5 feet	0.21	None	None	None	None	No; no exceedances.
1-Methylnaphthalene	90-12-0	mg/kg	1	100%	1.8	B314	12.5 feet	4,500	None	None	None	None	No; no exceedances.
2-Methylnaphthalene	91-57-6	mg/kg	1	100%	2.3	B314	12.5 feet	14,000	None	None	None	None	No; no exceedances.
Naphthalene	91-20-3	mg/kg	2	50%	0.4	B314	12.5 feet	0.13	50%	3.1	1	50%	No; associated with known TPH source and not retained separately.
cPAH TEQ[5]	CPAHTEQ	mg/kg	1	100%	0.021	B314	12.5 feet	0.058	None	None	None	None	No; no exceedances.

Notes:

-- Not available.

🟧 Greater than 5 percent of detected concentrations exceed PSL; retained as a COPC.

1 Only samples greater than 10 feet bgs deep were considered to be in the saturated zone.

2 Results have been rounded to two significant figures.

3 PSLs for saturated zone soil were developed and presented in Table 4.1.

4 The exceedance factor is calculated by dividing the maximum detected value by the PSL. Only values greater than one (indicating an exceedance of the PSL) are displayed. Exceedance factors have been rounded to two significant figures.

5 Calculation of cPAH TEQ concentrations is performed using the California Environmental Protection Agency 2005 TEFs as presented in Table 708-2 of WAC 173-340-900. Calculated using detected cPAH concentrations plus one-half the reporting limit for cPAHs that were not detected.

Abbreviations:

bgs	Below ground surface
CAS	Chemical Abstracts Service
COPC	Chemical of potential concern
cPAH	Carcinogenic polycyclic aromatic hydrocarbon
mg/kg	Milligrams per kilogram
NA	Not applicable
PAH	Polycyclic aromatic hydrocarbon
PSL	Preliminary screening level
TEF	Toxic equivalent factor
TEQ	Toxic equivalent

Table B.7

Frequency of Exceedance for Bulk Terminal Property Groundwater[1]

			Information about Dataset					Information about Detected Exceedances			Information about Non-Detects		
Analyte	CAS No.	Units	Number of Results	Percent Detected	Maximum Detected Value[2]	Location of Maximum Detect	Date of Maximum Detect	Drinking Water PSL[3]	Percent of Detects Exceeding Criteria	Exceedance Factor[4]	Number of Non-Detects	Percent of Non-Detects	Retained as a COPC?
Dissolved Metals													
Arsenic	7440-38-2	µg/L	8	75%	15	01MW43	9/27/2006	10	13%	1.5	2	25%	Yes.
Barium	7440-39-3	µg/L	8	75%	47	01MW40	9/27/2006	2,000	None	None	2	25%	No; no exceedances.
Cadmium	7440-43-9	µg/L	8	None	None	None	None	5	None	None	8	100%	No; no exceedances.
Chromium	7440-47-3	µg/L	8	50%	2.4	01MW43	9/27/2006	24,000	None	None	4	50%	No; no exceedances.
Lead	7439-92-1	µg/L	8	None	None	None	None	15	None	None	8	100%	No; no exceedances.
Mercury	7439-97-6	µg/L	8	None	None	None	None	2	None	None	8	100%	No; no exceedances.
Selenium	7782-49-2	µg/L	8	38%	2.4	01MW42	9/27/2006	50	None	None	5	63%	No; no exceedances.
Silver	7440-22-4	µg/L	8	None	None	None	None	80	None	None	8	100%	No; no exceedances.
Total Metals													
Arsenic	7440-38-2	µg/L	8	88%	21	01MW42	9/27/2006	10	25%	2.1	1	13%	Yes.
Barium	7440-39-3	µg/L	8	88%	58	01MW40	9/27/2006	2,000	None	None	1	13%	No; no exceedances.
Cadmium	7440-43-9	µg/L	8	None	None	None	None	5	None	None	8	100%	No; no exceedances.
Chromium	7440-47-3	µg/L	8	25%	2.2	01MW43	9/27/2006	24,000	None	None	6	75%	No; no exceedances.
Lead	7439-92-1	µg/L	8	None	None	None	None	15	None	None	8	100%	No; no exceedances.
Mercury	7439-97-6	µg/L	8	None	None	None	None	2	None	None	8	100%	No; no exceedances.
Selenium	7782-49-2	µg/L	8	13%	1.9	01MW42	9/27/2006	50	None	None	7	88%	No; no exceedances.
Silver	7440-22-4	µg/L	8	None	None	None	None	80	None	None	8	100%	No; no exceedances.
Total Petroleum Hydrocarbons													
Gasoline-Range Organics	TPHG	µg/L	47	36%	16,000	01MW19	5/16/2016	800	23%	20	30	64%	Yes.
Diesel-Range Organics	TPHD	µg/L	47	91%	6,600	01MW72	4/11/2012	500	57%	13	4	8.5%	Yes.
Oil-Range Organics	TPHO	µg/L	47	32%	1,400	01MW90	5/11/2016	500	15%	2.8	32	68%	Yes.
Volatile Organic Compounds													
Acetone	67-64-1	µg/L	28	25%	60	01MW03	6/21/2006	7,200	None	None	21	75%	No; no exceedances.
Benzene	71-43-2	µg/L	47	34%	2,600	01MW19	5/16/2016	5	28%	520	31	66%	Yes.
1,2-Dibromoethane	106-93-4	µg/L	30	6.7%	1.4	01MW27	12/12/2006	0.05	6.7%	28	28	93%	Yes.
1,2-Dichloroethane	107-06-2	µg/L	31	16%	48	01MW42	12/12/2006	5	10%	9.6	26	84%	Yes.
1,1-Dichloroethene	75-35-4	µg/L	29	14%	0.2	01MW01 01MW03 01MW08 01MW11	6/21/2006 6/21/2006 6/20/2006 6/21/2006	7	None	None	25	86%	No; no exceedances.
cis-1,2-Dichloroethene	156-59-2	µg/L	29	17%	2	01MW20	12/13/2006	70	None	None	24	83%	No; no exceedances.
trans-1,2-Dichloroethene	156-60-5	µg/L	29	10%	0.2	01MW01 01MW03 01MW08	6/21/2006 6/21/2006 6/20/2006	100	None	None	26	90%	No; no exceedances.
Ethanol	64-17-5	µg/L	30	6.7%	1,000	01MW27	12/12/2006	--	NA	NA	28	93%	No; no criteria.
Ethylbenzene	100-41-4	µg/L	47	36%	820	01MW19	5/16/2016	70	11%	12	30	64%	Yes.
Isopropylbenzene	98-82-8	µg/L	28	46%	31	01MW47	12/22/2006	800	None	None	15	54%	No; no exceedances.
Methyl tert-butyl ether	1634-04-4	µg/L	30	10%	1.1	01MW42	12/12/2006	24	None	None	27	90%	No; no exceedances.

Table B.7

Frequency of Exceedance for Bulk Terminal Property Groundwater[1]

			Information about Dataset					Information about Detected Exceedances			Information about Non-Detects		
Analyte	CAS No.	Units	Number of Results	Percent Detected	Maximum Detected Value[2]	Location of Maximum Detect	Date of Maximum Detect	Drinking Water PSL[3]	Percent of Detects Exceeding Criteria	Exceedance Factor[4]	Number of Non-Detects	Percent of Non-Detects	Retained as a COPC?
Volatile Organic Compounds (cont.)													
Tetrachloroethene	127-18-4	µg/L	29	10%	0.2	01MW01 01MW03 01MW08	6/21/2006 6/21/2006 6/20/2006	5	None	None	26	90%	No; no exceedances.
Trichloroethene	79-01-6	µg/L	29	14%	8.6	01MW20	12/13/2006	5	3.4%	1.7	25	86%	No; exceeds in less than 5 percent of samples.
1,2,4 Trimethylbenzene	95-63-6	µg/L	28	54%	760	01MW47	12/22/2006	80	14%	9.5	13	46%	Yes.
1,3,5 Trimethylbenzene	108-67-8	µg/L	28	36%	86	01MW18	6/20/2006	80	3.6%	1.1	18	64%	No; exceeds in less than 5 percent of samples.
Toluene	108-88-3	µg/L	47	30%	110	01MW19	5/16/2016	1,000	None	None	33	70%	No; no exceedances.
Vinyl Chloride	75-01-4	µg/L	29	10%	0.2	01MW01 01MW03 01MW08	6/21/2006 6/21/2006 6/20/2006	2	None	None	26	90%	No; no exceedances.
Total Xylenes	1330-20-7	µg/L	46	26%	1,600	01MW84	5/19/2016	10,000	None	None	34	74%	No; no exceedances.
Semivolatile Organic Compounds - PAHs													
Naphthalene	91-20-3	µg/L	28	43%	460	01MW47	12/22/2006	160	3.6%	2.9	16	57%	No; exceeds in less than 5 percent of samples.
Semivolatile Organic Compounds - Other													
Pentachlorophenol	87-86-5	µg/L	41	4.9%	18	01MW01	5/12/2016	1	2.4%	18	39	95%	No; exceeds in less than 5 percent of samples.

Notes:

-- Not available.

🟧 Greater than 5 percent of detected concentrations exceed PSL; retained as a COPC.

1 Only current well locations within the Bulk Terminal well network are included (decommissioned wells have been excluded).

2 Results have been rounded to two significant figures.

3 The PSLs for protection of drinking water are presented in Table 4.2. Although these PSLs are not the most stringent, they are appropriate for use because the Bulk Terminal parcel is not adjacent to the shoreline, and drinking water is the highest beneficial use for groundwater. The MCL was selected as the appropriate PSL for screening. For chemicals that do not have an MCL, the MTCA Method B cleanup level was used for screening.

4 The exceedance factor is calculated by dividing the maximum detected value by the PSL. Only values greater than one (indicating an exceedance of the PSL) are displayed. Exceedance factors have been rounded to two significant figures.

Abbreviations:

CAS	Chemical Abstracts Service
COPC	Chemical of potential concern
MCL	Maximum contaminant level
µg/L	Micrograms per liter
MTCA	Model Toxics Control Act
NA	Not applicable
PAH	Polycyclic aromatic hydrocarbon
PSL	Preliminary screening level

Table B.8
Frequency of Exceedance for ASKO Hydraulic Property Groundwater[1]

			Information about Dataset					Information about Detected Exceedances			Information about Non-Detects		
Analyte	**CAS No.**	**Units**	**Number of Results**	**Percent Detected**	**Maximum Detected Value[2]**	**Location of Maximum Detect**	**Date of Maximum Detect**	**Drinking Water PSL[3]**	**Percent of Detects Exceeding Criteria**	**Exceedance Factor[4]**	**Number of Non Detects**	**Percent of Non Detects**	**Retained as a COPC?**
Dissolved Metals													
Arsenic	7440-38-2	µg/L	6	100%	17	MW03	4/25/2006	10	17%	1.7	None	None	Yes.
Barium	7440-39-3	µg/L	6	67%	23	MW04	4/25/2006	2,000	None	None	2	33%	No; no exceedances.
Cadmium	7440-43-9	µg/L	6	None	None	None	None	5	None	None	6	100%	No; no exceedances.
Chromium	7440-47-3	µg/L	6	83%	2.7	MW03	4/25/2006	24,000	None	None	1	17%	No; no exceedances.
Lead	7439-92-1	µg/L	7	None	None	None	None	15	None	None	7	100%	No; no exceedances.
Mercury	7439-97-6	µg/L	6	None	None	None	None	2	None	None	6	100%	No; no exceedances.
Selenium	7782-49-2	µg/L	6	None	None	None	None	50	None	None	6	100%	No; no exceedances.
Silver	7440-22-4	µg/L	6	None	None	None	None	80	None	None	6	100%	No; no exceedances.
Total Metals													
Arsenic	7440-38-2	µg/L	6	100%	90	MW03	4/25/2006	10	17%	9	None	None	Yes.
Barium	7440-39-3	µg/L	6	100%	35	MW04	4/25/2006	2,000	None	None	None	None	No; no exceedances.
Cadmium	7440-43-9	µg/L	6	None	None	None	None	5	None	None	6	100%	No; no exceedances.
Chromium	7440-47-3	µg/L	6	17%	4.1	MW03	4/25/2006	24,000	None	None	5	83%	No; no exceedances.
Lead	7439-92-1	µg/L	7	None	None	None	None	15	None	None	7	100%	No; no exceedances.
Mercury	7439-97-6	µg/L	6	None	None	None	None	2	None	None	6	100%	No; no exceedances.
Selenium	7782-49-2	µg/L	6	None	None	None	None	50	None	None	6	100%	No; no exceedances.
Silver	7440-22-4	µg/L	6	None	None	None	None	80	None	None	6	100%	No; no exceedances.
Total Petroleum Hydrocarbons													
Gasoline-Range Organics	TPHG	µg/L	48	27%	1500	01MW92	4/4/2014	800	8.3%	1.9	35	73%	Yes.
Diesel-Range Organics	TPHD	µg/L	48	71%	6400	01MW92	4/4/2014	500	33%	13	14	29%	Yes.
Oil-Range Organics	TPHO	µg/L	48	23%	2300	01MW71	5/18/2016	500	17%	4.6	37	77%	Yes.
Volatile Organic Compounds													
Acetone	67-64-1	µg/L	17	12%	13	01MW53	12/7/2007	7,200	None	None	15	88%	No; no exceedances.
Benzene	71-43-2	µg/L	48	23%	15	01MW44	5/18/2016	5	6.3%	3	37	77%	Yes.
n-Butylbenzene	104-51-8	µg/L	15	33%	1.3	02MW05	6/21/2006	400	None	None	10	67%	No; no exceedances.
sec-Butylbenzene	135-98-8	µg/L	17	12%	0.91	02MW05	6/21/2006	800	None	None	15	88%	No; no exceedances.
tert-Butylbenzene	98-06-6	µg/L	17	5.9%	0.5	01MW08	6/20/2006	800	None	None	16	94%	No; no exceedances.
1,2-Dibromoethane	106-93-4	µg/L	17	5.9%	0.2	01MW08	6/20/2006	0.05	5.9%	4	16	94%	Yes.
1,2-Dichloroethane	107-06-2	µg/L	48	10%	5.5	01MW44	5/18/2016	5	2.1%	1.1	43	90%	No; exceeds in less than 5 percent of samples.
1,1-Dichloroethene	75-35-4	µg/L	48	19%	11	01MW71	5/18/2016	7	8.3%	1.6	39	81%	Yes.
cis-1,2-Dichloroethene	156-59-2	µg/L	48	46%	640	01MW92	4/4/2014	70	17%	9.1	26	54%	Yes.
trans-1,2-Dichloroethene	156-60-5	µg/L	48	17%	35	01MW92	4/4/2014	100	None	None	40	83%	No; no exceedances.

Table B.8

Frequency of Exceedance for ASKO Hydraulic Property Groundwater[1]

			Information about Dataset					Information about Detected Exceedances			Information about Non-Detects		
Analyte	CAS No.	Units	Number of Results	Percent Detected	Maximum Detected Value[2]	Location of Maximum Detect	Date of Maximum Detect	Drinking Water PSL[3]	Percent of Detects Exceeding Criteria	Exceedance Factor[4]	Number of Non Detects	Percent of Non Detects	Retained as a COPC?
Volatile Organic Compounds (cont.)													
Ethanol	64-17-5	µg/L	17	5.9%	250	01MW08	6/20/2006	--	NA	NA	16	94%	No; no criteria.
Ethylbenzene	100-41-4	µg/L	48	2.1%	1.3	MW03	5/16/2016	70	None	None	47	98%	No; no exceedances.
n-Hexane	110-54-3	µg/L	17	18%	1	01MW06 01MW07 01MW08	6/20/2006 6/20/2006 6/20/2006	480	None	None	14	82%	No; no exceedances.
Isopropylbenzene	98-82-8	µg/L	17	12%	6.2	02MW05	6/21/2006	800	None	None	15	88%	No; no exceedances.
p-Isopropyltoluene	99-87-6	µg/L	17	5.9%	0.2	01MW08	6/20/2006	--	NA	NA	16	94%	No; no criteria.
Methyl ethyl ketone	78-93-3	µg/L	17	5.9%	2	01MW08	6/20/2006	4,800	None	None	16	94%	No; no exceedances.
Methyl tert-butyl ether	1634-04-4	µg/L	17	5.9%	1	01MW08	6/20/2006	24	None	None	16	94%	No; no exceedances.
n-Propylbenzene	103-65-1	µg/L	17	18%	3.9	02MW05	6/21/2006	800	None	None	14	82%	No; no exceedances.
Tetrachloroethene	127-18-4	µg/L	48	4.2%	2.5	01MW55	5/18/2016	5	None	None	46	96%	No; no exceedances.
Trichloroethene	79-01-6	µg/L	48	42%	7800	01MW92	4/4/2014	5	31%	1600	28	58%	Yes.
1,2,4 Trimethylbenzene	95-63-6	µg/L	17	24%	3.6	MW03	12/14/2006	80	None	None	13	76%	No; no exceedances.
1,3,5 Trimethylbenzene	108-67-8	µg/L	17	5.9%	0.5	01MW08	6/20/2006	80	None	None	16	94%	No; no exceedances.
Toluene	108-88-3	µg/L	48	13%	2.9	01MW63	5/18/2016	1,000	None	None	42	88%	No; no exceedances.
Vinyl Chloride	75-01-4	µg/L	48	44%	81	01MW63	5/18/2016	2	29%	41	27	56%	Yes.
Total Xylenes	1330-20-7	µg/L	48	2.1%	6.1	MW03	5/16/2016	10,000	None	None	47	98%	No; no exceedances.
Semivolatile Organic Compounds - PAHs													
Acenaphthene	83-32-9	µg/L	6	None	None	None	None	960	None	None	6	100%	No; no exceedances.
Acenaphthylene	208-96-8	µg/L	6	None	None	None	None	--	NA	NA	6	100%	No; no criteria.
Anthracene	120-12-7	µg/L	6	None	None	None	None	4,800	None	None	6	100%	No; no exceedances.
Benz(a) anthracene	56-55-3	µg/L	6	None	None	None	None	0.88	None	None	6	100%	No; no exceedances.
Benzo(b) fluoranthene	205-99-2	µg/L	6	None	None	None	None	0.88	None	None	6	100%	No; no exceedances.
Benzo(k) fluoranthene	207-08-9	µg/L	6	None	None	None	None	0.88	None	None	6	100%	No; no exceedances.
Benzo(g,h,i)perylene	191-24-2	µg/L	6	None	None	None	None	--	NA	NA	6	100%	No; no criteria.
Benzo(a)pyrene	50-32-8	µg/L	6	None	None	None	None	0.2	None	None	6	100%	No; no exceedances.
Chrysene	218-01-9	µg/L	6	None	None	None	None	8.8	None	None	6	100%	No; no exceedances.
Dibenz(a,h) anthracene	53-70-3	µg/L	6	None	None	None	None	0.88	None	None	6	100%	No; no exceedances.
Fluoranthene	206-44-0	µg/L	6	None	None	None	None	640	None	None	6	100%	No; no exceedances.
Fluorene	86-73-7	µg/L	6	None	None	None	None	640	None	None	6	100%	No; no exceedances.
Indeno(1,2,3-cd)pyrene	193-39-5	µg/L	6	None	None	None	None	0.88	None	None	6	100%	No; no exceedances.
1-Methylnaphthalene	90-12-0	µg/L	6	17%	13	MW03	4/25/2006	1.5	17%	8.7	5	83%	No; associated with known TPH source and not retained separately.
2-Methylnaphthalene	91-57-6	µg/L	6	None	None	None	None	32	None	None	6	100%	No; no exceedances.

Table B.8

Frequency of Exceedance for ASKO Hydraulic Property Groundwater[1]

			Information about Dataset					Information about Detected Exceedances			Information about Non-Detects		
Analyte	CAS No.	Units	Number of Results	Percent Detected	Maximum Detected Value[2]	Location of Maximum Detect	Date of Maximum Detect	Drinking Water PSL[3]	Percent of Detects Exceeding Criteria	Exceedance Factor[4]	Number of Non Detects	Percent of Non Detects	Retained as a COPC?
Semivolatile Organic Compounds - PAHs (cont.)													
Naphthalene	91-20-3	µg/L	17	5.9%	0.5	01MW08	6/20/2006	160	None	None	16	94%	No; no exceedances.
Phenanthrene	85-01-8	µg/L	6	None	None	None	None	--	NA	NA	6	100%	No; no criteria.
Pyrene	129-00-0	µg/L	6	None	None	None	None	480	None	None	6	100%	No; no exceedances.
Total PAHs	TPAH	µg/L	6	17%	13	MW03	4/25/2006	--	NA	NA	5	83%	No; no criteria.
cPAH TEQ[5]	50-32-8	µg/L	6	None	None	None	None	0.2	None	None	6	100%	No; no exceedances.
Semivolatile Organic Compounds - Other													
Pentachlorophenol	87-86-5	µg/L	11	None	None	None	None	1	None	None	11	100%	No; no exceedances.

Notes:

-- Not available.

🟧 Greater than 5 percent of detected concentrations exceed PSL; retained as a COPC.

1 Only current well locations within the ASKO well network are included (decommissioned wells have been excluded).

2 Results have been rounded to two significant figures.

3 The PSLs for protection of drinking water are presented in Table 4.2. Although these PSLs are not the most stringent, they are appropriate for use because the ASKO parcel is not adjacent to the shoreline, and drinking water is the highest beneficial use for groundwater. The MCL was selected as the appropriate PSL for screening. For chemicals that do not have an MCL, the MTCA Method B cleanup level was used for screening.

4 The exceedance factor is calculated by dividing the maximum detected value by the PSL. Only values greater than one (indicating an exceedance of the PSL) are displayed. Exceedance factors have been rounded to two significant figures.

5 Calculation of cPAH TEQ concentrations is performed using the California Environmental Protection Agency 2005 TEFs as presented in Table 708-2 of WAC 173-340-900. Calculated using detected cPAH concentrations plus one-half the reporting limit for cPAHs that were not detected.

Abbreviations:

CAS	Chemical Abstracts Service
COPC	Chemical of potential concern
cPAH	Carcinogenic polycyclic aromatic hydrocarbon
MCL	Maximum contaminant level
µg/L	Micrograms per liter
MTCA	Model Toxics Control Act
NA	Not applicable
PAH	Polycyclic aromatic hydrocarbon
PSL	Preliminary screening level
TEF	Toxic equivalent factor
TEQ	Toxic equivalent

Table B.9

Frequency of Exceedance for East Waterfront Property Groundwater—Upland Wells[1]

			Information about Dataset					Information about Detected Exceedances			Information about Non-Detects		
Analyte	**CAS No.**	**Units**	**Number of Results**	**Percent Detected**	**Maximum Detected Value[2]**	**Location of Maximum Detect**	**Date of Maximum Detect**	**Drinking Water PSL[3]**	**Percent of Detects Exceeding Criteria**	**Exceedance Factor[4]**	**Number of Non-Detects**	**Percent of Non-Detects**	**Retained as a COPC?**
Total Petroleum Hydrocarbons													
Gasoline-Range Organics	TPHG	µg/L	12	8.3%	3,100	02MW04	5/18/2016	800	8.3%	3.9	11	92%	Yes.
Diesel-Range Organics	TPHD	µg/L	12	58%	1,400	02MW04	5/18/2016	500	8.3%	2.8	5	42%	Yes.
Oil-Range Organics	TPHO	µg/L	12	8.3%	620	02MW04	5/18/2016	500	8.3%	1.2	11	92%	Yes.
Volatile Organic Compounds													
Benzene	71-43-2	µg/L	12	8.3%	19	02MW04	5/18/2016	5	8.3%	3.8	11	92%	Yes.
Ethylbenzene	100-41-4	µg/L	12	8.3%	190	02MW04	5/18/2016	70	8.3%	2.7	11	92%	Yes.
Total Xylenes	1330-20-7	µg/L	12	8.3%	240	02MW04	5/18/2016	10,000	None	None	11	92%	No; no exceedances.

Notes:

🟧 Greater than 5 percent of detected concentrations exceed PSL; retained as a COPC.

1 Only current well locations within the East Waterfront well network are included (decommissioned wells have been excluded).

2 Results have been rounded to two significant figures.

3 The PSLs for protection of drinking water are presented in Table 4.2. Although these PSLs are not the most stringent, they are appropriate for use for all East Waterfront parcel wells that are not adjacent to the shoreline, and drinking water is the highest beneficial use for groundwater. The MCL was selected as the appropriate PSL for screening. For chemicals that do not have an MCL, the MTCA Method B cleanup level was used for screening.

4 The exceedance factor is calculated by dividing the maximum detected value by the PSL. Only values greater than one (indicating an exceedance of the PSL) are displayed. Exceedance factors have been rounded to two significant figures.

Abbreviations:

CAS	Chemical Abstracts Service
COPC	Chemical of potential concern
MCL	Maximum contaminant level
µg/L	Micrograms per liter
MTCA	Model Toxics Control Act
PSL	Preliminary screening level

Table B.10

Frequency of Exceedance for East Waterfront Property Groundwater—Shoreline Well[1]

			Information about Dataset					Information about Detected Exceedances			Information about Non-Detects		
Analyte	**CAS No.**	**Units**	**Number of Results**	**Percent Detected**	**Maximum Detected Value[2]**	**Location of Maximum Detect**	**Date of Maximum Detect**	**Most Stringent Preliminary Screening Level**	**Percent of Detects Exceeding Criteria**	**Exceedance Factor[4]**	**Number of Non-Detects**	**Percent of Non-Detects**	**Retained as a COPC?**
Total Petroleum Hydrocarbons													
Gasoline-Range Organics	TPHG	µg/L	1	None	None	None	None	800	None	None	1	100%	No; no exceedances.
Diesel-Range Organics	TPHD	µg/L	1	1	160	02MW07	5/19/2016	500	None	None	None	None	No; no exceedances.
Oil-Range Organics	TPHO	µg/L	1	None	None	None	None	500	None	None	1	100%	No; no exceedances.
Volatile Organic Compounds													
Benzene	71-43-2	µg/L	1	None	None	None	None	0.44	None	None	1	100%	No; no exceedances.
Ethylbenzene	100-41-4	µg/L	1	None	None	None	None	29	None	None	1	100%	No; no exceedances.
Total Xylenes	1330-20-7	µg/L	1	None	None	None	None	1,600	None	None	1	100%	No; no exceedances.

Notes:

1 Only the current shoreline well location within the East Waterfront parcel is included (decommissioned wells have been excluded).

2 Results have been rounded to two significant figures.

3 The most stringent PSLs for groundwater were developed and presented in Table 4.2.

4 The exceedance factor is calculated by dividing the maximum detected value by the PSL. Only values greater than one (indicating an exceedance of the PSL) are displayed. Exceedance factors have been rounded to two significant figures.

Abbreviations:

CAS	Chemical Abstracts Service
COPC	Chemical of potential concern
µg/L	Micrograms per liter
PSL	Preliminary screening level

Time Oil Bulk Terminal PPA

Supplemental Upland Remedial Investigation Work Plan

Appendix C
Standard Guidelines for Soil and Groundwater Sampling

F|S STANDARD GUIDELINE

Well Construction

DATE/LAST UPDATE: May 2015

These procedures should be considered standard guidelines and are intended to provide useful guidance when in the field, but are not intended to be step-by-step procedures, as some steps may not be applicable to all projects.

All field staff should be sufficiently trained in the standard guidelines and should review and understand these procedures prior to going in the field. It is the responsibility of the field staff to review the standard guidelines with the field manager or project manager and identify any deviations from these guidelines prior to field work. When possible, the project-specific Sampling and Analysis Plan should contain any expected deviations and should be referenced in conjunction with these standard guidelines.

1.0 Scope and Purpose

This standard guideline presents commonly used procedures for the installation of resource protection wells, in accordance with applicable sections of the Washington State Minimum Standards for Construction and Maintenance of Wells (Washington Administrative Code [WAC] 173-160, Part Two) and ASTM Standard Practice for Design and Installation of Groundwater Monitoring Wells (ASTM D5092-04[2010]e1). These wells may include groundwater monitoring wells, piezometers, groundwater extraction wells, injection wells, or vapor extraction wells. The guideline is intended to be used by field staff who are overseeing well drilling and construction.

2.0 Equipment and Supplies

Well Installation Equipment and Tools:

- Tape measure or measuring wheel
- Weighted tape or leadline
- Water level meter
- Hand-held Global Positioning System (GPS; optional)
- Camera
- Trash bags

- Well construction materials including polyvinyl chloric (PVC) screen and riser, sandpack, bentonite and well monument will be provided by the drilling subcontractor.

Paperwork:

- Work Plan and/or Sampling and Analysis Plan (SAP)/Quality Assurance Project Plan (QAPP)
- Health and Safety Plan (HASP)
- Copies of figures showing previous boring locations and boring logs from previous investigations and historical depth to water levels, if available
- Well installation forms (printed on Rite in the Rain paper)
- Permanent markers and pencils

Personal Equipment:

- Steel-toed boots
- Hard hat
- Safety vest
- Safety glasses
- Nitrile gloves
- Ear plugs
- Rain gear
- Work gloves

3.0 Standard Procedures

3.1 PREPARATION

First, before going into the field, it is important to discuss the project needs with the Project Manager (PM). These include the appropriate aquifer for well screening (especially if it is not the shallowest aquifer), soil sampling interval (if applicable to drilling method), screen length and placement (especially important at tidally influenced sites), well construction materials (i.e., screen slot size and grain size of the filter pack), surface completion of the wells, and any other important construction details. Any non-standard materials needed for well construction should also be communicated to the drilling firm when the work is scheduled, or a minimum of two weeks prior to the field event. Select a boring log template that is appropriate for the project needs.

Next, review the work plan and existing materials such as cross-sections, historical depth to water levels, or boring logs from previous investigations (if available) to familiarize yourself with the site geology. In addition to site-specific information (or alternatively if other information is not available), a geologic map of the area from a reputable source such as the U.S. Geological Survey (USGS) may also be reviewed.

Finally, check the area of the site where drilling will occur for underground objects. A OneCall locate request should be made at least one week and no less than three days prior to commencement of drilling in order to give public utility locators time to mark known, buried utility lines. All planned boring locations should be marked on the ground with white spray paint prior to making a locate request. In almost all cases, site maintenance managers or equivalent should be consulted for site selection and a private utility locator should clear any underground objects using electromagnetic techniques from the drilling area. If drilling in close proximity to buried utilities, field staff may need to request authorization for use of an air knife or vacuum extraction to clear the borehole to a depth below the utility lines.

3.2 DRILLING

1. Mark the desired well location using coordinates pre-loaded into a handheld GPS, or by measuring from known Site features. It is best to use both methods, if possible.
2. Before drilling begins, record the following information on each log:
    a. Operator’s name and company, equipment make/model, equipment measurements (i.e., sampler length and diameter, hammer weight and stroke if using hollow stem auger, boring diameter).
    b. Your name, date, project, boring name, and approximate descriptive location relative to existing site features. Include a description of the ground surface and whether or not concrete coring was necessary; if so, include core diameter, concrete thickness, and subcontractor information.
    c. A small hand drawn map showing your location with measurements to a stationary reference point, or GPS coordinates (or ideally, both). This is also a good place to note if you have had to move a boring location because of underground utilities, access issues, etc. It is important to record the reason for relocation and the direction and distance moved (i.e., moved 10 feet to the north due to presence of subsurface water line).
3. If you are using a hollow stem auger, it is important to communicate to the driller how often you would like a split spoon sample collected. Typically this would be continuous or every 5 feet but may be different depending on the project needs. Usually this is established before the driller issues a quote. Any changes will affect the cost of the work and should be discussed with the PM.
    a. Record any feedback from the driller about the drilling conditions. This may include difficult drilling or rig chatter (usually caused by hard materials), heaving sands (usually caused by hydrostatic pressure on the borehole), caving, or hole instability.

4. For split spoon samples, record the number of hammer blows (blow counts) necessary to drive the sampler each 6-inch increment, as reported by the driller. If more than 50 blows are needed, record the distance that the sampler was driven in 50 blows (i.e., 2-inches in 50 blows). This is referred to as the standard penetration test (SPT).
5. For all drilling methods, create a log of the soils encountered according to the Floyd|Snider Soil Logging Standard Guideline. Pay particular attention to the moisture content of the soils, making careful notation of the water table where free water is first encountered. After drilling has been completed to the desired depth, confirm the depth to the water table using a water level meter.

3.3 WELL DESIGN AND CONSTRUCTION

1. Determine the length and placement of the well screen based on the observed depth to the water table, the specifics of the work plan, and the observed lithology. The well screen is typically set across the water table of shallow aquifers for monitoring wells and piezometers. However, the screened interval may be fully submerged for groundwater extraction wells, sites with very shallow groundwater, or wells installed in deeper aquifers below confining units. If an area is tidally influenced, note the tide elevation during well completion; if the tide is at a high or low at the time of drilling the well screen may need to be lowered or raised accordingly so that the screen spans the water table when the tide is at zero. The hydraulic conductivity of the aquifer material will also factor into well screen placement. For example, wells screened in tight silts may not produce enough water to adequately develop and sample. In this case, it may be preferable to screen the well in a more transmissive unit. Include the length of any required bottom caps or sumps below the well casing when determining the total depth of the boring required to place the well screen at the desired interval. The Washington State minimum standards also require that the diameter of the well screen relative to the diameter of the borehole (annual space) be small enough to allow placement of a filter pack that is 4 inches in diameter larger than the screen. For example, a 2-inch diameter monitoring well should be completed within a borehole that has a minimum 6-inch diameter.
2. Determine the filter pack material. The purpose of the filter pack is to prevent fine-grained aquifer material from entering the well while still allowing groundwater to flow through. Filter pack is composed of clean, rounded, relatively uniform silica sand. The choice of sand for the filter pack will depend on the grain size range of the aquifer material, with emphasis on the finest aquifer material. Filter pack material should be approximately 10 to 15 times the grain size of the surrounding aquifer material. The particle size ranges of fine, medium, and coarse sand, and the particle size ranges of common filter pack materials are given in the two tables below. As indicated in these tables, suitable filter pack choices for an aquifer with appreciable fine sand would include a range from 20-40 to 10-20 sand. For aquifers where the smallest particle size is medium sand, a filter pack of 2-12 sand or similar may be appropriate. More precise filter pack designs are possible based on grain size curves (see Driscoll 1986, Blair 2006).

Unified Soil Classification System (USCS) Classification	**U.S. Sieve Size**	**Grain Size (inches)**	**Grain Size (millimeters)**
Fine Sand	40 to 200	.003 to 0.16	.074 to .42
Medium Sand	10 to 40	.016 to .06	.42 to 1.68
Coarse Sand	10 to 4	.06 to 0.19	1.68 to 4.76

Example Sand Pack Gradations (U.S. Sieve Sizes)	**Grain Size (inches)**	**Grain Size (millimeters)**
32-40	.016 to .02	.42 to .55
20-40	.016 to .03	.42 to .84
16-30	.05 to .02	.59 to 1.2
10-20	.03 to .08	.84 to 2
2-12	.06 to .3	1.7 to 8

3. Determine the screen slot diameter. The purpose of the well screen is to allow groundwater to flow into and through the well screen for sample collection. Monitoring well casings are typically constructed of PVC (Washington State minimum standards require Schedule 40 or thicker-walled PVC for borings up to 200 feet deep); however, materials such as stainless steel may be used for the purposes of longevity, heat, specific chemical resistance, or other site-specific concerns. The screened interval of the well consists of a series of slots that are commonly 0.01 inch or 0.02 inch in width. Similar to filter pack material, narrower slots allow less fine-grained material and also less groundwater to pass through them. The screen slot size should be selected to retain approximately 90% or greater of the filter pack material. The largest screen slot size practical should be selected.
4. Once the driller has assembled the well casing of the appropriate length, oversee placement of the casing and filter pack. The casing should be centered in the borehole and level. When using a hollow stem auger, the sand is typically poured from the surface while the augers are being lifted from the borehole. When using sonic drilling or other methods where the drill rods are removed prior to sand placement, it is preferable to use a Tremie tube lowered to the bottom of the borehole to deliver the sand, which helps to ensure that the sand has actually reached the bottom of the borehole. As the driller is pouring sand into the annular space, monitor the height of the sand in the borehole using a weighted tape or leadline to ensure that the space is being filled evenly. If possible, use a surge block to force water from the well out into the sand pack periodically to eliminate any bridges or gaps in the sand. The sand pack

placement is complete when it has reached a height minimum of 1 foot (but no more the 5 feet) above the top of the well screen.

5. A bentonite seal must be placed above the sand pack to isolate the screened interval of the aquifer and to prevent the annular space from acting as a preferential pathway for surface water, water above the screen zone, or other liquid (i.e., free product). The purpose of the bentonite plug is to prevent downward migration inside the borehole, which has the potential to cause groundwater contamination. Monitor the placement of the bentonite plug above the sand pack. The bentonite plug is typically composed of dehydrated bentonite chips, which are poured into the annual space from the surface; or a bentonite slurry, which is pumped into the space via a Tremie tube. A bentonite chip seal is still recommended (but not necessary) immediately above the sand pack when using bentonite slurry to minimize migration of the slurry into the sandpack. Pumping is preferable in situations where bentonite will be placed below the water table. The U.S. Environmental Protection Agency (USEPA) recommends that the bentonite seal consist of a minimum of 2 feet of bentonite placed above the sand pack. If using a bentonite chip seal, hydrate the chips with clean water so that they expand to seal the borehole.
6. Communicate the desired surface completion to the driller (i.e., an aboveground well monument or a monument flush with the ground surface) if you have not already done so. Verify that the well monument has been installed correctly. For flush-mounted wells, ensure that the well is level with the surrounding grade, especially in areas with pedestrian or vehicle traffic. In areas with frequent or heavy vehicle traffic, heavy-duty traffic-rated monuments or manholes should be used. For aboveground well monuments (i.e., stand pipes), ensure that the monument is level, anchored in a minimum of 2 feet of concrete, and protected by steel bollards, unless otherwise specified in the work plan. The concrete surrounding any well monument should seal the borehole at the ground surface.

4.0 Decontamination

All reusable equipment that comes into contact with soil and groundwater should be decontaminated as follows prior to moving to the next sampling location.

Split spoons, stainless steel bowls and spoons, the water level tape, and any other tools used for well drilling and installation must be decontaminated between boring locations. If collecting soils samples for chemical analysis, split spoons and any tools used for sample processing will be decontaminated between each sample; alternatively, disposable bowls and spoons may be used. Equipment decontamination will consist of a tap water rinse to remove soil particles, followed by scrubbing with brushes and an alconox (or similar)/clean water solution, and a final rinse with distilled or deionized water.

5.0 Investigation-Derived Waste

Unless otherwise specified in the project work plan, waste soils, liquids, and other drilling materials generated during well drilling and installation will be contained in accordance with applicable laws, and stored in a designated area until transported off-site for disposal.

The approach to handling and disposal of these materials is as follows. For investigation-derived waste (IDW) that is contained, such as waste soils, 55-gallon drums approved by the Washington State Department of Transportation (WSDOT) will be supplied by the driller and used for temporary storage pending profiling and disposal. Each container holding IDW will be sealed and labeled with its contents (e.g., “soil cuttings”), the date(s) on which the wastes were placed in the container, the owner’s name, contact information for the field person who generated the waste, and the site name.

IDW contained within drums will be characterized relative to applicable waste criteria using data from the sampling locations whenever possible. Material that is designated for off-site disposal will be transported to an off-site facility permitted to accept the waste. Manifests will be used as appropriate for disposal.

Disposable sampling materials and incidental trash such as paper towels and personal protective equipment (PPE) used in sample processing will be placed in heavy-duty garbage bags or other appropriate containers and disposed of as solid waste in the municipal collection system (i.e., site dumpster).

6.0 Field Documentation

All observations should be recorded on a soil boring/well completion form appropriate for the drilling method or in a bound field notebook. Field staff should record as much detail as possible in the field log (including well construction materials, Ecology well ID tag number, and surface completions) and note any anomalies or details that varied from the SAP. After the field work is complete, a set of final well construction logs (usually electronic) that serve as the record for the project will be completed in consultation with the project manager or field manager.

F|S STANDARD GUIDELINE

Well Development

DATE/LAST UPDATE: May 2015

These procedures should be considered standard guidelines and are intended to provide useful guidance when in the field, but are not intended to be step-by-step procedures, as some steps may not be applicable to all projects.

All field staff should be sufficiently trained in the standard guidelines and should review and understand these procedures prior to going in the field. It is the responsibility of the field staff to review the standard guidelines with the field manager or project manager and identify any deviations from these guidelines prior to field work. When possible, the project-specific Sampling and Analysis Plan should contain any expected deviations and should be referenced in conjunction with these standard guidelines.

1.0 Scope and Purpose

This Standard Guideline for Well Development presents commonly used procedures for monitoring well development for newly installed monitoring wells and/or existing wells that may require redevelopment. Monitoring well development restores hydraulic conductivity with the surrounding formations that were disturbed during the drilling process. Development removes residual fines from well filter pack materials and the borehole wall and reduces the turbidity of the water, which provides more representative groundwater samples. These wells may include groundwater monitoring wells, piezometers, or groundwater extraction wells. This guideline describes the purge and surge method of development and is intended to be used by field staff who are overseeing or completing well development. Often, the drilling subcontractors are asked to complete well development activities subsequent to new well installations, in which case, Floyd|Snider staff would oversee the development. Other development methods, such as jetting, are not described herein, but may be used if specified in the project-specific Work Plan or Sampling and Analysis Plan (SAP).

Well development shall be completed by continuous pumping at a steady rate using a portable pump and polyethylene tubing, with regular surging (e.g., using a surge block) to force water through the filter pack and surrounding formation. Wells should ideally be developed either during installation (following sand placement but prior to sealing) or soon after installation, unless otherwise specified in the work plan, using the described methodologies or equivalents. For wells that are completed using a grout or concrete seal, if development does not take place prior to sealing, it should be completed within 48 hours following well installation in order allow for grout and concrete to cure.

2.0 Equipment and Supplies

Well Development Equipment and Tools:

- Appropriate high volume pump (centrifugal, submersible, etc.) and correct diameter tubing, or bailer
- Hose clamps (optional)
- Power source (generator, 12-volt battery, or car battery) and appropriate power adapter for pump
- Water quality meter or turbidity meter (if needed)
- 2-, 4-, or 6-inch surge block (typically provided by the driller)
- Water level meter
- Washington State Department of Transportation (WSDOT)-approved 55-gallon drums
- Equipment decontamination supplies including:
  - Scrub brushes
  - Alconox or other soap
  - Distilled or deionized water
  - Paper towels
- Trash bags
- Camera

Paperwork:

- Work Plan and/or SAP/Quality Assurance Project Plan (QAPP)
- Bound field notebook or appropriate field forms
- Well development form (printed on Rite in the Rain paper)
- Health and Safety Plan (HASP)
- Well installation forms (printed on Rite in the Rain paper)

Personal Equipment:

- Steel-toed boots
- Safety vest
- Safety glasses
- Nitrile gloves
- Rain gear
- Work gloves

3.0 Standard Procedures

3.1 OFFICE PREPARATION

Meet with the project manager to identify key information and goals of the well development, including how long after construction the wells should be developed. Determine if Floyd|Snider or the driller will be doing the development.

3.2 WELL DEVELOPMENT PROCEDURES

The following procedures are general guidelines for monitoring well development. These same procedures are also appropriate for extraction wells, injection wells, and/or piezometers. Specific instructions provided in individual work plans shall supersede these procedures in the event there are discrepancies.

Visually inspect all well development equipment for damage; repair as necessary.

1. Decontaminate all hoses, surge blocks, and/or submersible pump by scrubbing with brush and alconox or other soap solution and rinsing with deionized water.
2. Prior to development, use a water level meter to measure the depth in each well to the static water level and total depth to a reference mark on the top of the well casing.
3. Attach a length of clean or disposable tubing, approximately 5 feet longer than the well casing, to the outlet of the submersible pump.
4. Each well development cycle consists of surging followed by well evacuation (pumping). Surging may be accomplished with a surge block sized to fit snugly inside the well casing, or with the submersible pump. Surging using a pump increases the hydraulic gradient and velocity of groundwater near the well by drawing the water level down and moving more fine-grained soil particles into the well casing. Surging using a pump is only effective if the well produces enough water for continuous pumping and the pump is of a large enough diameter relative to the well casing. If

pumping must be stopped to allow the well to recharge, a surge block is preferable for surging. If using a surge block, connect polyvinyl chloride (PVC) pipe or other rods longer than the well casing to the surge block. Lower the surging device into the well to a depth within the screened interval. A bailer can be used to surge in situations when a surge block is not available and the well has insufficient recharge for the submersible pump.

5. During development, it is important to note the color and clarity of the water and any other visual or olfactory observations on the field form or in the field notebook. Note any significant changes as development progresses.
6. Surging should consist of a minimum of ten consecutive surges (i.e., quickly raise and lower surge block or pump in well) with an appropriately sized surge block or pump over the full length of the screen. For long well screens (greater than 10 feet), surging should be done in short intervals of 2 to 3 feet at a time. In cases where the screen extends to above the water table, clean water may have to be added to the well to develop the top of the filter pack.
7. After surging, water is purged from well until the pumped stream starts to run clear. At that point, stop pumping and initiate another surge cycle. If a well has more hydraulic head than the pump is able to overcome, or if an insufficient volume of water for pumping is present, a disposable bailer may also be used for purging.
8. Repeat this procedure until evacuated water is visibly clear and essentially free of sediment. Perform a minimum of three surge and pump cycles.
9. Well development will be terminated when the variation in the turbidity Nephelometric Turbidity Units (NTUs) readings is less than 10 percent or until the discharge is visibly clear and free of sediment after a minimum of three surge and purge cycles. As an alternative, periodic water samples can be collected for field measurements of temperature, specific conductivity, and pH; well development should continue until field parameters stabilize to within ±5 percent on three consecutive measurements or 10 well volumes have been purged. If it is not possible reduce the turbidity further, the well should be purged up to a maximum of four hours or as determined sufficient by the field geologist or project manager.
10. Report field observations and volume of water removed on the standard well development form (attached). Take final water level measurements and record then on the field form or in the field notebook.
11. Contain the purged water and manage in accordance with the project-specific SAP or Section 5.0 below. Prior to developing the next well or after the completion of development activities, decontaminate all reusable equipment used in development in accordance with Section 4.0 below.
12. If feasible, it is best to wait at least two weeks after development to sample the wells. Wells can be sampled a minimum of 48 hours after the completion of development if

the project schedule requires a quick turnaround. However, the groundwater sample will be more representative of static conditions in the aquifer if allowed to stabilize for at least one to two weeks after development.

4.0 Decontamination

All reusable equipment that comes into contact with groundwater should be decontaminated as follows prior to moving to the next sampling location.

Water level meter and surge block: The water level indicator and tape will be decontaminated between sampling locations and at the end the day by spraying the entire length of tape that came in contact with groundwater with an Alconox (or similar)/clean water solution followed by a thorough rinse with distilled or deionized water. Surge block decontamination will consist of a tap water rinse to remove soil particles, followed by scrubbing with brushes and an alconox (or similar)/clean water solution and a final rinse with distilled or deionized water.

Submersible Pump: Decontaminating the pump requires running the pump in three progressively cleaner grades of water. Place the pump and the length of the power cord that was in contact with water into a bucket containing approximately four gallons of an Alconox (or similar)/clean water solution. Run the pump for approximately two minutes or until the volume of water in the bucket has been exhausted. Next, place the pump and cord into a second bucket containing approximately four gallons of clean water and run the pump for approximately two minutes or until the volume of water in the bucket is exhausted. Lastly, place the pump and power cord into a third bucket containing approximately four gallons of distilled or deionized water and run the pump for approximately two minutes or until the volume of water in the bucket is exhausted. The soap/water solution and rinse water may be re-used. When done for the day, dry the exterior of the pump and power cord with clean paper towels to the extent practical prior to storage. All decontamination water and rinse water (including soapy solution) should be managed in accordance with Section 5.0 below.

5.0 Investigation-Derived Waste

Unless otherwise specified in the project work plan, well development and decontamination water generated during development and any drilling materials will be contained and stored in a designated area until transported off-site for disposal in accordance with applicable laws.

The approach to handling and disposal of these materials is as follows. For investigation-derived waste (IDW) that is contained, such as well development water, WSDOT-approved 55-gallon drums will be supplied by the driller and used for temporary storage pending profiling and disposal. Each container holding IDW will be sealed and labeled as to its contents (e.g., “MW-1 Well development water”), the date(s) on which the wastes were placed in the container, the owner's name, contact information for the field person who generated the waste, and the site name.

IDW contained within drums will be characterized relative to applicable waste criteria using data from the sampling locations whenever possible. Material that is designated for off-site disposal will be transported to an off-site facility permitted to accept the waste. Manifests will be used as appropriate for disposal.

Disposable sampling materials and incidental trash such as paper towels and personal protective equipment (PPE) used in sample processing will be placed in heavy duty garbage bags or other appropriate containers and disposed of as trash in the municipal collection system (i.e., site dumpster).

6.0 Field Documentation

Well development procedures will be documented on the well development field form (attached) or a bound field notebook. Information recorded will at a minimum include date, personnel present (including subcontractors), purpose of field event, weather conditions, depth of water, well construction details for the well(s) being developed (i.e., diameter, total depth, screen interval), water quality field measurements (if collected), amount of purged water generated, and any deviations from the SAP.

Enclosure: Well Development Field Form

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WELL DEVELOPMENT FIELD FORM

Project Name:____________________________ Date: ________________

Project Number:___________________________ Field Personnel: ____

Driller (if applicable): __________________________

Purge Data

Well ID:	**Total Well Depth:**	**Well Condition/Damage Description:**

Well Casing Type/Diameter/Screened Level:	**One Casing Volume (gal):**
Method of Development (Circle): Surge Block Pump Surge Bailer	**Equipment Used (type of pump, etc.):**

Begin Purge (time):

End Purge (time):

Gallons Purged (time):

Purge Water Disposal Method (circle):

On-site Storage Tank On-site Treatment Drum Other:

Volume of Schedule 40 PVC Pipe

Diameter	O.D.	I.D.	Volume (Gal/Linear Ft.)	Weight of Water (Lbs/Lineal Ft.)
1 ¼”	1.660”	1.380”	0.08	0.64
2”	2.375”	2.067”	0.17	1.45
3”	3.500”	3.068”	0.38	3.2
4”	4.500”	4.026”	0.66	5.51
6”	6.625”	6.065”	1.5	12.5

Time	Depth to Water (feet)	Vol. Purged (gallons)	Rate (gpm)	pH	Conductivity	Turbidity	Temp	Comments
			--	--	--	--	--	Prior to purging

Notes:

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F|S STANDARD GUIDELINE

Soil Logging

DATE/LAST UPDATE: August 2018

These procedures should be considered standard guidelines and are intended to provide useful guidance when in the field, but are not intended to be step by step procedures, as some steps may not be applicable to all projects.

All field staff should be sufficiently trained in the standard guidelines and should review and understand these procedures prior to going in the field. It is the responsibility of the field staff to review the standard guidelines with the field manager or project manager and identify any deviations from these guidelines prior to field work. When possible, the project-specific Sampling and Analysis Plan should contain any expected deviations and should be referenced in conjunction with these standard guidelines.

1.0 Scope and Purpose

These soil logging standard guidelines should be used by the field staff performing subsurface investigations, such as a direct push or roto-sonic soil boring, installation of a monitoring well via hollow stem auger, or roto-sonic or mud rotary drilling. While many projects will not necessarily have a Licensed Geologist (LG) or Hydrogeologist (LHG) who reviews and stamps every boring log, it is important that the field staff discusses the soil logging needs for a particular investigation with the project geologist, the project manager, or whoever will ultimately be responsible for interpreting the findings of the field investigation. This discussion is in addition to field training and general knowledge about soil logging, and should happen prior to entering the field, with additional follow-up before drafting a final set of electronic logs, after the investigation is complete.

2.0 Equipment and Supplies

Logging Equipment and Tools:

- 100-foot tape measure or measuring wheel
- Handheld Global Positioning System (GPS; optional)
- Unified Soil Classification System (USCS) Soil Classification Field Guide

- Soil logging kit containing:
  - Stainless steel spoons
  - Paint scraper or trowel
  - Small Ziploc bags
  - Small stainless steel bowls or black mining pans for sheen testing
  - Spray bottle filled with water
  - Paper towels (preferably white)
  - Engineers tape
  - Note cards
  - Optional items include:
    - Empty VOA vials or small glass jars
    - Munsell color chart
    - Sieves
    - White and grayscale color cards for photographs
- Plastic sheeting and duct tape or clamps to cover the sampling table
- Camera
- Trash bags
- Coolers
- Jars
- Labels
- Ice

Paperwork:

- Work Plan and/or Sampling and Analysis Plan (SAP)/Quality Assurance Project Plan (QAPP)
- Health and Safety Plan (HASP)
- Copies of figures showing previous boring locations and boring logs from previous investigations, if available
- Boring log forms appropriate for drilling method, printed in Rite in the Rain paper and/or bound field notebook
- Permanent markers and pencils

Personal Equipment:

- Steel-toed boots
- Hard hat

- Safety vest
- Safety glasses
- Nitrile gloves
- Ear plugs
- Rain gear
- Work gloves

3.0 Standard Procedures

3.1 OFFICE PREPARATION

First, meet with the project manager or field manager to identify the key information and goals of the soil boring investigation. These may include fill history, known or suspected sources of contamination and potential field indications of these contaminants, identification of specific units, or important geotechnical measurements. If possible, select a boring log template that is appropriate for the project needs.

Next, review the work plan and all available existing materials such as cross-sections or boring logs from previous investigations to familiarize yourself with the site geology. In addition (or alternatively if other information is not available), you may also review a geologic map of the area from a reputable source such as United States Geological Survey (USGS).

Finally, check the area of the site where drilling will occur for underground objects. At minimum, a OneCall locate request should be made at least one week in advance of drilling in order to give public utility locators time to mark known buried utility lines. All planned boring locations should be marked on the ground with white spray paint prior to making a locate request. In almost all cases, a private utility locator should also clear the area of drilling any underground objects using electromagnetic techniques. If drilling is to occur in close proximity to buried utilities, the work plan may specify use of an air knife or vacuum to clear the borehole to a depth below the utility lines.

3.2 COLLECTING SOIL SAMPLES FOR CLASSIFICATION

1. Before beginning drilling, record the following information on each log:
    a. Operator's name and company, equipment make/model, equipment measurements (i.e., sampler length and diameter, hammer weight and stroke if using hollow stem auger, boring diameter)
    b. Your name, date, project, boring name and approximate descriptive location (i.e., where is the soil boring relative to known site features). Include a description of the ground surface and whether or not coring was necessary, if coring was necessary, include core diameter, concrete thickness, and subcontractor information.

   c. A small hand drawn map showing your location with measurements to a stationary reference point, or GPS coordinates (ideally, both). This is also a good place to note if you have had to move a boring location because of underground utilities, access issues, etc. It is important to note the reason for relocation and the direction and distance moved (i.e., moved 10 feet to the north due to presence of subsurface water line).

2. If you are using a hollow stem auger drilling method, it is important to communicate to the driller how often you would like a split spoon sample collected. Typically this would be continuous or every 5 feet but may be different depending on the project needs.

3. Note any feedback from the driller about the drilling conditions. This may include difficult drilling or rig chatter (usually caused by hard materials), heaving sands (usually caused by hydrostatic pressure on the borehole), caving, or hole instability.

4. For split spoon samples, record the number of hammer blows (blow counts) necessary to drive the sampler each 6-inch increment, as reported by the driller. If more than 50 blows are needed, record the distance that the sampler was driven in 50 blows (i.e., 2-inches in 50 blows). This is referred to as the standard penetration test.

5. Cover the sampling table with plastic sheeting. Lay an engineer's tape lengthwise across the sampling table. Once a sample has been collected, orient it on the table so that the top is aligned with the 0-foot mark on the tape.

6. Split open the sampler, core barrel liner, or sample collection bag. Record the depth interval that the sampler was driven and the depth interval of soil that was recovered. For split spoons or single-cased core barrels, such as Geoprobe direct-push rods, determine whether any loose 'slough' soil has been dislodged by the drilling equipment and deposited at the top of your core (AMS direct push rods are double cased and do not create slough). Do not include slough in the measurement of the soil recovered. Often the core will be filled with an uninterrupted column of soil that is shorter in length than the total drive interval. In such cases, record the recovery interval as it is situated in the core unless you are able to determine the actual depth where the soil sample originated. For the purposes of recording soil observations and collecting samples for analysis, assume that the recovered column of soil has been evenly compressed unless you are able to determine the interval(s) in which compression has occurred. Decompress the recovered soil when making further observations (e.g., if the recovered soil column is 80 percent of the length of the drive interval, assume 0.8 feet of recovered soil represent 1 foot of soil in situ).

7. Before further disturbing the soil, take volatile organic compound (VOC) measurements with a photoionization detector (PID), if using. Take measurements by making crevices in the soil with a spoon or scraper and inserting the PID probe into these openings. Alternatively, collect small spoonfuls of soil into Ziploc bag(s), seal the bag(s), gently shake the bag(s), and insert the PID probe through the top of the bag(s) and into the headspace once the soil vapor has been allowed to equilibrate with the

surrounding air (headspace method). The bag headspace screening method is typically more accurate and is useful at sites with low concentrations of VOCs, whereas the in-situ method is a faster and more qualitative method, best used at sites with higher VOC concentrations. If sampling for VOCs by the U.S. Environmental Protection Agency (USEPA) Method 5035, these soil samples should also be collected prior to disturbing the core. Soil sampling procedures using USEPA Method 5035 are described in detail in the Soil Sample Collection Standard Guideline.

8. Use a straight edge to scrape the soil level and expose the center of the core. Photograph the core alongside the measuring tape and an index card displaying the soil boring location/ID and depth interval.

3.3 SOIL CLASSIFICATION

Soils are described using the following characteristics: Color, consistency, MAJOR CONSTITUENT, minor constituent, geotechnical properties, moisture content, other observations (e.g. visual or olfactory indications of contamination). The USCS field guide is included in this guidance for reference. The steps below should help guide the logger in classifying soils according to the USCS.

1. Record the color of the soil. A descriptive color (i.e., light brown) or a color identified using the Munsell color chart are both valid.
2. Determine whether organic matter influences the properties of the material. If so, record as an organic soil.
3. If the soil is predominantly inorganic, identify whether the major constituent is coarse- or fine-grained. Coarse-grained soils include sands and gravels; fine-grained soils include silts and clays.
    a. For coarse grained soils, determine:
        i. Grain size(s) present including fine, medium, or coarse, and grain size distribution including well-graded (a mixture of fine to coarse grains) or poorly-graded (uniform in size). The USCS guide is helpful for determining grain sizes. If the major constituent is gravel, note its angularity using “rounded,” “sub-angular” or “angular.”
        ii. Minor constituent(s). If a minor constituent represents less than approximately 15% of the sample, note this as “with [minor constituent]” and optionally, whether it is “trace” (<5%) or “few” (5-15%). If a minor constituent represents more than 15% of the sample, use “[minor constituent]-y.” For example, a sand with 5% silt would be classified as a “SAND with trace silt” and sand with 30% silt would be classified as a “SILTY SAND.” For coarse-grained soils with fines between 5% and 15%, the USCS includes several dashed classifications, such as SW-SM. It is often helpful to record an estimated percentage for soil constituents to aid in classification according to the USCS.

b. For fine-grained soils, determine:

   i. Major constituent. To determine whether a material is silt or clay, a simple settling test may be performed in a glass vial or gloved hand by spraying a small amount of the sample with water. Silt particles will settle out of suspension in water within a few minutes, whereas clay particles will remain suspended for a longer period of time.

   ii. Minor constituent(s). As described above, determine the approximate percentage and record as “with [minor constituent]” or “[minor constituent]-y” as appropriate. It is often helpful to record an estimated percentage to aid in classification according to the USCS.

   iii. Geotechnical properties. Depending on project data needs, geotechnical properties may be optional but often provide helpful information. Geotechnical properties include plasticity (ranging from “non-plastic” to “highly plastic” as determined by a thread test) and consistency (ranging from “loose” to “very dense” for coarse-grained soils and “soft” to “hard” for fine-grained soils). When using split spoon samplers, blow counts recorded during the standard penetration test (also referred to as N-values) are used to determine consistency; when using direct-push or sonic drilling, consistency is described qualitatively.

4. Using the USCS guide and the description of the soil, determine the appropriate USCS symbol and record it on the log. If it is difficult to distinguish the major constituent of a soil, a borderline “/” symbol may be used to denote the two potential major constituents present. This is not the same as the USCS classifications that utilize a dash, such as SW-SM.

5. Determine whether contacts between stratigraphic units are abrupt, or gradational. Note abrupt contacts using a solid line and gradational contacts using a dotted line. If the contact between units is not visible and was missed between sample depths, a dashed line is used.

6. If the site or area geology is known, and you are confident in your identification of a specific stratum, note the geologic unit. At a site where the geology is uncertain, you may make some more general notes about the depositional environment, such as identifying probable estuarine deposits, colluvium, glacial till, etc.

7. Note the moisture content of the soil, using “dry,” “moist,” “wet,” or “saturated.” Mark the water table at the time of drilling on the log at the depth where saturated soil is first observed.

3.4 OTHER OBSERVATIONS

1. Record other materials observed in the sample. These may include minor amounts of rootlets or other plant matter, evidence of organisms such as shell fragments, and/or anthropogenic debris such as brick fragments, plastic, or metal debris.
2. Record potential indications of contamination. These may include odors, colored or black staining on soils, colored crystals, hydrocarbon sheens, or non-aqueous phase liquid (NAPL) product.
    a. To test for hydrocarbon sheen, put a small amount of soil in a bowl, saturate with water and swirl, noting whether a rainbow sheen appears on the surface of the water. Alternatively, place a small amount of water in the bottom of the bowl and a small amount of soil along the side, then tilt the bowl so that the water slowly touches the soil. If observed, note the color of the sheen and describe as slight (discontinuous on the water surface), moderate (continuous but spreading slowly) or high (rainbow sheen covering entire surface water).
    b. To test for the presence of NAPL, use a clean paper towel to blot the surface of the core and note the proportion of the towel that is saturated with oil (be sure to allow the towel to dry when blotting moist to wet soils to distinguish between saturation due to NAPL and due to water).
3. Note the final depth of the boring and any reasons for early termination of the boring (i.e., refusal).
4. If monitoring wells will be installed, follow the Standard Guidelines for monitoring well construction and well development.

4.0 Decontamination

All reusable equipment that comes into contact with soil should be decontaminated as follows prior to moving to the next sampling location.

Split spoons, stainless steel bowls and spoons, and any other tools used for soil classification must be decontaminated between boring locations. If collecting soil samples for chemical analysis, split spoons and any tools used for sample processing must be decontaminated between each sample; alternatively, disposable bowls and spoons may be used. Equipment decontamination will consist of a tap water rinse to remove soil particles, followed by scrubbing with brushes and an alconox (or similar)/clean water solution and a final rinse with distilled or deionized water.

5.0 Investigation-Derived Waste

Unless otherwise specified in the project work plan, waste soils and other drilling materials generated during soil boring activities will be contained, transported, disposed of in accordance with applicable laws, and stored in a designated area until transported off-site for disposal.

The approach to handling and disposal of these materials is as follows. For investigation-derived waste (IDW) that is contained, such as waste soils, 55-gallon drums approved by the Washington State Department of Transportation (WSDOT) will be supplied by the driller and used for temporary storage pending profiling and disposal. Each container holding IDW will be sealed and labeled as to its contents (e.g., “soil cuttings”), the dates on which the wastes were placed in the container, the owner’s name, contact information for the field person who generated the waste, and the site name.

Whenever possible, IDW contained within drums will be characterized relative to applicable waste criteria using data from the sampling locations. Material that is designated for off-site disposal will be transported to an off-site facility that is permitted to accept the waste. Manifests will be used as appropriate for disposal.

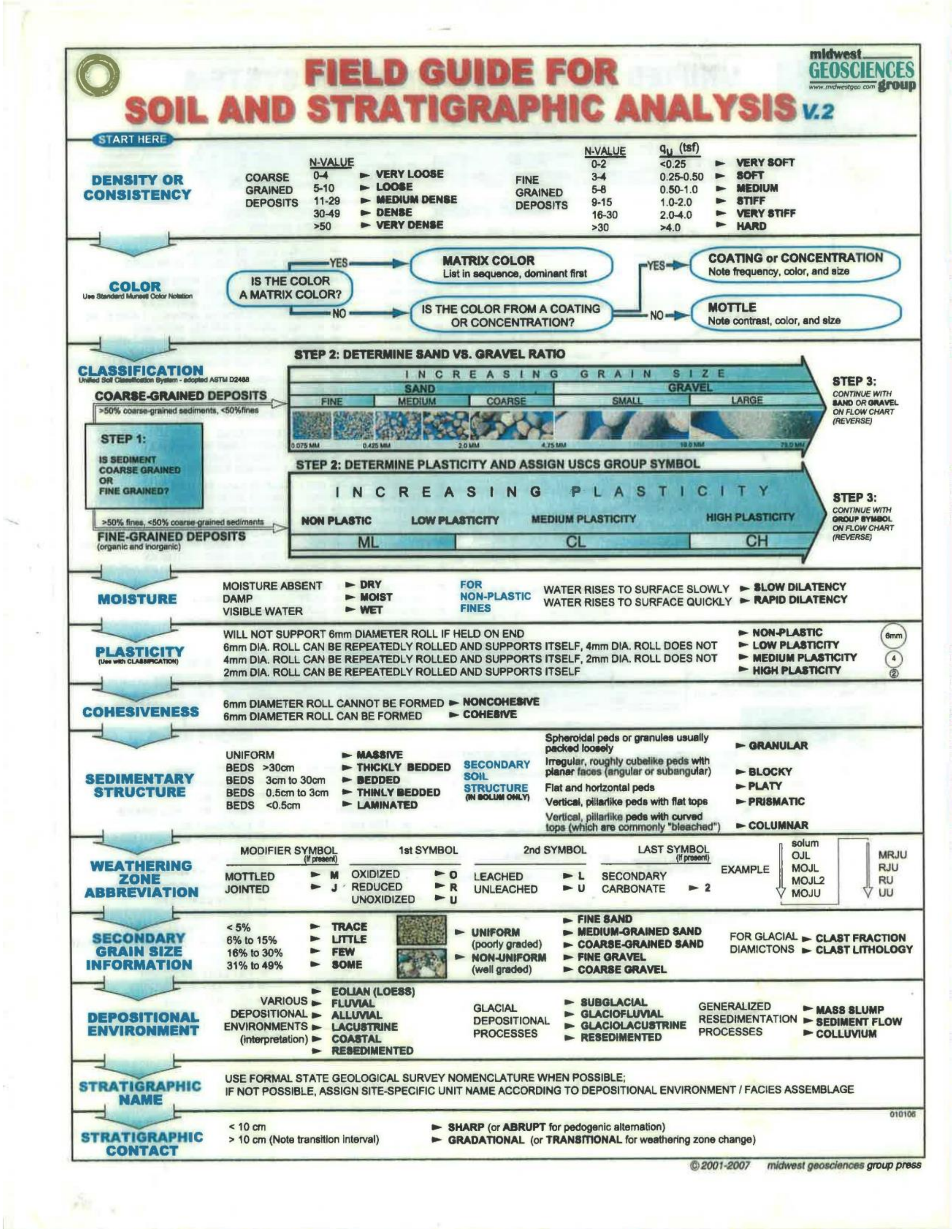
Disposable sampling materials and incidental trash such as paper towels and personal protective equipment (PPE) used in sample processing will be placed in heavy duty garbage bags or other appropriate containers and disposed of as solid waste in the municipal collection system (i.e., site dumpster).

6.0 Field Documentation

All observations should be recorded on a soil boring form appropriate for the drilling method or in a bound field notebook. Field staff should make an effort to record as much detail as possible in the field log. After the field work is complete, a set of final logs (usually electronic) that serve as the record for the project will be completed in consultation with the project manager or field manager.

Enclosure: USCS Soil Classification Field Guide

USCS SOIL CLASSIFICATION FIELD GUIDE



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FIELD GUIDE FOR SOIL AND STRATIGRAPHIC ANALYSIS v.2

START HERE

DENSITY OR CONSISTENCY

COARSE GRAINED DEPOSITS	N-VALUE	
	0-4	► VERY LOOSE
	5-10	► LOOSE
	11-29	► MEDIUM DENSE
	30-49	► DENSE
	>50	► VERY DENSE

FINE GRAINED DEPOSITS	N-VALUE	q_u (tsf)	
	0-2	<0.25	► VERY SOFT
	3-4	0.25-0.50	► SOFT
	5-8	0.50-1.0	► MEDIUM
	9-15	1.0-2.0	► STIFF
	16-30	2.0-4.0	► VERY STIFF
	>30	>4.0	► HARD

COLOR
Use Standard Munsell Color Notation

IS THE COLOR A MATRIX COLOR?
- YES ► MATRIX COLOR — List in sequence, dominant first
- NO ► IS THE COLOR FROM A COATING OR CONCENTRATION?
  - YES ► COATING or CONCENTRATION — Note frequency, color, and size
  - NO ► MOTTLE — Note contrast, color, and size

CLASSIFICATION
Unified Soil Classification System - adopted ASTM D2488

STEP 1: IS SEDIMENT COARSE GRAINED OR FINE GRAINED?

COARSE-GRAINED DEPOSITS
>50% coarse-grained sediments, <50%fines

STEP 2: DETERMINE SAND VS. GRAVEL RATIO

INCREASING GRAIN SIZE

SAND			GRAVEL	
FINE	MEDIUM	COARSE	SMALL	LARGE

0.075 MM · 0.425 MM · 2.0 MM · 4.75 MM · 19.0 MM · 75.0 MM

STEP 3: *CONTINUE WITH* **SAND** *OR* **GRAVEL** *ON FLOW CHART (REVERSE)*

FINE-GRAINED DEPOSITS
(organic and inorganic)
>50% fines, <50% coarse-grained sediments

STEP 2: DETERMINE PLASTICITY AND ASSIGN USCS GROUP SYMBOL

INCREASING PLASTICITY

NON PLASTIC	LOW PLASTICITY	MEDIUM PLASTICITY	HIGH PLASTICITY
ML	CL		CH

STEP 3: *CONTINUE WITH* **GROUP SYMBOL** *ON FLOW CHART (REVERSE)*

MOISTURE

MOISTURE ABSENT ► DRY
DAMP ► MOIST
VISIBLE WATER ► WET

FOR NON-PLASTIC FINES
WATER RISES TO SURFACE SLOWLY ► SLOW DILATENCY
WATER RISES TO SURFACE QUICKLY ► RAPID DILATENCY

PLASTICITY
(Use with CLASSIFICATION)

WILL NOT SUPPORT 6mm DIAMETER ROLL IF HELD ON END ► NON-PLASTIC
6mm DIA. ROLL CAN BE REPEATEDLY ROLLED AND SUPPORTS ITSELF, 4mm DIA. ROLL DOES NOT ► LOW PLASTICITY
4mm DIA. ROLL CAN BE REPEATEDLY ROLLED AND SUPPORTS ITSELF, 2mm DIA. ROLL DOES NOT ► MEDIUM PLASTICITY
2mm DIA. ROLL CAN BE REPEATEDLY ROLLED AND SUPPORTS ITSELF ► HIGH PLASTICITY

6mm 4 2

COHESIVENESS

6mm DIAMETER ROLL CANNOT BE FORMED ► NONCOHESIVE
6mm DIAMETER ROLL CAN BE FORMED ► COHESIVE

SEDIMENTARY STRUCTURE

UNIFORM ► MASSIVE
BEDS >30cm ► THICKLY BEDDED
BEDS 3cm to 30cm ► BEDDED
BEDS 0.5cm to 3cm ► THINLY BEDDED
BEDS <0.5cm ► LAMINATED

SECONDARY SOIL STRUCTURE (IN SOLUM ONLY)
Spheroidal peds or granules usually packed loosely ► GRANULAR
Irregular, roughly cubelike peds with planar faces (angular or subangular) ► BLOCKY
Flat and horizontal peds ► PLATY
Vertical, pillarlike peds with flat tops ► PRISMATIC
Vertical, pillarlike peds with curved tops (which are commonly "bleached") ► COLUMNAR

WEATHERING ZONE ABBREVIATION

MODIFIER SYMBOL (if present)		1st SYMBOL		2nd SYMBOL		LAST SYMBOL (if present)	
MOTTLED	► M	OXIDIZED	► O	LEACHED	► L	SECONDARY CARBONATE	► 2
JOINTED	► J	REDUCED	► R	UNLEACHED	► U		
		UNOXIDIZED	► U				

EXAMPLE
solum
OJL
MOJL
MOJL2
MOJU

MRJU
RJU
RU
UU

SECONDARY GRAIN SIZE INFORMATION

< 5% ► TRACE
6% to 15% ► LITTLE
16% to 30% ► FEW
31% to 49% ► SOME

► UNIFORM (poorly graded)
► NON-UNIFORM (well graded)

► FINE SAND
► MEDIUM-GRAINED SAND
► COARSE-GRAINED SAND
► FINE GRAVEL
► COARSE GRAVEL

FOR GLACIAL DIAMICTONS ► CLAST FRACTION ► CLAST LITHOLOGY

DEPOSITIONAL ENVIRONMENT

VARIOUS DEPOSITIONAL ENVIRONMENTS (interpretation)
► EOLIAN (LOESS)
► FLUVIAL
► ALLUVIAL
► LACUSTRINE
► COASTAL
► RESEDIMENTED

GLACIAL DEPOSITIONAL PROCESSES
► SUBGLACIAL
► GLACIOFLUVIAL
► GLACIOLACUSTRINE
► RESEDIMENTED

GENERALIZED RESEDIMENTATION PROCESSES
► MASS SLUMP
► SEDIMENT FLOW
► COLLUVIUM

STRATIGRAPHIC NAME

USE FORMAL STATE GEOLOGICAL SURVEY NOMENCLATURE WHEN POSSIBLE;
IF NOT POSSIBLE, ASSIGN SITE-SPECIFIC UNIT NAME ACCORDING TO DEPOSITIONAL ENVIRONMENT / FACIES ASSEMBLAGE

STRATIGRAPHIC CONTACT

< 10 cm ► SHARP (or ABRUPT for pedogenic alternation)
> 10 cm (Note transition interval) ► GRADATIONAL (or TRANSITIONAL for weathering zone change)

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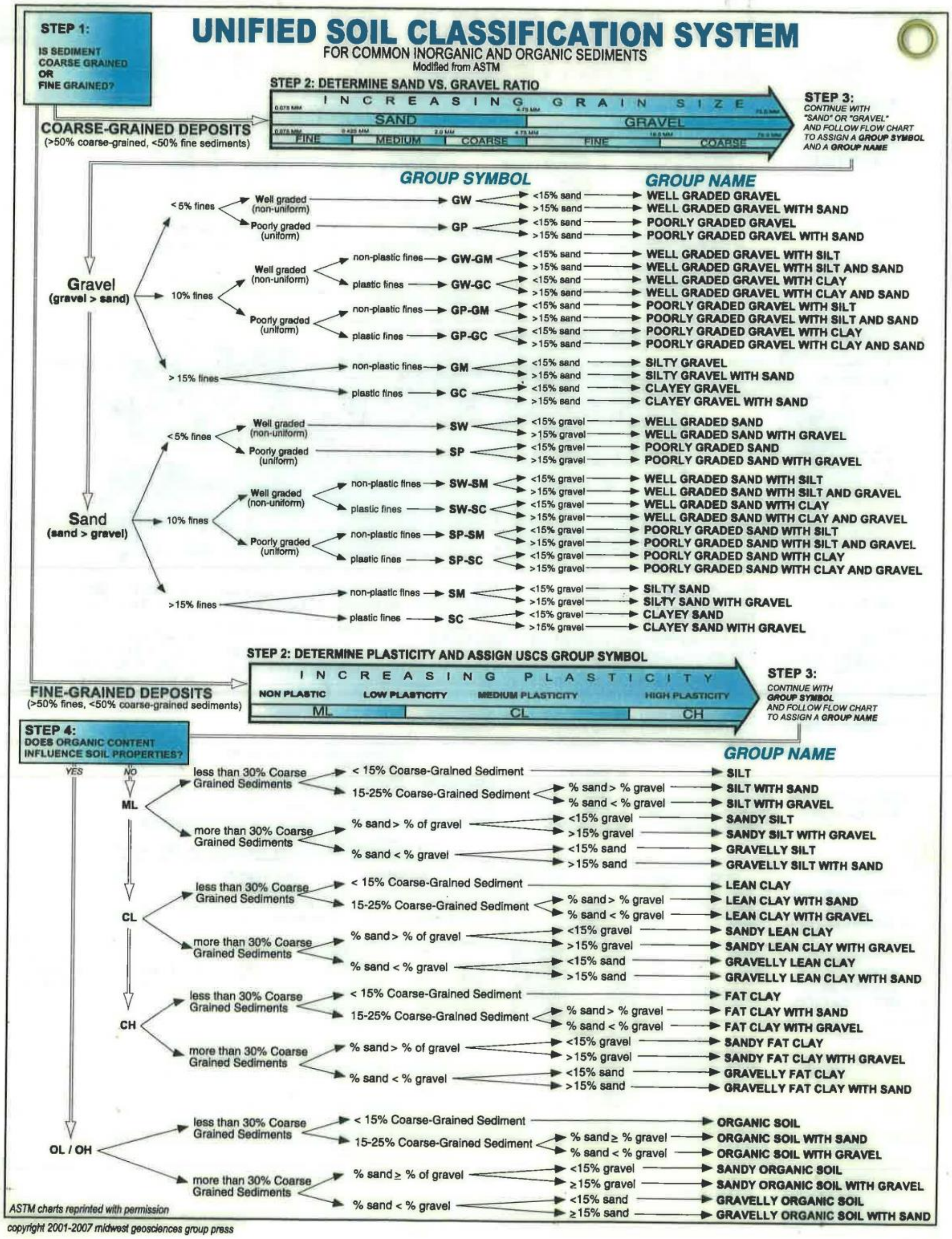

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F|S STANDARD GUIDELINE

Shallow Soil Sample Collection

DATE/LAST UPDATE: May 2015

These procedures should be considered standard guidelines and are intended to provide useful guidance when in the field, but are not intended to be step by step procedures, as some steps may not be applicable to all projects.

All field staff should be sufficiently trained in the standard guidelines for the sampling method they intend to use and should review and understand these procedures prior to going into the field. It is the responsibility of the field staff to review the standard guidelines with the field manager or project manager and identify any deviations from these guidelines prior to field work. When possible, the project-specific Sampling and Analysis Plan should contain any expected deviations, and should be referenced in conjunction with these standard guidelines.

1.0 Scope and Purpose

This standard guideline presents commonly used procedures for the manual collection of shallow soils by means of scoop, trowel, shovel, or hand auger. The guideline is intended to be used by field staff who collect shallow soil samples in the field. Shallow is typically defined as ground surface to approximately 4 feet below ground surface (bgs).

It is important that the field staff completing the soil sample collection discusses the specific needs for a particular investigation with the project geologist, the project manager, or whoever will ultimately be responsible for interpreting the findings of the field investigation. This discussion is in addition to the field training and general knowledge about soil sampling, and should happen prior to entering the field, with additional follow-up before finalizing the field forms, after the investigation is complete.

2.0 Equipment and Supplies

Soil Sampling Equipment and Tools:

- Tape measure or measuring wheel
- Shovel or trowel
- Hand auger (typically used for sample depths > 2 and < 4 feet; an extension can be used if conditions allow deeper sample collection using this method)
- Stainless steel bowls and spoons
- Graduated plunger and collection tubes for volatile organic carbon (VOC) samples (if needed)
- Trash bags and plastic sheeting (if necessary)
- Decontamination tools including:
  - Paper towels
  - Spray bottles of alconox (or similar) solution
  - Deionized or distilled water
- Camera
- Hand-held global position system (GPS; optional)
- Coolers, sample jars, labels, ice

Paperwork:

- Work Plan and/or Sampling and Analysis Plan/Quality Assurance Project Plan (SAP/QAPP)
- Health and Safety Plan (HASP)
- Sample collection forms printed in Rite in the Rain paper, or Rite in the Rain field notebook

Personal Equipment:

- Steel-toed boots
- Safety vest
- Safety glasses
- Nitrile gloves
- Rain gear
- Work gloves

3.0 Standard Procedures

3.1 OFFICE PREPARATION

Prior to going into the field, review the SAP/QAPP tables to become familiar with the desired sample locations and depth intervals. Note any locations that may be covered by pavement and arrange for these locations to be pre-cored or cored on the day of sampling.

At least one week prior to sampling, coordinate with the laboratory specified in the SAP/QAPP to get coolers and appropriate sample containers. Familiarize yourself with the volume requirements and container types, preservation methods and holding times for each class of analytes.

3.2 SAMPLING

1. Locate the desired sample location, using a handheld GPS or by taking field measurements from known site features. Remove surface coverings such as pavement, vegetation, gravel, or landscape materials.
2. Dig or auger to the bottom depth of the shallowest sample to be collected, using a tool that has been cleaned and decontaminated. Verify that the target depth has been reached using a measuring tape.
3. If using a scoop or trowel, collect the soil in a decontaminated stainless steel bowl; if using a shovel, the soil may either be collected in bowls or set aside on plastic sheeting in favor of scraping the sides of the shovel hole to collect the sample. Any soil from depth intervals that are not targeted for sampling should be set aside on plastic sheeting. If using a hand auger, it may be necessary to empty the hand auger onto plastic sheeting, or into a bowl, in order to reach the target depth without overflowing the sampler.
4. If collecting soil samples for VOC analysis by the U.S. Environmental Protection Agency (USEPA) Method 5035, collect these samples from the undisturbed soil, if practical; VOC samples may also be collected from the base or sides of a shovel hole.
5. Note the soil types encountered at each target depth, changes in lithology, and any other observations or indications of contamination on a soil sample collection form or in a field notebook. Detailed procedures for soil classification using the Unified Soil Classification System (USCS), if needed, are provided in the Soil Logging Standard Guideline. Take photographs to document soil type and sample location.
6. Homogenize the soils that have been collected into a bowl, or use a decontaminated or disposable scoop to scrape soil from the shovel hole at the desired depth interval and then homogenize these soils.

7. Fill the required laboratory-provided jars, taking care not to overfill. If large gravels (diameter greater than ~ 1 inch) are encountered, these should be discarded to ensure that an adequate soil volume is collected for analysis. Use a clean paper towel to remove soil particles from the threaded mouth of the jar before securing lids to ensure a good seal.
8. Label each jar with the sample name, date, time, sampler initials and required analyses. If collecting a field duplicate, use the sample nomenclature specified in the work plan and note the field duplicate name and sample time in the sample log. If collecting extra volume for matrix spike/matrix spike duplicate (MS/MSD) analysis, use the same name on all jars. Soil samples should be protected from moisture by placing the filled sample jars into separate sealed Ziploc bags before placing them into a cooler containing ice.
9. Complete a chain-of-custody form for all samples, including sample names, date and time of collection, number of containers, and required analyses and methods. Keep samples on ice to maintain temperatures of 4-6 degrees Celsius (°C) and transport to the laboratory under chain of custody procedures.

4.0 Decontamination

All reusable equipment that comes into contact with soil should be decontaminated as follows prior to moving to the next sampling location.

Stainless steel bowls and spoons, shovels, trowels, hand augers and any other tools used for sample processing will be decontaminated between each sample; alternatively, disposable bowls and spoons may be used. Equipment decontamination will consist of a tap water rinse to remove soil particles, followed by scrubbing with brushes and an alconox (or other soap)/clean water solution and a final rinse with distilled or deionized water.

5.0 Investigation-Derived Waste

Unless otherwise specified in the project work plan, the excavated shallow soils should be used to backfill the hole and restore the grade to the surrounding ground surface. Waste soil that cannot be used to backfill the hole should be placed in 55-gallon drums approved by the Washington State Department of Transportation (WSDOT) for temporary storage pending profiling and disposal. Each container holding investigation-derived waste (IDW) will be sealed and labeled as to its contents (e.g., “soil”), the dates on which the wastes were placed in the container, the owner’s name and contact information for the field person who generated the waste, and the site name.

IDW that is placed into drums for temporary storage will be characterized relative to applicable waste criteria using data from the sampling locations whenever possible. Material that is designated for off-site disposal will be transported to an off-site facility permitted to accept the waste. Manifests will be used, as appropriate for disposal.

Disposable sampling materials and incidental trash such as paper towels and personal protective equipment (PPE) used in sample processing will be placed in heavy duty garbage bags or other appropriate containers and disposed of as solid waste in the municipal collection system (i.e., site Dumpster).

6.0 Field Documentation

All observations including sample collection locations, soil descriptions, sample depths, and sample collection times should be recorded on a soil sample collection form or in a bound field notebook. Information recorded should additionally include personnel present (including subcontractors), purpose of field event, weather conditions, sample collection date and times, sample analytes, and any deviations from the SAP.

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F|S STANDARD GUIDELINE

Soil Sample Collection

DATE/LAST UPDATE: May 2015

These procedures should be considered standard guidelines and are intended to provide useful guidance when in the field, but are not intended to be step by step procedures, as some steps may not be applicable to all projects.

All field staff should be sufficiently trained in the standard guidelines for the sampling method they intend to use and should review and understand these procedures prior to going into the field. It is the responsibility of the field staff to review the standard guidelines with the field manager or project manager and identify any deviations from these guidelines prior to field work. When possible, the project-specific Sampling and Analysis Plan should contain any expected deviations and should be referenced in conjunction with these standard guidelines.

1.0 Scope and Purpose

This standard guideline presents commonly used procedures for collection of soil samples for characterization and laboratory analysis. The methods presented in this guideline apply to the collection of soil samples during the following characterization activities: soil borings via drilling, manual collection of shallow soil samples, test pit excavation, excavation confirmation, and stockpile characterization. Specific details regarding the collection of discrete and composite samples, and special sampling techniques for volatile organic compounds (VOCs) are also included. The guideline is intended to be used by staff who collect soil samples in the field.

It is important that the field staff completing the soil sample collection discusses the specific needs for a particular investigation with the project geologist, the project manager, or whoever will ultimately be responsible for interpreting the findings of the field investigation. This discussion is in addition to field training and general knowledge about soil sampling, and should happen prior to entering the field, with additional follow-up before finalizing the field forms, after the investigation is complete.

2.0 Equipment and Supplies

Soil Sampling Equipment and Tools:

- Tape measure or measuring wheel
- Stainless steel bowls and spoons
- Graduated plunger and collection tubes for VOC samples (if needed)
- Trash bags
- Decontamination tools including:
    - Paper towels
    - Spray bottles of alconox (or similar) solution
    - Deionized or distilled water
- Adhesive drum labels, or paint or grease pen
- Washington State Department of Transportation- (WSDOT) approved drums for investigation-derived waste (IDW) disposal, if needed (if drilling, to be provided by driller)
- Camera
- Hand-held global position system (GPS; optional)
- Coolers, sample jars, labels, ice

Paperwork:

- Work Plan and/or Sampling and Analysis Plan/Quality Assurance Project Plan (SAP/QAPP)
- Health and Safety Plan (HASP)
- Sample collection forms printed in Rite in the Rain paper, or Rite in the Rain field notebook

Personal Equipment:

- Steel-toed boots
- Safety vest
- Safety glasses
- Nitrile gloves
- Rain gear
- Work gloves

3.0 Standard Procedures

3.1 OFFICE PREPARATION

Prior to going into the field, review the SAP/QAPP tables to become familiar with the desired sample intervals, nomenclature, field Quality Assurance (QA) samples, analytes, sample containers, and holding times for each analytical method.

At least one week prior to sampling, coordinate with the laboratory specified in the SAP/QAPP to get coolers and appropriate sample containers. Familiarize yourself with the volume requirements and container types, preservation methods, and holding times for each class of analytes.

3.2 GENERAL SOIL SAMPLE COLLECTION PROCEDURES

1. Locate the desired sample location and depth interval using a handheld GPS or by taking field measurements from known site features. Note the soil type and any other observations or indications of contamination on a soil boring log, soil sample collection form or field notebook, as described in the Soil Logging Standard Guideline. Note the location and depth of the sample and take a photograph, if possible.
2. Refer to subsections 3.2.1 through 3.2.4 for the appropriate soil collection procedures for drilling, shallow soil, test pit excavation, excavation confirmation, and stockpiles. If collecting samples for VOC analysis by the U.S. Environmental Protection Agency (USEPA) Method 5035, refer to Section 3.3 for specific sample collection procedures for this method. If composite soil sampling is recommended, refer to Section 3.4 for details.
3. Once soil has been collected from the desired depth or interval, mix thoroughly until the sample is homogenous in color, texture, and moisture.
4. Fill the required laboratory-provided jars, taking care not to overfill. If large gravels (diameter greater than ~ 1 inch) are encountered, these should be discarded to ensure that an adequate soil volume is collected for analysis. If necessary, use a clean paper towel to remove soil particles from the threaded mouth of the jar before securing lids to ensure a good seal.
5. Label each jar with the sample name, date, time, field staff initials and required analyses. If collecting a field duplicate, use the sample nomenclature specified in the work plan and note the field duplicate name and sample time in the sample log. If extra volume for matrix spike/matrix spike duplicate (MS/MSD) analysis is being collected, use the same name on all jars. Soil samples should be protected from moisture by placing the filled sample jars into separate sealed Ziploc bags before placing them into a cooler.

6. Complete a chain-of-custody form for all samples, including sample names, date and time of collection, number of containers, and required analyses and methods. Keep samples on ice to maintain temperatures of 4-6 degrees Celsius (°C) and transport to the laboratory under chain-of-custody procedures.

3.2.1 Soil Sample Collection via Drilling

These procedures should be used for drilling via direct-push, hollow stem auger, or roto-sonic methods where a pre-designated sample interval (i.e. 0 to 5 feet below ground surface [bgs]) is retrieved from the subsurface using a split spoon sampling device, lined core, or bag sampler.

1. Ensure that reusable sampling equipment has been thoroughly decontaminated prior to sampling.
2. Use a stainless steel spoon or trowel, or disposable scoop to remove an equal volume of soil across the targeted depth interval from the sampler.
   a. If using a split spoon sampler or other reusable sampler, avoid collecting the soil that is touching the sides of the sampler to the extent practical.
   b. If the soil touching a reusable sampler must be collected to obtain adequate volume for analysis, notify the PM and record in the field logbook.

3.2.2 Manual Collection of Shallow Soil Samples

These procedures should be used for shallow soil sampling via scoop, trowel, shovel, or hand auger.

1. Dig or auger to the bottom depth of the shallowest sample to be collected, using a tool that has been cleaned and decontaminated. Verify that the target depth has been reached using a measuring tape.
2. If using a scoop or trowel, collect the soil directly into a decontaminated stainless steel bowl.
3. If using a shovel, the soil may either be collected in bowls or set as aside on plastic sheeting in favor of collecting the sample from the sidewall of the hole. If sampling the sidewall, use a decontaminated or disposable scoop or trowel to collect soil from the target depth, or scrape along the sidewall to collect soil across a target depth interval. Transfer soil to a decontaminated stainless steel bowl, repeating until a sufficient volume has been collected.
4. If using a hand auger, empty the cylinder of the auger directly into a decontaminated stainless steel bowl. It may be necessary to empty the hand auger onto plastic sheeting or into a bowl in order to reach the target depth without overflowing the sampler.
5. Any soil from depth intervals that are not targeted for sampling should be set aside on plastic sheeting and returned to the hole after sampling.

3.2.3 Sample Collection from Test Pits or Limited Soil Excavations

These procedures should be used for collecting samples from test pit explorations excavated using a back hoe or excavator. These same general procedures should also be followed for post-excavation soil samples used to confirm that an excavation has removed contaminated material or to document post-excavation conditions after target excavation limits have been reached.

1. Measure the length, width, and depth of the test pit or excavation area to verify that the target extents have been reached. The lateral spacing of the test pit or excavation confirmation samples, or exact location of samples should be specified in the work plan and typically depend on the size of the excavation area but can vary significantly from project to project.
2. If not specified in the work plan, sidewall samples may be collected either midway between the ground surface and base of the excavation, or incrementally along the entire height of the sidewall. Both sidewall and base (bottom) samples should penetrate a minimum of 6 inches beyond the excavated surface.
3. If the test pit or excavation is less than 4 feet deep, or has been benched to accommodate safe entry, a sample may be collected directly from the sidewall(s). To collect soil from a sidewall, use a decontaminated or disposable scoop, trowel, or shovel to obtain soil from the desired depth or depth interval directly into a decontaminated stainless steel bowl.
4. If a test pit or excavation cannot be safely entered, instruct the excavator operator to scoop sidewall material from the target depth or depth interval. Collect the soil sample from the excavator bucket using a decontaminated stainless steel spoon, trowel, or disposal scoop, avoiding material that has come into contact with the teeth or sides of the bucket. Place an adequate volume of soil into a decontaminated stainless steel bowl. If necessary, follow the compositing procedures in Section 3.4.

3.2.4 Stockpile Sampling

These procedures should be used for classifying stockpiled soil, including excavated soil and imported backfill material.

1. Where potentially contaminated soils have been previously excavated and stockpiled on site, Washington State Department of Ecology (Ecology) guidance recommends using a decontaminated or disposable scoop or trowel, penetrating 6 to 12 inches beneath the surface of the pile at several locations until sufficient volume for analysis is achieved. A decontaminated shovel may also be used to facilitate collection of soil from large piles. The locations for soil collection should be where contamination is most likely to be present based on field screening (i.e. staining, odor, sheen, or elevated photoionization detector [PID] readings). If there are not field indications of contamination, the locations should be distributed evenly around the stockpile.

2. The stockpile may need to be broken up into sections for sample collection depending on the size of the pile (i.e., segregate the pile in half or quarters). If this is necessary, it is important to document where each set of samples were collected from (i.e., north quadrant) and create a field sketch of the pile for reference.
3. If a sampling frequency is not specified in the work plan, the general rule of thumb for contaminated soil stockpile profiling is to collect and submit 3 analytical samples (these samples can be multi-point composites or grabs) for stockpiles less than 100 cubic yards (CY), 5 samples for stockpiles between 100 and 500 CY, 7 samples for stockpiles 500 to 1,000 CY, 10 samples for stockpiles 1,000 to 2,000 CY, and 10 samples for stockpiles larger than 2,000 CY with an additional sample collected for every 500 CY of material. This rule of thumb is consistent with Ecology guidance for site remediation.
4. Samples for characterization of stockpiles of imported backfill or other presumed clean material should also be collected as described above. If not described in the work plan, the typical sample frequency for imported or clean material characterization is one sample per 500 CY.

3.3 SOIL SAMPLE COLLECTION FOR VOC ANALYSIS

If collecting soil samples for VOC analysis by USEPA Method 5035, collect these samples first before disturbing the soil. This method uses a soil volume gauge fitted with a disposable soil sampling plunger tube to collect a soil plug that can be discharged directly to a VOA vial, limiting the loss of volatiles during sampling. The collection of VOC samples using the 5035 method specifies use of an airtight VOA vial with a septum lid. Ecology's interpretation of the USEPA 5035 method allows for field preservation of the sample with methanol or sodium bisulfate, or laboratory preservation (i.e. field collection into an un-preserved vial). It is important to note that if laboratory preservation is the selected method, samples must be received at the laboratory within 48-hours of sample collection. The method of sample preservation for the 5035 method will vary for each site and is dependent on site-specific conditions. Preservation method selection should be coordinated with the laboratory and specified in the sampling plan.

1. Note the volume of soil needed for analysis as specified by the laboratory (commonly 5 or 10 grams). Raise the handle of the soil volume gauge to the slot in the gauge body corresponding to the desired volume and turn clockwise until the tabs in the handle lock into the slot.
2. Insert a sample tube at the open end of the gauge body and turn clockwise until the tabs on the tube lock into the "0 gram" slot. Remove the cap from the sample tube and press directly (where possible) into the shallow soil, soil core/sampler, excavation base or sidewall, or stockpile.
3. Continue pressing the sample tube until the plunger is stopped by the sample volume gauge. If a depth interval (for example 9 to10 feet) is targeted for VOC sampling, collect small volumes of soil across this interval until the sample tube is filled

4. Twist counterclockwise to disengage the sample tube, then depress the plunger to eject the soil plug directly into a laboratory-provided VOA vial. If multiple vials per sample are required, the same plunger may be re-used to fill the remaining vials.

3.4 COMPOSITE SAMPLE COLLECTION

For this guideline, composites are considered to be samples that are collected across more than one location, or multiple depth intervals at a single location. Samples collected over continuous depth intervals within a sampling device (i.e. split spoon) are addressed for each sampling method in Section 3.2 above.

Compositing of sample material may be performed in the field, or by the analytical laboratory. To collect a field composite sample, identify the locations and depth(s) that will comprise the composite. Collect soil from the first target sub-sample depth or depth interval and hold in a decontaminated stainless steel bowl, covered with aluminum foil to prevent cross contamination and label with the location and depth. Continue to collect and hold individual sub-samples until all components of the composite have been collected, then transfer an equal amount of each sub-sample to a clean bowl and homogenize. Fill necessary sample jars from homogenized composite. In some cases, project plans may require that each individual sample that comprised the composite be collected in jars and submitted to the laboratory in the event that individual sample analysis is desired, or if laboratory compositing is requested in addition to field compositing as a field quality control measure. In this case, label each individual jar, but indicate HOLD on the chain-of-custody, and note that the sample is part of composite XYZ.

To collect a laboratory composite sample, collect, and label each sub-sample using the procedures described above in Section 3.2. Record each sub-sample on the chain-of-custody form, and indicate on this form which samples should be composited by the laboratory and the desired name of the composite sample. It is important to communicate to the laboratory if discrete samples will also require analysis (in some cases) or only the composite sample.

4.0 Decontamination

All reusable equipment that comes into contact with soil should be decontaminated prior to moving to the next sampling location.

Stainless steel bowls and spoons, and any tools used for sample processing will be decontaminated between each sample; alternatively, disposable bowls and spoons may be used. Equipment decontamination will consist of a tap water rinse to remove soil particles, followed by scrubbing with brushes and an alconox (or other soap)/clean water solution and a final rinse with distilled or deionized water.

5.0 Investigation-Derived Waste

Unless otherwise specified in the project work plan, waste soils will be contained, transported, disposed of in accordance with applicable laws, and stored in a designated area until transported off-site for disposal.

The approach to handling and disposal of these materials is as follows. For IDW that is containerized, such as waste soils, 55-gallon drums approved by WSDOT will be used for temporary storage pending profiling and disposal. Each container holding IDW will be sealed and labeled as to its contents (e.g., “soil”), the dates on which the wastes were placed in the container, the owner’s name and contact information for the field person who generated the waste, and the site name.

IDW that is placed into drums for temporary storage will be characterized relative to applicable waste criteria using data from the sampling locations whenever possible. Material that is designated for off-site disposal will be transported to an off-site facility permitted to accept the waste. Manifests will be used, as appropriate for disposal.

Disposable sampling materials and incidental trash such as paper towels and personal protective equipment (PPE) used in sample processing will be placed in heavy duty garbage bags or other appropriate containers and disposed of as solid waste in the municipal collection system (i.e., site Dumpster).

6.0 Field Documentation

All observations including sample collection locations, soil descriptions, sample depths, collection times, analyses, and field QC samples should be recorded on a boring log, soil sample collection form, or bound field notebook. Information recorded should additionally include personnel present (including subcontractors), purpose of field event, weather conditions, sample collection date and times, sample analytes, and any deviations from the SAP.

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F|S STANDARD GUIDELINE

Low-Flow Groundwater Sample Collection

DATE/LAST UPDATE: August 2015

These procedures should be considered standard guidelines and are intended to provide useful guidance when in the field, but are not intended to be step-by-step procedures, as some steps may not be applicable to all projects.

All field staff should be sufficiently trained in the standard guidelines for the sampling method they intend to use and should review and understand these procedures prior to going into the field. It is the responsibility of the field staff to review the standard guidelines with the field manager or project manager and identify any deviations from these guidelines prior to field work. When possible, the project-specific Sampling and Analysis Plan should contain any expected deviations and should be referenced in conjunction with these standard guidelines.

1.0 Scope and Purpose

This standard guideline provides details necessary for collecting representative groundwater samples from monitoring wells using low-flow methods. These guidelines are designed to meet or exceed guidelines set forth by the Washington State Department of Ecology (Ecology). Low-Flow sampling provides a method to minimize the volume of water that is purged and disposed from a monitoring well, and minimizes the impact that purging has on groundwater chemistry during sample collection.

2.0 Equipment and Supplies

Groundwater Sampling Equipment and Tools:

- For wells with head less than 25 feet:
    - Peristaltic pump with fully-charged internal battery or standalone battery and appropriate connectors

- For wells with head greater than 25 feet:
    - Bladder pump and controller, as well as an air cylinder, or air compressor (with extension cord if near an electrical outlet; with battery and appropriate connectors or generator if not near an outlet)

      OR
    - Low-flow submersible pump and controller (with extension cord if near an electrical outlet; with battery and appropriate connectors or generator if not near an outlet)
- Multi-parameter water quality meter
- Water level meter
- Poly tubing
- Silicone tubing
- Filters (if field filtering)
- Tools for opening wells (1/2-inch, 9/16-inch, and 5/8-inch sockets, ratchet, screwdriver)
- Well keys
- Tube cutters, razor blade, or scissors
- 5-gallon buckets and clamp
- Paper towels
- Bailer or pump to drain well box if full of stormwater
- Hammer
- Alconox (or similar decontamination solution), deionized water, spray bottles
- Tape measure
- Trash bags

Lab Equipment:

- Sample jars/bottles
- Coolers
- Chain-of-Custody Forms
- Labels
- Ice
- Ziploc bags

Paperwork:

- Field notebook with site maps
- Table of well construction details and/or well logs, if available
- Sampling forms
- Purge water plan
- Rite-in-the-Rain pens, paper, and permanent markers
- Site-Specific Health and Safety Plan (HASP)
- Sampling and Analysis Plan (SAP) and/or Quality Assurance Project Plan (QAPP) (including tables of analytes and bottle types)

Personal Protective Equipment (PPE):

- Boots/waders
- Safety vest
- Safety glasses
- Rain gear
- Nitrile gloves
- Work gloves

3.0 Standard Procedures

Low-Flow groundwater sampling consists of purging groundwater within the well casing at a rate equal to or less than the flow rate of representative groundwater from the surrounding aquifer into the well screen. The flow rate will depend on the hydraulic conductivity of the aquifer and the drawdown, with the goal of minimizing drawdown within the monitoring well. Field parameters are monitored during purging and groundwater samples are collected after field parameters have stabilized. Deviations from these procedures should be approved by the Project Manager and fully documented.

3.1 CALIBRATION OF WATER QUALITY METERS

All multi-parameter water quality meters to be used will be calibrated prior to each sampling event. Calibration procedures are outlined in each instrument's specific user manual.

3.2 MONITORING, MAINTENANCE, AND SECURITY

Prior to sampling, depth to water and total depth measurements will be collected and recorded for accessible monitoring wells onsite (or an appropriate subset for larger sites). Check for an existing measuring point (notch or visible mark on top of casing). If a measuring point is not observed, a measuring point should be established on the north side of the casing. The conditions of the well box and bolts will also be observed and deficiencies will be recorded on the sampling forms or logbook (i.e., missing or stripped bolt). The following should also be recorded:

- Condition of the well box, lid, bolts, locks, and gripper cap, if deficiencies
- Condition of gasket if deficient and if water is present in the well box
- Note any obstructions or kinks in the well casing
- Note any equipment in the well casing, such as transducers, bailers, or tubing
- Condition of general area surrounding the well, such as subsidence, potholes, or if the well is submerged within a puddle.

Replace any missing or stripped bolts, and redevelop wells if needed.

3.3 LOW-FLOW PURGING METHOD AND SAMPLING PROCEDURES

Groundwater samples will be collected using low-flow purging and sampling procedures consistent with Ecology guidelines and the U.S. Environmental Protection Agency (USEPA) standard operating procedures (USEPA 1996). The following describes the Low-Flow purging and sampling procedures for collecting groundwater samples using a peristaltic pump. If the water level is greater than 20 feet below ground surface (bgs), Grundfos or Geotech submersible pumps or bladder pumps can be used since their pumping rates can be adjusted to low-flow levels.

- Place the peristaltic pump and water quality equipment near the wellhead. Slowly lower new poly tubing down into the well casing approximately to the middle of the well screen. If the depth of the well screen is not known, lower the tubing to the bottom of the well, making sure that the tubing has not been caught on the slotted well casing, and then raise the tubing 3 to 5 feet off the bottom of the casing. Document the estimated depth of the tubing placement within the well. Connect the tubing to the peristaltic pump using new flex tubing and connect the discharge line to the flow-through cell of the water quality meter. The discharge line from the flow cell should be directed to a bucket to contain the purged water.
- If using a low-flow submersible pump, connect the pump head to dedicated or disposable tubing. If using a bladder pump, connect both the air intake and water discharge ports to decontaminated or disposable tubing, using the manufacturer's instructions to ensure a secure connection. Lower the pump with tubing into the well as described above and connect the water discharge tubing directly to the flow-through cell.
- Measure the depth to water to the nearest 0.01 foot with a decontaminated water level meter and record the information on a sampling form.
- Start pumping the well at a purge rate of 0.1 to 0.2 liters per minute and slowly increase the rate. Purge rate is adjusted using a speed control knob or arrows on peristaltic and low-flow submersible pumps. The purge rate for bladder pumps is controlled by the air compressor, which first pressurizes the pump chamber in order

to compress the flexible bladder and force water through the discharge line, and then vents the chamber in order to allow the bladder to refill with water.

  - A good rule of thumb is to pressurize to 10 psi + 0.5 psi/foot of tubing depth and begin with 4 discharge/refill cycles per minute; using greater air pressure and accelerating the pump cycles will increase the purge rate.

- Check the water level. If the water level is dropping, lower the purge rate. Maintain a steady flow with no or minimal drawdown (less than 0.33 feet according to USEPA 2002). Maintaining a drawdown of less than 0.33 feet may not be feasible depending on hydrogeological conditions. If possible, measure the discharge rate of the pump with a graduated cylinder or use a stopwatch when filling sampling jars (500 milliliters [mL] polyethylene or glass ambers) to estimate the rate. When purging water through a flow cell, the maximum flow rate for accurate water quality readings is about 0.5 liters per minute (L/minute).
- Monitor and record water quality parameters every three to five minutes after one tubing volume (including the volume of water in the flow cell) has been purged.
  - One foot of ¼-inch interior diameter tubing holds about 10 mL of water, and flow-through cells typically hold less than 200 mL of water; one volume should be purged after about 5 minutes at a flow rate of 0.1 L/minute.
- Water-quality indicator parameters that will be monitored and recorded during purging include:
  - pH
  - Specific conductivity
  - Dissolved oxygen
  - Temperature
  - Turbidity
  - Oxidation reduction potential (ORP)
- Purging will continue until temperature, pH, turbidity, and specific conductivity are approximately stable (when measurements are within 10 percent) for three consecutive readings, or 30 minutes have elapsed. Because these field parameters (especially dissolved oxygen and ORP) may not reach the stabilization criteria, collection of the groundwater sample will be based on the professional judgment of field personnel at the time of sampling.
- The water sample can be collected once the criteria above have been met.
- If drawdown in the well cannot be maintained at 0.33 feet or less, reduce the flow or turn off the pump for 15 minutes and allow for recovery. If the water quality parameters have stabilized, and if at least two tubing volumes and the flow cell volume have been purged, then sample collection can proceed when the water level has recovered and the pump is turned back on. This should be noted on the sampling form.

- To collect the water sample, maintain the same pumping rate. After the well has been purged and the sample bottles have been labeled, the groundwater sample will be collected by directly filling the laboratory-provided bottles from the pump discharge line prior to passing through the flow cell. All sample containers should be filled with minimum disturbance by allowing the water to flow down the inside of the bottle or vial. When collecting a volatile organic compound (VOC) sample, fill to the top to form a meniscus over the mouth of the vial prior to placing the cap to eliminate air bubbles. Be careful not to overflow preserved bottles/pre-cleaned Volatile Organic Analyte (VOA) vials.
- If sampling for filtered metals, collect these samples last and fit an in-line filter at the end of the discharge line. Take note of the flow direction arrow on the filter prior to fitting. A minimum of 0.5 to 1 liter of groundwater must pass through the filter prior to collecting the sample.
- Sample labels will clearly identify the project name, sampler's initials, sample location and unique sample id, analysis to be performed, date, and time. After collection, samples will be placed in a cooler maintained at a temperature of approximately 4 to 6 degrees Celsius (°C) using ice. Chain-of-Custody Forms will be completed. Upon transfer of the samples to the laboratory, the Chain-of-Custody Form will be signed by the persons transferring custody of the sample containers to document change in possession.
- When sample collection is complete at a designated location, remove and properly dispose of the non-dedicated tubing. In most cases, this waste is considered solid waste and can be disposed of as refuse. Close and lock the well.

4.0 Decontamination

All reusable equipment that comes into contact with groundwater should be decontaminated using the processes described in this section prior to moving to the next sampling location.

Water Level Meter: The water level indicator and tape will be decontaminated between sampling locations and at the end the day by spraying the entire length of tape that came in contact with groundwater with an Alconox (or similar)/clean water solution followed by a thorough rinse with distilled or deionized water.

Water Quality Sensors and Flow-Through Cell: Distilled water or deionized water will be used to rinse the water quality sensors and flow-through cell. No other decontamination procedures are recommended since they are sensitive equipment. After the sampling event, the water quality meters will be cleaned and maintained according to the specific manual.

Submersible Pump (if applicable: Decontaminating the pump requires running the pump in three progressively cleaner grades of water.

1. Fill a bucket with approximately 4 gallons or more to sufficiently cover the pump of an Alconox (or similar)/clean water solution. Place the pump and the length of the

power cord (if applicable) that was in contact with water into the bucket and run the pump for approximately two minutes or until the volume of water in the bucket has been exhausted.

2. Fill a second bucket containing approximately 4 gallons or more to sufficiently cover the pump of clean water. Place the pump and cord into this bucket and run the pump for approximately two minutes or until the volume of water in the bucket has been exhausted.
3. Fill a third bucket with approximately 4 gallons or more to sufficiently cover the pump of distilled or deionized water. Place the pump and cord into this bucket and run the pump for approximately two minutes or until the volume of water in the bucket has been exhausted.

Bladder Pump: Clean the inside and outside of the pump body with an Alconox (or similar)/clean water solution, followed by a thorough rinse with distilled or deionized water. The outside of the air supply line that came in contact with groundwater may also be cleaned with Alconox (or similar) solution and re-used; bladders and water discharge lines must be replaced after each sample is collected.

5.0 Investigation-Derived Waste (IDW)

Unless otherwise specified in the project work plan, water generated during groundwater sampling activities will be contained, transported, disposed of in accordance with applicable laws, and stored in a designated area until transported off-site for disposal.

The approach to handling and disposal of these materials for a typical cleanup site is as follows. For IDW that is containerized, such as purge water, 55-gallon drums (or other smaller sized drums) approved by the Washington State Department of Transportation will be used for temporary storage pending profiling and disposal. Each container holding IDW will be sealed and labeled as to its contents (e.g., “purge water”), the dates on which the wastes were placed in the container, the owner’s name and contact information for the field person who generated the waste, and the site name.

IDW containerized within drums will be characterized relative to applicable waste criteria using data from the sampling locations whenever possible. Material that is designated for off-site disposal will be transported to an off-site facility permitted to accept the waste. Manifests will be used, as appropriate for disposal.

Disposable sampling materials and incidental trash such as paper towels and PPE used in sample processing will be placed in heavy-duty garbage bags or other appropriate containers and disposed of as trash in the municipal collection system.

6.0 Field Documentation

Groundwater sampling activities will be documented in field sampling forms and/or field notebooks, and Chain-of-Custody Forms. Information recorded will, at a minimum, include personnel present (including subcontractors or client representatives), purpose of field event, weather conditions, sample collection date and times, sample analytes, depths to water, water quality parameters, well box/lid conditions, amount of purged water generated, and any deviations from the SAP. Photographs of damaged well casings or well boxes should be taken.

7.0 References

USEPA. 1996. Low-Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells, Revision 2. Region 1. July 30, 1996.

_____. 2002. Groundwater Sampling Guidelines for Superfund and CAR Project Managers. Office of Solid Waste and Emergency Response. EPA 542.S-02-001. May 2002.

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F|S STANDARD GUIDELINE:
Special Condition

LNAPL in Monitoring Wells

DATE/LAST UPDATE: September 2018

Standard Guideline(s) to which this Special Condition is appended:

1. Groundwater Sampling Submersible Pump
2. Low-Flow Groundwater Sampling

These procedures should be considered standard guidelines and are intended to provide useful guidance when in the field, but are not intended to be step-by-step procedures, as some steps may not be applicable to all projects.

All field staff should be sufficiently trained in the standard guidelines and special procedures for the sampling method they intend to use and should review and understand these procedures prior to going into the field. It is the responsibility of the field staff to review the standard guidelines and special conditions with the field manager or project manager and identify any deviations from these guidelines prior to field work. When possible, the project-specific Sampling and Analysis Plan should contain any expected deviations and should be referenced in conjunction with these standard guidelines and special conditions.

1.0 Special Condition Applicability

These special condition guidelines can be applied when light non-aqueous phase liquids (LNAPLs) are encountered in a monitoring well, expectedly or unexpectedly. This document can be used in in conjunction with other groundwater sampling guidelines, such as low-flow sampling.

2.0 Equipment and Supplies

In addition to equipment outlined in the groundwater sampling guidelines, the following equipment is necessary:

- Interface probe
- Absorbent socks
- Speedy dry, kitty litter, absorbent pads, or other similar oil absorbent material
- Bailer(s)

3.0 Special Condition Guidelines and/or Procedures

3.1 SAFETY PROTOCOLS

LNAPL should be treated as a flammable and potentially explosive material. When evaluating or sampling LNAPL, monitor the breathing space in the work area with a photoionization detector (PID). Remove any potential sources of sparks from the surrounding area, only use intrinsically-safe equipment, and ensure that a working fire extinguisher is readily accessible.

3.2 UNEXPECTED LNAPL

If LNAPL is unexpectedly encountered at a site during groundwater sampling or monitoring, immediately call the project manager (PM) after implementing the proper safety protocols. If LNAPL has never been observed or reported at the site, its presence may indicate a new release and Washington State Department of Ecology (Ecology) will need to be notified within 24 hours of detection.

If there is an odor or sheen on the water level meter during monitoring, confirm the presence of LNAPL with an interface probe or a bailer. Record the odor (diesel, gasoline, or solvent), color, and thickness.

3.3 MEASURING LNAPL THICKNESS AND CORRECTING GROUNDWATER ELEVATIONS

In order to determine LNAPL thickness, use an interface probe to measure the depth to LNAPL and the depth to water below the top of casing (TOC). Be sure to decontaminate the interface probe prior to and after recording the depths. Generally, interface probes have a grounding wire which should be attached to the metal well box prior to measuring depths. This will prevent any sparks from static electricity.

If significant LNAPL is present at the site, it may be necessary to correct water level elevations for the depression of the LNAPL/water interface in the well to obtain total hydraulic head. LNAPL depression is caused by the weight of the hydrocarbons floating on groundwater. The correction is calculated by multiplying the specific gravity of the LNAPL by the LNAPL thickness. This value is added to the LNAPL/groundwater interface elevation. The following equation shows how to make this correction.

$$\text{Corrected Groundwater Elevation} = \\ (\textit{TOC Elevation} - \textit{Depth to Groundwater}) + (0.80^{1} \times \text{LNAPL thickness})$$

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[1] A generic LNAPL specific gravity of 0.80 is used in this equation. This value typically ranges between 0.72 and 0.88, depending on the type of fuel. If collecting a sample, ask the lab to report the specific gravity, otherwise, use 0.80 as an average.

3.4 COLLECTING AN LNAPL SAMPLE

If LNAPL is present, the PM may want to collect a sample if it has not been analyzed previously. Determining the physical and chemical properties of LNAPL is useful in characterizing the site. Density, viscosity, specific gravity, and chemical composition can be used to determine the effective solubility, identifying potential sources, and evaluating remedial design approaches. A sample can be collected using a bailer or an intrinsically-safe peristaltic pump. Generally, filling a 40 milliliter vial is sufficient for a lab to analyze LNAPL. However, call the lab and ask what type of sample container is needed to run the analyses.

3.4.1 Sampling with a Bailer

If using a bailer, slowly lower the bailer through the LNAPL layer and into the underlying water column. Take care to allow as little water as possible into the bailer. Not much volume is needed for analysis. If available, a wide-mouth funnel tip can be attached at the end of the bailer, which can help capture more LNAPL volume but it is not necessary. Upon retrieval, carefully decant the water from the bailer by opening the check valve at the bottom of the bailer. Then fill the sample containers with LNAPL by pouring from the top of the bailer.

3.4.2 Sampling with a Peristaltic Pump

An intrinsically-safe peristaltic pump can be used to sample if the LNAPL is shallower than 25 feet below the ground surface. The sample tubing can be attached to the interface probe with a zip tie to help determine when the tubing intake has encountered the surface of the LNAPL. Turn on the peristaltic pump and fill the sample container(s) from the pump discharge.

3.5 COLLECTING A GROUNDWATER SAMPLE IN A WELL WITH LNAPL

Standard methods for collecting groundwater samples in wells that contain LNAPL typically involve passing disposable polyethylene sample tubing through the LNAPL, which coats the tubing with product and entrains product in the samples. However, this method often results in groundwater concentrations that are biased high. Therefore, the following procedures can be utilized to obtain groundwater samples in monitoring wells containing LNAPL, whether or not LNAPL is removed prior to sampling.

Place a silicon stopper on the end of a ¾-inch-diameter, Schedule 40 PVC pipe. The pipe can be lowered into the well until the end extends approximately 1 foot below the bottom LNAPL/groundwater interface. Then a stainless steel rod can be lowered through the PVC pipe to push the silicon stopper off the end of the PVC pipe. This will create a clear, LNAPL-free conduit for the polyethylene sample tubing to pass through and lowered to the appropriate depth required for sampling. A line should be attached to the silicon stopper to allow retrieval of the stopper from the well after sampling is finished. This technique will provide more representative groundwater quality data below the LNAPL plume. New disposable polyethylene tubing shall be used for each location and all reusable equipment shall be decontaminated prior to reuse.

3.6 PURGING OR REMOVING LNAPL

LNAPL can be removed from the well with a bailer or a peristaltic pump, using the same steps as above until the LNAPL is completely removed. In addition, if there is less the 0.1 foot of LNAPL in the wells, an absorbent sock can be used to remove LNAPL. However, it is easier to completely remove LNAPL with a peristaltic pump.

Place purged LNAPL in a labeled container on site that is appropriate for LNAPL storage, which will be disposed of at a later date. Purged LNAPL can also be absorbed using speedy dry, kitty litter, absorbent pads, or similar material, which can be placed in a properly labeled drum on site. If LNAPL is not adsorbed, ground the drum by installing a grounding rod for safe temporary storage. Some types of LNAPL, such as chlorinated solvents, may require special handling and disposal requirements. Field staff should confirm the appropriate handling procedures with the PM before purging LNAPL. Do not purge the well of LNAPL if there are no appropriate containers on site.

3.7 LNAPL BAILDOWN TESTING (OPTIONAL)

In some instances, the PM will request that LNAPL recovery be recorded after removing LNAPL from a well, otherwise known as a baildown test. These data can be used to determine LNAPL yield of the well.

An LNAPL baildown test is conducted using a peristaltic pump to selectively remove LNAPL from the well and an interface probe to measure thickness. Similar to collecting an LNAPL sample with a peristaltic pump, the intake tubing should be zip-tied to the interface probe to ensure that the tubing intake is set at the top of the LNAPL layer.

Prior to beginning the test, record the LNAPL thickness. Begin pumping at the top of the LNAPL layer and continue pumping, lowering the tubing as necessary, until the interface probe can no longer detect LNAPL. Stop pumping as soon as the LNAPL has been removed, then use a stopwatch to start measuring the LNAPL recovery time.

Collect LNAPL thickness measurements until the LNAPL has accumulated to the same thickness that was measured prior to beginning the baildown test. A total of 20 to 30 measurements are generally sufficient to determine transmissivity. Measurements should be taken closer together at the start of the test, so begin collecting measurements every 30 to 60 seconds and adjust the intervals as needed for the pace of the LNAPL recovery. Record measurement of elapsed time and LNAPL thickness in the field notebook.

4.0 Field Documentation

Record all LNAPL thicknesses and field observations in the field notebook. As previously stated, if LNAPL is encountered at a site with no known previous occurrences, contact the PM and take the appropriate steps in notifying Ecology.